The Impact of Weather Index Insurance on Credit Default Rates of Farmers under Group lending: Evidence from a Framed Field Experiment

Yingmei Tang, Huifang Cai, Jiansheng Chen, Mario J. Miranda and Rongmao Liu

April 5, 2020

Abstract

Motivation	Higher natural risk and credit default rate lead to farmers' credit constraints, which hinders the development of rural areas. Can weather index insurance as a new and effective risk management tool reduce farmers' credit default rates?
Purpose	The aims of this paper is to study under group lending (a) the impact of weather index insurance on farmers' credit default rates; (b) the role of social capital in it.
Approach and Methods	This paper conducts a framed field experiment with 324 rural households in Heilongjiang Province in China through a binary selection model.
Findings	(a) natural disasters are the main drivers of farmers' credit defaults; (b) weather index insurance can effectively reduce the farmers' credit default rates after helping farmers diversify natural risks;(c) social capital, households' income, whether farmers value personal reputation and moral standards, and the farmers' default experience are also important factors influencing the credit default rates of farmers; (d) social capital is the key factor that group lending perform effectively, and which can promote the impact of weather index insurance on credit default rates.
Policy implication	The government should implement weather index insurance to help farmers resist natural risks, and encourage banks to cooperate with insurance companies to ease farmers' credit constraints, which can also promote the progress of other developing countries.

Key words: group lending, weather index insurance, credit default rates, framed field experiment, social capital

1. INTRODUCTION

Agriculture is highly correlated to natural risks, especially for developing countries that lack risk-sharing tools. If a large number of farmers are exposed to natural disasters which reduce family cash flow, loan default would have a substantial increase following a natural shock (Skees et al., 2007). High loan default problems plague rural financial markets in China. At the end of 2017, the credit default rate of rural finance institutions was 4.2% which was 2.5 times that of commercial banks (China Rural Financial Services Report, 2018). Loan default problems discourage rural financial institutions from providing loans to defaulting farmers, which limits household's ability to use costly inputs and the investment of agricultural technology will be greatly reduced. The defaulting farmers therefore fall into the poverty trap and the development of agricultural sector in developing countries is impede (Smith et al., 2010; Carter et al., 2011).

Rural financial institutions attempt to reduce risk exposure by requiring collateral, but small farmers have too limited resources to offer any collateral. Then they are asked to form small groups. Group based lending can use social networks as an alternative to collateral. Individuals in the group are able to select trustworthy villagers, monitor each other's use of funds and help other members to repay the loan, which in turn enables a lower default rate, compared with individual credit (Karlan, 2006; Cassar et al., 2007; Dufhues et al. 2012). The social ties of group members act as an informal risk insurance method due to the fact that they can rely on these resources to repay the loans when they suffered a loss event (Postelnicu, 2015).

Dufhues et al. (2012, 2013), Farrin and Miranda (2015) state that this risk sharing arrangement is extremely effective at managing idiosyncratic risk, however, when all households in a region suffer from systemic risks, the method is invalid and therefore it is insufficient (Barnett and Mahul, 2007; Jensen et al., 2014; Jensen and Barrett, 2017). The protection of social safety nets is usually limited to large scale weather-related disasters. If the entire community experiences disastrous weather effects, the members may be unable to offer support for each other. All group members may be in financial hardship, it is difficult for them to help their neighbors who are suffering from the same event (Skees, 2008; Clarke and Dercon, 2009; Van Campenhout and Bizimungu, 2018). During a widespread adverse weather event such as a drought, all members of the group suffer losses simultaneously, which renders most of the group members unable to repay their own loans, let alone the loans of other group members (Cassar et al., 2007).The covariate nature of many of these shocks means that traditional mutual assistance or informal insurance mechanisms tend to break down. Neither credit nor insurance markets will work well for the poor if the social protection programs and other formal and informal functions badly (Alderman and Haque, 2007; Fisher et al., 2017). In developing countries, rural financial institutions have begun to provide insurance as part of their microfinance service delivery, which is a policy option helping rural households in developing countries emerge from a poverty trap (Clarke and Dercon, 2009; Miranda and Farrin, 2012; Farrin and Miranda, 2015). Group lending would work best when borrowers have risk insurance arrangements embedded in their external ties. Credit-linked insurance passes on the insurance costs to the borrower through a higher loan interest rate; in presence of experiencing loss

event，group lending members can use indemnity to repay loans, the bank receives any indemnities from the index insurance contract and forgives debt for borrowers (Postelnicu, 2015; Farrin et al., 2015). Carter et al. (2007) indicates that traditional agricultural insurance calculates the indemnity based on individual loss, the members of the lending group do not know each other's compensation. The insured group members can hide information on indemnity, and not repay loans resulting in moral hazard among group lending members. Compared with traditional agricultural insurance, the indemnity of weather index insurance for all farmers in a certain area is the same, which has the potential to avoid the moral hazard of members' hiding subsidy income and not repaying loans when many farmers simultaneously in the event of a widespread natural disaster.

The index insurance pilot programs have been in Africa and Southeast Asia for decades. Numerous studies have reported the interaction between index insurance and agricultural credit. Carter et al. (2007, 2011, 2016) and Cheng et al. (2014) argue that index insurance can replace credit collateral. In a low collateral environment, farmers taking out loan purchase index insurance, which can not only reduce borrowers' risks can also protect lenders by reducing default rates. When liability is limited, farmers can rely on indemnity to repay loans in case of economic default. However, Clarke et al. (2009), Farrin et al. (2015), and Marr et al. (2015) find that though index insurance can increase the scale of credit, it tends to reduce the repayment incentives for rural households and results in a higher credit default rate, this leads to more serious credit rationing in rural financial institutions. Gine and Yang (2009) also find that farmers' demand for loan decreased when loans were interlinked with index insurance contract even though farmers were faced with income losses caused by drought. While Karlan et al. (2011) argue that providing loans with insurance to farmers did not significantly influence the farmers' loan uptake in Ghanaian farmers.

Small householders in rural China have lower incomes and poor ability to resist risks. When natural disasters occur, rural financial institutions face high default rates. The financial instrument reducing the adverse impact of natural disasters on farmers is needed to transfer the risk of rural financial institutions. In 2009, Chinese central government established a nationwide policy promoting the interlinked insurance and credit to reduce the shock of natural disasters in the agricultural sector and helped farmers to access the financial market. In 2013 and 2016, the central government issued a series of important documents to promote the pilot program of interlinked insurance and credit in China.

Consequently, some studies investigate the influence of interaction between agricultural insurance and credit in China. Liu et al. (2012), Zhang et al. (2013), Xie et al. (2014) and Ren et al. (2017) had found that agricultural insurance can reduce the uncertainty of farmers' income and also can be used as substitution of collateral to increase the credit availability of farmers. Ye et al. (2015), Feng et al. (2015) and Liu et al. (2017) state that agricultural insurance markets and rural credit markets can share the information of rural households, then overcome the information asymmetries and improve the transaction efficiency of two markets.

Due to the diversity of the study areas and the study methods, the research conclusions about the

impact of index insurance on credit default rate are controversial. Borrowers from different countries with different socio-cultural environment have different traits (Dufhues et al. 2012). No research so far has tested the influence of index insurance on the rural credit in China. This research aimed to investigate the relationship between index insurance and loan repayment in presence of group lending by carrying out a series of framed field experiments.

The possible contributions of this research are as follows: Framed field experiments were used to obtain farmers' dynamic repayment with and without index insurance, and then to analyze insurance's impact on the credit defaults of farmers in group lending, which will enrich the literature on weather index insurance and credit default rates, and promote the development of rural areas in other country.

The remainder of this paper is organized as follows: Section 2 describes the experimental design. Section 3 presents the empirical strategies. Section 4 is conclusion and policy implication.

2. EXPERIMENT DESIGN

2.1 Study area

The data were collected by framed field experiments which were conducted in Mulan, Hulan and Tonghe County in Heilongjiang province, China in July 2017. These three counties are all main growing areas of high-quality rice, and located in Songhua River Basin with high frequency of flood disasters. In 2013, there was a catastrophic flood disaster in the region. Farmers' take-up rate of agricultural insurance is higher than other areas; and they will have a full understanding of agricultural insurance.

Three counties have 120 villages, and the cultivated land can be divided into two different geological conditions: low lands closing to the river and high lands far from the river. In order to avoid the farmers' response to the weather index insurance affected by the difference of the cultivated land which is different in the probability of flooding, when selecting the village, the number of samples from two types of villages is equal. A random sample of participants with 324 farmers was recruited from 14 villages.

2.2 Sample selection

In order to ensure that the participants can correctly understand the experimental context of loan taking out and repayment, insurance purchase, etc., criteria for selecting the subjects were as follows: (a) Households have taken out loans from rural financial institutions in the past ten years; (b) Farmers have more than 5 years of planting experience and are still engaged in agricultural production; (c) Farmers can be responsible for or participate in family decisions. We obtain the villagers list from the village committee and select the eligible farmers to form a sub-list.

Because the number of farmers in each village is quite different, then the sample distance is 2, 4, and 10, respectively, in the villages with less than 50 households, 51 to 100 households, and more than 100 households. Totally 324 farmers was random selected.

2.3 Field Experiment Design

Other than college students, the field experiment chooses farmers as subjects who can better understand the experimental context, which overcomes the lack of external validity of laboratory experiments. The conclusions have better externalities and can be extended to the real world (Harrison et al., 2004; Carpenter et al., 2005).

In the experiment, the subjects are randomly assigned to the control group and the treatment group, and the experimental treatment is completely independent of the individual characteristics and other factors that may affect the experimental results, which will avoid missing variable and the endogeneity of variables in the model (Harrison et al., 2004; Carpenter et al., 2005).

2.3.1 Sample grouping

The intention of this research is to investigate the impact of weather index insurance on credit default rates of farmers in group lending. The self-control experiment was adopted in this framed field experiment, i.e. the control and treatment group are the same objects then observe the changes of their behaviors without and with insurance. The experiment was carried out for six rounds representing six agricultural planting cycles. In the first three rounds of experiments, farmers need to make repayment decisions for joint loans when they had no weather index insurance, which is control group. In the last three rounds, farmers would make repayment decisions with weather index insurance, which is treatment group. Each subject needs to participate in six rounds of experiments. The influence of weather index insurance can be measured by comparing the control group and the treatment group.

2.3.2 Experimental control

Some external factors that are not related to the research may affect the experimental results, which need to be controlled to ensure the external validity of the experiment.

2.3.2.1 Peer effects

The decision of subjects could be influenced by peers and the experimenters, which will reduce the validity of experimental results. In order to reduce the impact of mutual communication between farmers, the subjects sat in a village committee meeting room and were separated by clapboard to ensure that they cannot communicate the choices with each other. Each experimenter was responsible for four subjects in the experiment. They introduced the experiment context to the subjects, answering their questions and supervising if the participants make independent decisions. In order to avoid experimenters' expression influence farmers' decision, unified experimental manuals were prepared and the experimenters were trained before the experiment. All experimenters introduced the instruction in neutral and unified language and cannot imply the

subjects to meet researcher's expectations.

2.3.2.2 Demand effect

The participants will subjectively guess the purpose of the experiment and to give the answer that the experimenters expect, which would affect their experimental decisions and lead to biased results (deviations of the results). Thus, more choices were provided to farmers, avoiding the demand effects and ensuring the authenticity of farmers' credit decision.

2.3.2.3 Endowment effect

The initial endowment in the experiment will affect the subjects' repayment decision, and which will result in bias results (Carpenter et al., 2005). To eliminate the influence of the endowment effect and improve the external validity of the experimental results, each subject was provided with the same initial endowment in the experiment.

2.3.2.4 Status quo bias

Status quo bias means that people tend to maintain choices that have been made in the past. To avoid this preference, the farmers draw lots to determine the weather at the end of each round. Different weather leads to changes of income, which made farmers rethink and not just repeat his choice of former rounds.

2.3.3 Experiment Scenario

2.3.3.1 The experiment parameters setting

Each subject was provided with an acre of land and had to take out loan for agricultural production. Assuming that there is no credit constraint, farmers can get RMB 450 *yuan* to cover materialized cost of agricultural production. The loan interest rate of local rural credit cooperative is 11%. The loan term is a planting cycle. Climate risks are the main drivers affecting household income. The weather conditions in the experiment are simplified into good weather and bad weather, and the probability is 60% and 40%, respectively; which was designed based on the historical data of local weather. At the end of each round, the representatives of each group draw lots to determine the weather condition. Due to the different geographical conditions of cultivated land, the losses of farmers may differ even if the weather is the same. According to the results of the preliminary investigation, three kinds of income RMB 0, 1400, and 2100 *yuan* were set in each weather situation, which was drew lots by farmers at the end of each round. The income distribution is shown in Table 2. These experiment parameters were all set according to pre-experiment and local agricultural production.

Table 2: Probability distribution of income in experiment

Income	0	1400	2100
Probability of Good weather (60%)	1/10	1/5	7/10

6

Probability of Bad weather (40%)	3/10	2/5	3/10

2.3.4 Experiment process

The experiment includes four parts: introduction of the experiment context, the first field experiment of group lending without index insurance, the second field experiment of group lending with index insurance and a short questionnaire survey.

2.3.4.1 Introduction of the experiment

There were 12 farmers participating in each session and they were randomly divided into 6 groups. Every two farmers form a joint lending group. They provide each other with a guarantee for loans, and each member is jointly and severally liable for the loan of another member. The experimenters introduced the experimental procedure, the meaning of the experimental parameters, the operation mechanism of joint group lending, group members' rights and obligations, the tasks of the subjects, and the precautions during the experiment. Then the experiment one began.

When the farmers had no index insurance, it is the control group; the value is 0. After the farmers were provided with index insurance, it is the treatment group and the value is 1

2.3.4.2 Experiment one: group lending without weather index insurance.

Farmers got initial funding RMB 450 *yuan* through the joint lending, and then simulated agricultural production; then the representative of lending group drew lots to determine the weather and farmers draws the ball to determine the personal income; subsequently, each member made a decision on whether to repay the loan according to their income. If the income of farmers was 0 they had to default; if two members all repaid the loan they could proceed to the next round; if they both default, they were unable to participate in the next round and only receive a fixed income of 700 *yuan*; If one repaid the loan while the other defaulted, then the one who repaid need to make a second choice on whether he/she was willing to help the defaulting member repay the loan. If he/she was likely to do so then he/she would repay RMB 1000 *yuan* equal to the principal plus interest of two lending group members, and this group is eligible to enter the next round. If he/she refused to repay for another member, the group will only receive a fixed income of 700 yuan in the next round. Group of repaying loan will participant in the second round of experiments. The last two rounds were the same as the first round.

2.3.4.3 The game of introducing weather index insurance

The experiment two aimed to test the influence of weather index insurance on the repayment. Weather index insurance is not available in the study area. Subjects may not understand the compensation mechanism of this product, the challenge we faced in experiment design was that poor understanding of index insurance would influence the experiment efficiency. To help farmers understand terms and the claims mechanism of the weather index insurance, we play a game to introduce index insurance before the experiment two. After the game we accessed the farmers' understanding through a test, if the participants could not give the correct answer, we helped them

understand it until they fully understand.

2.3.4.4 Experiment two: group lending with weather index insurance

In this experiment, all the farmers needed to purchase index insurance with premium of 50 *yuan* when they took out loan, and when the loan due, the amount that the farmer would repay was 550 *yuan*. If encounter bad weather, they would receive the same indemnity which could be used to repay the loan. If he/she was willing to help another member who defaulted to repay the loan, he/she needed to repay the loan of 1100 *yuan*. In the context of experiment two, in addition to the income from planting, farmers also received indemnity from insurance companies in bad weather. The other procedures were the same as experiment one and the experiment lasted for three rounds to test if the index insurance influences the loan default rate.

2.3.4.5 A short questionnaire survey

Based on the researches of Cassar et al. (2007), Seileret al. (2012), Su et al. (2014) and Kong et al. (2017), individual characteristics of farmers, households' characteristics and social capital are all main drivers influencing the household's loan repay. After the experiment, a structured questionnaire survey was conducted to gather the information about households. The questionnaire consists of three parts: the first part is the characteristics of the individual and households, including age, education experience, household farm size, etc. The second part is whether the subjects have the experience of taking out loans, repayments of loan and purchasing agricultural insurance in reality. The third part includes information of farmers' attitude to morality, guilt and personal reputation. The questions are as follows: whether you think there is a moral obligation to repay the loan; to repay the loan when 50% or 99% of people default; whether the loan repayment is in order to maintain personal reputation and social status in the community; whether you feel guilty if you default. The entire experiment lasted one hour and farmers were paid RMB 80 *yuan* as compensation which equals two and half hours wages of local labor.

3. EMPIRICAL STRATEGY

3.1 Univariate test (Paired sample T test)

Univariate test examines whether weather index insurance has a significant impact on default rate by comparing the average default rates of the same subject before and after treatment. Firstly, the paired sample T test is used to examine the impact of index insurance on farmers' credit default rates without introducing any control variables. The results are shown in Table 3.

Table 3: T test results of farmer's credit repayment

Variable	Without index	With	index	Differences

	insurance		insurance			
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Individual repayment	0.704	0.025	0.858	0.019	-0.154***	0.030
Group repayment	0.667	0.026	0.809	0.022	-0.142***	0.035

Notes: ***, **,* indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

It can be seen from Table 3, the probability of individual repayment is 0.858 when the farmers have index insurance; while it is 0.704 when there is no index insurance. That is, the repayment probability increases by 0.154 after farmers were provided with insurance and the difference is significant at the 1% level, which denotes that the index insurance can promote the repayment of farmers. On the other hand, the probability of group repayment is 0.667 when group members have not index insurance, while it is 0.809 after they purchase index insurance. The probability of group repayment increases by 0.142 and the difference is significant at the 1% level. Index insurance can diversify risks caused by extreme weather, and then improve the farmers' ability to resist risks. Paired sample T test preliminarily verified that the combination of index insurance and joint liability can effectively improve repayment rate of group, but further empirical testing is needed.

The combination of index insurance and joint liability can effectively prevent the credit default of farmers in the group, and then reduce the credit risk of rural financial institutions, which is consist with the researches of Miranda and Gonzalez-Vega (2011) and Skees and Collier (2010). They found that when a weather index insurance policy was bundled with a loan it can help offset loan defaults and liquidity problems caused by.

3.2 Binary selection model

In Paired sample T test, only the impact of index insurance was examined. While there would be other drivers may influence the repayment in reality. Then the Logit model was used to further analyze the impact of index insurance and other important drivers which influence the tendency of farmers' repayment.

The model can be expressed as follows:

$$P(y = 1 \mid x) = F(x, \beta) = \Lambda(x'\beta) = \exp(x'\beta)/1 + \exp(x'\beta)$$

$$Y = \beta_0 + \beta_1 ins + \beta_k X_k + \varepsilon$$

Where Y represents whether the farmers repay the loan, if it is yes the value is 1otherwise it is 0; ins indicates whether the farmers have index insurance, if it is yes the value is 1 otherwise it is

0; X_k denotes control variables, including individual and household characteristics, etc.(see Table 4); and ε is residuals.

Some variables may have mutually reinforcing effects, that is, they promote each other's influence. Based on the study of Fafchamps and Minten (2001) and Durlauf et al (2005), social capital is as important as human capital in poor developed financial market, and it affects farmers' access to credit markets and bad reputation will increase the credit cost of farmers. Social capital can also affect the repayment behavior of borrowers (van Bastelaer, 2000). Then the interaction items of personal reputation and index insurance, guilty and index insurance were put into the model to investigate the credit default rate of households and its influencing drivers and to examine whether the impact of index insurance will be affected by farmers' social capital.

Table 4: Variables measurement and descriptive statistics

	Variable (Measurement And assignment)	Min	Max	Mean	S.D.
	Whether repayment in experiment(REPAY) (yes=1; no=0)	0	1	0.781	0.414
	Whether has Index insurance (INSURANCE) (yes=1; no=0)	0	1	0.5	0.500
cognitive social capital	Whether repayment is moral obligation (MORAL) (no=1;uncertain=2;yes=3)	1	3	2.574	0.757
	Whether repayment to maintain reputation and social status(REPUTATION) (no=1;uncertain=2;yes=3)	1	3	2.361	0.905
	Whether feel guilty of default? (GUILTY) (no=1;uncertain=2;yes=3)	1	3	2.188	0.906
	Age of household's head (AGE)	18	71	45.537	12.080
	Gender(GENDER) (male=1;female=0)	0	1	0.414	0.493
Personal characteristics	Education(EDUCATION)(Elementary school=1; middle school =2; high school =3; college=4)	1	4	1.577	0.656

Households	Income in experiment (INCOME)	0	2100	1641.98	1032.11
Economic	Family size (FAMILY)	1	8	4.043	1.428
Characteristics	Whether farmers have default experience in reality (DEFAULT) (yes=1; no=0)	0	1	0.194	0.396

Table 4 shows the overview of the subjects. The average repayment rate in the experiment is 0.781, while the default rate in reality is 0.194, which indicates that most farmers have higher willingness to repay the loan whether in reality or in experiment. In terms of social capital, the average value of MORAL is 2.574, which means that most farmers think that repayment is moral obligation. The average of variable REPUTATION is 2.361; it means that most farmers think that repayment can maintain reputation and social status in community. The mean of variable GUILTY is 2.188, that is more than half of the people will feel embarrassed if they can not repay the loan. Overall, most farmers think they have responsibility for repayment. The average age of farmers is about 45 years old. Most farmers have received junior high school education, and there are about four people in each family and the average income of farmers is 1642 *yuan* in experiment.

3.3 Analysis of credit default

3.3.1 The comparison between the default rates in reality and in the experiment

To examine the external validity of the experiment, that is whether the farmers express the same idea in reality as in the experiment, we obtain farmers' default rates in reality through questionnaire, then compare the default rates in the reality and experiment. The results are shown in Table 5.

Table 5: Comparison of default rate in experiment with that in reality

	Passive default[1]		Active default[2]		Total	
	Number	Rate (%)	Number	Rate (%)	Number	Rate (%)
In Reality	40	12.35	31	9.57	62[a]	19.14
In Experiment	84	12.96	58	8.95	142	22.91

Note: Some farmers may have both defaulted actively and passively, so the sum of active defaults and passive defaults is greater than the total number of farmers' defaults.

As can be seen from Table 5, 62 farmers had defaulted in reality, accounting for 19.14% of the sample. 40 farmers among them defaulted passively due to natural disaster and the proportion is 12.35%. In the experiment, 142 farmers defaulted and the proportion is 22.91% which is very close to that in reality (19.14%). Among them 84 farmers defaulted passively and the proportion is

---

[1] Passive default means that farmers don't have enough income to repay the loan because of the systematic risk.

[2] Active default is that farmers refuse to repay the loan even if they have enough income.

12.96%. Default rates of farmers in the experiment are very approximately with those in reality, which indicates that the external utility of the experiment is reliable.

3.3.2 Analysis of individual default rate in experiment

To investigate the influence of index insurance on the default rate, we measure the farmers' default in the control group and treatment group respectively, and the results are shown in Table 6.

Table 6: Farmers' individual default rate and the differences between groups in experiment

	Group	Passive default		Active default		Total	
		Number	Rate (%)	Number	Rate (%)	Number	Rate (%)
First year	Control group	60	18.52	36	11.11	96	29.63
	Treatment group	24	7.41	22	6.79	46	14.2
	Diff	-36	-11.11	-14	-4.32	-50	-15.3
Second year	Control group	51	23.61	27	12.5	78	36.11
	Treatment group	22	8.40	20	7.63	42	16.03
	Diff	-29	-15.21	-7	-4.87	-36	-20.08
Third year	Control group	26	20	16	12.31	42	32.31
	Treatment group	13	6.07	17	7.94	30	14.01
	Diff	-13	-13.93	1	-4.37	-12	-18.3

It can be seen from Table 6 that three-year total credit default rate in the control group is 29.63%, 36.11%, and 32.31%, respectively; the proportion of passive default is 18.52%, 23.61%, and 20%, which are higher than those proportions of active default; which indicates that natural disasters is the main reason of farmers' credit default.

In the treatment group, three-year total credit default rate are 14.2%, 16.03%, and 14.01%, respectively; and they decrease 15.43%, 20.08%, 18.3% comparing with those of control group; In which, passive defaults decrease by 11.11%, 15.21%, and 13.93% respectively, and the all decrease by more than 10%. It indicates that index insurance indemnity improves the solvency of farmers when suffering natural disaster, and then reduces the passive default rate. Active default rates decrease by 4.32%, 4.87%, and 4.37%, respectively, which are significantly lower than those of passive default rates. That is, if farmers do not want to repay their loans subjectively, they will still default even if their solvency increases. Credit system in China is not perfect, especially in rural credit market; the penalty for loan default is not severe. Farmers will trade off between the cost of default and repaying the loan to maximize their utility. The cost of default equals to the increase of

future loan interest rate plus opportunity costs that may result from impaired personal reputation. In the joint lending, the credit default will be subject to multiple restrictions by rural financial institution, joint lending group members and the insurance companies after the farmers purchase index insurance. Thus, in general, index insurance has a positive effect on farmers' repayment.

3.3 The group default rate in the experiment

In the experiment, every two farmers formed a lending group; we not only measure the individual repayment, but also examine the group repayment in different condition in the control and treatment group. The group repayment in different groups is shown in Table 7.

Table7: Group repayment in different groups in the experiment

	Group	repayment		default	
		Number	Rate (%)	Number	Rate (%)
First year	Control group	108	66.67	54	33.33
	Treatment group	131	80.86	31	19.14
	Diff	23	14.19	-23	-14.19
Second year	Control group	65	60.19	43	39.81
	Treatment group	107	81.68	24	18.32
	Diff	42	21.19	-19	-21.49
Third year	Control group	49	75.38	16	24.62
	Treatment group	93	86.92	14	13.08
	Diff	44	11.54	-2	-11.54

As can be seen from Table 7, the default rates of group are 33.33%, 39.81%, and 24.62%, respectively, in the control group; they decrease by 14.19%, 21.49%, and 11.54%, respectively, after the farmers purchasing index insurance, and which indicates that index insurance reduces the default rate of group significantly. Index insurance can mitigate the impact of natural disasters, which not only increases the repayment ability of group members, but also improves their ability to help others repay the loans. Group members may have different loss when natural disaster occurs, while the compensation of index insurance for farmers is the same. The group members with low loss have sufficient money to help other members repay the loan, and which will improve the overall repayment rate of the groups. Therefore, the combination of index insurance and group lending will help reduce agricultural credit risk which results from the weather shocks in rural financial market and then in turn improve the credit availability of farmers.

4. EMPIRICAL ANALYSIS

To further investigate the influence of index insurance, the logit model is adopted to measure the impact of index insurance on default rate of farmers. *Column* 1 is without the interaction term of insurance and social capital. *Columns* 2 and 3 contain the interaction terms of insurance and reputation, guilty, respectively. The results are shown in Table 8.

Table 8: The impact of index insurance on repayment rate of farmers

Variables	(1)	(2)	(3)
ins	0.963***	——	——
	(0.204)		
Rep	0.189*	——	0.168
	(0.110)		(0.108)
Gly	0.083	0.082	——
	(0.106)	(0.104)	
Mor	0.333**	0.326***	0.324**
	(0.129)	(0.125)	(0.127)
ins*Rep	——	0.331***	——
		(0.081)	
ins*Gly	——	——	0.289***
			(0.086)
Inc	0.003***	0.003***	0.003***
	(0.0001)	(0.0001)	(0.0001)
Exp	-1.520***	-1.500***	-1.487***
	(0.243)	(0.245)	(0.244)
Age	-0.010*	-0.010*	-0.009*
	(0.009)	(0.009)	(0.009)
Gen	0.048	0.056	0.056
	(0.192)	(0.192)	(0.185)

Edu	0.102	0.105	0.102
	(0.138)	(0.137)	(0.136)
Fmy	-0.035	-0.038	-0.032
	(0.071)	(0.071)	(0.071)
Observations	1470	1470	1470
R^2	0.457	0.451	0.448
likelihood	-425.35	-429.53	-431.95
LR chi2	432.63	432.16	435.81
Prob>chi2	0.000	0.000	0.000

Source: Authors' calculations based on data collected by the field economics experiment.

Notes: ***, **,* indicate statistical significance at the 1%, 5%, and 10% levels, respectively. The values in brackets are standard errors.

It can be seen from *column*1 in Table 8, index insurance has a positive impact on repayment of farmers and is significant at the 1% level. The coefficient is 0.963, that is to say that index insurance can reduce default rate of farmers in group lending. Liu et al. (2012) and Ren et al. (2017) found that rural financial institutions are more willing to lend to insured farmers and to give certain preferential interest rates to encourage farmers to purchase insurance contracts. Index insurance can transfer systemic risks and reduce the income fluctuation when farmers suffered extreme weather, which improves farmers' ability to repay loans. Due to the contract of index insurance is standard; all insured individuals will receive the same indemnity when the weather index reaches the trigger. The compensation is transparent to the bank and other members of the lending group. If the group members who received insurance compensation do not repay the loan, the credibility of the lending group and the other members will be affected, and the other farmers will not be willing to form a joint lending group with those who have actively defaulted. The bank will also raise interest rates due to their higher default risk. In general, the standardized weather index contracts combined with group lending, facilitating mutual supervision by group members will impose costly social sanctions on one another. The double sanction of the higher loan interest rates and the pressure of bad reputation promote farmers to repay the loan, which will help reduce the probability of farmer's active default.

Durlauf et al (2005) found that social capital can amplify sanctions of reputation which make it difficult for farmers to gain access to credit markets and increase farmers' cost of credit; while farmers who repay their loans on time can obtain more credit. The moral and reputation concern of farmers are included as control variable to test whether personal reputation and social image will influence the farmers' willingness to repay their loans.

In Table 8, the coefficient of Moral is positive and significant at the 5%, and 10% levels, respectively. It means the farmers who believe that repayment is a moral obligation will be significantly less likely to strategically default, which is consistent with intuition. That is, farmers with higher moral standards will pay more attention to complying with social norms, and will not actively default when they have income. The variable of default experience has a negative effect on the credit repayment and is significant at the 1% level. That is to say, farmers who had defaulted before are more likely to fall into financial crisis or do not care about the adverse effects of default.

Reputation concern of farmers has a positive impact on the credit repayments and is significant at the 10% level. Fafchamps and Minten (2001) argue that group members' shame felt toward their peers is effective in group credit. Thus farmers who care about their personal reputation and social image will have a higher willingness to repay their loans.

In *column 2*, the coefficient of the interaction term of index insurance and reputation is 0.33 and significant at the 1% level. In *column 3*, the coefficient of the interaction term of index insurance and guilty is 0.289 and significant at the 1% level. It implies that farmers who value their reputation and the public image in the community would have a higher repayment rate after they purchased index insurance. Due to market imperfections, it is difficult for lenders to get the information of borrowers, which increase the transaction costs. This limitation may be overcome by social capital (Fafchamps & Minten, 2001). A good reputation is an important social capital. If Members of the group lending with index insurance do not repay their loans, their breach of contract will be widely spread within the community. Insurance companies are also involved in this joint guarantee loan, and it has become an external supervision. Farmers will bear more external pressure after default. They will be subject to serious reputation and economic sanctions. Peer pressure is effective in groups with joint liability (Fafchamps & Minten, 2001). Farmers who care about their image and status will actively repay their loans in order to maintain a good social reputation, which will help reduce the credit default rate. In the context of group lending, ex-post moral hazard of farmers can be reduced through mutual supervision of members in the group.

The variable of households' income has a positive impact on repayment and is significant at the 1% level, which indicates that the higher households' income is, the lower the probability of credit default is. The household' income increases farmers' ability and willingness of loan repayment. Default experience of farmers has a significantly negative impact on the credit repayment and is significant at the 1% level. Farmers who have experienced loan defaults usually have poor ability to plan for repayment, or are more likely to fall into financial difficulties. They more tend to default. The coefficient of variable of age is negative and significant at the 10% level, that is to say, the default rates of older farmers are lower than those of younger farmers. Older farmers more value the traditional virtues of Chinese nation, such as integrity, honest and trustworthy.

Robust test

In our experiment, each lending group includes two farmers and they make the decision if they repay the credit in the group lending. The repayment rates of individuals are parts of the group. To

examine if the result is robust, we replace the individual credit repayment with group loan repayment to explore if the index insurance can improve the loan repayment in lending group. The regression results are shown in Table 9.

As can be seen from Table 9, the coefficients of insurance, the interaction term of index insurance and reputation, and the interaction term of index insurance and guilty are all positive and significant at the 1% level, which indicates that index insurance has a positive effect on the credit repayment of the group lending. It implies that the index insurance can increase the individual repayment rate of farmers. The coefficient of insurance in Table 9 (0.86) is very close to that in Table 8 (0.963). The coefficients of the interaction term of index insurance and reputation, and the index insurance and guilty are significant and the same direction with those in Table 9. That is to say, the research result of this research is reliable.

Table 9 Regression results of robust test

variables	Model 1	Model 2	Model 3
Ins	0.860***	——	——
	(0.142)		
Ins*Rep	——	0.229***	——
		(0.056)	
Ins*Gly	——	——	0.258***
			(0.059)
Other control variables	Controlled	Controlled	Controlled
Sample size	1470	1470	1470
R^2	0.201	0.198	0.199
Wald chi2	216.05	217.48	224.25

Significance levels: ***: $p<0.01$, **: $p<0.05$, *: $p<0.1$. The values in brackets are standard errors.

6. Conclusions and implication

To explore the impact of weather index insurance on the credit default rate of farmers in the joint liability lending, a field experiment was conducted to collect data with 324 rural households in Songhua River Basin of Heilongjiang Province, China. The binary selection model is employed to

examine the impact of weather index insurance on the credit default rate. The results suggest that passive default caused by natural disasters is the main reason of farmers' default. Index insurance can diversify risks and reduce the impact of natural disasters on income, which can help reduce the credit default rate of individual farmers and the groups. Farmers' social capital, default experience and planting income are also main factors affecting the default rate of farmers. The variables of whether repayment can maintain reputation and social status and households' income have positive impact on the credit default rate of farmers, while the variables of whether think repayment is moral obligation and whether feel guilty of default have negative effect on the default rate of farmers. It means that social capital and index insurance can effectively reduce farmers' credit default rate and help rural finance institution diversify credit risk. Under joint liability lending, farmers with higher social capital will have better repayment rate when they have index insurance.

The results have some policy implications. When farmers' income is stable they are able to repay loans. Government should promote weather index insurance which helps farmers resist natural risk and smooth the income fluctuations, which will improve farmers' solvency and then decrease the credit risk of rural finance institution. Government should encourage the collaboration of insurance company and rural finance institution; they can share the information of farmers and overcome the lack of information of borrowers in rural financial markets, reducing transaction costs in rural financial markets, achieving the coordinated development of rural financial institutions and agricultural insurance company. Social capital plays an important role in the rural financial institution and can effectively reduce the credit risk of farmers. Rural financial institutions should establish local credit reporting systems and promote the culture of integrity in rural areas; make full use of the informal sharing mechanism of social capital, to improve the service effect of credit and insurance when they promote agricultural credit and agricultural insurance in rural areas, and promote the perfection of rural financial markets of China and other developing countries.

References:

Alderman, H., & Haque, T. (2007). *Insurance against Covariate Shocks: The Role of Index-based Insurance in Social Protection in Low-income Countries of Africa*. World Bank working papers. https://doi.org/10.1596/978-0-8213-7036-0

Barnett, B. J., & Mahul, O. (2007). Weather Index Insurance for Agriculture and Rural Areas in Lower-Income Countries. *American Journal of Agricultural Economics*, *89*, 1241-1247. https://doi.org/10.1111/j.1467-8276.2007.01091.x

Carpenter, J. P., Harrison, G. W., & List, J. A. (2005). Field Experiments in Economics: An Introduction. *Field Experiments in Economics*, *70*, 439-442. https://doi.org/10.1016/S0193-2306(04)10001-X

Carter, M. R., Cheng, L., & Sarris, A. (2016). Where and how index insurance can boost the adoption of improved agricultural technologies. *Journal of Development Economics*, *118*, 59-71. https://doi.org/10.1016/j.jdeveco.2015.08.008

Carter, M. R., Cheng, L., & Sarris, A. (2011). *The Impact of Inter-linked Index Insurance and Credit Contracts on Financial Market Deepening and Small Farm Productivity*. Annual Meeting of the American Applied Economics Association, 24-26. Retrieved from https://www.mendeley.com/catalogue/impact-interlinked-index-insurance-credit-contracts-fina ncial-market-deepening-small-farm-productivi/

Carter, M. R., Galarza, F., & Boucher, S. (2007). Underwriting Area-based Yield Insurance to Crowd-in Credit Supply and Demand. *Savings and Development*, *31*, 335-362. https://www.jstor.org/stable/41406457

Cassar, A., Crowley, L., & Wydick, B. (2007). The Effect of Social Capital on Group Loan Repayment: Evidence from Field Experiments. The Economic Journal, *117*, F85-F106. https://doi.org/10.1111/j.1468-0297.2007.02016.x

Cheng, L. (2014). *The Impact of Index Insurance on Borrower's Moral Hazard Behavior in Rural Credit Markets*. Working paper, University of California, Davis, CA. Retrieved from https://arefiles.ucdavis.edu/uploads/filer_public/2014/06/20/lan-cheng-jmp-11-27.pdf

Clarke, D., & Dercon, S. (2009). *Insurance, Credit and Safety Nets for the Poor in a World of Risk*. DESA Working Paper No. 81. Retrieved from https://core.ac.uk/download/pdf/6913320.pdf

Durlauf, S. N., & Fafchamps, M. (2005). Chapter 26 Social Capital. *Handbook of Economic Growth, 1*, 1639-1699. https://doi.org/10.1016/S1574-0684(05)01026-9

Dufhues, T., Buchenrieder, G., & Quoc, H. D. (2012). Social Capital and Loan Repayment Performance in Northern Vietnam. *Agricultural Economics*, *43*, 277-292. https://doi.org/10.1111/j.1574-0862.2012.00582.x

Dufhues, T., Buchenrieder, G., &Munkung, N. (2013). Social Capital and Market Imperfections: Accessing Formal Credit in Thailand. *Oxford Development Studies, 41*, 54-75. https://doi.org/10.1111/10.1080/13600818.2012.753999

Farrin, K., & Miranda, M. J. (2015). A Heterogeneous Agent Model of Credit-linked Index Insurance and Farm Technology Adoption. *Journal of Development Economics, 116,* 199-211. https://doi.org/10.1016/j.jdeveco.2015.05.001

Fafchamps, M., & Minten, B. (2001). Social capital and agricultural trade. *American Journal of Agricultural Economics*, *83*, 680–685. https://doi.org/10.1111/0002-9092.00190

Feng, Q., & Huang, Y. N. (2015). Research on the Operation Efficiency of the Interaction Mechanism between Rural Credit and Agricultural Insurance, *Chinese Journal of Management Science, 23*, 378-385. http://www.cnki.com.cn/Article/CJFDTotal-ZGGK2015S1058.htm

Fisher, E., Hellin, J., Greatrex, H., & Jensen, N. (2019). Index insurance and climate risk management: Addressing social equity. *Development Policy Review, 37,* 581– 602.

https://doi.org/10.1111/dpr.12387

Giné, X., & Yang, D. (2009). Insurance, Credit, and Technology Adoption: Field Experimental Evidence from Malawi. *Journal of Development Economics*, 1-11. https://doi.org/10.1016/j.jdeveco.2008.09.007

Guiso, L., & Sapienza, P. (2013). The Determinants of Attitudes toward Strategic Default on Mortgages. *Journal of Finance*, *68*, 1473-1515. https://doi.org/10.1111/jofi.12044

Harrison, G., & List, J. (2004). Field experiments. *Journal of Economic Literature, 42*, 1009-1055. https://doi.org/10.1257/0022051043004577

Jensen, N., & Barrett, C. (2017). Agricultural index insurance for development. *Applied Economic Perspectives and Policy, 39*, 199-219. https://doi.org/10.1093/aepp/ppw022

Jensen, N. D., Barrett, C. B., & Mude, A. (2014). Cash transfers and index insurance: A comparative analysis from northern Kenya. *Journal of Development Economics, 129*, 14-28. https://doi.org/10.1016/j.jdeveco.2017.08.002

Karlan, D. S. (2007). Social connections and group banking. *Economic Journal, 117*, F52-F84. https://doi.org/10.1111/j.1468-0297.2007.02015.x

Karlan, D., Ã., & Jonathan, M. (2010). Chapter 71-Access to Finance. *Handbook of Development Economics, 5*, 4703-4784. https://doi.org/10.1353/mcb.2004.0039

Kong, R., Turvey, C. G. & H, X. X. (2009). Empirical Analysis of Trust, Guilt and Farmers' Loan Choice—Based on Questionnaires in Gansu, Henan and Shaanxi Provinces, *Chinese Rural Economy, 11*, 50-59. http://www.cnki.com.cn/Article/CJFDTotal-ZNJJ200911007.htm

Liu, S. C., & Zhi, D. D. (2017). A Research on Coupling and Coordinated Development between Agricultural Insurance and Agricultural Credit-with Shandong Province as an Example. *Insurance Studies, 2*, 29-39. https://doi.org/10.13497/j.cnki.is.2017.02.004

Liu, Z. X., & Huang, Q. G. (2012). Information Production Capacity, Agricultural Insurance and Credit Rationing in Rural Financial Markets-An Empirical Analysis Based on Mo dified S-W Model, *Chinese Rural Economy, 5*, 53-64. http://www.cnki.com.cn/Article/CJ FDTotal-ZNJJ201205007.htm

Miranda, M. J., & Farrin, K. (2012). Index insurance for developing countries. *Applied Economic Perspectives and Policy, 34,* 391–427. https://doi.org/10.1093/aepp/pps031

Miranda, M. J., & Gonzalez-Vega, C. (2011).Systemic risk, index insurance, and optimal management of agricultural loan portfolios in developing countries. *American Journal of Agricultural Economics, 93*, 399-406. https://doi.org/10.1093/ajae/aaq109

Marr, A., Winkel, A., van Asseldonk, M., Lensink, R., & Bulte, E. (2016). Adoption and impact of index-insurance and credit for smallholder farmers in developing countries. *Agricultural Finance Review, 76,* 94–118. https://doi.org/10.1108/AFR-11-2015-0050

People's Bank of China. (2019). *China Rural Financial Services Report (2018).* Retrieved from http://www.gov.cn/xinwen/2019-09/20/content_5431568.htm

Postelnicu, L., Hermes, N., & Juarez, R. S. (2015). *Social Capital and the Repayment of Microfinance Group Lending-A Case Study of Pro Mujer Mexico.* Working Papers CEB, 30, 43-50. https://doi.org/10.1002/chin.199926046

Ren, L.,Wang, X. Y., & Zhao, H. (2017). Research on the Credit Availability of Farmer H ouseholds and the Optimal Amount of Credit: Based on the Collateral Substitution of Agricultural Insurance. *Management Review, 6*, 32-42. https://doi.org/10.14120/j.cnki.cn11 -5057/f.2017.06.014

Seiler, M. J., Seiler, V. L., Lane, M. A., & Harrison, D. M. (2012). Fear, Shame and Guilt: Economic and Behavioral Motivations for Strategic Default. *Real Estate Economics, 40*, S199-S233. https://doi.org/10.1111/j.1540-6229.2012.00349.x

Skees, J. R., & Collier, B. (2011). *New approaches for index insurance.*2020 Vision Briefs. Retrieved from http://www.ifpri.org/publication/innovations-rural-and-agricultural-finance-new-approaches-index-insurance?print=

Skees, J. R., & Murphy, H. A. G. (2007). Proceedings Issue Using Index-Based Risk Transfer Products to Facilitate Micro Lending in Peru and Vietnam. *American Journal of Agricultural Economics, 89*, 1255-1261. https://doi.org/10.2307/30139470

Skees, J. R. (2008). Innovations in Index Insurance for the Poor in Lower Income Countrie s. *Agricultural and Resource Economics Review, 37*, 1-15. https://doi.org/10.1017/S1068 280500002094

Smith, V. H., & Watts, M. (2010). The New Standing Disaster Program: A Sure Invitation to Moral Hazard Behavior. *Applied Economic Perspectives and Policy, 32*, 154-169. https://doi.org/10.1093/aepp/ppp003

Su, Z., & Hu, D. (2014). Are Farmers' Credit Defaults All Active Defaults?—Credit Default Mechanism of Farmers under the Condition of Asymmetric Information. *Management World, 9*, 77-89. https://doi.org/10.19744/j.cnki.11-1235/f.2014.09.008

Van Bastelaer, T. (2000). *Does social capital facilitate the poor's access to credit—a review of the microeconomic literature*. Social Capital Initiative Working Paper no. 8, The World Bank, Washington DC. https://www.jstor.org/stable/30139470

Van Campenhout, B., & Bizimungu, E. (2018). Risk and returns of sustainable crop intensification: The case of smallholder rice and potato farmers in Uganda. *Development*

Policy Review. 36, O605-O633. https://doi.org/10.1111/dpr.12356

Xie, Y. M., & Gao, J. (2014). Study on the Effect of "interlinked credit and insurance" on the Income Fluctuation of Farmers in China. *Journal of Sun Yat-Sen University(Social Science Edition)*, 158-164. https://doi.org/10.13471/j.cnki.jsysusse.2014.01.019

Ye, T., Li, Y., Gao, Y., Wang, J., & Yi, M. (2017). Designing index-based livestock insurance for managing snow disaster risk in Eastern Inner Mongolia, China. *International Journal of Disaster Risk Reduction, 23*, 160–168. https://doi.org/10.1016/j.ijdrr.2017.04.013

Zhang, J. J., & Xu, C. M. (2013). Interlinked Agricultural Credit Insurance's Impacts on Farmers' Income: On Data from Jiangsu and Hubei Provinces, *Finance &Trade Economics, 5*, 55-61. https://doi.org/10.19337/j.cnki.34-1093/f.2013.05.008