Natural disaster shock, risk aversion and corn farmers' adoption of degradable mulch film: evidence from Zhangye, China

Ruishi Si
*School of Public Administration, Xi'an University of Architecture and Technology,
Xi'an, China*

Noshaba Aziz
*College of Economics and Management, Nanjing Agricultural University,
Nanjing, China*

Mingyue Liu
*Institute of Agricultural Economics and Development,
Chinese Academy of Agricultural Sciences, Beijing, China, and*

Qian Lu
College of Economics and Management, Northwest A&F University, Yangling, China

Abstract

Purpose – Degradable mulch film (DMF) is a potential alternate to polyethylene (PE) mulching. In this regard, the purpose of this paper is to explore the effects and paths of natural disaster shock and risk aversion influencing farmers' DMF adoption.

Design/methodology/approach – This research is conducted by collecting cross-sectional data of corn farmers in Zhangye, China. First, by using the Tobit model, the paper attempts to explore the effects of natural disaster shock and risk aversion influencing farmers' DMF adoption. Second, IV-Tobit model is applied to deal with endogenous problems between risk aversion and DMF adoption. Additionally, the researchers used a moderating model to analyze feasible paths of natural disaster shock and risk aversion impacting farmers' DMF adoption.

Findings – The outcomes show that natural disaster shock and risk aversion significantly and positively affect farmers' DMF adoption. Though risk aversion plays a significant moderating effect in influencing farmers' DMF adoption by natural disaster shock, the moderating effect has a serious disguising effect. By considering the heterogeneity of risk aversion, the paper further confirms that if the intensity of natural disaster shock is increased by one unit, the intensity of MDF adoption by farmers with high-risk aversion also tends to increase by 15.85%.

Originality/value – This study is the pioneer one, which is evaluating the intensity of farmers' DMF adoption from adoption ratio, investment amount, labor input and adoption time. Additionally, the research provides important guidelines for policymakers to motivate medium and low-risk aversion farmers to adopt DMF.

Keywords Risk aversion, Corn farmers, DMF adoption, Hydro-meteorological diaster

Paper type Research paper

1. Introduction

Over the past three decades, climate change caused by greenhouse gases triggered the frequency and severity of natural disasters, i.e. hydro-meteorological and climatic disasters (Serrano-Ruíz *et al.*, 2020). The natural disasters, in turn, damage the agricultural sectors of many developing countries and putting them at risk of growing food insecurity around the world (Tilman *et al.*, 2011). Extreme weather conditions such as low temperature, drought and floods have generally increased food crisis, especially in some developing countries having the weak potential to resist the natural disaster shock (Abd-Elmabod *et al.*, 2020; Maponya and Mpandeli, 2012). According to the recent report of the Food and Agriculture Organization (FAO, WHO, IFAD, WFP and UNICEF, 2020), it is documented that approximately 690 million people around the world are facing hunger. The main reason behind such shortfall of food is climate change that affects rainfall patterns and ultimately agricultural production, leading to higher food prices and food insecurity (Theurl *et al.*, 2020). So there is an urgent need to take prompt actions to combat such uncertain circumstances faced by people in developing countries by improving farmers' resistance and adaptability to natural disaster shock and boosting agricultural output sustainably.

To prevent and mitigate the adverse effects of disasters on agricultural productivity, polyethylene (PE) mulching played a vital and significant role in enhancing agricultural productivity (Li *et al.*, 2018; Wang *et al.*, 2009). However, the PE mulching has a highly stable molecular structure, high tensile strength and customizability, which is easy to be finely broken but is challenging to conserve the natural environment (Borrowman *et al.*, 2020; Sintim and Flury, 2017). Residual mulch lowers the permeability of soil-water, declines the levels of soil microbial activities and soil fertility and also degenerates the soil structure and quality (Shogren, 2000; Chen *et al.*, 2019). Additionally, in developing countries, farmers' awareness regarding environmental protection is minimum, the labor cost of mulch film recycling is also relatively high and the industry chain of mulch film recycling has not yet been established (Immirzi *et al.*, 2009). Therefore, these factors accelerate the PE mulching pollution, which, in turn, threatens food security and put adverse effects on the ecological environment, especially in deprived areas heavily reliant on agriculture (Yin *et al.*, 2019).

Contrary to the PE, a mixture of degradable masterbatch and plastic particle masterbatch, i.e. degradable mulch film (DMF), is a promising alternate that has the potential to not only overcome undesired environmental effects but also lead to augment crop yield (Qian *et al.*, 2018). So DMF is emerged as a potential alternate to PE mulching both technically and agronomically (Mario, 2017). In the existing literature, numerous researchers focused on biodegradable mulch and photodegradable mulch films (Zhang *et al.*, 2020). Among them, the biodegradable mulch film is considered as most important based on its division into corn starch-based biodegradable mulch film and potato starch-based biodegradable mulch film. Biodegradation is mainly achieved by the effect of microorganisms in nature on the DMF (Sintim and Flury, 2017). On the other hand, the photodegradable mulch film is produced by mixing photodegradable particles and plastic particles. The DMF is broken by light irradiation and turns into organic matter, carbon

dioxide and dust, thereby degrading the mulch film (Kyrikou and Briassoulis, 2007). Thus, the degradation rate of DMF is greatly affected by environmental factors such as temperature, light and humidity (Tang and Ma, 2018).

Moreover, existing research studies mainly used a comparative experimental method to analyze the effects of DMF on heat preservation, drought resistance and moisture preservation as compared with PE mulching. Moreno and Moreno (2008) used tomato growers' data in Brazilian and described that although the biodegradable mulch film degrades fast, this degradation mainly occurs in the later stage of crop growth without affecting yield and quality of the crop. Touchaleaume et al. (2016) in southern France found by investigating corn farmers that DMF is sufficient to ensure the heat demand required for the growth of crops. Besides, other scholars also evaluated the eco-environmental effects of DMF. They believed that it could conserve the moisture of soil, maintain solute transport, improve the water resource utilization efficiency, reduce pesticide residues and, in turn, maintain food safety (Ming and Chen, 2020; Deng et al., 2019).

Despite the advantageous effects of DMF, still, farmers in developing countries prefer to adopt PE mulching and their enthusiasm for DMF is considerably low (Shen et al., 2019). In this regard, no published article is available in the present literature that has focused on exploring the mechanism of possible factors influencing the farmers' DMF adoption. Farmers' DMF adoption belongs to green production behavior/technology, which results from the combined effect of internal and external factors. From the perspective of external factors, DMF can reduce natural disaster shock and increase crop yields (Ming and Chen, 2020). From the standpoint of internal factors, the reason for adopting DMF by farmers may be to avoid natural disaster shock and environmental damage such as soil pollution caused by the PE mulching, which indirectly manages or controls crop production risks (Maponya and Mpandeli, 2012).

So based on the above discussion, this paper attempts to make the following significant contributions to the existing literature. First, this study is the pioneer one which is evaluating the intensity of farmers' DMF adoption from perspectives of adoption ratio, investment amount, labor input and adoption time. Second, natural disaster shock and risk aversion are incorporated into the unified analysis framework of farmers' DMF adoption and the effects and path of natural disaster shock and risk aversion are also discussed. Third, the IV-Tobit model is adopted to deal with the possible endogenous issue between risk aversion and farmers' DMF adoption. Finally, based on the empirical findings, different countermeasures are proposed to promote farmers' DMF adoption, generally in the context of developing countries and particularly in the context of China.

The remaining part of the paper is structured as follows: Section 2 encompasses the theoretical background. Section 3 covers the empirical analysis. Then, empirical results are presented in Section 4. Based on the empirical findings, the conclusion and policy recommendations are narrated in Section 5.

2. Theoretical background
2.1 Natural disaster shock and farmers' green technology adoption
A rich body of literature concerning the impacts of natural disaster shock has shown that it undergoes a transformation from natural phenomena to social risks emphasizing the economic loss due to natural disasters (Wei and Liu, 2020). The previous research evidenced that natural disasters such as drought, floods and locusts raging have reduced the grain output by 27.15% each year in East Africa developing countries (Thornton et al., 2010). Hence, the consensus is that natural disaster shocks are a major culprit exacerbating the agricultural vulnerability in developing countries (Jones and THornton, 2003).

Nevertheless, there is considerable controversy regarding the relationship between natural disaster shocks and farmers' adoption of green technology.

Some scholars believe that natural disaster shock exerts a "restriction" effect on farmers' green technology adoption (Guo *et al.*, 2017; Cole *et al.*, 2013). Specifically, natural disasters are prone to have devastating effects on agricultural production and capital stock (Binswanger and Sillers, 1983). Although farmers can actively take part in planting those crops that are adaptable to the seasons' fluctuations to reduce losses as the fixed investment in the early production is challenging to recover, which may exert a financial burden and lead to vulnerability of the whole family (Yang *et al.*, 2016). For smooth household consumption and sustainably maintaining family livelihoods, some farmers seek non-agricultural employment such as migrant work or business to compensate for the losses caused by natural disasters (Adeagbo *et al.*, 2016). Therefore, natural disaster shock is the principal factor inhibiting farmers from adopting green technologies owning to reduced income and labor transfer.

However, other scholars hold that natural disaster shock has an "inducing" effect on farmers' green technology adoption (Kide, 2014; Idrisa, 2012). Farmers in developing countries have strong industrial dependence. This dependence arises from experience, psychological confidence and difficulties in choosing other industries (Kuhl, 2020). Traditional small-scale farmers are not willing to adapt to modern sustainable agricultural development, so they are unable to resist natural disaster risks. In this vein, the agricultural transformation and upgrading based on the adoption of green agricultural technology have become a universal demand for farming operators (Idrisa, 2012) and farmers suffering from natural disaster shock are willing to replace traditional planting techniques with green agrarian techniques.

2.2 Natural disaster shock, risk aversion and farmers' degradable mulch film adoption
The possible reason for the above dispute is that they ignored the heterogeneity of farmers' risk aversion. Specifically, Haile *et al.* (2020) considered that small farmers with a strong sense of risk aversion are more inclined to manage climate risks. As the intensity of natural disaster risk increases, farmers with high-risk aversion tend to allocate the family income and labor resources, enhance agricultural investment and family labor and adopt DMF to alleviate low temperatures or drought risk damage. Farmers with medium-risk aversion are more inclined to engage in part-time agriculture and spend free time outside of agricultural production for engaging in other industries such as business or commerce. These farmers may support agricultural investment through non-agricultural income, thereby increasing the DMF adoption. Non-agricultural household income supplementing agricultural production investment has become the primary mode of smallholder farming in low-income developing countries (Tessema *et al.*, 2013). Additionally, Qian *et al.* (2020) addressed that farmers with low-risk aversion are negatively and significantly related to adaptation strategies. Low-risk aversion farmers routinely avoid playing their role in agricultural operations and prefer to switch to non-agricultural industries such as migrant workers or business operations. Therefore, their enthusiasm for adopting DMF maybe somehow relatively low. Based on the preceding analysis, we have designed our research to explore the impact mechanism of natural disaster shock and risk aversion on corn farmers' DMF adoption (Figure 1). Also, this research puts forward the following hypotheses:

H1. Natural disaster shock and risk aversion significantly and positively affect the DMF adoption of corn farmers with high-risk aversion.

H2. Natural disaster shock and risk aversion significantly and positively affect the DMF adoption of corn farmers with medium-risk aversion.

H3. Natural disaster shock and risk aversion significantly and negatively affect the DMF adoption of corn farmers with low-risk aversion.

3. Methodology

3.1 Study area

The study area named Zhangye is located in the western part of Gansu province, China. It is located at 97°20'–102°12' east longitude and 37°28' ~ 39°57' north latitude, with a total area of 39,436.53 square kilometers, accounting for 8.67% of the total area of Gansu Province (Figure 2). Zhangye governs Ganzhou, Linze, Gaotai, Shandan, Minle and Sunan counties, having climate types of plain with warm temperate arid climate and mountain area with semi-arid alpine climate. The main meteorological disasters are drought, sandstorm and dry, frost, etc. Besides, Zhangye is a profoundly impoverished area in western China. Corn is the main crop and in 2018, the corn production area was 1.2 million hectares, accounting for 18.29% of the agricultural sown area. To adapt to natural conditions and ensure the growth of crops, farmers have used more than 300,000 hectares of mulch film in Zhangye (Wang, 2017).

3.2 Sample selection

The samples and other data were collected from 2nd January to 16th January 2019. The research team used a stratified random sampling method to gather data from 6 counties of Zhangye. Three townships from each county, five villages from each town and 15 farmers from each village are randomly selected for the study purpose. A total of 1,350 questionnaires were distributed in the survey, 120 invalid questionnaires such as blanks and information omissions were eliminated and 1,230 valid questionnaires were finally used for analysis. The survey questionnaire's content includes the corn farmers' individual, family, business, environmental and societal characteristics, DMF adoption and social capital in the year 2018. The research team also collected data from meteorological and agricultural departments of each county to ensure the types and frequency of natural disasters that happened in the year, 2018. Also, we used SPSS 22.0 software to further test the sample's reliability and validity. The results show that the Cronbach α value is 0.8415 and the Kaiser-Meyer-Olkin (KMO) value is 0.7221($p < 0.01$), indicating that the sample is well represented.

3.3 Dependent variables

The vast majority of research studies divided technology adoption into adoption decision and adoption intensity. In the research sample, only 34.17% of corn farmers decided to adopt the DMF. Although adoption decision is a necessary factor in determining farmers'
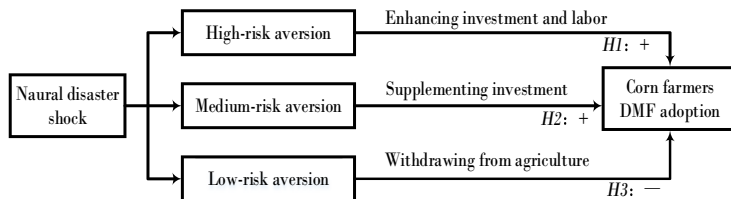

Figure 1.
Mechanism analysis and hypothesis

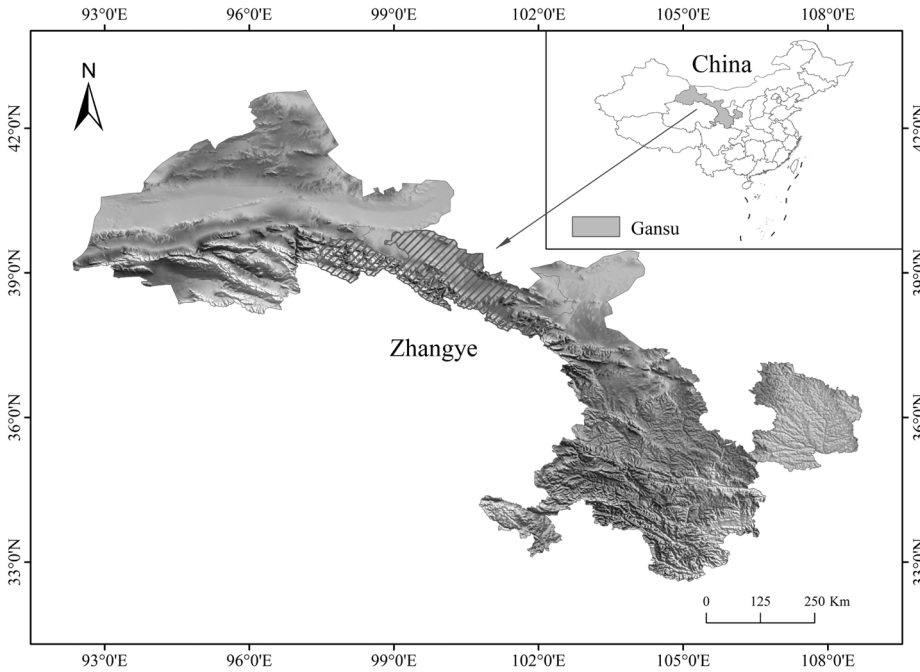**Notes:** + represents positive influence; — denotes negative influence

Source: Arc GIS 10

behavior within the framework of planned behavior theory, it inevitably brings about the problem of sample self-selection (Ntshangase *et al.*, 2018). Therefore, the intensity of technology adoption has become a more substantial indicator to measure farmers' agricultural technology adoption. In the existing literature, the measurement of technology adoption intensity is mainly based on the ratio of adoption area to total cultivated land area, investment amount, labor input and adoption time (Paltasingh, 2018). Therefore, we adopted exploratory factor analysis to comprehensively measure the intensity of farmers' DMF adoption from adoption ratio, investment amount, labor input and adoption time.

We extracted the common factors according to the fundamental principle, i.e. feature value is greater than 1. The results show that the feature value of the common factor is 3.2720, the variance contribution rate is 83.26%, the Cronbach's α value is 0.8112, the KMO value is 0.7021, the approximate chi-square value is 125.206 and the probability value is 0.000. Consequently, the indexes show excellent reliability and validity. Given some negative values of the factor analysis result, to make the result more intuitive, the factor value of the sample is converted into an index of 1–100 by following Bian and Li (2000). The conversion formula is as follow:

$$Factor_{afterconversion} = \left(Factor_{beforeconversion} + B\right)A$$
$$A = 99/(Factor_{max} - Factor_{Minimum})$$
$$B = \left[\left((Factor_{max} - Factor_{Minimum})/99\right)\right] - Factor_{Minimum}$$

(1)

$Factor_{afterconversion}$, $Factor_{beforeconversion}$, $Factor_{max}$ and $Factor_{Minimum}$ represent the factor value of each sample after and before conversion, the maximum and minimum values of factors in all samples before conversion, respectively. The descriptive analysis of farmers' DMF adoption intensity is shown in Table 1.

3.4 Explanatory variables

Drawing the weighted assignment method by Wei and Liu (2020), this study measured the intensity of natural disaster shock. The question in the questionnaire is, "In the past three years, which type of natural disasters have you suffered from? 1 = drought, 2 = cryogenic freezing, 3 = flooding and 4= insect pests and diseases." This is a multiple-choice question. In the sample, according to the occurrence ratio, the occurrence order natural disasters is: drought (62.17%) > cryogenic freezing (55.25%) > insect pests and diseases (30.12%) > flooding (27.29%). Then, the four disasters are converted into a discrete binary variable: "choice = 1, no choose = 0" and assigned a weight to each of the natural disasters according to their proportion. Finally, the intensity of natural disaster shock can be achieved by accumulating the weight assignment results of each natural disaster. The calculation formula is as follows:

$$Disaster = \sum_{i}^{k} w_i \times Indicator_i / \sum_{i}^{k} w_i, \, i = 1, \cdots, k \qquad (2)$$

where $Indicator_i$ denotes the ist indicator (drought, cryogenic freezing, insect pests and diseases, flooding). w_i represents indicator weight (the ratio of natural disaster occurrence).

In this study, we adopted the special scenario method proposed by Nakano and Magezi (2020) to judge the degree of risk aversion by asking farmers about the decision to grow corn under different expected price risks in the market. The question in the questionnaire is, "which of the following situations will you decide to grow? 1 = At 0.15–0.55 USD/kg, the average price is 0.35 USD/kg; 2 = At 0.20–0.50 USD/kg, the average price is 0.35 USD/kg; 3 = At 0.25–0.45 USD/kg, the average price is 0.35 USD/kg; 4 = At 0.30–0.40 USD/kg, the average price is 0.35 USD/kg; 5 = The price is 0.35 USD/kg set by the government." If the farmer chooses 1, the farmer has the lowest risk aversion; if he or she chooses 5, the farmer has the highest risk aversion. Additionally, according to expected price risks, we divide risk aversion into low-risk aversion (expected price is 1 and 2), medium-risk aversion (expected

Index	Implication	Maximum	Minimum	Mean
The intensity of farmers' DMF adoption	The score of exploratory factor analysis (before conversion)	−1.3014	1.2985	0
	The score of exploratory factor analysis (after conversion)	100	1	37
Adoption ratio	The ratio of farmer's DMF adoption area to family cultivated land area (0–1)	0	1	0.3125
Investment amount	Cost of purchasing DMF (US$)	64.1225	291.2082	178.5712
Labor input	Labor required for laying DMF (people)	2	9	4.2625
Adoption time	The time required for laying DMF(day)	3	11.5	6.1725
Note: Labor includes family labor and hired labor				

Table 1.
Descriptive analysis of farmers' DMF adoption intensity

price is 3) and high-risk aversion (expected price is 4 and 5). The descriptive analysis of explanatory variables is given in Table 2.

3.5 Control variables

To avoid problems of endogeneity, heteroscedasticity and autocorrelation, the control variables such as gender, age and education of household's head, environmental awareness, net family income, price gay between DMF and PE, social network, farmland location and technology training are incorporated in the model.

From Table 3, it is found that male households head account for 72.19% of the sample and are still acting as the primary decision-makers in the family. About 73.85% of household heads are from age above 40 years, with an average of 57.18 and 71.45% of

Index	Implication	Maximum	Minimum	Mean
Natural disaster shock	Weighted assignment	0.9102	0.2025	0.6805
Drought	Choice = 1, no choose = 0	1	0	0.6217
Cryogenic freezing	Choice = 1, no choose = 0	1	0	0.5525
Flooding	Choice = 1, no choose = 0	1	0	0.2729
Insect pests and diseases	Choice = 1, no choose = 0	1	0	0.3012
Risk aversion	Expected price risks (1–5)	5	1	0.3701
Low-risk aversion	Expected price risks (1–2)	2	1	1.6025
Medium-risk aversion	Expected price risks (3)	3	3	3.0000
High-risk aversion	Expected price risks (4–5)	5	4	4.4016

Table 2.
Summary statistics of explanatory variables

Variables	Definition	(%)	Mean	SD
Gender	Male = 1	72.19	0.72	0.25
	Female = 0	27.81		
Age	18–40 years	26.15	57.18	8.20
	41–60 years	40.35		
	61+ years	33.50		
Education	0–6 year (primary school)	36.28	7.19	1.72
	7–9 (middle school)	35.17		
	10–12 (high school)	20.25		
	12+ (university)	8.3		
Family net income	<1000 US$	28.30	1785.20	65.25
	1001–2000	40.15		
	2000–3000	22.10		
	>3000	9.45		
Social network	No. of homogeneous relationship (blood, kinship and geographic relationship people)	76.25	7.19	2.54
	No. of heterogeneous relationship (technical extension staff and market sales staff, etc.)	23.75	1.35	0.46
Farmland location	Flat area = 1	64.30	0.64	0.17
	Sloping area = 0	35.70		
Environmental awareness	DMF can improve the ecological environment (1 = strongly disagree–5 = strongly agree		2.65	0.89
Technology training	No. of training about DMF in 2018		3.15	0.96
Price gay	Price gay (US$) between DMF and PE/kg		1.16	0.25

Table 3.
Summary statistics of the sampled corn farmers

household heads have received education less than nine years i.e. primary and middle school level, with an average of 7.19 years.

In the context of net income, about 70% of households have net income below 2,000 USD, with an average of 1,785.20 USD and is regarded as low-income areas in China. Approximately 76.25% of households' social network is homogenous based on blood, kinship and geography. Farmers have fewer exchanges with heterogeneous social personnel such as personnel of agricultural extension and market sales, which also has proven that poor areas in rural society are a typical acquaintance society. Additionally, 64.30% of the cultivated land is flat land and the proportion of slope land is only 35.70%, providing favorable conditions for corn planting in arid and semi-arid areas.

3.6 Empirical analysis
3.6.1 Tobit and IV-Tobit model. The typical characteristic of Tobit model is that the selection equation model can express the constraints, which supports certain continuous variables under the constraints (Wooldridge, 2006). Thus, the Tobit model is mainly applied to analyze restricted continuous data where the range of the dependent variable is partially or all limited. By following the study of Paltasingh (2018), who also used the Tobit regression model to analyze adoption intensity, we examine the effects of natural disaster shock and risk aversion on corn farmers' DMF adoption. The model assumes that the observed dependent variable (the intensity of DMF adoption) Y_j for observations $j = 1,\ldots n$ satisfies:

$$Y_j = \max\left(Y_j^*, 0\right) \tag{3}$$

Where Y_j^* is a latent variable generated by the classical linear regression model:

$$Y_j^* = \beta' X_j + U_j, \; Y_j = \begin{cases} Y_j^* & \text{if } Y_j^* > 0 \\ 0 & \text{if } Y_j^* \leq 0 \end{cases} \tag{4}$$

Where X_j is a vector of regressors, β' is the corresponding vector of parameters and U_j is assumed to be independent normally distributed: $U_j \sim N(0, \sigma^2)$.

The empirical latent variable model to analyze the effects of natural disaster shock and risk aversion on corn farmers' DMF adoption is specified as follows:

$$Y_j^* = \beta_0 + \beta_1 X_{1j} + \cdots \beta_n X_{nj} + \varepsilon_j \tag{5}$$

Where X_{nj} represents the explanatory and control variables in this paper, ε_j denotes the random error term. Besides, there may be a mutual causality between risk aversion and farmers' DMF adoption. Farmers with a higher risk-aversion may tend to adopt DMF. Moreover, Frankel and Romer (1999) believed that geographic factors are the ideal factors to be taken as instrumental variables. Therefore, "the closest distance between cultivated land and water source" is selected as an instrumental variable. Thus, we use the IV-Tobit model for model estimation to eliminate the estimation bias caused by possible endogenous problems.

3.6.2 Moderating effect model. To explore the path of natural disaster shock and risk aversion influencing corn farmers' DMF adoption, we further verify the moderating effect of risk aversion influencing corn farmers' DMF adoption by natural disaster. Following Wen *et al.* (2005), a group regression and Tobit models are used to test the moderating effects of risk aversion.

4. Results and discussion

4.1 Evaluation of models fitting effect

We use the hierarchical regression method to estimate the Tobit model (Model 1, Model 2 and Model 3). From Table 4, the values of the LR χ^2 test are 135.25, 135.03 and 135.70, as well as p values, which are all 0.000. Specifically, compared to Model 1 and Model 2, when natural disaster shock and risk aversion are added into the Tobit model simultaneously, the value of LR χ^2 turned larger and the explanatory variables' marginal effects (MEs) turned less, indicating the fitting effect of Model 3 is better. Besides, if the natural disaster shock or risk aversion is omitted, the estimated result of the model may be overestimated.

Furthermore, taking into account the endogeneity of risk aversion, IV-Tobit is used and found that the MEs of natural disaster shock and risk aversion are further reduced. Therefore, correlation and endogeneity are performed to determine whether there is an instrumental variable. First, according to the correlation test rule (Xu *et al.*, 2018), risk aversion is taken as the explained variable and the closest distance between cultivated land and water source as the explanatory variable to perform the first-stage Tobit regression, obtaining the fitted value of the endogenous variable. The result in Model 4 shows that the F-test value is 13.2405 (P = 0.0000), indicating that the endogenous variables (risk aversion) and instrumental variables are highly correlated. Second, the fitted value of the endogenous variable is used as an explanatory variable for IV-Tobit regression and Model 4 reports the regression results of the second stage. The results show that Wald χ^2 test value is 147.29 (P = 0.0000), DWH test value is 8.2503 (P = 0.0000), supporting the rejection of the null hypothesis, i.e. risk aversion is an exogenous variable. Therefore, Models 1–3 equations have serious endogenous problems and the Tobit model regression estimation leads to biased results in this case.

Variables	Tobit (Model 1)	Tobit (Model 2)	Tobit (Model 3)	IV-Tobit (Model 4)
Natural disaster shock	0.1725** (0.0814)		0.1402** (0.0704)	0.1385** (0.0621)
Risk aversion		0.2812*** (0.0862)	0.2618*** (0.0902)	0.2006*** (0.0666)
Gender	0.0904* (0.0502)	0.0726* (0.0403)	0.0604* (0.0323)	0.0665* (0.0357)
Age	−0.1002*** (0.0335)	−0.0802*** (0.0211)	−0.0962*** (0.0283)	−0.0902*** (0.0251)
Education	0.1329 (0.0914)	0.1244 (0.0778)	0.1201 (0.0741)	0.1190 (0.0799)
Family net income	0.0105** (0.0477)	0.0104** (0.0495)	0.0105** (0.0482)	0.0105** (0.0460)
Social network	0.0606*** (0.1650)	0.0502*** (0.0132)	0.0485*** (0.0134)	0.0506*** (0.0177)
Farmland location	0.1820*** (0.0430)	0.1841*** (0.0484)	0.1720*** (0.0457)	0.1712*** (0.0502)
Environmental awareness	0.0436 (0.0335)	0.0391 (0.0283)	0.0496 (0.0330)	0.0401 (0.0282)
Technology training	0.0529 (0.0348)	0.0625 (0.0429)	0.0735 (0.0495)	0.0622 (0.0403)
Price gay	0.1104*** (0.0312)	0.0902*** (0.0249)	0.1046*** (0.0288)	0.1062*** (0.0331)
LR χ^2 test	135.25***	135.03***	135.70***	
Wald χ^2 test				147.29***
Prob > F	0.0000	0.0000	0.0000	0.0000
The first stage model (F test)				13.2045***
DWH test				8.2503***
Sample	1230	1230	1230	1230

Notes: The ME reported in the table. Robust standard errors (SE) in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 4.
Influencing effects of natural disasters shock and risk aversion

4.2 Influencing effects of natural disaster shock and risk aversion
According to Model 4, natural disaster shock shows significant results with positive impact (ME = 0.1385, SE = 0.0621) and infers that if the intensity of natural disaster shock is increased by one unit, the intensity of farmers' DMF adoption will increase by 13.85%. Drought and cryogenic freezing are the main meteorological disasters in the sample area, which are still the main reasons behind farmers' DMF adoption. Compared with PE mulching, our research also confirms the applicability and advantages of DMF through farmers' behavior response toward natural disaster shock (Borrowman *et al.*, 2020). Our results are in alignment with the results of Deng (2019) and Kide (2014), who also proved that natural disaster shock has an "inducing" effect on farmers' green technology adoption. Of course, what further requires is that we believe that there are two possibilities of the inducing effect: subjective acceptance and passive adaptation. In the context of natural disaster shock, farmer's experience has provided sufficient technical expertise for DMF adoption such as the depth of soil cover, the time of DMF adoption and the amount of water and fertilizer (Li *et al.*, 2020). Besides, psychological confidence plays an important role for farmers in adopting new technologies (Torske *et al.*, 2016). By agricultural infrastructural reforms such as drip irrigation and artificial hail prevention, it is apparent that new technologies can reduce the risks of lower yield caused by conventional natural disasters. Therefore, natural disaster shock may stimulate corn farmers to adopt DMF actively. On the other side, there is a vocational skill bottleneck in the job transition of farmers in poor areas. Low-skilled occupations cannot guarantee family income stability and registration system barriers for farmers entering into urban make it difficult for them to integrate into the city sustainability (Peou, 2016). Therefore, some farmers are willing to adopt DMF to reduce the damage of natural disasters shock and increase agricultural production income.

In the context of risk aversion, it is positively and significantly influencing farmers' DMF adoption (ME = 0.2006, SE = 0.0666), denoting that if the degree of risk aversion increases by one unit, the intensity of farmers' DMF adoption increases by 20.06%. Risk aversion is mainly manifested in farmers' risk attitude, which is a state of faith, opinion or tendency that can be selected based on a certain type of fact or conditions (Elwell, 2009). Our findings are in alignment with the outcome of De Brauw and Eozenou (2014). They stated that farmers in developing countries are generally taking risk aversions seriously and they are willing to switch to adaptive measures to combat risks. Some farmers spare no effort to avoid risks and adopt DMF has proven their deviation from the profit maximization goal to agricultural production behavior (Liu and Huang, 2013). In terms of promoting corn yield, DMF and PE have similar effects and in most studies, there were found no significant differences in crop yields (Ghimire *et al.*, 2018). The farmers who adopt DMF are more concerned about the risk of soil pollution caused by PE mulch film residues and then adopt the DMF with higher market prices to avoid the "vicious circle" of environmental pollution and corn production (Yin *et al.*, 2019). However, it needs to be soberly observed that the existing research conclusions do not seem to explain well that some farmers in poor areas have given up traditional agricultural production or have not adopted new agricultural production technologies, but instead are engaged in migrant labor, commodity trade or tourism to achieve livelihood transformation. To explain possible internal mechanisms, our research in 4.3 further analyzed the path of natural disaster shock influencing corn farmers' DMF adoption by giving full consideration to the heterogeneity of risk aversion.

Furthermore, we also find that some vital control variables significantly influence farmers' adoption of DMF. If the head of the household is male, the adoption of DMF increases by 6.65%, just as Ernah and Waibel (2016) concluded that male-headed households are more likely to adopt agricultural technologies. In the context of age, if the

age of households' head is increased by one year, it is expected that the intensity of farmers' DMF adoption decrease by 9.02% that entails that the older the head of the household is, the more conservative the ideology and lower willingness to adopt new technologies as found in the study of Ma and Abdulai (2019). Our research also confirms that price gay is a driving factor in farmers' production-consumption decisions and is parallel to the study of Silva *et al.* (2020). Compared with PE mulch, the price of DMF is generally higher and farmers with more net family income are more likely to adopt DMF. Therefore, if the price of gay expands by one dollar, the intensity of farmers' DMF adoption will increase by 10.62% and if household net income increases by one dollar, the intensity of farmers' DMF adoption will also increase by 1.05%. Consistent with Liverpool-Tasie and Parkhi (2020), it is believed that social network plays a crucial role in the farmers' technology adoption. If the social network increases by one person, farmers' DMF adoption will increase by 5.06%. Besides, compared with sloping land, the farmers' DMF adoption in plain areas will increase by 17.12%. Although the sloping land may have lower temperatures and greater water evaporation, it does not have the topographical advantages of DMF adoption.

4.3 Influencing path of natural disaster shock and risk aversion
To explore the path of natural disaster shock and risk aversion influencing corn farmers' DMF adoption, we further verify the mediating effect between natural disaster shock and farmers' DMF adoption by considering the heterogeneity of risk aversion. Table 5 shows the influencing path of natural disaster shock and risk aversion via the Tobit model and group regression. According to Model 5–7, the values of the LR χ^2 test are 76.28, 60.16 and 67.25 at the 1% significance level, respectively. Consequently, Model 5–7 has an excellent fitting effect. Besides, to better explain the model estimation results between different groups of risk aversion, we plotted the relationship between the degree of risk aversion and the ratio of non-agricultural income (Figure 3). It is found that if the degree of risk aversion is higher, the ratio of non-agricultural income is lower and the intensity of farmers' DMF adoption may be greater. However, if the degree of risk aversion is lower, the non-agricultural income of farmers is higher and they may concentrate on non-agricultural work.
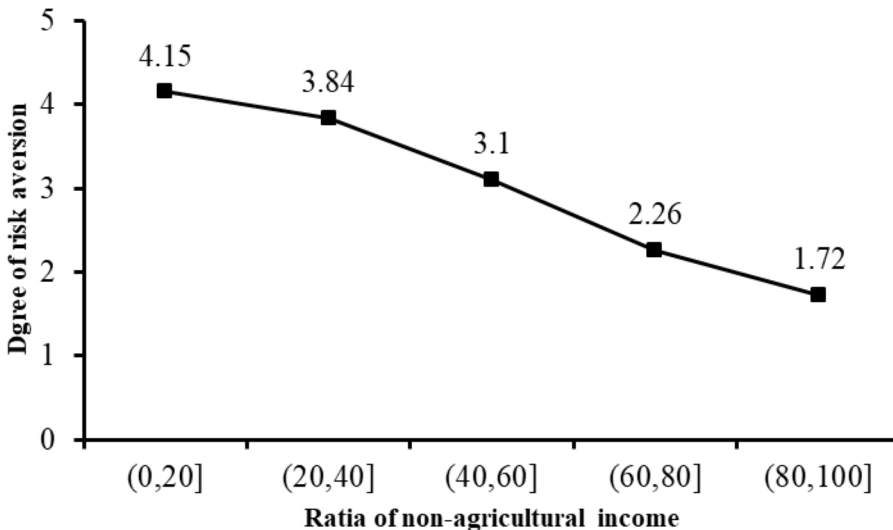

Figure 3.
Relationship between the degree of risk aversion and the ratio of non-agricultural income

From Model 5, natural disaster shock positively influences the high-risk aversion farmers' DMF adoption, denoting that if the intensity of natural disaster shock increases by one unit, the intensity of high-risk aversion farmers' DMF adoption will increase by 15.85% and hypothesis *H1* is confirmed. Likewise, the research of Petrolia *et al.*(2013) evidence the same and stated that although farmers in deprived areas have a shortage in resisting natural risks they are not still at loss and keep a strong desire to adopt innovative agricultural technologies. From the perspective of risk management, farmers can reduce risk damage through risk response measures before behavioral decisions and implement risk prevention and control strategies at the lowest cost (Chhun *et al.*, 2020; Deh-Haghi *et al.*, 2020). Farmers with high-risk aversion tend to consider the marginal and expected utility of DMF adoption, make full use of the optimal effects of DMF such as soil pollution control, nutrients conservation and soil erosion prevention that PE mulching does not have, and then allocate the remaining family funds and labor to enhance DMF adoption. Pan *et al.* (2018) in their study also considered that some farmers even make short-term loaning decisions to continuously increase the intensity of green agricultural technology adoption.

However, the *H2* hypothesis is falsified as natural disaster shock has not shown a positive and significant impact on medium and low-risk aversion farmers' DMF adoption. However, *H3* is confirmed. Cost-benefit estimation is the key to explore whether farmers can adopt green agricultural technology and the cost-benefit also determines the degree of farmers' participation in environmental governance (Prem *et al.*, 2010). As far as medium-risk aversion farmers are concerned, they are in a state of hesitation in adopting DMF because they are engaged in non-agricultural occupations such as migrant workers or commerce in the idle season, while in spring and autumn when agricultural production is on the peak, they keep on engaged themselves in corn production. Zhao (2014) states that it precisely owns to the instability of non-agricultural jobs, the reality of poor working conditions and the mentality of farmers inclined to stable food guarantees and the best choice for medium-risk aversion farmers is non-agricultural concurrent employment. However, due to the low chain of corn planting industry and the income earned from part-time work is relatively higher than corn planting (Todaro, 1969), farmers pay insufficient attention to the environmental pollution that PE mulch may bring and generally express the preference for lower-priced PE mulch instead of DMF.

If farmers have a low degree of risk aversion, they usually adopt a comprehensive evaluation of the cost of risk damage and the effectiveness of risk aversion and then take decisions to temporarily leave agricultural production to transfer natural risks (Peou, 2016). Therefore, for low-risk aversion farmers, they remain silent and let go of the natural disaster shock and the willingness and intensity of DMF adoption are relatively low. Our research has further confirmed the findings of Gomez-Zavaglia *et al.* (2020) and Ioannou *et al.*(2020)

Variables	High-risk aversion (Model 5)	Medium-risk aversion (Model 6)	Low-risk aversion (Model 7)
Natural disaster shock	0.1585** (0.0717)	0.1201 (0.0755)	0.1120 (0.0692)
Control variables	Controlled	Controlled	Controlled
LR χ^2 test	76.28***	60.16***	67.25***
Prob > F	0.0000	0.0000	0.0000
Sample	568	317	365

Notes: The ME reported in the table. Robust standard errors (SE) in parentheses. ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$

Table 5. Influencing path of natural disaster shock and risk aversion

and state that with the intensification of global climate change, agricultural production had suffered more severe damage and a great number of small farmers have abandoned the cultivated land management and agricultural production, especially in developing countries and numerous farmers are shifting to cities, which further jeopardizes the sustainable agricultural development and, in turn, threatening global food security (Table 5).

5. Conclusion and policy implications

Although PE mulching has the advantage of drought resistance, maintaining soil temperature and moisture preservation, white pollution has further weakened the quality of cultivated land and restricted the sustainable development of agriculture. In this vein, DMF is considered as a potential alternate to PE mulching, to diminish the undesirable environmental and economic drawbacks that occurred by the application of PE agricultural mulch. Unfortunately, it is apparent that the enthusiasm of farmers for DMF adoption is not high.

Our research concludes that the intensity of farmers' DMF adoption is relatively low and the natural disaster shock and risk aversion show significant results with positive effects. If the intensity of natural disaster shock and risk aversion is increased by one unit, the intensity of farmers' DMF adoption will increase by 13.85% and 20.06%, respectively. Additionally, risk aversion has shown a positive and significant moderating effect on corn farmers' DMF adoption by natural disasters shock. What needs attention is that the moderating effect had serious disguising effects. Specifically, based on the heterogeneity of risk aversion, we state that if the intensity of natural disaster shock increases by one unit, the intensity of high-risk aversion farmers' MDF adoption will increase by 15.85%.

Nevertheless, natural disaster shock does not significantly impact the medium and low-risk aversion farmers' DMF adoption. In short, the outcome of our research conclusions provides essential guidelines for policymakers to stimulate and manage target populations such as medium and low-risk aversion farmers to improve the intensity of DMF adoption. Also, we also found that the role of the government and the endogenous forces of farmers are weak in promoting the adoption of DMF by farmers.

In essence, the policies aiming at promoting farmers' DMF adoption should include the following three aspects. First, the government should formulate a price subsidy policy for DMF based on the price difference between DMF and PE, reducing the additional cost pressure on farmers' DMF adoption. Second, the government and cooperative organizations should conduct demonstrations publically, provide technical guidance and stimulate farmers, especially low and medium-risk aversion farmers to fully realize the incomparable advantages of DMF adoption in not only increasing the production but also conserving and protecting the environment and improving their confidence in resisting natural disaster shock and enhancing the ability and degree of risk aversion. Finally, the government should speed up the cultivation of professional farmers, improve the new agricultural management system, attract more talents to engage in specialized agricultural production and initially solve the problems of non-farming and low DMF adoption. Additionally, the agricultural insurance system should be established and improved. The construction of farmland water conservancy and other infrastructures should be strengthened to enhance agricultural risk resistance and provide the necessary guarantee for the promotion of DMF adoption.

Our research also provides important enlightenment for future research: when exploring the influencing factors or mechanisms of farmers' green agricultural technology adoption, the scholars should fully consider the heterogeneity of risk preference and risk aversion, which is a foundation for putting forward differentiated and incentive policy. Of course, in

our study, DMF adoption is also affected by natural factors such as light, temperature and humidity and their degradation speed may not match the crop production cycle. Moreover, owing to a lack of data, this research did not consider the effects of other socio-economic factors such as organizational participation and extension of agricultural technology. These shortcomings provide exciting avenues for future research.

References

Abd-Elmabod, S.K., Muñoz-Rojas, M., Jordán, A., Anaya-Romero, M., Phillips, J.D., Laurence, J. and Zhang, Z. (2020), "Climate change impacts on agricultural suitability and yield reduction in a Mediterranean region", *Geoderma*, Vol. 374 No. 5, p. 114453.

Adeagbo, A., Daramola, A., Carim-Sanni, A., Akujobi, C. and Ukpong, C. (2016), "Effects of natural disasters on social and economic well being: a study in Nigeria", *International Journal of Disaster Risk Reduction*, Vol. 17, pp. 1-12.

Bian, Y. and Li, Y. (2000), "Social network capital of Chinese urban families", *Tsinghua Sociology Review*, No. 2, pp. 1-18.

Binswanger, H.P. and Sillers, D.A. (1983), "Risk aversion and credit constraints in farmers' decision-making: a reinterpretation", *The Journal of Development Studies*, Vol. 20 No. 1, pp. 5-21.

Borrowman, C.K., Johnston, P., Adhikari, R., Saito, K. and Patti, A.F. (2020), "Environmental degradation and efficacy of a sprayable, biodegradable polymeric mulch", *Polymer Degradation and Stability*, Vol. 175, p. 109126.

Chen, N., Li, X., Šimůnek, J., Shi, H., Ding, Z. and Peng, Z. (2019), "Evaluating the effects of biodegradable film mulching on soil water dynamics in a drip-irrigated field", *Agricultural Water Management*, Vol. 226 No. 2, p. 105788.

Chhun, S., Kumar, V., Martin, R.J., Srean, P. and Hadi, B.A.R. (2020), "Weed management practices of smallholder rice farmers in Northwest Cambodia", *Crop Protection*, Vol. 135 No. 9, p. 104793.

Cole, S., Gine, X., Tobacman, J. and Al, E. (2013), "Barriers to house-hold risk management: evidence from India", *American Economic Journal: Applied Economics*, Vol. 5 No. 1, p. 104.

De Brauw, A. and Eozenou, P. (2014), "Measuring risk attitudes among Mozambican farmers", *Journal of Development Economics*, Vol. 111, pp. 61-74.

Deh-Haghi, Z., Bagheri, A., Fotourehchi, Z. and Damalas, C.A. (2020), "Farmers'acceptance and willingness to pay for using treated wastewater in crop irrigation: a survey in Western Iran", *Agricultural Water Management*, Vol. 239 No. 5, p. 106262.

Deng, L., Meng, X., Yu, R. and Wang, Q. (2019), "Assessment of the effect of mulch film on crops in the arid agricultural region of China under future climate scenarios", *Water*, Vol. 11 No. 9, p. 1819.

Deng, L., Yu, Y., Zhang, H., Wang, Q. and Yu, R. (2019), "The effects of biodegradable mulch film on the growth, yield, and water use efficiency of cotton and maize in an arid region", *Sustainability (Switzerland)*, Vol. 11 No. 24, pp. 1-15.

Elwell, R. (2009), "Understanding and managing risk attitude", *Ergonomics*, Vol. 52 No. 2, pp. 271-272.

Ernah, P.,P. and Waibel, H. (2016), "Adoption of sustainable palm oil practices by Indonesian smallholder farmers", *Asean Economic Bulletin*, Vol. 33 No. 3, pp. 291-316.

FAO, WHO, IFAD, WFP and UNICEF (2020), The State of Food Security and Nutrition in the World 2019, New York, NY.

Frankel, J. and Romer, D. (1999), "Does trade cause growth?", *American Economic Review*, Vol. 89 No. 3, pp. 379-399.

Ghimire, S., Wszelaki, A., Moore, J., Inglis, D. and Miles, C. (2018), "The use of biodegradable mulches in pie pumpkin crop production in two diverse climates", *HortScience*, Vol. 53 No. 3, pp. 288-294.

Gomez-Zavaglia, A., Mejuto, J.C. and Simal-Gandara, J. (2020), "Mitigation of emerging implications of climate change on food production systems", *Food Research International*, Vol. 134 No. 4, p. 109256.

Guo, G., Lu, Q. and Li, Y. (2017), "Influence of exogenous shocks and social network on farmers' water-saving irrigation technology adoption-based on the investigation of the Zhangye, Gansu", *Arid Land Resources and Environment*, Vol. 31 No. 12, pp. 33-38.

Haile, K.K., Nillesen, E. and Tirivayi, N. (2020), "Impact of formal climate risk transfer mechanisms on risk-aversion: empirical evidence from rural Ethiopia", *World Development*, Vol. 130 No. 6, p. 104930.

Idrisa, Y. (2012), "Analysis of awareness and adaptation to climate change among farmers in the Sahel Savannah agro-ecological zone of Borno state, Nigeria", *British Journal of Environment and Climate Change*, Vol. 2 No. 2, pp. 216-226.

Immirzi, B., Santagata, G., Vox, G. and Schettini, E. (2009), "Preparation, characterisation and field-testing of a biodegradable sodium alginate-based spray mulch", *Biosystems Engineering*, Vol. 102 No. 4, p. 461472.

Ioannou, A., Gohari, G., Papaphilippou, P., Panahirad, S., Akbari, A., Dadpour, M.R. and Krasia-Christoforou, T. (2020), "Advanced nanomaterials in agriculture under a changing climate: the way to the future?", *Environmental and Experimental Botany*, Vol. 176 No. 4, p. 104048.

Jones, P. and THornton, P. (2003), "The potential impacts of climate change on maize production in Africa and Latin America in 2055", *Global Environmental Change*, Vol. 13 No. 1, pp. 51-59.

Kide, G. (2014), "Smallholder farmers' adaptation strategies to climate change in Ethiopia: evidence from Adwa Woreda of Tigray region", *Journal of Economics and Sustainable Development*, Vol. 5 No. 7, pp. 162-182.

Kuhl, L. (2020), "Technology transfer and adoption for smallholder climate change adaptation: opportunities and challenges", *Climate and Development*, Vol. 12 No. 4, pp. 353-368.

Kyrikou, I. and Briassoulis, D. (2007), "Biodegradation of agricultural plastic films: a critical review", *Journal of Polymers and the Environment*, Vol. 15 No. 2, pp. 125-150.

Li, H., Huang, D., Ma, Q., Qi, W. and Li, H. (2020), "Factors influencing the technology adoption behaviours of Litchi farmers in China", *Sustainability (Switzerland)*, Vol. 12 No. 1, pp. 1-13.

Li, Q., Li, H., Zhang, L., Zhang, S. and Chen, Y. (2018), "Mulching improves yield and water-use efficiency of potato cropping in China: a meta-analysis", *Field Crops Research*, Vol. 221 No. 2, pp. 50-60.

Liu, E. and Huang, J. (2013), "Risk preferences and pesticide use by cotton farmers in China", *Journal of Development Economics*, Vol. 103 No. 7, pp. 202-215.

Liverpool-Tasie, L.S.O. and Parkhi, C.M. (2020), "Climate risk and technology adoption in the midstream of crop value chains: evidence from Nigerian maize traders", *Journal of Agricultural Economics*, doi: 10.1111/1477-9552.12394.

Ma, M. and Abdulai, A. (2019), "IPM adoption, cooperative membership and farm economic performance: insight from apple farmers in China", *China Agricultural Economic Review*, Vol. 11 No. 2, pp. 218-236.

Maponya, P. and Mpandeli, S. (2012), "Climate change and agricultural production in South Africa: impacts and adaptation options", *Journal of Agricultural Science*, Vol. 4 No. 10, pp. 48-60.

Mario, M. (2017), "Soil degradable bioplastics for a sustainable modern agriculture", available at: www.springer.com/gp/book/9783662541289#aboutBook (accessed 20 June 2020).

Ming, X. and Chen, H. (2020), "Experiment on cultivation performance of plant fiber-based degradable film in paddy field", *Applied Sciences*, Vol. 10 No. 2, p. 495.

Moreno, M.M. and Moreno, A. (2008), "Effect of different biodegradable and polyethylene mulches on soil properties and production in a tomato crop", *Scientia Horticulturae*, Vol. 116 No. 3, pp. 256-263.

Nakano, Y. and Magezi, E.F. (2020), "The impact of microcredit on agricultural technology adoption and productivity: evidence from randomized control trial in Tanzania", *World Development*, Vol. 133, p. 104997.

Ntshangase, N., Muroyiwa, B. and Sibanda, M. (2018), "Farmers' perceptions and factors influencing the adoption of no-till conservation agri-culture by small-scale farmers in Zashuke, KwaZulu-Natal province", *Sustainability*, Vol. 10 No. 2, p. 555.

Paltasingh, K. (2018), "Land tenure security and adoption of modern rice technology in Odisha, Eastern India: revisiting Besley's hypothesis", *Land Use Policy*, Vol. 78 No. 11, pp. 236-244.

Pan, S., Yan, L., Qu, Z. and Deng, Y. (2018), "A study of the factors influencing farmers' willingness and behaviors in green agricultural development: an empirical analysis based on the survey data of farmers in Lishui city Zhejiang province", *Journal of Jiangxi University of Finnace and Economics*, Vol. 116 No. 2, pp. 79-89.

Peou, C. (2016), "Negotiating rural-urban transformation and life course fluidity: rural young people and urban sojourn in contemporary Cambodia", *Journal of Rural Studies*, Vol. 44, pp. 177-186.

Petrolia, D., Landry, C. and Coble, K. (2013), "Risk preferences, risk perceptions, and flood insurance", *Land Economics*, Vol. 89 No. 2, pp. 227-245.

Prem, K., Ng, D., Pasman, H., Sawyer, M., Guo, Y. and Mannan, M. (2010), "Risk measures constituting a risk metrics which enables improved decision making: value-at-risk", *Journal of Loss Prevention in the Process Industries*, Vol. 23 No. 2, pp. 211-219.

Qian, C., Xiaoping, L., Xianxiong, X. and Minjuan, Z. (2020), "The impact of non-agricultural employment on farmers' ecological production behavior: based on the mediating effect of agricultural production and operation characteristics and the regulating effect of the family life cycle", *China Rural Survey*, No. 1, pp. 76-93.

Qian, H., Zhang, M., Liu, G., Lu, T., Qu, Q., Du, B. and Pan, X. (2018), "Effects of soil residual plastic film on soil microbial community structure and fertility", *Water, Air, and Soil Pollution*, Vol. 229 No. 8, p. 261.

Serrano-Ruíz, H., Eras, J., Martín-Closas, L. and Pelacho, A.M. (2020), "Compounds released from unused biodegradable mulch materials after contact with water", *Polymer Degradation and Stability*, Vol. 178, p. 109202.

Shen, L., Zhang, Y., Lan, Y. and Li, R. (2019), "Effects of degradable films with different degradation cycles on soil temperature, moisture and maize yield", *International Journal of Agricultural and Biological Engineering*, Vol. 12 No. 3, pp. 36-44.

Shogren, R.L. (2000), "Biodegradable mulches from renewable resources", *Journal of Sustainable Agriculture*, Vol. 16 No. 4, pp. 33-47.

Silva, J.R.D., Mauad, J.R.C., Domingues, C.H. D F., Marques, S.C.C. and Borges, J.A.R. (2020), "Understanding the intention of smallholder farmers to adopt fish production", *Aquaculture Reports*, Vol. 17 No. 10, p. 100308.

Sintim, H.Y. and Flury, M. (2017), "Is biodegradable plastic mulch the solution to agriculture's plastic problem?", *Environmental Science and Technology*, Vol. 51 No. 3, pp. 1068-1069.

Tang, X. and Ma, M. (2018), "Effects of degradable film degradation properties on soil temperature, moisture, and maize yield", *Journal of Agro-Environment Science*, Vol. 37 No. 1, pp. 114-123.

Tessema, Y.A., Aweke, C.S. and Endris, G.S. (2013), "Understanding the process of adaptation to climate change by small-holder farmers: the case of east Hararghe Zone, Ethiopia", *Agricultural and Food Economics*, Vol. 1 No. 1, pp. 1-17.

Theurl, M.C., Lauk, C., Kalt, G., Mayer, A., Kaltenegger, K., Morais, T.G. and Teixeira, R.F.M. (2020), "Food systems in a zero-deforestation world: dietary change is more important than intensification for climate targets in 2050", *Science of the Total Environment*, Vol. 735 No. 9, p. 139353.

Thornton, P., Jones, P. and Alagarswamy, G. (2010), "Adapting to climate change: agricultural system and household impacts in East Africa", *Agricultural Systems*, Vol. 103 No. 2, pp. 73-82.

Tilman, D., Balzer, C. and Hill, J. (2011), "Global food demand and the sustainable intensification of agriculture [sustainability science]", *Proceedings of the National Academy of Sciences*, Vol. 108 No. 50, pp. 20260-20264.

Todaro, M. (1969), "A model of labor migration and urban unemployment in less developed countries", *American Economic Review*, Vol. 59 No. 1, pp. 138-148.

Torske, M.O., Bjørngaard, J.H., Hilt, B., Glasscock, D. and Krokstad, S. (2016), "Farmers' mental health: a longitudinal sibling comparison – the HUNT study, Norway", *Scandinavian Journal of Work, Environment and Health*, Vol. 42 No. 6, pp. 547-556.

Touchaleaume, F., Martin-Closas, L., Angellier-Coussy, H., Chevillard, A., Cesar, G., Gontard, N. and Gastaldi, E. (2016), "Performance and environmental impact of biodegradable polymers as agricultural mulching films", *Chemosphere*, Vol. 144, pp. 433-439.

Wang, L. (2017), "3332 working method of remaining film picking up in Zhangye city", *Agricultural Machinery Technology Promotion*, Vol. 23 No. 6, pp. 20-21.

Wang, F.X., Feng, S.Y., Hou, X.Y., Kang, S.Z. and Han, J.J. (2009), "Potato growth with and without plastic mulch in two typical regions of Northern China", *Field Crops Research*, Vol. 110 No. 2, pp. 123-129.

Wei, Q. and Liu, W. (2020), "Disaster impact, community resilience and residents' confidence: an empirical study based on the general social survey in Yunnan ethnic minority areas", *China Rural Survey*, Vol. 4, pp. 1-20.

Wen, Z., Hou, J. and Zhang, L. (2005), "Comparison and application of moderating effect and mediating effect", *Acta Psychology*, No. 2, pp. 268-274.

Wooldridge, J. (2006), *Introductory Econometrics: A Modern Approach*, 3rd ed., Thomson/South-Western, Mason.

Xu, X., Xu, C. and Li, C. (2018), "The influence of relationship networks on farmers' forest land inflow behavior: based on survey data in Zhejiang province", *China Rural Economy*, No. 9, pp. 62-78.

Yang, H., Zhuang, T. and Lan, H. (2016), "Meteorological disasters are vulnerable to farmers in poor areas sexual impact research: based on 53271 households in 592 poverty-stricken counties across the country analysis", *Agricultural Technology Economy*, Vol. 3, pp. 103-112.

Yin, M., Li, Y., Fang, H. and Chen, P. (2019), "Biodegradable mulching film with an optimum degradation rate improves soil environment and enhances maize growth", *Agricultural Water Management*, Vol. 216 No. 2, pp. 127-137.

Zhang, W., Wang, L., Zhou, J., Zhu, K. and Sun, S. (2020), "Degradability of biodegradable plastic films and its mulching effects on soil temperature and maize yield in northeastern China", *International Journal of Agricultural and Biological Engineering*, Vol. 13 No. 2, pp. 146-153.

Zhao, B. (2014), "Analysis of the problems of large-scale farmland management under the background of concurrent farming in my country", *Truth-Seeking*, Vol. 105 No. 11, pp. 91-96.

Corresponding author
Qian Lu can be contacted at: luqian110203@163.com