Risk preferences, productive investment and straw return technology adoption by farmers in China

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Abstract: The low adoption rate of straw return technology has become the key to restricting the development of sustainable agriculture in China. Risk preferences are an important factor affecting farmers' adoption of straw return technology. Based on a two-phase micro-survey data of 1,038 rice farmers in Jiangsu, Jiangxi, and Hunan provinces, this paper uses experimental economics methods to measure farmers' risk aversion and loss aversion. Furthermore, this paper aims to investigate the impact of risk preferences on farmers' adoption of straw return technology and its mechanism. The results revealed that both risk aversion and loss aversion significantly inhibit farmers' adoption of straw return technology: farmers who are more risk-averse and more afraid of loss are less likely to adopt straw return technology. After using the instrumental variable (IV) method and the method of substituting variables for a robustness check, this result still holds. It is further found that risk preferences affect farmers' technology adoption by promoting their productive investment. The higher the degrees of risk aversion and loss aversion, the lower the probability of farmers' productive investment, and the lower the possibility of adopting straw return technology. Additionally, crop insurance, farm scale, and governmental regulations can alleviate the negative impact of risk aversion and loss aversion on farmers' adoption of straw return technology. Therefore, we propose that local governments need to promote green agricultural development by propagating the benefits of straw return technology, extending crop insurance, promoting the appropriate scale operations, and strengthening governmental regulation to promote farmers' adoption of straw return technology.

Keyword: Risk preferences; Productive investment; Crop insurance; Farm scale; Governmental regulations; Straw return technology

JEL classification: Q16; Q18;

1. Introduction

Straw return technology[1], as a kind of conservation tillage technology that is able to effectively alleviate soil fertility degradation, can avoid farmers burning straw in the harvest season and reduce environmental pollution (Li et al., 2020; Meng et al., 2021). It has been promoted in China for more than 20 years but the technology adoption rate is still low (Gao et al., 2018; Mao et al., 2021). Based on straw burning monitoring data obtained by remote-sensing satellites of the Ministry of Ecology and Environment of the PRC, although there is no large-scale straw burning due to Chinese governmental regulations, the "spark" of straw burning still occurs from time to time[2]. Especially, in developing countries that rely heavily on agricultural production, straw burning is more common. It is also the main cause of seasonal air pollution and health problems (Guo, 2021; Lai et al., 2021; Lopes et al., 2020; Rangel and Vogl, 2019). Because farmers are the direct users of cultivated land, changing their traditional production behavior is undoubtedly key to popularizing straw return technology. However, it will have little impact if farmers only adopt straw return technology periodically or in the short term. Only if farmers adopt straw return technology continuously

[1] Straw return technology is a protective farming measure for farmland that uses straw grinder to crush the harvested straw (wheat straw, corn straw, etc.) on the spot and cover it on the ground (Meng et al., 2021; Yuan et al., 2021).
[2] Data source: http://www.secmep.cn/ygyy/dqhjjc/.

can it play an ecologically beneficial role (Huang et al., 2021). Therefore, exploring the long-term mechanism of Chinese farmers' adoption of straw return technology has important practical significance for promoting the comprehensive utilization of straw and reducing agricultural non-point-source pollution[1].

Existing literature has studied farmers' adoption of straw return technology from many aspects, such as householder age, gender, education (Ndiritu et al., 2014; Wu and Babcock, 1998), time preference (Mao et al., 2021), technical cognition (Lu et al., 2020), technology subsidies (Kurkalova et al., 2006), media channels and social interaction (Jiang et al., 2021), stability of land tenure (Gao et al., 2018), technical information (Hou et al., 2019), environmental cognition (Sattler and Nagel, 2010), and farm scale (Wu et al., 2018). Some studies have also confirmed that risk preferences are a key factor affecting farmers' adoption of agricultural production technology (Alpizar et al., 2011; Haile et al., 2020). However, few studies have analyzed risk preferences and farmers' adoption of straw return technology from the perspective of productive investment, i.e., whether they invest in new production technology or assets (tractors, in this paper). Therefore, this paper attempts to analyze whether the lower levels of farmers' adoption of straw return technology are associated with risk

[1] Environmental problems are exacerbated by the fact that China is the world’s largest producer of field crops. In fact, China produces one billion tons of straw a year. Great quantities of straw are used ineffectively. Crop straw burning poses a major challenge to China's environment, especially agricultural diffuse pollution (Li et al., 2018).

aversion, and if so, will crop insurance, farm scale, and governmental regulation mitigate this negative impact?

Prospect theory indicates that due to the uncontrollable production risks and asymmetric information, farmers consider both profit maximization and risk minimization when making production decisions (Mao et al., 2019). Farmers have very limited ability to withstand unexpected risks such as natural disasters and climate change in agricultural production. Therefore, they will take conservative production decisions in the case of incomplete information to avoid risks. Farmers' strong degree of risk aversion and loss aversion will inhibit their technology adoption, which includes straw return technology as a new method of production (Liu, 2013; Jin et al., 2015). Straw return technology is an important conservation tillage technology due to its functions of water conservation, preservation of soil moisture, and soil fertility enhancement. It can help boost farmers' ability to resist natural disasters, but also carries risks of uncertain net income and, improper use also carries dangers (Xu et al., 2021). For example, it may lead to increased incidence of crop diseases and thus increased pesticide expenditure (Jiang et al., 2021). In addition, after returning straw to the field, it is unable to improve the physical structure of the soil well in case of drought or insufficient plowing depth (Wang et al., 2021; Yuan et al., 2021). Meanwhile, in terms of income uncertainty, it is difficult for farmers to control the technical benefits of straw return technology[1]. Compared with field incineration, straw returning incurs additional costs, thus making its net benefits uncertain[2]. Therefore, the higher their risk aversion and loss aversion, the less likely farmers are to adopt straw return technology.

Based on theoretical analysis, this paper uses two-phase field survey data of 1,038 rice farmers in China and explores the influence and mechanism of risk preferences on farmers' adoption of straw return technology through empirical methods. Further, we analyze the different impacts of risk preferences on farmers' adoption of straw return technology due to crop insurance, farm scale, and governmental regulation. It is found that high levels of risk aversion and loss aversion significantly inhibit farmers' adoption of straw return technology. Additionally, the higher the farmers’ risk aversion and loss aversion degree, the less likely they were to adopt straw return technology. This effect remains significant after controlling for the potential endogeneity problems using instrumental variables (IV).

This paper further studies the deep-seated reasons why risk preferences affect farmers' adoption of straw return technology from the perspective of productive investment.

[1] The quality of straw returning mainly refers to whether the straw is thrown evenly, the stubble height, the length of cutting and the depth of land turning. These indexes will affect the degree of straw maturity, and then affect the sowing, planting and later growth of subsequent crops.

[2] According to the interview survey conducted in Peixian county (Xuzhou, Jiangsu Province) and Gaoyou county (Xuzhou, Jiangsu Province), straw returning requires more straw shredding, soil suppression, and mulching than not returning straw to the field, with an additional cost of about 40 yuan per mu.

Specifically, we use whether farmers buy tractors and harvesters to measure their productive investment. Farmers need to use a harvester to crush the straw to the field when harvesting rice. Then, after the straw is decomposed in the field, a tractor must be used to turn the soil. Renting this equipment is not feasible because it will increase the cost. Therefore, if farmers already own or are willing/able to buy these two types of equipment, their willingness to adopt straw return technology over the long term will be higher.

It is found that risk preferences can affect farmers' adoption of straw return technology by affecting their productive investments. In other words, farmers who are more risk-averse and more afraid of loss are less likely to make productive investments, including adopting straw return technology. In addition, crop insurance, farm scale, and governmental regulation positively moderated the inhibitory effects of risk aversion and loss aversion on farmers' adoption of straw return technology. These conclusions are helpful to understand the phenomenon and underlying reasons for straw return technology promotion obstruction and have important reference significance for promoting the adoption of straw return technology among farmers.

Compared with previous studies, this paper makes the following contributions. Firstly, this study confirms the inhibitory impact of low risk preferences on farmers' adoption of straw return technology and discusses the underlying mechanism from the perspective of productive investment, which supports existing evidence on determinants of farmers' adoption of straw return technology. Secondly, this paper discusses whether crop insurance, farm scale, and governmental regulation can help to relieve the inhibition impact of high risk aversion and loss aversion on farmers' adoption of straw return technology. This provides a new perspective to overcome the difficulties in promoting straw return technology caused by risk aversion and loss aversion. Thirdly, the risk aversion and loss aversion degree of rice farmers were measured by the experimental economics method, which supplements existing data on farmers' risk preferences.

2. Literature review and theoretical analysis

2.1 Literature review

2.1.1 Factors affecting farmers' adoption of straw return technology

Previous studies have shown that factors such as years of education, farm scale, and land tenure stability have a positive influence on farmers' adoption of straw return technology (Tang et al., 2019; Tarfasa et al., 2018; Gebremedhin, 2015). Firstly, improving how many years of education that farmers receive can powerfully promote their adoption of straw return technology (Ward et al., 2018). Well-educated farmers have stronger technical learning abilities and better understanding of the advantages of straw return technology (Javed and Khan, 2020). Secondly, great differences exist in farmers' adoption of straw return technology according to different farm scales (Gailhard and Bojnec, 2015). In contrast to small-scale farmers, large-scale farmers have a greater magnitude effect. They place more importance on long-term benefits and sustainable development of agricultural production and have resource endowment advantages (Mao et al., 2021). Finally, land tenure stability can significantly affect farmers' adoption of straw return technology (Gao et al., 2018). Unstable land tenure will reduce farmers' enthusiasm for land investment (Jacoby et al., 2002), whereas stable land tenure will make it easier for farmers to obtain credit, provide financial support for technology investment, and alleviate the liquidity constraints of farmers' technology adoption (Kabubo-Mariara et al., 2010).

Studies have also shown that policy factors such as technical subsidies, technical training, and governmental regulation play important roles in farmers' adoption of straw return technology (Kurkalova et al., 2006; Gao et al., 2018). Firstly, technical subsidies can reduce farmers' cost of adopting straw return technology and produce the incentive effect of "little cost for big reward" (Gupta, 2012). Secondly, technical training and demonstrations help increase farmers' understanding and recognition of agricultural technology, improve farmers' acceptance of new technologies, and thus promote farmers' adoption of agricultural technology (Shikuku, 2018). Accordingly, the extension of agricultural technology information is helpful for farmers to adopt straw return technology (Martey and Kuwornu, 2021). Timely and effective communication with technology extension personnel can provide farmers with accurate agricultural technology information and help them fully understand potential benefits (Caffaro et al., 2020). Finally, governmental regulation can effectively restrict farmers' production through penalty measures such as fines and detention to promote farmers to adopt straw return technology (Ramsey et al., 2013; Omotilewa et al., 2019).

Other studies have shown that social capital, information access, and other factors also affect farmers' adoption of straw return technology (Wossen et al., 2015). First, social capital plays a significant role in promoting farmers' adoption of straw return technology. Social learning through informal groups (such as farmers) and communicating information with peers (such as neighbors) can improve the adoption rate of straw return technology (Lopes et al., 2020). One reason is that farmers can replace the formal credit market with their rich social capital, and broaden the sources of funds, which can thus promote their adoption of agricultural technology (Wossen et al., 2015). Another reason is that information exchanges between farmers and others can broaden farmers' technical knowledge, which in turn could help alleviate the low adoption rate of straw return technology caused by farmers' limited knowledge level and technical perceptions (Wu et al., 2016). For example, Nakano et al. (2018) found that social capital is very important in the cognition and adoption of agricultural technology. Frequent technical training can promote farmers' adoption of new agricultural technology. Second, the information acquisition channel of the media can also increase farmers' information flow and reduce the cost of obtaining technical information, so that farmers can more fully understand the advantages of straw return technology, thus increasing their willingness to adopt (Jiang et al., 2020).

2.1.2 Risk preferences and farmers' technology adoption

According to prospect theory, risk preferences will affect individual decision-making (Tanaka, 2010), including farmers' decision-making regarding technology adoption. Specifically, in contrast to traditional agricultural technology, the benefits generated by advanced agricultural technology are uncertain, so farmers who prefer more risk will be more inclined to adopt advanced agricultural technology. For example, Serra et al. (2008) found that organic agricultural technology will reduce the use of agrochemicals, making farmers face greater risks. Therefore, risk-preferring farmers are more inclined to adopt organic agricultural technology.

Moreover, the impact of risk preferences on farmers' technology adoption will vary according to farmers' information acquisition ability and gender (Liu, 2013; Ghadim et al., 2005). First, the adoption of new agricultural technology will expose farmers to risks such as uncertain seed quality and profit. An improved ability to acquire information can enhance farmers' understanding of the technology and thus help relieve the inhibitory influence of risk aversion on their technology adoption (Magnan et al., 2020). Second, compared with females, males are more able to obtain technical information through radio and television. TV and radio promote more up-to-date information compared with informal word-of-mouth networks, and women tend to get information through channels other than TV. Thus, different-gender farmers have different patterns of information acquisition and different sources of information, and the impact of risk aversion on their technology adoption is also different (Jin et al., 2015). In addition, farmers with stronger risk aversion or loss aversion tend to be late adopters of new agricultural biotechnology (Liu, 2013).

In summary, most existing studies have examined farmers' adoption of straw return technology from the aspects of individual characteristics, family characteristics, and policy incentives. Furthermore, studies on the influence of risk preferences on farmers' technology adoption mostly focused on the adoption of new agricultural biotechnology, green control techniques, and conservation tillage technology. Few studies concentrated on how risk preferences impact farmers' adoption of straw return technology, especially from the perspective of productive investment. Studies on the roles of crop insurance, farm scale, and governmental regulation in the influence of risk preferences on farmers' adoption of straw return technology are lacking.

China, as a largely agricultural nation, produces more than 1 billion tons of crop straw annually. The adoption rate of straw return technology in China is low, and great volumes of straw are burned in the open air, which seriously affects the environment and residents' health. Thus, it is even more urgent to improve the adoption rate of straw return technology (Li et al., 2018). In view of this, this paper will analyze the influence of risk preferences on farmers' adoption of straw return technology, investigate its mechanism from the perspective of productive investment, and deeply explore the regulatory effects of crop insurance, farm scale, and governmental regulation.

2.2 Hypothesis development

Based on prospect theory, it can be argued that risk-averse farmers prefer to minimize loss rather than maximize profit in production decision-making (Duan et al., 2021) due to the large uncertainty and risk in agricultural production (Hao, 2010). Although straw return technology can improve the ability of crops to resist natural disasters (Xu et al., 2021), when compared with direct open-air incineration, straw return technology requires additional costs and may increase the incidence of crop diseases and pests and require the use of more pesticides (Jiang et al., 2021). In addition, it is difficult for farmers to master the depth of turning up the soil and stubble height required to obtain the economic and environmental benefits of straw return technology (Yuan et al., 2021). Thus, overall, farmers face uncertain costs versus benefits when considering whether to adopt straw return technology. As the implementation subject of agricultural technology, farmers' risk preferences are therefore one important factor affecting their adoption of straw return technology (Karlan et al., 2013; Channa et al., 2021). Accordingly, the influence of risk preferences on farmers' adoption of straw return technology mainly occurs in the following ways.

First, farmers face the uncertainty of net income and risks of technology adoption by adopting straw return technology, which leads to low willingness among risk- and loss-averse farmers to adopt straw return technology (Xu et al., 2021). The first risk is that of uncertain net income. Using straw return technology means that diseases and pests originally carried by crops remain in the field and can thus increase the disease incidence of newly planted crops, increase pesticide expenditure, and raise the cost of straw return technology for farmers (Jiang et al., 2021). At the same time, China experiences frequent fluctuations in agricultural product prices. Farmers are at a disadvantage in terms of access to market price information and have weak bargaining power (Gao et al., 2017). Insufficient and asymmetric information tends to make farmers passive recipients of prices. The high cost of adopting straw return technology and the unstable price of agricultural products make it difficult for farmers to obtain higher incomes. Straw return technology requires high input costs, but its benefits are uncertain. Therefore, there is uncertainty regarding whether farmers will obtain high incomes after investing in this technology, which decreases their willingness to invest.

The second impact relates to the risk of uncertainty of technical effects. Straw return technology is representative of intertemporal agricultural technology. Straw can only increase the soil quality after it is thoroughly decomposed, which is a variable process (Gao et al., 2018). Specifically, there is no fixed timeframe for the decay of straw because the degree of such decay varies greatly in different seasons and different regions. In south China, straw decay takes about 6 months, whereas in northeast China, straw decay takes at least a whole year. This intertemporal agricultural characteristic of straw return technology also increases farmers' time costs, so that farmers need to weigh the expected income against the current cost (Chen et al., 2017; Huang et al., 2021). Furthermore, straw return technology needs appropriate methods, quantities, and timing to have beneficial effects (Wang et al., 2021). Studies have shown that different methods, amounts, and times have different effects on the technical benefits of straw return technology (Liu et al., 2019). Improper application of straw return technology will also undermine the technical effects, so farmers will not get the expected benefits.

In addition, some studies showed that farmers with different risk preference levels have different timeframes of technology adoption. Farmers will naturally have different attitudes towards the effectiveness of the technology. The more skeptical they are about the effectiveness of new agricultural technology, the more risk-averse, or the more afraid of loss, the later they will adopt the technology (Liu, 2013). Therefore, risk preferences not only affect whether or not farmers will adopt straw return technology, but will also affect their continuous adoption and use of this method. In conclusion, because adopting straw return technology carries the risk of uncertain net income and technical effects, the more risk-preferring farmers tend to adopt straw return technology, and are more tend to continue to adopt the technology.

Risk preferences can also affect farmers' adoption of straw return technology by promoting their participation in credit (Abate et al., 2016). Straw return technology cannot be carried out without relevant agricultural machinery. Buying machinery or using socialized services for straw return technology will increase farmers' costs. Therefore, a shortage of funds has become the main reason hindering farmers’ adoption of straw return technology. Obtaining credit helps to alleviate farmers' liquidity constraints (Fayaz et al., 2006) and increase their opportunities to invest to obtain higher incomes (Makate et al., 2019). However, in terms of agricultural credit, farmers are not only limited by factors such as collateral (Akram and Hussain, 2008), but also face the risk of losing their collateral in the process of applying for loans. Therefore, they face risk rationing (Guirkinger and Boucher, 2010). Therefore, farmers’ decision to borrow depends on their willingness to bear risks. Farmers who are more afraid of risks and losses are less likely to apply for loans. These farmers might even voluntarily abandon participating in credit in order to avoid risks (Binswanger and Sillers, 1983; Visser et al., 2020). Conversely, farmers who prefer risk are more likely to participate in credit, face fewer less liquidity constraints in agricultural production, and have a higher probability of adopting straw return technology (Abay et al., 2017).

Risk preferences also affect farmers' adoption of straw return technology by promoting productive investment[1]. On the one hand, farmers with higher risk aversion have lower

[1] According to the definition of the agricultural survey team of the National Bureau of statistics, farmers' agricultural productive fixed assets investment mainly includes draught animals, product animals, large and medium-sized iron and wood agricultural tools, agricultural, forestry, animal husbandry and fishery machinery, transportation machinery, production houses and other production fixed assets (http://www.stats.gov.cn/ztjc/ztfx/dfxx/200907/t20090730_34888.html) .

investment willingness and investment intensity (Duan et al., 2021). This relates to the high risk of agricultural production, which makes farmers with stronger risk aversion more reluctant to invest in high-input production systems (Oyinbo et al., 2019). On the other hand, straw returning includes rotten material returning, crushing returning, and covering returning. These straw returning methods are inseparable from agriculturally productive fixed assets such as crushing returning machines and combining harvesters with straw returning device[1]. Owning their own agricultural machines and tools will make it easier for farmers to adopt straw return technology, which is conducive to mobilizing farmers' enthusiasm and initiative in carrying out mechanized operations such as crushing straw and returning it to the field[2]. Therefore, the higher farmers' level of risk preference, the higher their willingness to make the productive investment, and the greater the possibility of their purchasing straw returning machinery. In turn, the higher availability of straw returning machinery further promotes farmers' adoption of straw return technology (Hou et al., 2019). Based on this, this paper proposes the following hypotheses:

H1: Higher risk preferences can significantly promote farmers' adoption of straw return technology.

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[1] Reference material：Reply to recommendation No. 4764 of the second session of the 13th National People's Congress (moa.gov.cn).

[2] Reference material：Ministry of agriculture and rural development of the people's Republic of China (moa.gov.cn).

H2: Higher risk preferences promote farmers' adoption of straw return technology by promoting farmers' productive investment.

The influence of risk preferences on farmers' adoption of straw return technology will also be affected by crop insurance, farm scale, and governmental regulation. Specifically, as an important part of the insurance system, crop insurance plays a role of "guaranteeing cost," which will affect the technology adoption decisions of farmers with different levels of risk preference (Nicola, 2015). Farmers who are more risk-averse and afraid of loss are more tend to adopt technologies bundled with insurance (Visser et al., 2020). Farrin and Miranda (2015) found that the agricultural technology adoption rate with bundled insurance is higher than that of uninsured agricultural technology. Crop insurance can positively alleviate the inhibition caused by risk aversion and loss aversion on farmers' adoption of straw return technology. The reasons are as follows: First, crop insurance can reduce farmers' risks and losses related to the occurrence of natural disasters. Because most farmers are risk-averse (Senapati, 2020), as an effective tool for farmers' risk management, crop insurance can reduce agricultural risks (Belissa et al., 2019) to alleviate farmers' risk aversion in the adoption of straw return technology. Second, at present, most crop insurance implemented in China is policy crop insurance, which is conducive to improving farmers' welfare and expected incomes (Coble and Barnett, 2013). It increases farmers' capacity to bear the cost of straw return technology and thus promotes its adoption. Third, crop insurance can compensate for agricultural losses and reduce uncertainty to improve the initial cost-benefit structure of farmers and improve their ability to resist risks (Vickery et al., 2017). Therefore, crop insurance can effectively alleviate farmers' inhibiting risk caused by risk aversion and loss aversion on the adoption of straw return technology. Specifically, the higher the degree of risk aversion and loss aversion, the more willing farmers are to insure, and participating in crop insurance can promote farmers to adopt the technology. Based on the above analysis, this paper proposes:

H3: Crop insurance has a positive regulatory effect on the impact of risk preferences on the adoption of straw return technology.

Due to the differences in farm scale, capital, and information among farmers, in contrast to small-scale farmers, large-scale farmers have a stronger ability to bear risks (Saqib et al., 2016). Thus, the influence of risk preferences on farmers' adoption of straw return technology will vary with farm scale. First, due to the economies of scale, the costs and benefits of adopting technology between large-scale farmers and small-scale farmers are different. Large-scale farmers find it easier to obtain economies of scale (Hu et al., 2019). Their mechanical cost of adopting straw return technology is relatively low. Second, the risk resistance of large-scale farmers and small-scale farmers is different. In contrast to small-scale farmers, large-scale farmers have sufficient funds and are more able to obtain credit to alleviate liquidity constraints (Makete et al., 2019). They are more able to bear technology costs and possible losses, and have stronger ability to resist risks. Third, large-scale farmers have stronger ability to bear climate, yield, and market price risks. They have lower discount rates and place more importance on the long-term benefits of agricultural production. Therefore, they are more tend to adopt straw return technology, which has a longer income period (Mao et al., 2021; Helfand and Taylor, 2020). In conclusion, farm scale can positively regulate the promotion of risk preferences on straw return technology. In contrast to small-scale farmers, large-scale farmers have stronger anti-risk ability in agricultural production and are more tend to adopt straw return technology. Based on the above discussion, this paper proposes:

H4: Farm scale has a positive regulatory effect on the impact of risk preferences on the adoption of straw return technology.

Governmental regulation is one important means of government intervention in the economy (Burgess, 1995; Liu et al., 2020; Ye and Lin, 2020). It has a significant impact on farmers as a microeconomic subject, especially in terms of adopting straw return technology.

Government regulation includes not only imposing punishment and restraint measures on farmers for straw burning, but also the vigorous promotion of straw return technology. Regulation can impose mandatory constraints on farmers, improve farmers' ability to obtain information, and increase their understanding of technology, all of which impact farmers' adoption of straw return technology (Hou et al., 2019). First, strict law enforcement enables better implementation of government policies (Laar et al., 2020). In the Chinese context, this can be seen in measures such as the Chinese government restraining straw burning by implementing strict laws and regulations, such as detention and fines. Although the cost is higher for farmers to adopt straw return technology compared with using other treatment methods, farmers face detention or fines for burning straw (Lai et al., 2021), which will not only cause farmers to lose labor time or money, but also increase their cost. Based on deterrence theory, whether an individual complies with laws and regulations depends on the trade-off between the benefits brought by breaking the law and the possibility and severity of punishment (Akers, 2017; Kaine et al., 2010). Farmers who are risk- or loss-averse will be forced by the government to reduce straw burning, and are thus more likely to adopt straw return technology.

Second, governmental regulation promotes farmers' adoption of agricultural technology by increasing farmers' information sources and alleviating information asymmetry (Caffaro et al., 2020). The Chinese government provides farmers with agricultural information through policy publicity, project demonstrations, and technical training to improve farmers' information acquisition ability. At the same time, it can also reduce the risk of green agricultural technology adoption by farmers, and effectively alleviate farmers' inhibiting risk caused by risk aversion (Martey and Kuwornu, 2021). In sum, in terms of governmental regulation, farmers face the trade-off between the punishment cost of violation of law and the benefits obtained by violation of law, as well as the net income granted through government support policies. Because of the cost-effectiveness brought by their own behavior choice, farmers will be more inclined to adopt straw return technology. Therefore, in the case of governmental regulation, farmers who are risk- and loss-averse will be more inclined to adopt straw return technology. Based on the above arguments, this paper proposes the following hypothesis:

H5: Governmental regulation has a positive regulatory effect on the impact of risk preferences and the adoption of straw return technology.

3. Model, Variable, and Data

3.1 Background on straw return technology

Straw return technology is one of the conservation tillage technologies. It is that the crop straw is directly crushed and covered on the ground after harvesting, and then turned into the soil by rotary tillage to be used as base fertilizer (Meng et al., 2021). Many studies have confirmed the benefit of straw return technology in increasing crop yield and improving soil quality (Han et al., 2020; Yan et al., 2020). Straw return technology has the functions of conserving water, preserving soil moisture, increasing soil fertility, and restraining wind erosion and water erosion. It is helpful to improve the ability of crops to resist natural disasters (Xu et al., 2021). However, popularizing straw return technology is still lagging. It's calculated by the data of the Ministry of Agriculture and Rural Affairs of the PRC that straw returning areas in China are 51.3 million hectares[1], accounting for less than 44.4% of the total cultivated field. Most Chinese farmers do not want to adopt straw return technology, but burn straw. The reason may be as follows: First, straw burning can quickly kill pests and weeds when cleaning the field for the next round of cultivation. The burned ashes can also make the farmland fertile (He et al., 2020). Second, because of fragmented and small-scale land, uncertain technical effects, and other characteristics, farmers adopt mechanized straw return technology costly. The farmers' cost of collecting, storing, and transporting straw is also high

1 Reference material: http://zdscxx.moa.gov.cn:8080/nyb/pc/index.jsp

(Lai et al., 2021; Xu et al., 2021). Opening burning is the most convenient and lowest cost for farmers to deal with straws (Chen et al., 2016).

But straw burning has a bad influence on air quality, health, and economics (Zivin et al., 2020; Guo, 2021; He et al., 2020). For example, Zivin et al. (2020) studied the impact of agricultural fires on cognitive ability. The results show that between the upwind and downwind fires increase by one standard deviation, the test score decreases by 1.42% standard deviation, which further reduces the probability of entering the best university by 0.51% standard deviation during the exam. Guo (2021) used the panel data of 290 cities and 620 days to analyze the impact of straw burning on air quality in China. The results show that the urban air pollution index increased by 7.3, which was equivalent to 11% of the average level on the first day of straw burning. The impact of this pollution continued for 11 days and the distance was far 600 kilometers away. In order to prevent straw burning, the Chinese government has successively promulgated policies and regulations to support straw sustainable management, including launching straw return technology training, carrying out straw return technology subsidies, and even carrying out strict prohibitions and penalties for straw burning (Hou et al., 2019). But the adoption rate of straw return technology in China is still low. According to the data on straw burning obtained by the remote sensing satellite of the Ministry of Ecology and Environment of the PRC, there are different degrees of straw burning in different provinces and cities in China from 2014 to 2017 (as shown in Figure 1 and Figure 2), particularly in northeast China and in central China. The degree of straw burning is different in different months in China in 2017(as shown in Figure 3). Figure 3 displays that the degree of straw burning is lower from January to March. During this time, straw burning mainly is distributed in northeast China, where farmers burn crop residues to clear farmland for sowing. May, June, October and November are the harvest seasons in northern China, and the straw burning degree is relatively higher.

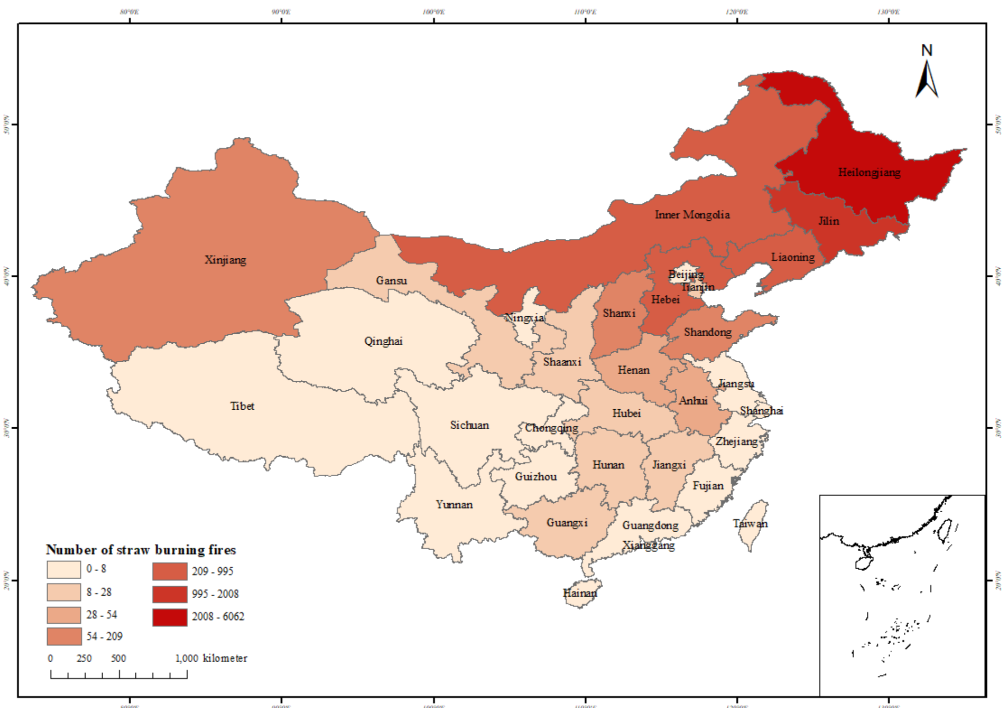

Fig.1. Straw burning in each province in China from 2014 to 2017

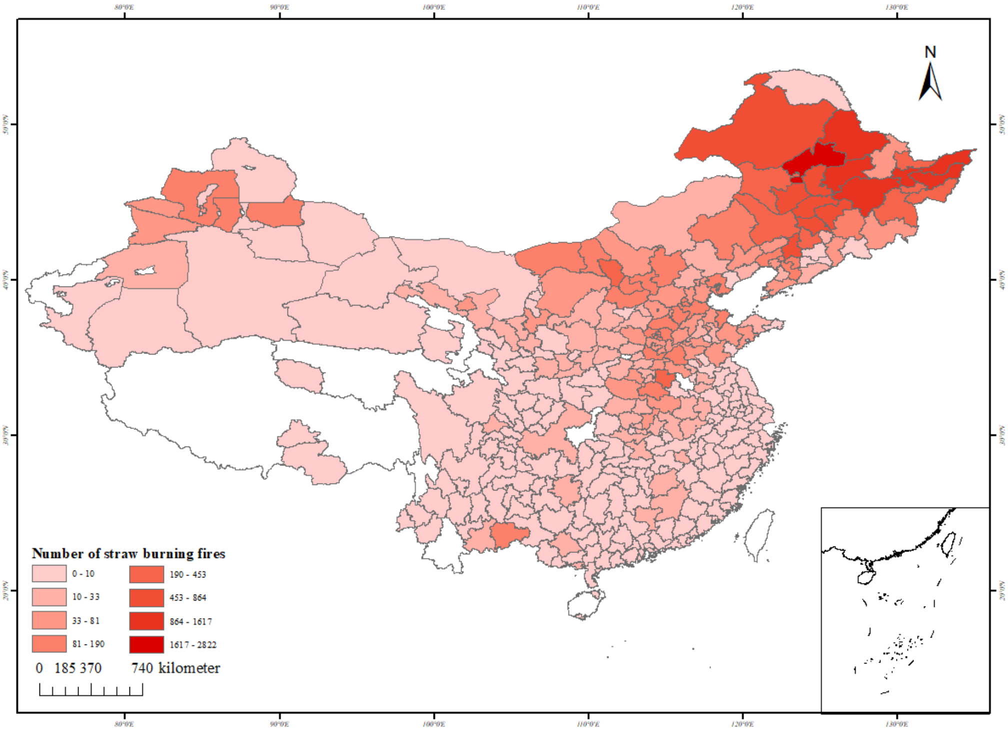

Fig.2. Straw burning in each city in China from 2014 to 2017

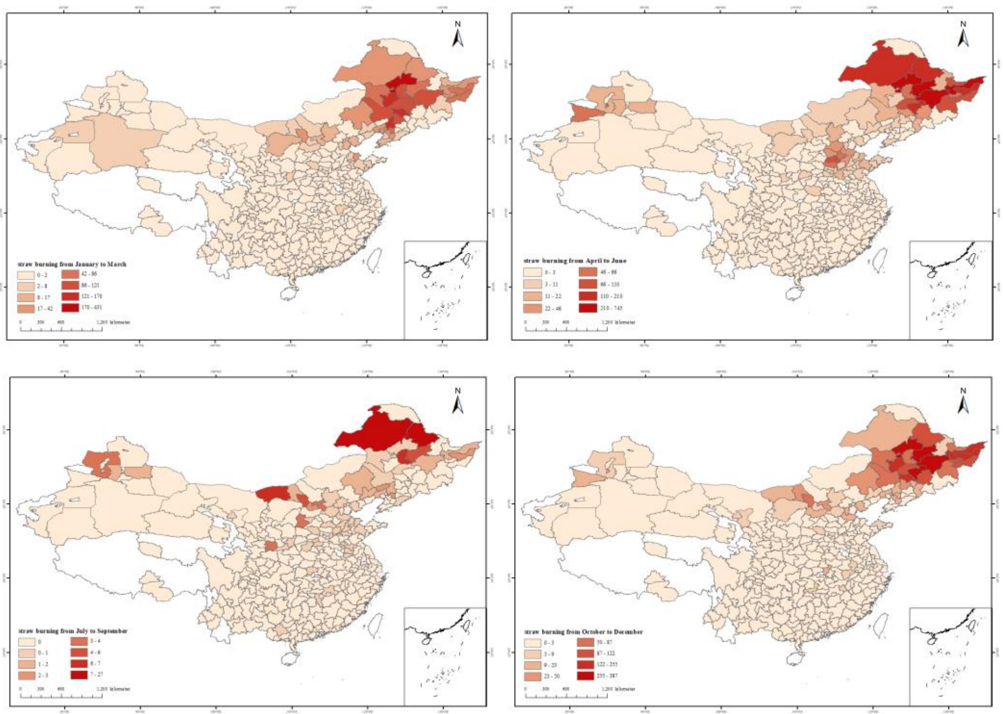

Fig.3. Straw burning in different months in 2017

3.2 Econometric model

Based on the previous theoretical analysis, we select straw return technology as the explained variable and risk preferences as the core explanatory variable to verify the hypothesis of this paper. We construct the empirical models in three steps. The first step is to establish baseline regression to investigate how risk preferences affect the farmers' adoption of straw return technology. The model is set as equation (1). Besides, the mean value of other farmers' risk preferences in the same village except themselves is used as the IV for the robustness check of baseline regression. The second step is based on the intermediary effect model to investigate the mechanism of risk preferences on the farmers' adoption of straw return technology to verify hypothesis 2. The models are as follows in formula (5) ~ (7) of session five. The third step is based on the baseline regression model. The interactive terms of risk preferences and crop insurance, farm scale and governmental regulation are introduced respectively to analyze the regulatory effect of crop insurance, farm scale and governmental regulation on the impact of farmers' risk preferences on their adoption of straw return technology to verify hypothesis 3, hypothesis 4, hypothesis 5. The models are as follows in formula (8) ~ (10) of session five. The baseline regression model is set as follows:

$$Y_i = \beta_0 + \beta_1 Risk + \beta_2 X_i + \varepsilon_i \tag{1}$$

Where, Y_i is the explained variable (farmers' adoption of straw return technology). It is a dummy variable. $Y_i = 1$ indicates that the farmer i adopts the straw return technology. $Y_i = 0$ indicates that the farmer i does not adopt the straw return technology. $Risk_i$ represents risk preferences of farmer i , measured by risk aversion and loss aversion. X_i is the control variable, indicating other factors influencing farmers' adoption of straw return technology. The control variables include the age, education level and the experience of rice cultivation of household head, number of labors involved in agricultural production, training times of straw returning of household head, straw return technology subsidy. ε_i is a random disturbance term, representing unobservable factors and obeying standard normal distribution. β_0 is the constant. β_1 , β_2 is the coefficient to be estimated. β_1 is the core coefficient we focus on, represents the impact of farmers' risk preferences on their adoption of straw return technology.

3.3 Data and sample

To explore the impact of farmers' risk preferences on their adoption of straw return technology, we adopt the multistage sampling method. We go to Hunan, Jiangsu, and Jiangxi for research (the survey region is shown in figure 4). Sampling is divided into three stages.

In the first stage, the rice planting area, geographical location and economic development were comprehensively considered. Hunan, Jiangsu, and Jiangxi are among the top five rice planting areas in China. The income of rice farmers in the three provinces is affected by the quality of cultivated land. The degree of economic development in these provinces is quite different, which makes the farmers' production behavior quite different. Therefore, we selected Hunan, Jiangsu, and Jiangxi as sample regions. In the second stage, according to the geographical location, economic development degree and rice planting area in sample regions, we selected 3 cities in each sample province by stratified sampling. We selected 3 counties in each sample city. Then, we randomly selected 4 towns that mainly planted rice in each sampled county, and selected 36 sample towns in all. In the third stage, we numbered the list of farmers provided by the village cadres, and randomly selected 20 farmers from each sample town.

The questionnaire includes family characteristics, land use, rice production costs and benefits, straw return technology adoption, and farmers' risk preferences. In order to reduce data errors, before the formal investigation, we invited the experts to train graduate students. The questionnaire is conducted by training graduate students through one-to-one interviews. 1123 households are interviewed in total. Among them 723 households were interviewed in 2017 (including 240 households in Hunan province, 251 households in Jiangxi province and

242 households in Jiangsu province). In 2019, we tracked sample farmers to investigate and 400 households were interviewed. Excluding some samples with missing variables, we obtained 1038 valid samples. The effective rate of the questionnaire is 92.4%.

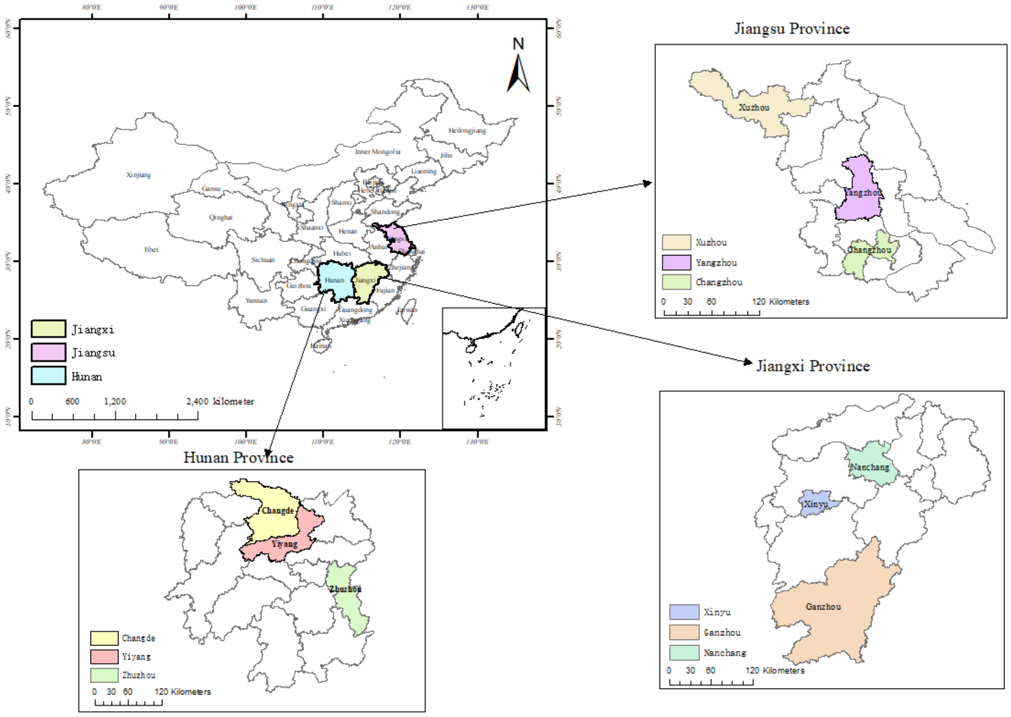

Fig.4 Research area

3.4 Variables

The explained variable of this paper is the farmers' adoption of straw return technology. In the baseline regression, we choose whether farmers to adopt straw return technology to measure the explained variable. Its value is 1 if the farmers adopt the technology. Otherwise, the value is 0. Moreover, as straw return technology is an inter-temporal technology, farmers can continue to adapt it to bring the economic and ecological benefits of straw return technology (Li et al., 2017; Wang et al., 2018). Therefore, in this paper, the farmers' continuous technology adoption is measured by the years from the first adoption of straw return technology to 2017 and 2018. We further analyze the influence of farmers' risk preferences on their adoption of straw return technology and test the robustness of regression results.

The core explanatory variable of this paper is risk preferences, which are specifically measured by risk aversion and loss aversion. According to the research of Tanaka et al. (2010), The degree of farmers' risk aversion and loss aversion is measured by experimental economics based on the expected utility theory and prospect theory. The utility function is set as follows:

$$U(x,p;y,q)=\begin{cases} v(y)+\pi(p)(v(x)-v(y)); xy>0 \;\; and\; |x|>|y| \\ \pi(p)v(x)+\pi(q)v(y); Otherwise \end{cases} \tag{2}$$

$$v(x)=\begin{cases} x^{1-\sigma}; x>0 \\ -\lambda(-x)^{1-\sigma}; x<0 \end{cases} \tag{3}$$

$$\pi(p)=\frac{1}{\exp(\ln(1/p)^{\alpha}} \tag{4}$$

Among equation (2) ~ (4), $U(x,p;y,q)$ is a utility function. $v(x)$ is a value function, which is the utility of the farmers' income. x, y respectively represents the high bonus amount and low bonus amount under the same option in the game. p, q respectively indicate the probability of farmers to choose x or y. $\pi(p)$, $\pi(q)$ represent the weight of p, q in the utility function. σ and λ respectively represent the degree of farmers' risk aversion and farmers' loss aversion. α indicates that farmers attach importance to the occurrence of small probability events. The higher the value, which represents farmers lay more importance on small probability events, and the more they dislike risks. When $\alpha = 1$, the probability weighting function $\pi(p)$, $\pi(q)$ are linear. When $\alpha < 1$, the probability weighting function is an inverted S type. When α and λ are 1 at the same time, the above function is simplified to the expected utility function.

After the questionnaire interview, we conducted a risk preferences experiment on the interviewed farmers. In order to get the three parameters of prospect theories, we designed three series of different lottery games with 35 multiple-choice questions (As shown in Table 1). Each line is different option of the series, which is divided into option A and option B. There are 14 multiple choice questions in Series 1 in Table 1. The risk of Option A is low, and the bonus amount is never unchanged. The risk of Option B is high, and the bonus amount increases gradually. During the experiment, farmers only have one chance to change the option. They also can never change the option. At the beginning of the game, the bonus amount is small, which is less attractive to farmers. With the increase of bonus amount, the farmers are more likely to change their options. We continually acquire farmers' options willingness, recording the question number when the farmers change from option A to option B. At the end of Series 1, according to the same steps to play Series 2 (as shown in Series 2 in Table 1. There are 14 multiple choice questions. The bonus amount and corresponding probability are all changing compared with Series 1) and Series 3 (as shown in Series 3 in Table 1. There are 7 multiple-choice questions. The bonus amount and corresponding probability are all changing compared with Series 1 and Series 2. Farmers are likely to lose an amount of money). According to the recording of question numbers, we can calculate the degree of risk aversion σ and the degree of loss aversion λ. After finishing all the series, we asked the farmers to randomly select a question number from the number plates with 1~35 choice questions to play the real game, and gave farmers the actual cash reward to make sure that all the answers collected in the game are rational.

[Table 1 about here]

Moreover, based on previous studies (Christopher et al., 2004; Adnan et al., 2018), we control the variables of individual characteristics and management characteristics in the all model, including the age, education level and the experience of rice cultivation of household head, the number of labors involved in agricultural production, training times of straw returning of household head, straw return technology subsidy. Table 2 is the detailed description of all variables in the paper. According to the statistical description in Table 2, the average age of the household head is 58 years. The average educational years of the household head is about 5 years. The average planting year is about 33 years. The average number of laborers in the production process of respondents' families is 3.

[Table 2 about here]

4. Empirical analysis

4.1 Main results

Table 3 reports the results of baseline regression which is the impact of farmers' risk preferences on their adoption of straw return technology. The results show turn out to be that risk preferences significantly positively affect farmers to adopt straw return technology. Columns (1) ~ (2) investigate the impact of farmers' risk aversion on adopting straw return technology. The results show that whether the time fixed effect is controlled or not, the coefficient symbol of risk aversion is significant and negative at the 1% level. It makes clear that the more risk-averse farmers are less willing to adopt straw return technology. Columns (3) ~ (4) further report the impact of farmers' loss aversion on adopting straw return technology. Whether the time fixed effect is controlled or not, the coefficient of loss aversion is significant and negative at the 1% level. It indicates that farmers with the higher degree of loss aversion are less willing to adopt straw return technology. This result supports hypothesis 1. This conclusion is comparable with existing studies. For example, Brick and Visser (2015) found that risk aversion inhibited the technology adoption of small-scale self-sufficient farmers in South Africa. Thus, risk aversion and loss aversion will significantly inhibit farmers from adopting straw return technology.

The reason for the result is that compared with direct incineration, straw return technology can improve the rural environment and improve soil fertility. However, it needs to be mechanically crushed and turned into the soil, which increases capital investment and takes a long time to take effect. At the same time, soil microorganisms produced by excessive or uneven straw returning will compete for crop nutrients. It makes the income of straw returning face great uncertainty (Gadde et al., 2009). But farmers have limited tolerance for accidental losses and tend to pursue risk minimization in the face of uncertainty in the production. Therefore, risk-averse farmers are improbable to adopt straw return technology (Djanibekov and Finger, 2018). In addition, due to loss aversion, farmers think highly of loss than gain under the target income level (Liu, 2013). When farmers perceive that the negative utility brought by straw return technology is greater than the positive utility brought by income, they are less tend to adopt straw return technology (Schleich et al., 2019). In conclusion, the more risk aversion and loss aversion farmers are, the less willing they are to adopt straw return technology.

[Table 3 about here]

4.2 Endogeneity treatment

It is found that risk aversion and loss aversion remarkably inhibit farmers' adoption of straw return technology, but this conclusion may be affected by endogeneity. The one is the problem of missing variables. Adopting straw return technology is affected by many factors (Tang et al., 2019; Gao et al., 2018). Due to the availability of data, it is difficult to control all factors affecting farmers' adoption of straw return technology. Unobserved missing variables such as farmers' IQ and personal ability may affect their technology adoption. This can lead to endogeneity. Although the influence of farmers' risk preferences on their adoption of straw return technology does not change significantly with the addition of control variables, we still cannot completely rule out the possibility of "missing variables". The other is the problem of reverse causality. Straw return technology can bring environmental and economic benefits to farmers, improve farmers' income, and enhance their ability to deal with risks. It may affect farmers' risk preferences. Therefore, we cannot completely rule out the possibility of "reverse causality".

We use the IV method to solve the endogeneity. The principle of the IV method is that IV is related to endogenous variables, and has nothing to do with the unobservable factors affecting farmers' adoption of straw return technology. Therefore, referring to Fisman and Svensson (2007)'s selection method of IV, this paper selects the mean value of risk preferences of other farmers in the same village except themselves as the IV. Theoretically, the average risk preferences of other farmers in the village will directly influence the farmers' risk preferences, but not directly influence their adoption of straw return technology, meeting the relevance and exogenous assumptions. The results of the IV are in Table 4. The risk aversion and loss aversion coefficients are significant and negative at the level of 1%. The results of Table 4 are consistent with the baseline regression results, indicating that risk aversion and loss aversion significantly inhibit farmers' adoption of straw return technology. Furthermore, this paper makes a weak IV test. In the first stage, the F-statistics are 20.812 and 14.596 respectively, which is greater than the critical value of Cragg -Donald statistics (Stock and Yogo, 2005). It indicates that it is proper to use the mean value of risk preferences of other farmers in the same village except themselves as the IV of risk preferences. There is no problem with weak IV.

[Table 4 about here]

In addition, Oster (2019) confirmed that when there are unobservable missing variables in a model, $\beta^* = \beta^*(Rmax, \delta)$ can be used to examine the consistent estimation of the real coefficient. δ is the proportional coefficients. Based on OLS, the proportional coefficients (δ) of regression are 2.362, 2.047, 4.508 and 5.791, all greater than 1. Risk aversion and loss aversion negatively influence farmers' adoption of straw return technology (The results are in Table 3). Since all regressions fully control other variables, the baseline results of this study are unlikely to be misled by unobservable missing variables.

4.3 Robustness check

The phased or short-term adoption of straw return technology has limited impact on the agricultural production environment. Only by continuous adoption can farmers give full play to the long-term protection of straw return technology on the atmospheric environment and cultivated land quality (Li et al., 2017; Wang et al., 2018). Existing researches show that the more risk preferences farmers are, the more willing they are to increase agricultural productive investment and adopt agricultural technologies with high risk and high returns (Haile et al., 2020). Therefore, risk preferences may have an impact on farmers' continuous adoption of straw return technology. To further analyze the causality between risk preferences and farmers' continuous adoption of straw return technology, this paper selects the adoption time of straw return technology to measure farmers' continuous adoption of straw return technology, and further verifies the robustness of the baseline regression.

Table 5 reports the estimated results of the influence of farmers' risk preferences on their continuous adoption of straw return technology. Columns (1) and (2) reveal that the coefficient of risk aversion is significant and negative at the level of 1% whether the time fixed effect is controlled or not, which indicates that risk aversion restrains farmers from continuously adopting straw return technology. The more risk-averse farmers are later to adopt straw return technology. Column (3) and (4) reveal that the coefficient of loss aversion is significantly negative at the 1% level, hinting that the farmers' loss aversion negatively affects farmers' continuous adoption of straw return technology. The farmers with the higher degree of loss aversion will delay adopting straw return technology. The reason for this result is that without external interference, farmers determine whether to continue to adopt straw return technology by measuring the perceived value of straw return technology. When farmers think that the benefits of straw return technology meet their expectations, they will continue to adopt it. Farmers with the higher degree of risk aversion and loss aversion will lay more importance on the risk minimization of technology adoption, and the lower the perceived value of technology. Therefore, the more risk aversion or loss aversion farmers are, the later they adopt straw return technology, and the less likely they are to continue to adopt straw return technology. This conclusion is also comparable with existing studies. For example, Liu (2013) took Chinese cotton farmers as an example and confirmed that the more risk-averse and loss-averse farmers adopt BT cotton later.

[Table 5 about here]

5. Additional analysis

5.1 The impact mechanism of risk preferences on farmers' adoption of straw return technology

The above empirical research shows that risk aversion and loss aversion can inhibit farmers to adopt straw return technology. Naturally, it will be further considered. What mechanism does risk preferences affect this? Based on the intermediary effect model, this part further discusses the mechanism of farmers' risk preferences on their adoption of straw return technology from the perspective of farmers' productive investment.

Risk preferences promote farmers' adoption of straw return technology by promoting productive investment. Taking rice straw return technology as an example, the process of rice straw returning is as follows: after mechanical harvesting of rice, rice straw is crushed and covered on the ground. Mechanical rotary tillage is adopted for autumn returning when the soil moisture content is about 30%. In order to ensure the role of straw returning in promoting soil nutrient transformation and improving soil fertility, an appropriate amount of nitrogen and phosphorus fertilizer needs to be applied before returning to the field, and the plow depth is generally about 15 cm[1]. When farmers own agricultural types of machinery such as harvesters and rotary cultivators, straw returning is more convenient, and farmers have the higher initiative to adopt straw return technology. Therefore, investing in productive assets (such as tractors and harvesters) is conducive to farmers' straw returning. Some studies have shown that farmers who prefer risk are more willing to take risks, lay more importance on the potential benefits of modern technology and high-risk investment, and are more willing to make productive investments (Mao et al., 2019; Giné and Yang, 2009; Duan et al., 2021). It can be inferred that risk preferences will affect farmers' productive investment, and then affect their adoption of straw return technology. In order to estimate whether risk preferences will promote farmers' productive investment and then affect their adoption of straw return technology, this paper constructs the following econometric model:

$$Invest_i = \beta_0 + \beta_1 Risk_i + \beta_2 X_i + \varepsilon_i \tag{5}$$

$$Y_i = \beta_0 + \beta_1 Invest_i + \beta_2 X_i + \varepsilon_i \tag{6}$$

$$Y_i = \beta_0 + \beta_1 Risk_i + \beta_2 Invest_i + \beta_3 X_i + \varepsilon_i \tag{7}$$

Among them, $Invest_i$ refers to the productive investment of farmers, which is expressed by whether farmers invest in tractors and harvesters. The meanings of other variables are the same as equation (1). The results of the mechanism of risk preferences

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1 Data resource: http://www.agri.cn/kj/syjs/zzjs/201511/t20151119_4907024.htm

influencing farmers' adoption of straw return technology are shown in Table 6 and Table 7 respectively. For the convenience of analysis, this paper adds the results of column (2) in Table 3 to column (1) in table 6 and the results of column (4) in Table 3 to column (1) in Table 7. Columns (2) in Table 6 and Table 7 are the results of the influence of productive investment on farmers' adoption of straw return technology. The results show that farmers' productive investment can promote them to adopt straw return technology. Column (3) of Table 6 is the results of the influence of risk aversion on farmers' productive investment. Column (3) of Table 7 is the results of the influence of loss aversion on farmers' productive investment. The risk aversion and loss aversion coefficients are significantly negative at the level of 1%, that is, risk aversion and loss aversion significantly negatively affect farmers' productive investment. Column (4) of Table 6 includes both risk aversion and productive investment. Column (4) of Table 7 includes both loss aversion and productive investment. The productive investment coefficients in both tables are significantly positive, and the coefficients of risk aversion and loss aversion are still significantly negative at the level of 1%. According to the mediation effect test procedure, it can be concluded that the mediation effect exists. The p-value in the Sobel test of mediation effect is less than 0.05, showing that there is the mediation effect. Therefore, productive investment is part of the intermediary variable that risk preferences affect farmers' adoption of straw return technology. Risk aversion and loss aversion can restrain farmers from adopting straw return technology by affecting farmers' productive investment. This result verifies hypothesis 2.

[Table 6 about here]

[Table 7 about here]

5.2 Risk preferences, crop insurance, and straw return technology

In order to further understand the impact of farmers' risk preferences on their straw return technology adoption and explore the difference between this effect and whether they participate in crop insurance, this paper adds the interaction term between risk preferences and crop insurance on the basis of benchmark regression, and investigates the regulatory effect of crop insurance on the impact of farmers' risk preferences on adopting straw return technology. The econometric model set is as follows:

$$Y_i = \beta_0 + \beta_1 Risk_i + \beta_2 Insur_i + \beta_3 Risk_i \times Insur_i + \beta_4 X_i + \varepsilon_i \tag{8}$$

Among them, $Insur_i$ indicates the participation of farmers in crop insurance, which is expressed by whether farmers participate in crop insurance. $Risk_i \times Insur_i$ is the interactive term between risk preferences and whether to participate in crop insurance, measuring the effect of crop insurance in the impact of farmers' risk preferences on their adoption of straw return technology. $Risk_i$ is measured by risk aversion and loss aversion. The meanings of other variables are the same as equation (1). The results of equation (8) are shown in Table 8. Columns (1) and (2) of Table 8 indicate that the inhibition of farmers' risk aversion on their adoption of straw return technology decreases with farmers' participation in crop insurance. Columns (3) and (4) show that the farmers with high degree of loss aversion will increase the possibility of adopting straw return technology with the participation of crop insurance. The above analysis shows that participating in crop insurance weakens the inhibition of farmers' risk aversion and loss aversion on adopting straw return technology. This is mainly because farmers in developing countries face serious income risks and have limited opportunities to obtain formal financial products to avoid risks (Hill and Viceisza, 2012). As a practical way for farmers to cope with losses, crop insurance can promote farmers to invest in high-risk and high return activities (Liu et al., 2020). On the one hand, crop insurance can improve farmers' expected income. When the occurrence of unexpected risks such as natural disasters has a negative impact on farmers' income, insurance companies can reduce production risks and improve farmers' willingness to adopt technology (Gunnsteinsson, 2020). On the other hand, crop insurance promotes farmers with high loss aversion to adopt the technology by smoothing production risk (Visser et al., 2020). Therefore, with the participation in crop insurance, the inhibition of risk aversion and loss aversion on farmers' straw return technology will be weakened. Hypothesis 3 of this paper is verified.

[Table 8 about here]

5.3 Risk preferences, farm scale, and straw return technology

We add the interaction term of risk preferences and farm scale into the baseline model to further examine the moderating effect of farm scale in the impact of farmers' risk preferences on adopting straw return technology. The model is as follows:

$$Y_i = \beta_0 + \beta_1 Risk_i + \beta_2 Scale_i + \beta_3 Risk_i \times Scale_i + \beta_4 X_i + \varepsilon_i \tag{9}$$

Where $Scale_i$ represents the farm scale, measured by whether the farmer is a large-scale farmer. According to the average farm scale of all interviewed farmers, those above the average are classified as large-scale farmers; those below the average are classified as small-scale farmers. $Risk_i \times Scale_i$ is the interaction term between risk preferences and farm scale, measuring the different influence of farmers' risk preferences on their adoption of straw return technology due to the differences in farm scale. $Risk_i$ is measured by risk aversion and loss aversion. The definition of other variables is consistent with equation (1). The results of equation (9) are shown in Table 9. Column (1) and column (2) in Table 9 reflect the moderating effect of farm scale in the influence of farmers' risk aversion on adopting straw return technology. The results show that the coefficient of the interaction term between risk aversion and farm scale is significant and positive at the level of 1%. Column (3) and column (4) reflect the moderating effect of farm scale in the impact of loss aversion on farmers' adoption of straw return technology. The results indicate that the interaction term between loss aversion and farm scale is significant and positive at the 1% level. Therefore, the inhibition of farmers' risk aversion and loss aversion on their adoption of straw return technology has weakened with expanding farm scale.

The reason for this result is as follows. The fixed cost of straw return technology is high. First, in order to pursue economies of scale and maximize profits, large-scale farmers lay more importance on the long-term benefits in the production process (Hu et al., 2019). Small-scale farmers have low income and limited credit support. Small-scale farmers' technology adoption is subject to financial constraints. The possibility of their technology adoption is low (Tarfasa et al., 2018). Second, based on the scale effect, the cost and obstacles for large-scale farmers to adopt straw return technology are small. Their unit cost is low (Muzari et al., 2012). They can obtain more benefits than small-scale farmers after adopting the technology (Foster and Rosenzweig, 2010). Therefore, the farm scale has a positive regulatory effect in the influence of risk aversion and loss aversion on farmers' adoption of straw return technology. This conclusion verifies hypothesis 4 of this paper.

[Table 9 about here]

5.4 Risk preferences, governmental regulation, and straw return technology

It is worth mentioning that the impact of farmers' risk preferences on their adoption of straw return technology may also be affected by governmental regulation. Therefore, we add an interaction item between risk preferences and governmental regulation into the baseline model to further explore the moderating effect of governmental regulation in the impact of farmers' risk preferences on adopting straw return technology. The model is as follows:

$$Y_i = \beta_0 + \beta_1 Risk_i + \beta_2 Punish_i + \beta_3 Risk_i \times Punish_i + \beta_4 X_i + \varepsilon_i \tag{10}$$

Among them, $Punish_i$ represents governmental regulation measured by the government's penalties for straw burning. $Risk_i \times Punish_i$ is an interactive item between risk preferences and governmental regulation measuring the influence of farmers' risk preferences on adopting straw return technology due to the differences in governmental regulation. $Risk_i$ is risk preferences measured by risk aversion and loss aversion. The definition of other variables is consistent with equation (1). The results of equation (10) are in Table 10. The column (2) of Table 10 reveals that the interaction term between risk aversion and governmental regulation is significant and positive at the 5% level. Column (4) shows that the interaction term between loss aversion and governmental regulation is significant and positive at the 1% level. The results in the two columns indicate that governmental regulations play a positive regulatory role in the influence of farmers' risk aversion and loss aversion on their adoption of straw return technology. The stronger the local government regulation of straw burning behavior, the weaker the inhibitory effect of farmers' risk aversion and loss aversion on their adoption of straw return technology.

The reason for the results is that farmers burn straw mainly because of the externality of straw burning and the high cost of alternative technologies such as straw return technology (He et al., 2020). As the country with the largest number of straw in the world, the Chinese government has adopted a series of policies and regulations to deal with straw burning in order to prevent its negative impact on the environment (Fang et al., 2020). On the one hand, the government effectively restricts farmers' production behavior through strict laws, regulations, and systems (Ramsey et al., 2013). The risk-averse and loss-averse farmers are more tend to actively adopt the straw return technology in order to avoid administrative punishment. On the other hand, governmental regulations also include technical training, technical publicity, and demonstration effects. These regulations can improve farmers' awareness of the straw return technology, and enhance their ability to cope with the risk of improper technology adoption (Martey and Kuwornu, 2021), and promote farmers with high risk aversion and high loss aversion to adopting the technology. Based on the above analysis, hypothesis 5 in this paper has been verified.

[Table 10 about here]

6. Conclusions and Implications

Straw return technology is key to improving the agricultural ecological environment and realizing high-quality agricultural development. Based on the micro-survey data of 1,038 two-period rice farmers in Jiangsu, Jiangxi, and Hunan provinces, this paper measures the degree of farmers' risk aversion and loss aversion in the method of experimental economics. On this basis, we use an econometric model to examine the influence of risk preferences on farmers' adoption of straw return technology and the underlying mechanism. The results show that both risk aversion and loss aversion significantly inhibit farmers' adoption of straw return technology. Farmers with higher degrees of risk aversion and loss aversion are less likely to adopt straw return technology, and the less likely they are to continue to use straw return technology. Further research found that risk aversion and loss aversion inhibited farmers' productive investment, thereby inhibiting adopting straw return technology.

In addition, crop insurance, farm scale, and governmental regulations play a moderating role in the impact of risk preferences on farmers' adoption of straw return technology. Specifically, as farmers participate in crop insurance, the effect of risk aversion and loss aversion on their adoption of straw return technology weakens. In addition, the continuous expansion of farmers' farm scale can reduce the negative impact of risk aversion and loss aversion on their adoption of straw return technology. Additionally, governmental regulations also affect the influence of risk preferences on farmers' adoption of straw return technology. The stronger the governmental regulation, the weaker the inhibition of risk aversion and loss aversion on farmers' adoption of straw return technology.

Therefore, the analyses carried out in this paper confirm that risk preferences influence farmers' adoption of straw return technology, which has important theoretical contributions and practical significance compared with previous studies. Existing research focused on the influence of farmers' characteristics (Adnan et al., 2018), technical cognition (Lu et al., 2020), land tenure (Gao et al., 2018), technical information (Hou et al., 2019), farm scale (Wu et al., 2018) and other factors on adopting straw return technology, ignoring the role of risk preferences. As an important conservation tillage technology, straw return technology can improve soil quality (Cong et al., 2020). However, due to the uncertainty of technological benefits and the risk of improper use of this technology (Xu et al., 2021), farmers with high risk aversion and loss aversion are less willing to adopt it (Brick and Visser, 2015). Therefore, we explore the mechanism of risk preferences on farmers' straw return technology adoption. We find that high risk preferences promote farmers' adoption of straw return technology by promoting their productive investment, whereas low risk preference acts as a deterrent. This conclusion is not only conducive to increasing the adoption rate of straw return technology, but also can be applied to the promotion of other conservation tillage technologies, thereby alleviating the inhibitory effect of risk aversion and loss aversion on adopting conservation tillage technologies.

This paper deeply studies the influence of farmers' risk preferences on adopting straw return technology and its long-term mechanism. It identifies the following policy implications for promoting the continuous adoption of straw return technology by Chinese farmers: First, the Chinese government should fully consider farmers' risk aversion and loss aversion psychology, and effectively guide farmers to continue to adopt straw return technology. The government should also (1) emphasize the function of straw return technology to increase crop yields by increasing fertility, water storage, and moisture preservation, (2) strengthen publicity regarding the economic benefits of continuing to adopt straw return technology, and

(3) encourage farmers to continue to adopt straw return technology. In addition, the government should understand farmers' agricultural machinery needs through village collectives and cooperatives, provide targeted agricultural machinery subsidies, and encourage farmers to invest in agricultural machinery and equipment.

Second, crop insurance is a practical way for farmers to cope with risks and reduce the impact of disasters. Therefore, the government should continually promote the development of the crop insurance market and increase premium subsidies to further stimulate farmers' insurance demand. Third, the government should promote the scale operation of farmers and formulate appropriate policies according to different farm scale to encourage farmers to adopt straw return technology. Local governments should strengthen policy publicity and guidance to promote the orderly transfer of land by farmers and realize large-scale operations. At the same time, large-scale farmers are the breakthrough point in the promotion of straw return technology. The government should encourage large-scale farmers' adoption of straw return technology and give full play to the demonstration role of large-scale farmers in increasing the adoption rate of technology.

Fourth, grassroots organizations should increase their human and material resources during the harvest season and increase the implementation of policies that ban straw burning.

At the same time, organizations at all levels should overcome the deficiencies of excessive reliance on rigid regulations and single rewards and punishments and improve diversified government regulatory measures such as rewards instead of punishments and project demonstrations.

This paper also has several limitations. First, when studying the influence of farmers' risk preferences on adopting straw return technology, this paper uses two-period survey data to estimate the result, but it is better to use continuous multiple panel data. Therefore, we will follow up by investigating farmers to analyze the long-term dynamic change process of farmers' adoption of straw return technology. Second, the risk preferences calculated in this paper can be considered laboratory risk preferences. It is better to measure actual risk preferences for certain behavior. In further research, we will combine specific technologies to measure the farmers' risk preferences in the actual decision-making process (such as technology adoption).

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Tables

Table1 Loss and gain of different choices in risk preference experiment (Unit: Yuan)

	Option A	Option B	Expected payoff difference (A−B)
Series 1			
1	The probability of winning 20 yuan is 30%; the probability of winning 5 yuan is 70%.	The probability of winning 34 yuan is 10%; the probability of winning 2.5 yuan is 90%.	3.85
2	The probability of winning 20 yuan is 30%; the probability of winning 5 yuan is 70%.	The probability of winning 37.5 yuan is 10%; the probability of winning 2.5 yuan is 90%.	3.50
3	The probability of winning 20 yuan is 30%; the probability of winning 5 yuan is 70%.	The probability of winning 41.5 yuan is 10%; the probability of winning 2.5 yuan is 90%.	3.00
4	The probability of winning 20 yuan is 30%; the probability of winning 5 yuan is 70%.	The probability of winning 46.5 yuan is 10%; the probability of winning 2.5 yuan is 90%.	2.60
5	The probability of winning 20 yuan is 30%; the probability of winning 5 yuan is 70%.	The probability of winning 53 yuan is 10%; the probability of winning 2.5 yuan is 90%.	1.95
6	The probability of winning 20 yuan is 30%; the probability of winning 5 yuan is 70%.	The probability of winning 62.5 yuan is 10%; the probability of winning 2.5 yuan is 90%.	1.00
7	The probability of winning 20 yuan is 30%; the probability of winning 5 yuan is 70%.	The probability of winning 75 yuan is 10%; the probability of winning 2.5 yuan is 90%.	-0.25
8	The probability of winning 20 yuan is 30%; the probability of winning 5 yuan is 70%.	The probability of winning 92.5 yuan is 10%; the probability of winning 2.5 yuan is 90%.	-2.00
9	The probability of winning 20 yuan is 30%; the probability of winning 5 yuan is 70%.	The probability of winning 110 yuan is 10%; the probability of winning 2.5 yuan is 90%.	-3.75
10	The probability of winning 20 yuan is 30%; the probability of winning 5 yuan is 70%.	The probability of winning 150 yuan is 10%; the probability of winning 2.5 yuan is 90%.	-7.75
11	The probability of winning 20 yuan is 30%; the probability of winning 5 yuan is 70%.	The probability of winning 200 yuan is 10%; the probability of winning 2.5 yuan is 90%.	-12.75
12	The probability of winning 20 yuan is 30%; the probability of winning 5 yuan is 70%.	The probability of winning 300 yuan is 10%; the probability of winning 2.5 yuan is 90%.	-22.75
13	The probability of winning 20 yuan is 30%; the probability of winning 5 yuan is 70%.	The probability of winning 500 yuan is 10%; the probability of winning 2.5 yuan is 90%.	-42.75
14	The probability of winning 20 yuan is 30%; the probability of winning 5 yuan is 70%.	The probability of winning 850 yuan is 10%; the probability of winning 2.5 yuan is 90%.	-77.75
Series 2			
1	The probability of winning 20 yuan is 90%; the probability of winning 15 yuan is 10%.	The probability of winning 27 yuan is 70%; the probability of winning 2.5 yuan is 30%.	-0.15
2	The probability of winning 20 yuan is 90%; the probability of winning 15 yuan is 10%.	The probability of winning 28 yuan is 70%; the probability of winning 2.5 yuan is 30%.	-0.85

3	The probability of winning 20 yuan is 90%; the probability of winning 15 yuan is 10%.	The probability of winning 29 yuan is 70%; the probability of winning 2.5 yuan is 30%.	-1.55
4	The probability of winning 20 yuan is 90%; the probability of winning 15 yuan is 10%.	The probability of winning 30 yuan is 70%; the probability of winning 2.5 yuan is 30%.	-2.25
5	The probability of winning 20 yuan is 90%; the probability of winning 15 yuan is 10%.	The probability of winning 31 yuan is 70%; the probability of winning 2.5 yuan is 30%.	-2.95
6	The probability of winning 20 yuan is 90%; the probability of winning 15 yuan is 10%.	The probability of winning 32.5 yuan is 70%; the probability of winning 2.5 yuan is 30%.	-4.00
7	The probability of winning 20 yuan is 90%; the probability of winning 15 yuan is 10%.	The probability of winning 34 yuan is 70%; the probability of winning 2.5 yuan is 30%.	-5.05
8	The probability of winning 20 yuan is 90%; the probability of winning 15 yuan is 10%.	The probability of winning 36 yuan is 70%; the probability of winning 2.5 yuan is 30%.	-6.45
9	The probability of winning 20 yuan is 90%; the probability of winning 15 yuan is 10%.	The probability of winning 38.5 yuan is 70%; the probability of winning 2.5 yuan is 30%.	-8.20
10	The probability of winning 20 yuan is 90%; the probability of winning 15 yuan is 10%.	The probability of winning 41.5 yuan is 70%; the probability of winning 2.5 yuan is 30%.	-10.30
11	The probability of winning 20 yuan is 90%; the probability of winning 15 yuan is 10%.	The probability of winning 45 yuan is 70%; the probability of winning 2.5 yuan is 30%.	-12.75
12	The probability of winning 20 yuan is 90%; the probability of winning 15 yuan is 10%.	The probability of winning 50 yuan is 70%; the probability of winning 2.5 yuan is 30%.	-16.25
13	The probability of winning 20 yuan is 90%; the probability of winning 15 yuan is 10%.	The probability of winning 55 yuan is 70%; the probability of winning 2.5 yuan is 30%.	-19.75
14	The probability of winning 20 yuan is 90%; the probability of winning 15 yuan is 10%.	The probability of winning 65 yuan is 70%; the probability of winning 2.5 yuan is 30%.	-26.50
Series 3			
1	The probability of winning 12.5 yuan is 50%; the probability of winning 2 yuan is 50%.	The probability of winning 15 yuan is 50%; the probability of winning 3 yuan is 50%.	3.00
2	The probability of winning 2 yuan is 50%; the probability of winning 2 yuan is 50%.	The probability of winning 15 yuan is 50%; the probability of winning 2.25 yuan is 50%.	-2.25
3	The probability of winning 0.5 yuan is 50%; the probability of winning 2 yuan is 50%.	The probability of winning 15 yuan is 50%; the probability of winning 3 yuan is 50%.	-3.00
4	The probability of winning 0.5 yuan is 50%; the probability of winning 2 yuan is 50%.	The probability of winning 15 yuan is 50%; the probability of winning 4.25 yuan is 50%.	-4.25
5	The probability of winning 0.5 yuan is 50%; the probability of winning 4 yuan is 50%.	The probability of winning 15 yuan is 50%; the probability of winning 5.25 yuan is 50%.	-5.25
6	The probability of winning 0.5 yuan is 50%; the probability of winning 4 yuan is 50%.	The probability of winning 15 yuan is 50%; the probability of winning 5.75 yuan is 50%.	-5.75
7	The probability of winning 0.5 yuan is 50%; the probability of winning 4 yuan is 50%.	The probability of winning 15 yuan is 50%; the probability of winning 6.5 yuan is 50%.	-6.50

Table 2 Variables definitions and summary statistics

Variable	Explanation	Mean	Std	Min	Max
Explained variables					
Technology adoption decision	Whether farmers adopt the straw return technology (Adopted=1; Non-adopted=0)	0.671	0.469	0	1
Technology adoption time	The number of years that farmers first adopted the straw return technology to 2017 and 2018	6.369	9.356	0	41
Key explanatory variables					
Risk preferences					
Risk aversion(σ)	Standard measure of risk aversion	0.474	0.399	0.05	1.5
Loss aversion(λ)	Sensitivity to loss versus gain	3.350	2.818	0.14	7.605
Control variables					
Age	Age of household head (years)	57.635	10.226	27	87
Education	Education level of household head (years)	9.992	4.692	0	18
Experience	Experience of rice cultivation of household head (years)	32.944	14.619	1	77
Labor	Number of labors involved in agricultural production (person)	2.796	1.406	1	13
Training	Training times of straw returning of household head (Times)	0.659	2461	0	35
Technology subsidies	Whether there is straw return technology subsidy policy (Yes = 1; No = 0)	0.160	0.367	0	1
Other variables					
Governmental regulation	Whether the local government is fined or detained for burning straw (Yes = 1; No = 0)	0.090	0.286	0	1
Crop insurance	Whether farmers participate in crop insurance (Participate=1; Non-participate=0)	0.419	0.494	0	1
Farm scale	Large-scale farmers=1; Small-scale farmers=0	0.799	0.400	0	1
Productive investment	Whether farmers have tractors and harvesters (Yes = 1; No = 0)	0.234	0.423	0	1
Regional characteristics					
Hunan Province	Hunan Province is 1; otherwise 0	0.427	0.495	0	1
Jiangsu Province	Jiangsu Province is 1; otherwise 0	0.213	0.409	0	1
Jiangxi Province	Jiangxi Province is 1; otherwise 0	0.360	0.480	0	1

Table 3 The result of the impact of risk preferences on farmers' adoption of straw return technology

	(1)	(2)	(3)	(4)
	Technology adoption decision			
Risk aversion	-0.442***	-0.454***		
	(0.034)	(0.034)		
Loss aversion			-0.054***	-0.057***
			(0.005)	(0.005)
Age	-0.002	-0.002	-0.002	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)
Education	-0.004	-0.003	-0.003	-0.002
	(0.003)	(0.003)	(0.003)	(0.003)
Experience	0.001	0.001	0.002	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Labor	0.022**	0.016	0.010	0.004
	(0.010)	(0.010)	(0.011)	(0.011)
Technology training	-0.001	-0.001	-0.003	-0.002
	(0.004)	(0.003)	(0.004)	(0.004)
Technology subsidies	0.055	0.052	0.022	0.018
	(0.047)	(0.048)	(0.045)	(0.045)
Jiangsu Province	0.384***	0.301***	0.338***	0.250***
	(0.051)	(0.054)	(0.047)	(0.051)
Jiangxi Province	-0.043	-0.063**	-0.049	-0.070**
	(0.031)	(0.031)	(0.032)	(0.033)
Year FE	No	Yes	No	Yes
Constant	0.863***	0.958***	0.865***	0.966***
	(0.098)	(0.100)	(0.100)	(0.101)
Observation	1038	1038	1038	1038
R^2	0.250	0.273	0.217	0.242
δ	2.362	2.047	4.508	5.791

Note: ***, and ** are significant at the level of 1%, and 5%, respectively. Robust standard errors are in brackets.

Table 4 The result of endogeneity treatment

	(1)	(2)	(3)	(4)
	Technology adoption decision			
Risk aversion	-1.151***	-1.139***		
	(0.261)	(0.259)		
Loss aversion			-0.080***	-0.085***
			(0.031)	(0.032)
Age	0.001	0.001	-0.001	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Education	-0.005	-0.005	-0.003	-0.003
	(0.003)	(0.003)	(0.003)	(0.003)
Experience	0.001	0.001	0.002	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Labor	0.024**	0.017	0.005	-0.002
	(0.011)	(0.011)	(0.013)	(0.013)
Technology training	-0.006	-0.005	-0.004	-0.004
	(0.006)	(0.006)	(0.005)	(0.005)
Technology subsidies	0.082	0.077	0.015	0.009
	(0.070)	(0.071)	(0.052)	(0.053)
Jiangsu Province	0.470***	0.363***	0.342***	0.245***
	(0.081)	(0.081)	(0.052)	(0.056)
Jiangxi Province	-0.068*	-0.092**	-0.059*	-0.084**
	(0.037)	(0.037)	(0.034)	(0.035)
Year FE	No	Yes	No	Yes
Constant	1.106***	1.214***	0.937***	1.056***
	(0.147)	(0.152)	(0.131)	(0.140)
Observation	1038	1038	1038	1038
F-value	17.02***	20.28***	27.07***	28.30***

Note: ***, **, and * are significant at the level of 1%, 5%, and 10%, respectively. Robust standard errors are in brackets.

Table 5 The result of the impact of risk preferences on farmers' adoption of straw return technology: Changing the measurement method of farmers' adoption of straw return technology

	(1)	(2)	(3)	(4)
	Technology adoption time			
Risk aversion	-2.758***	-3.189***		
	(0.753)	(0.726)		
Loss aversion			-0.231**	-0.317***
			(0.112)	(0.107)
Age	-0.006	0.004	-0.010	0.000
	(0.039)	(0.037)	(0.039)	(0.037)
Education	-0.069	-0.050	-0.064	-0.045
	(0.059)	(0.057)	(0.059)	(0.057)
Experience	0.023	0.014	0.024	0.015
	(0.027)	(0.026)	(0.027)	(0.026)
Labor	0.275	0.071	0.223	0.001
	(0.239)	(0.229)	(0.244)	(0.234)
Technology training	0.157	0.179	0.157	0.175
	(0.120)	(0.123)	(0.120)	(0.121)
Technology subsidies	0.706	0.593	0.532	0.377
	(1.273)	(1.214)	(1.296)	(1.236)
Jiangsu Province	0.130	-2.926**	-0.172	-3.269**
	(1.185)	(1.275)	(1.182)	(1.269)
Jiangxi Province	0.880	0.148	0.886	0.135
	(0.712)	(0.709)	(0.715)	(0.713)
Year FE	No	Yes	No	Yes
Constant	6.754***	10.215***	6.462***	10.018***
	(2.352)	(2.312)	(2.367)	(2.324)
Observation	1038	1038	1038	1038
R^2	0.021	0.098	0.012	0.089

Note: ***, and ** are significant at the level of 1%, and 5%, respectively. Robust standard errors are in brackets.

Table 6 The result of the impact mechanism of risk aversion on farmers' adoption of straw return technology

	Technology adoption decision	Technology adoption decision	Productive investment	Technology adoption decision
	(1)	(2)	(3)	(4)
Risk aversion	-0.454***		-0.248***	-0.438***
	(0.034)		(0.035)	(0.036)
Productive investment		0.161***		0.063**
		(0.030)		(0.028)
Age	-0.002	-0.003	-0.001	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Education	-0.003	-0.002	0.002	-0.003
	(0.003)	(0.003)	(0.002)	(0.003)
Experience	0.001	0.002	-0.004***	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Labor	0.016	0.014	0.012	0.016
	(0.010)	(0.011)	(0.009)	(0.010)
Technology training	-0.001	-0.000	0.009	-0.001
	(0.003)	(0.003)	(0.006)	(0.004)
Technology subsidies	0.052	0.023	0.091	0.047
	(0.048)	(0.041)	(0.063)	(0.047)
Jiangsu Province	0.301***	0.248***	0.097*	0.295***
	(0.054)	(0.048)	(0.059)	(0.054)
Jiangxi Province	-0.063**	-0.044	-0.011	-0.062**
	(0.031)	(0.035)	(0.028)	(0.031)
Year FE	Yes	Yes	Yes	Yes
Constant	0.958***	0.732***	0.442***	0.930***
	(0.100)	(0.104)	(0.097)	(0.101)
Observation	1038	1038	1038	1038
R^2	0.273	0.151	0.110	0.276

Note: ***, **, and * are significant at the level of 1%, 5%, and 10%, respectively. Robust standard errors are in brackets.

Table7 The result of the impact mechanism of loss aversion on farmers' adoption of straw return technology

	Technology adoption decision	Technology adoption decision	Productive investment	Technology adoption decision
	(1)	(2)	(3)	(4)
Loss aversion	-0.057***		-0.022***	-0.054***
	(0.005)		(0.004)	(0.005)
Productive investment		0.161***		0.108***
		(0.030)		(0.028)
Age	-0.002	-0.003	-0.001	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)
Education	-0.002	-0.002	0.002	-0.003
	(0.003)	(0.003)	(0.002)	(0.003)
Experience	0.001	0.002	-0.003***	0.002
	(0.001)	(0.001)	(0.001)	(0.001)
Labor	0.004	0.014	0.007	0.003
	(0.011)	(0.011)	(0.010)	(0.011)
Technology training	-0.002	-0.000	0.009	-0.003
	(0.004)	(0.003)	(0.006)	(0.004)
Technology subsidies	0.018	0.023	0.075	0.010
	(0.045)	(0.041)	(0.064)	(0.044)
Jiangsu Province	0.250***	0.248***	0.071	0.242***
	(0.051)	(0.048)	(0.060)	(0.050)
Jiangxi Province	-0.070**	-0.044	-0.011	-0.069**
	(0.033)	(0.035)	(0.029)	(0.032)
Year FE	Yes	Yes	Yes	Yes
Constant	0.966***	0.732***	0.418***	0.921***
	(0.101)	(0.104)	(0.099)	(0.101)
Observation	1038	1038	1038	1038
R^2	0.242	0.151	0.078	0.250

Note: ***, and ** are significant at the level of 1%, and 5%, respectively. Robust standard errors are in brackets.

Table 8 The result of risk preferences and crop insurance on farmers' adoption of straw return technology

	(1)	(2)	(3)	(4)
	Technology adoption decision			
Risk aversion	-0.440***	-0.547***		
	(0.034)	(0.045)		
Loss aversion			-0.055***	-0.063***
			(0.005)	(0.006)
Crop insurance	0.102***	-0.012	0.110***	0.044
	(0.027)	(0.042)	(0.027)	(0.040)
Crop insurance×Risk aversion		0.221***		
		(0.066)		
Crop insurance×Loss aversion				0.020**
				(0.009)
Age	-0.002	-0.002	-0.002	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)
Education	-0.004	-0.003	-0.003	-0.003
	(0.003)	(0.003)	(0.003)	(0.003)
Experience	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Labor	0.018*	0.016	0.006	0.007
	(0.010)	(0.010)	(0.011)	(0.011)
Technology training	-0.001	-0.002	-0.002	-0.003
	(0.003)	(0.004)	(0.004)	(0.004)
Technology subsidies	0.058	0.068	0.025	0.028
	(0.046)	(0.047)	(0.043)	(0.043)
Jiangsu Province	0.330***	0.329***	0.284***	0.280***
	(0.052)	(0.053)	(0.049)	(0.049)
Jiangxi Province	-0.053*	-0.053*	-0.059*	-0.058*
	(0.031)	(0.031)	(0.032)	(0.032)
Year FE	Yes	Yes	Yes	Yes
Constant	0.917***	0.974***	0.921***	0.939***
	(0.101)	(0.101)	(0.102)	(0.103)
Observation	1038	1038	1038	1038
R^2	0.284	0.292	0.254	0.257

Note: ***, **, and * are significant at the level of 1%, 5%, and 10%, respectively. Robust standard errors are in brackets.

Table 9 The result of risk preferences and farm scale on farmers' adoption of straw return technology

	(1)	(2)	(3)	(4)
	Technology adoption decision			
Risk aversion	-0.393***	-0.801***		
	(0.035)	(0.106)		
Loss aversion			-0.050***	-0.088***
			(0.004)	(0.011)
Farm scale	0.386***	0.104	0.410***	0.236***
	(0.036)	(0.085)	(0.037)	(0.070)
Farm scale × Risk aversion		0.491***		
		(0.110)		
Farm scale × Loss aversion				0.046***
				(0.011)
Age	-0.002	-0.002	-0.002	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)
Education	-0.002	-0.002	-0.001	-0.001
	(0.003)	(0.003)	(0.003)	(0.003)
Experience	0.002*	0.002*	0.002**	0.002*
	(0.001)	(0.001)	(0.001)	(0.001)
Labor	0.007	0.005	-0.004	-0.005
	(0.009)	(0.009)	(0.010)	(0.010)
Technology training	-0.001	0.000	-0.002	-0.001
	(0.003)	(0.003)	(0.004)	(0.004)
Technology subsidies	0.043	0.047	0.013	0.013
	(0.046)	(0.046)	(0.043)	(0.042)
Jiangsu Province	0.296***	0.275***	0.252***	0.247***
	(0.050)	(0.051)	(0.047)	(0.046)
Jiangxi Province	0.022	0.032	0.021	0.015
	(0.031)	(0.030)	(0.032)	(0.032)
Year FE	Yes	Yes	Yes	Yes
Constant	0.552***	0.815***	0.538***	0.696***
	(0.102)	(0.126)	(0.102)	(0.117)
Observation	1038	1038	1038	1038
R^2	0.359	0.382	0.340	0.350

Note: ***, **, and * are significant at the level of 1%, 5%, and 10%, respectively. Robust standard errors are in brackets.

Table 10 The result of risk preferences and governmental regulation on farmers' adoption of straw return technology

	(1)	(2)	(3)	(4)
	Technology adoption decision			
Risk aversion	-0.453***	-0.465***		
	(0.034)	(0.036)		
Loss aversion			-0.056***	-0.061***
			(0.005)	(0.005)
Governmental regulation	0.136***	0.041	0.136***	-0.024
	(0.031)	(0.049)	(0.034)	(0.043)
Governmental regulation × Risk aversion		0.170**		
		(0.071)		
Governmental regulation × Loss aversion				0.050***
				(0.009)
Age	-0.001	-0.001	-0.001	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)
Education	-0.003	-0.003	-0.002	-0.002
	(0.003)	(0.003)	(0.003)	(0.003)
Experience	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Labor	0.017*	0.016	0.004	0.003
	(0.010)	(0.010)	(0.011)	(0.011)
Technology training	-0.000	-0.000	-0.002	-0.000
	(0.004)	(0.004)	(0.004)	(0.004)
Technology subsidies	0.047	0.048	0.013	0.010
	(0.047)	(0.047)	(0.044)	(0.044)
Jiangsu Province	0.279***	0.274***	0.228***	0.218***
	(0.054)	(0.054)	(0.051)	(0.051)
Jiangxi Province	-0.068**	-0.064**	-0.076**	-0.074**
	(0.031)	(0.031)	(0.032)	(0.032)
Year FE	Yes	Yes	Yes	Yes
Constant	0.934***	0.943***	0.942***	0.971***
	(0.101)	(0.101)	(0.101)	(0.102)
Observation	1038	1038	1038	1038
R^2	0.280	0.281	0.248	0.255

Note: ***, **, and * are significant at the level of 1%, 5%, and 10%, respectively. Robust standard errors are in brackets.