Working Paper Series

#2015-005

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UNU-MERIT Working Papers

ISSN 1871-9872

Maastricht Economic and social Research Institute on Innovation and Technology, UNU-MERIT

Maastricht Graduate School of Governance MGSoG

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Risk preference or financial literacy? Behavioral experiment on index insurance demand*

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February 6, 2015

Abstract

We use a unique cross-sectional household data from Ethiopia to investigate the effect of risk preference, financial literacy and other socio-economic characteristics on demand for index insurance. We measure risk preference based on survey experiments using lottery choice game with real monetary prizes. First, we find no evidence of risk aversion on demand for index insurance. Second, we find positive impact of financial literacy on purchasing insurance. Third, relaxing liquidity constraint enhance the take-up of insurance. Finally, demographic and village characteristics have little role in the decision to uptake insurance. These findings have implications on product design and marketing strategies. The product design should focus on ways that better account for liquidity constraint of the household. Interventions that strengthen efforts in provision of financial literacy programs are worthy. Our results are robust to changes in specification and estimation method.

JEL Classification: D14; D81; G2; G22; O16
Key Words: Risk aversion; financial literacy; weather index insurance; lottery choice game; Ethiopia

*We acknowledge the research funding from Maastricht Graduate School of Governance, Maastricht University and UNU-MERIT. We are grateful for comments from Jaap Bos, Franziska Gassmann, Stein Holden, Melissa Siegel and Adam Szirmai. Also, we thank conference participants at European financial management conference, Nordic conference on development economics, Joint conference of African econometric society and Ethiopian economic association, and UNU-MERIT 25th year conference. The usual disclaimer applies.

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1 Introduction

Weather risk poses a constant threat to economic well being, especially for agrarian economy in Sub Saharan Africa (SSA). At an aggregate level, adverse weather slows down economic growth. For instance, Barrios et al. (2010) found rainfall as significant determinant of economic growth in developing countries. Likewise, Dell et al. (2008) report negative effect of rising temperature on poor countries economic growth. Similarly, poor rainfall is followed by declining economic growth, for instance, in Ethiopia (World Bank, 2007a) and Morocco (Varangis et al., 2003). At micro level, weather risk leaves households vulnerable to destitution. Calvo and Dercon (2007) and Dercon (2004) show that rainfall shocks have a substantial impact on consumption growth in rural Ethiopia. Overall, developing countries suffer from brunt of weather risk in terms of food insecurity, low economic growth and poverty.

Though weather risks are largely uncontrollable, they can be managed or transferred. Insurance presents a strategy to pool and transfer risk. Insurance payouts in the aftermath of shocks can help farmers to avoid inefficient coping mechanisms, for instance selling productive assets. It can furthermore affect risk taking of farmers by developing a greater sense of income security. In general, insurance schemes have the potential to curb welfare losses due to shocks and may effectively complement the existing informal risk-sharing strategies. Further, it is also widely recognized that the missing rural financial markets for the poor are one reason for being trapped in poverty. According to World Bank (2007b), only a few rural households could meet their credit and other financial services need. There is a huge need for financial innovation that could enhance access to financial services directly and indirectly through managing the systemic risk that undercut their supply.

Insurance markets may strengthen the rural financial development by transferring the weather risks from the local market in to global market (Skees, 2008). The 2008 World Development Report points the possibility of using insurance as a way of reducing imperfect information in managing farmers risk (World Bank, 2007b). Likewise, multilateral institutions like United Nation Framework Convention on Climate Change (UNFCC) and Intergovernmental Panel on Climate Change (IPCC) have suggested the possibility of using insurance market to adapt to climate change. Despite this fact, the insurance market is underdeveloped or inexistent in most developing countries. Generally cited reasons are, among others, information asymmetries and transaction costs (Clarke and Dercon, 2009; Skees, 2008).

One innovation addressing adverse selection, moral hazard and high transaction cost problems of insurance schemes is Weather Index Insurance (WII). WII makes payouts based on values obtained from an index without calculating actual losses of a policy holder. The index can be objectively measured, is highly correlated with losses and hard to be manipulated by the insurer or policy holder. For instance, WII measures a specific weather variable (for example, rainfall or temperature) for a specific locality and a particular product based on historical weather data. Based on yield-weather relationship a *threshold* is set at which the index triggers payout. Similarly, a *limit* is set at which the index triggers the maximum payout. Payouts are made for policy holders if the amount

of rainfall is below or above a certain threshold. Though weather based insurance schemes has its merit of reducing moral hazard, adverse selection and transaction cost; it has a demerit which is basis risk. Basis risk is the possibility that actual losses do not match insurance payouts. The index may pay when there is no loss and may go not paying during loss.

Despite the intuitively convincing arguments in favor of microinsurance, demand for the product is rather low. For instance, Randomized Control Trial (RCT) based index insurance offers report take up rate of 20% in Ethiopia (Hill and Robles, 2010), 17% in Malawi (Giné and Yang, 2009), 16% in India (Cole et al., 2012b). Norton et al. (2011) report take-up rate between 6% and 36% in Ethiopia. This poses a need to understand why farmers do or do not take-up WII.

Standard theory of insurance demand suggests an inverse relationship between price, liquidity constraint and insurance demand. Extensions suggest demand is affected by cost of attention and information gathering (Reis, 2006) and trust for the insurer (Guiso et al., 2008). Cole et al. (2010) argue that the psychological manipulation of the product could influence household demand for insurance. Empirically, only a few studies have assessed the factors that affect demand *inter alia* Giné et al. (2008); Cole et al. (2012b); Mobarak and Rosenzweig (2012) and Karlan et al. (2014). These studies show mixed evidence on take-up of the WII product. Besides, they report negative effect of risk aversion on WII take-up contrary to theoretical predictions. Moreover, the highest take-up rates are reported in Ethiopia, where there are no previous studies. Thus, the overall goal of this study is to examine the barriers for trading WII in Ethiopia. Why do households buy or do not buy WII?

Using a unique rural household data from Ethiopia, we assess the take-up and factors that influence demand for large commercially traded index insurance in Africa. The novelty in our study are: First, we innovatively measure risk preference and financial literacy in a survey setting. There are three common approaches in eliciting risk preference in micro studies. One approach is based on qualitative question. For instance, asking individuals about their risk preference and rank themselves on some scale (For instance, 0 being highly risk averse and 10 mostly risk preferring). Or, asking respondents to make a choice about risky decisions. The other approaches are either to use incentivized or non-incentivized risk experiments (such as Binswanger lottery games, multiple price listing, etc). Harrison and Rutström (2008) provide an extensive review on eliciting risk preference and the limitations in using the qualitative and non-incentivized risk experiments. In this vein and unlike previous studies that measure risk attitude using hypothetical or qualitative questions, we elicit risk preference using lottery choice game with real monetary prizes. We find on average households to be risk averse with risk aversion parameter of 0.38. This is close to estimates based on comparable method in South Africa, which is 0.393 (Brick et al., 2012), 0.45 in Peru (Galarza, 2009) but lower than estimates in Harrison et al. (2010) for Ethiopia, which is 0.54. However, the qualitative measures indicate most households as risk preferring.

Similarly, we actually measure financial literacy using a series of questions (see appendixC). This enable us to get an indicative measure on the level of financial literacy of the households. Often, observational studies measure housheold's financial literacy using a self-reported measure in which

households indicate whether they are literate or not. Another approach taken in a randomized evaluation setting is to offer financial education for a group and claim that they are financially literate with out actually testing their financial literacy score. Such approach could be misleading since what we measure may be their training attendance hours. Expectedly, we find low level of financial literacy in the study villages. On average, households answer about 48% of the questions correctly. In contrast, the self-reported measure indicates majority of the households (about 66%) understand insurance well.

Second, we layout a simple theoretical framework on how financial literacy affect demand for insurance. We show that financial literacy enhances demand for insurance. Third, we apply a consistent econometric framework that account for possible endogeneity in observational study. Specifically, we apply special regressor approach due to Lewbel (2000). The burgeoning literature on financial literacy point the possible endogeneity of the financial literacy variable (Van Rooij et al., 2011a) in observational data. Hence, financial literacy can be a suspect of endogeneity, since some unobserved factors may influence both financial literacy and participation in insurance market. For instance, unobserved factor such as innate ability that directly affect financial literacy and also positively influence participation decision in insurance. In addition to the possibility of omitted variable, financial literacy is often subject to measurement errors. In such cases, there are several econometric approaches to address the endogenetiy problem such as linear probability model with instrument variable (IV-LPM), maximum likelihood (ML), control function (CF) and special regressor, among others. The variants of estimators from these approaches differ depending on the assumption they impose on the endogenous regressor and its relation with other regressors in the model (Lewbel et al., 2012). Special regressor imposes least restrictions allowing the enogenous regressor to be continuous, limited or discrete. And it only requires that the instruments satisfy the usual conditions for instrument variables.

Main results of our paper are: We find no evidence of risk preference effect on demand for WII. Financial literacy significantly and positively affects index insurance demand. Relaxing liquidity constraint also enhances the uptake of WII. Our results relate to two literature. first, we contribute to the nascent literature on microinsurance. Prior studies focus on price as key factor in affecting demand for index insurance. However, this is not the whole story since RCT based studies indicate demand for index insurance does not double even when it is offered for free (Karlan et al., 2014) suggesting other non-price factors that our study confirms. Second, our paper contributes to financial innovation and household financial decision making literature providing micro evidence from Africa for the case of innovative financial product, WII.

The structure of our paper is as follows: In Section 2 and 3, respectively, we review the literature, discuss the context of the study and describe our dataset. Section 4 layout the theoretical framework. We discuss our empirical strategy in Section 5. We provide estimation results and discuss robustness issues in Section 6. We conclude in Section 7.

2 Literature

Despite the bulk of literature in informal insurance in developing countries, scanty cover of formal insurance is surfaced. Importantly, the few coverage of formal insurance in developing countries is also dominated with studies on health and life insurance. Recently, agricultural insurance market in developing countries is emerging. This is partly due to innovation in the insurance products that addresses the twin evils (information asymmetry and transaction costs). Only very few studies examined agricultural insurance in developing countries setting, among others, Karlan et al. (2014); Dercon et al. (2012); McIntosh et al. (2013); Cole et al. (2012b); Hill et al. (2011),and Giné et al. (2008). It is presumed that provision of insurance could affect farmers production decision behavior and enhance their productivity that would translate in to welfare improvements. However, take-up for the product is low. This motivates to understand why take-up is low.

Understanding the demand for insurance in developing countries is challenging. There are different alternative explanations to why farmers buy or do not buy insurance. We largely follow the conceptualization in Hill et al. (2011). Demand for WII can be conceptualized as a stand alone risk hedging instrument, financial innovation to be adopted or as an element of a portfolio of risk management activities. Thus, it is important to take in to account the different perspectives in assessing the demand for insurance. Our empirical review also come from three strands. Willingness to pay (WTP) based assessment of WII take-up (Hill et al., 2011); survey based assessment of demand for WII (Giné et al., 2008; Cai and Song, 2012) and RCT based studies (Cai, 2012; Dercon et al., 2012; Cole et al., 2012b; Gaurav et al., 2011; Cai et al., 2009). Following the conceptualization in Hill et al. (2011) and other prior empirical studies on insurance demand, we put forth the key possible factors that influence demand for WII below.

2.1 Price

Standard theory predicts for an expected utility maximizing household, price will have negative effect on insurance demand, ceteris paribus (Patt et al., 2009). Previous studies (Cole et al., 2012c; Mobarak and Rosenzweig, 2012; Karlan et al., 2014) report negative effect of price on WII demand. These studies offer randomly diffeent discounts on WII and report price elasticity of about 0.44 (Mobarak and Rosenzweig, 2012), between 0.7 and 1.1 (Cole et al., 2012c). In the extreme case, where the index insurance is offered for free, Karlan et al. (2012) found an increase in take up ranging between 40-100% among Ghanian households. Overall, demand for index insurance does respond to prices but not necessarily higher at lower prices. For instance, Cole et al. (2012b) report less than 50% uptake of index insurance offered at a price below the fair actuarial price. Price alone can not explain the demand for index insurance, hence, a careful investigation at non-price factors contributes to our understanding of demand determinants in WII.

2.2 Liquidity constraint and wealth

In simple static framework, Giné et al. (2008) show that credit constraint negatively influences insurance demand. Financial constraint could have two opposing effects. On the one hand, financially constrained households may highly value the stabilization effect of income by reducing income volatility, since they have less consumption smoothing capacity ex-post. On the other hand, financially constrained households have limited finance they have to decide allocating on either production investment or insurance purchase. Although the risk averse households would benefit from insurance purchase, the shadow value of liquid assets in such situation would be very high and hence decide on production investment. In dynamic setting, they suggest that financial constraint may not have negative influence and rather would have ambiguous effect on insurance demand. Hence, impact of financial constraint on insurance take-up should be established on empirical ground.

In a randomized experiment that hand out money to households right before insurance purchase decision, Cole et al. (2012b) find relaxing liquidity constraint increases uptake of index insurance. In a game experiment with Ethiopian farmers, Norton et al. (2011) observe similar effect of relaxing liquidity constraint on household decision to buy insurance. A limitation in these experiments is one can not disentangle whether the effects are reciprocity or genuine relaxation of liquidity constraint effects. Likewise, Giné et al. (2008) find positive relationship with insurance uptake.

Alike to liquidity constraint, under expected utility theory, the wealth effect on demand for insurance is difficult to determine *a priori*. Since risk aversion varies with wealth that may change the demand for insurance. The empirical literature is also mixed. Cole et al. (2012c) and Gaurav et al. (2011) report positive effect, while Giné et al. (2008) find no evidence; in contrast, Karlan et al. (2014) report negative effect of wealth on index insurance demand.

2.3 Risk aversion and basis risk

Considering the product as stand alone risk hedging instrument, standard insurance theory predicts a positive effect of risk aversion. It predicts a negative relationship between basis risk and insurance demand. The higher the risk aversion of the individual, the higher will be uptake of insurance. This is in sharp contrast to existing empirical evidence on demand for WII. For instance, empirical results report negative effect of risk aversion on WII demand (Karlan et al., 2014; Cole et al., 2012b; Hill et al., 2011; Giné et al., 2008).

An explanation could be drawn conceptualizing the product purchase decision in some how similar to farmer's technology adoption (Giné et al., 2008). In their empirical studies, they report a negative effect of risk aversion on insurance take-up. Similar findings are reported in early technology adoption decision literature (Feder, 1980; Just and Zilberman, 1983). Clarke (2011) justifies the possible negative relationship as a rational response to dead-weight costs and non-contractual performance.

Though index insurance is advantageous in terms of reducing asymmetric information and transaction costs, it has the disadvantage of basis risk. Index insurance may make payouts when the marginal utility of the money is low and does not make payouts when they are needed most.

Linking to the demand for insurance, individuals purchase less of index insurance if they perceive higher basis risk in the product. Cole et al. (2012b) measure basis risk as the distance between rainfall station and the farmer's village. They report no significant correlation between basis risk and insurance uptake. Mobarak and Rosenzweig (2012) find a negative effect of basis risk on insurance demand in the absence of informal risk sharing coverage.

2.4 Financial literacy

Formal insurance is a new concept; and relatively, WII is a complex one to most rural residents in developing countries. Farmers are expected to make regular payments in expectation of compensation in some uncertain future period. The insurance contract makes payment when the weather (e.g. rainfall) index is below certain predetermined level and not necessarily during harvest loss. This partly distinguish WII from crop insurance. Besides, some individuals may benefit while others may not receive payouts as far as the index does not reach the trigger level in their locality. Importantly, it may not pay even during losses due to basis risk. Furthermore, index insurance is based on some index measure (e.g., rainfall in millimeter, temperature in degree Celsius) that are not common knowledge in rural developing countries. Also, the way the index measure is gathered (from rain gauges or satellite) pose another understanding problem (Patankar, 2009). A huge challenge in index insurance is to make it understandable for individuals. Thus, interventions that could increase insurance literacy and diffusing information through existing social networks may ease the understanding of insurance. Hence, insurance purchase decisions will be higher. Overall, its introduction could be considered as an innovation. Thus, its diffusion could be alike to innovation (technology) diffusion (Hill et al., 2011). According to Rogers (1995) early technology adopters are educated and have affinity to similar previous technologies. The last point could indicate that insurance purchase decision will be more likely by members of informal risk sharing networks (here after IRSN).

Karlan et al. (2014) report positive effect of education on insurance take-up. Similarly, Cole et al. (2012c) find positive effect of household education on financial market participation. This is possibly due to the fact that households with high level of education are able to understand the product and better perceive the benefits from the product hence may take-up the product. Similar theoretical and empirical technology adoption literature is abound (for instance: Schultz (1982) and Feder et al. (1985)).

Giné et al. (2008) find insignificant effect of education on demand. Unexpectedly, Gaurav et al. (2011) report negative relationship between education and insurance purchase. However, they report positive effect of financial awareness on index insurance uptake in India. Cole et al. (2012b) distinguish financial awareness into financial literacy and understanding of probability concepts. They find financial literacy per se has no effect, however, understanding of probability concept is positively correlated with insurance demand in India.

In their RCT, Cole et al. (2012b) find a significant effect of insurance literacy on uptake that range between 20 to 25 percentage point. They randomly assigned households to either receive a

visit from insurance educator or receive a flyer about the index insurance product.[1] In a participatory training they demonstrate both how payouts are triggered in the rainfall index and also offer weather forecast for next ten days. Both treatments do not lead to uptake increase. While Cai and Song (2012) play repeated games with Chinese farmers, they find about 9.6 percentage point rise in uptake of index insurance. For Patt et al. (2009) there is no difference in understanding of insurance whether the literacy session is using traditional or game based explanations.

Cai (2012), in RCT in China compare a basic information session versus an intensive training session. She observe a higher take-up of about 14 percentage points among intensive training participants. While Giné et al. (2011) find positive effect of financial literacy on insurance purchase, the impact is higher conditional on sufficient residents of the village receiving the information.

2.5 Alternative risk management strategies

Insurance is only one of the households' portfolio of risk management strategies, since households use different strategies to protect themselves against income shocks. Common in developing countries are IRSN; saving and credit market provide some protection against idiosyncratic or smaller shocks in a specific area. Provision of formal insurance could be a substitute or complement to the IRSN. Individuals involve in a mutual insurance group to help each other during bad times (Dercon et al., 2006; Fafchamps and Lund, 2003). There are explicit form of groups like funeral association groups that help households cover unexpected expenses for funeral and related ceremonies. There are also flexible transfer arrangements between friends and family. They could allow individuals smooth their consumption overtime (coping with risk) hence demand less insurance. When efficient the informal risk sharing networks crowd out insurance (Arnott and Stiglitz, 1991). A drawback of such informal groups is that they may not be able to resist large covariate shocks or consecutive multiple idiosyncratic shocks. Hence, formal insurance serve as substitute to IRSN.

By relaxing the liquidity constraint, IRSN may allow individuals purchase insurance. Cognizant of the fact that covariate shocks deteriorate their ability, IRSN may have interest to purchase insurance. Moreover, due to the basis risk in the index insurance individuals would like to continue their membership in IRSN. Thus, index insurance and informal insurance may complement each other (Mobarak and Rosenzweig, 2012). In sum, the effect of other risk management strategies is subject to empirical investigation.

2.6 Demographic and other characteristics

Individual's characteristics such as age, gender and household size could influence the insurance purchase decisions. For instance, age found to increase the likelihood of purchasing index insurance in Gaurav et al. (2011). On the contrary, Cole et al. (2012b) report negative effect of age on insurance take-up. Similarly, the gender of the household head have a mixed effect in index insurance

[1] Since the study is based on randomized trails, one should be cautious on the results possibly been driven due to Hawthorne effect.

purchase (Karlan et al., 2014; Cole et al., 2012b; Gaurav et al., 2011; Giné et al., 2008). Thus, the empirical evidence is inconclusive.

Insurance involves making payments today in order to receive payouts in the future, thus time preference of individuals could affect their insurance take-up decision. Those with high positive discount rate may not have an incentive to buy insurance, keeping other things same. The effects would be even stronger for individuals with hyperbolic discounting or time-inconsistent preference. Hill et al. (2011) and Cole et al. (2012b) report positive effect of time preference on uptake of insurance.

Experiencing shocks could also affect insurance take-up decisions, ambiguously though. On the one hand, experiencing a shock may lead one to think that more shocks to occur, hence overestimate the probability of newer shocks thereby demand insurance. On the other hand, experiencing a recent shock lead to think that consecutive shocks are less likely hence underestimate newer shocks there by leading to less demand for insurance. The few empirical evidence also show mixed result. For instance, Bendig and Arun (2011) find past shocks to positively correlate with households use of financial services in Srilanka. On the other hand, Cole et al. (2012b) and Stein and Tobacman (2011) report no evidence of shock affecting insurance demand.

Given the scanty literature on this new financial product, the existing evidence is not decisive (Cole et al., 2012a). Further, the review clearly demonstrate mixed evidence. In this paper, in light of the aforementioned literatures, we examine why rural households do or do not participate in insurance market? We do this by examining household actual purchase of WII policy among cross-section of rural households in Northern Ethiopia. Most of index insurance study are based on small-scale pilot schemes, ours focus on assessing actual demand for WII in a largely traded insurance program. Details of the insurance scheme are discussed in Section 3. This provides us with better understanding of WII demand in developing countries.

3 Context and data

3.1 Microinsurance sector and weather index insurance scheme

Though formal insurance sector is not a recent phenomenon in Ethiopia, it accounts for less than 1% of GDP and has very low penetration rate. It is also largely in urban areas. The rural areas account for about 80% of the inhabitants that face multiple perils (drought, flood, illness and so on). In terms of risk exposure, Ethiopia faced several shocks such as drought, flood, epidemic, earthquake and insect infestation among others. Using data from household survey in Ethiopia (Hill et al., 2011) report the most frequent self reported shocks are drought (40.2%), illness (30.2 %), death of household member (22.8%) and pest infestation (22%). Thus, drought shock is the most frequent risk and has significant negative repercussions on household asset and welfare.

Until 2006, there was no formal insurance product designed to address the need and capacity of rural inhabitants. In 2006, World Bank piloted a weather index insurance in Halaba woreda, in Southern Ethiopia. Between 2007 and 2009, Oxfam America (OA), Relief Society of Tigray (REST),

Dedebit Credit and Saving Institution (DECSI), Swiss Re, Institute for Climate and Society (IRI), Nyala Insurance Share Company (NISCO) and other partners piloted a climate resiliency project that offers weather index insurance in Adiha, Northern Ethiopia. Similarly, World Food Program (WFP) in collaboration with NISCO piloted index insurance for Haricot Bean farmers around Adama during 2009. Since 2011, there are series of pilots in different part of Ethiopia under the Index Insurance Innovation Initiative (I4). The pilots are testing interlinking insurance and credit, providing insurance through existing informal risk sharing networks (e.g. *iddir*) and provision of index based livestock insurance for pastoralists. Association of Ethiopian Microfinance Institution (AEMFI) in collaboration with World Bank and NISCO are piloting Livestock Indemnity Insurance for high value livestocks (cattle and sheep) both in urban and rural areas around Addis Ababa. Brief historical account of microinsurance in Ethiopia is provided in Amha et al. (2013).

The focus of this study is on the microinsurance product designed to address weather shock that was piloted in 2009 in village Adiha, Tigray and later scaled to 5 more villages in 2010. In 2013, the WII scheme covered around 79 villages insuring about 20,015 households in Tigray and a pilot roll-out village in Amhara insuring 350 households (Oxfam America, 2013). Currently, two local insurance companies (NISCO and Africa Insurance Company) underwrite the policies. According to Oxfam America (2013), the product insures different crops (Teff, Wheat, Barley and others) in two windows, early index and late index. The early index addresses deficit or delay of onset rainfall, while the late index targets deficit or early end of rainfall. Both windows pay once every four or five years. Farmers had an option of purchasing insurance with cash or with labor (Insurance for Work-IFW).[2] The average premium paid in 2010 was about 270 Birr ($19) per household (Oxfam America, 2011). Specifically, our focus is on early purchase of the insurance in 2012 that was offered by NISCO in the five villages in Tigray. The following section describe our data and sampling procedure.

3.2 Data and sampling

The study is based on a unique cross-sectional data we collected from 275 rural households in Northern Ethiopia. We chose the northern region due to the introduction of large commercial weather index insurance in the area (see section 3.1 for details). The data was collected during May-June, 2013. We filled standard household socio-economic questionnaire with focus on household experience on risk and insurance. The questionnaire includes modules on household demographics, household assets and wealth, detailed consumption expenditure. It also includes modules on risk and time preference, financial literacy, risk and risk coping mechanisms. Details of insurance participation, insurance premium and related questions are also incorporated. The survey took approximately up to two hours per household. We interviewed household heads.[3]

[2]The IFW arrangement allows farmers to work extra days in the productive safety net program (PSNP) and make payments for premium through contribution from their remuneration from PSNP. The arrangement relaxes financial constraint. PSNP is an innovative social protection scheme that covered more than 7 million households in Ethiopia.

[3]The interview was handled by enumerators with undergraduate degree in Economics and Business that have previous experience of similar work. Detailed training sessions was given, where each question is discussed and

The sampling procedure followed was stratified random sampling. First, households are stratified by their purchase decision of insurance. Households that purchased weather index insurance and those that did not purchase the WII. Second, households are randomly drawn systematically from the sample frames of both the purchasers and non-purchasers. We randomly sampled about 13% of those that purchased (169) are included in our sample. Further, we sampled around 4% of the households (106) that did not buy WII. The sample was drawn from five tabias (villages). In five of the sampled villages, WII was marketed by local insurance company in collaboration with local NGO, an international NGO and other partners. Overall, we sampled and administered the interviews on 275 households distributed across five villages. Table 1 describes the sample size drawn from purchasers and non purchasers in each village.

3.3 Eliciting risk preference: the lottery game

In order to elicit risk preference of the households, we included lottery based choice with real money prize. Our design was simple and based on only three consecutive tasks to make it easily understandable for the majority of low literacy level respondents. The respondent was presented with two choices, a sure amount and a probability based alternative, and asked to choose one. Importantly, the questions were not framed as gambles over varying probabilities but rather presented as equal-probability outcomes. Since in environments where education levels are low, understanding of probabilities is poor. The monetary values were economically meaningful, since the hourly wage was nearly 6.25 Birr in the study village. So, the respondents have an incentive to carefully make decision given the expected reward of 15 Birr in the game. Indeed, we separately compensated the respondents for the interview hours. The game consists of series of specific safe and risky options as shown in Table 2.

Respondents were asked each task and made their choice and collected their prizes immediately at the end of interview. Given their choice, we can rank households in their risk preference. The most risk averse will be one that chose all safe sure amounts, while the least risk averse will be that chose all the risky options.

Assuming expected utility (EU) maximizing agent, the respondent will choose risky option (R) over the safe option (S) if $E[U(R)] \geq E[U(S)]$ as in equation (1) below:

$$E[U(R)] = \Big(0.5 \cdot U(R_l) + 0.5 \cdot U(R_h)\Big) \geq U(S) = E[U(S)] \tag{1}$$

For sake of comparability with previous literature and to get continuous (cardinal) risk aversion coefficients, we assume specific utility functions (Constant Relative Risk Aversion-CRRA-utility). Assuming the agents preference is CRRA utility of the form $U(x) = \frac{x^{1-r}}{1-r}$, we can estimate r, the risk aversion parameter, based on the agents observed decision in the risk elicitation questions. Details of the estimation procedure is given in Appendix B. The result is reported in 3.6.

elaborated to get them in to a similar picture. The enumerators were closely supervised by the research fellow and recruited supervisor with rich experience on socio-economic surveys. The enumerators and the field supervisors were fluent in local language of the interview.

3.4 Eliciting time preference

Similarly, we elicited time preference of the households using series of questions of the form. "Do you choose X amount today t or $X + e$ amount in the future $t + n$". Unlike the risk preference, the choice was hypothetical and no monetary rewards given to the respondents. Assuming that each response resulted from discounted utility computation (Samuelson, 1937), we can elicit range of discount rates for each time preference questions. A discounted utility maximizing agent prefers present X over future Y at τ period from today if present payoff is at least same as present value of the future payoff. For simplicity, assuming a linear utility, the agent chooses X over Y as in equation(2) below.

$$X \geq \left(\frac{1}{1+\rho}\right)^{\tau} Y \tag{2}$$

where $\left(\frac{1}{1+\rho}\right)^{\tau}$ is the exponential discount factor and ρ is the discount rate. Pluging values of X, Y and τ, we can solve for ρ that gives us discount rate ranges for each time preference question. We computed the discount rates based on the choice responses. It is possible to estimate the time preference parameter using ML method, we did not pursue since the observed choice responses were based on hypothetical questions. The result is reported in 3.6.

3.5 Measuring financial literacy

We also asked respondents series of questions on financial literacy given in Appendix C. We constructed our index by summing the correctly answered questions divided by the total number of questions (10 in the case of basic financial literacy and 15 for advanced financial literacy) and multiplied by 100. Based on the correctly answered questions by each respondent, the index of financial literacy ranges between 0 and 100. We measured financial literacy using three set of questions. The first set of questions assess basic financial numeracy of the respondent. These cover questions on summation, multiplication and ratios. The second set of questions covered issues of interest rate, inflation and financial knowledge in transaction. The first and second set of questions are adopted from Cole et al. (2011). The last set of questions are largely adopted from survey instruments used in Madajewicz et al. (2010). The questions assess specific issues in regard to index insurance. Specifically, they ask on when, how and to what extent the WII cover losses. Exact wording of the questions are provided in Appendix C.

3.6 Descriptive statistics

Variable description is provided in Table 12 in the appendix. The demographic characteristics used in the estimation are head's age, sex and household size. The mean age of the household head in the sample is 45. Nearly, 40% of the sampled households headed by female. Average size of the household in the sample is 5, slightly higher than the regional average. In terms of preference (risk and time), our mean estimate of risk aversion is 0.38, denoting average households

to be risk averse. This is close to estimates based on comparable method in South Africa, which is 0.393 (Brick et al., 2012), 0.45 in Peru (Galarza, 2009) but lower than estimates in Harrison et al. (2010) for Ethiopia, which is 0.54. Figure 1 shows the distribution of risk aversion across the sampled households. Most of the household heads in our sample are risk averse with few exceptions that are risk neutral. As one can see, the distribution is bimodal. Nearly, 55% of the household heads have a discount rate above 30% making the majority present biased. This result is close to monthly discount rate in Indonesia in Cole et al. (2011). The elicited monthly discount rate could be exaggerated since previous studies (Holden, 2013; Hill et al., 2011; Harrison and Rutström, 2008) claim an overestimation of the discount rate using hypothetical question.

Our sample is composed of household heads with 65% illiterate, 28% with some elementary level and the rest with some secondary level of education. About 49% and 45% of the questions used to measure basic financial literacy and advanced financial literacy are correctly answered by respondents. The result is comparable to financial literacy findings in Indonesia (52%) and India (34%) by Cole et al. (2011). Figure 2 shows the distribution of basic and advanced financial literacy index across the sampled households. Both distributions are unimodal. Only close to half of the questions are correctly answered. Similarly, those that answered accurately at least 80% of the questions in the basic and advanced financial literacy measures, respectively, are about 6% and 2% of the sampled respondents. This suggests the low level of financial literacy. The respondents have closely similar distribution.

Almost all respondents in our sample heard about weather index insurance and about 67% reported that they understand the WII well. In regard to use of other risk management strategies, 8% and 16% of the respondents participate in *eqqub* and *iddir*. 63% of the respondents participate in the productive safety net program (PSNP) and about 12% received remittances. Credit and saving participations are around 43% and 11% in our sample. Mean land holding is about 2.6 timad (about 0.6 hectare). The sample of respondents for the demand estimation is composed of 21% from Adiha, 17% Awetbikalsi, 17% Genetie, 19% Hadealga and the remaining from Hadushadi.

Table 4 reports the descriptive statistics disaggregated by insurance buyers and non-buyers. There is significant difference in characteristics between buyers and non-buyers as shown in Tables 5 and 6. Buyers are less risk averse and score higher on financial literacy ($p < 0.01$). Buyers are younger, have small land ownership and relatively more educated than non-buyers ($p < 0.05$). Likewise, buyers have statistically significant higher participation in PSNP and *eqqub* and *iddir* . High proportion of the buyers have formal saving but lower proportion of remittance receipt ($p < 0.1$). The mean comparison test indicates that demand for WII is influenced by risk preference, financial literacy, education and complemented by participation in other risk management strategies (PSNP, *eqqub* and remittance). We proceed to examine whether the results hold once we control for range of socio-economic characteristics in multiple regression framework presented in section 6.

4 Theoretical framework

Theoretically, several factors suggested to affect insurance demand. In a simple framework, Giné et al. (2008) show an inverse relationship between price, liquidity constraint and insurance demand. Extensions suggest insurance demand is affected by trust for the insurer (Karlan et al., 2014; Guiso et al., 2008) and basis risk (Clarke, 2011; Karlan et al., 2014). These models assume well-informed agents. Since insurance market and its functioning is hardly known in most rural developing countries, its benefit is not immediately known. Thus, there will be difference in demand for index insurance given the level and investment made on financial literacy. In this section, we layout a framework on the effect of financial literacy on demand for index insurance in line with Jappelli and Padula (2013).

Consider a risk averse farmer with von Neumann-Morgenstern utility of final wealth given by $u(.)$. Where $u(.)$ is assumed twice differentiable everywhere with $u'' < 0 < u'$. Consider the farmer lives for two periods with initial wealth of w_0 and stock of financial literacy (Φ_0). In period one, the agent consumes c_1 and uses the remaining wealth on production investment. For simplicity, we assume no saving. The production investment requires use of different inputs such as land and labor denoted by x. The initial stock of financial literacy is what the farmer knows about finance, that is related to schooling decision, parental background and other factors not explicitly modelled here.

Raising the stock of financial literacy allows the farmer to access good investment opportunities, to make better production decisions that improve production, thereby increasing the return (benefit) from financial products (in this specific case, index insurance). The return from financial literacy can be given as $g(\phi)$. On the cost side, financial literacy accumulation requires time and money. So, the farmer can decide how much to invest in period 1 to raise the stock of financial literacy, given the additional cost of getting financial literacy, f. For instance, the farmer make frequent contacts with extension agents to understand benefits and costs of different investments. With introduction of index insurance market, a risk averse farmer would like to insure his investment buying some insurance. The index insurance works as follows, the farmer need to pay a price p that pays off i in the dry state d.

Production investment is risky business with a return function of $F(.)$, which is uncertain as it depends on weather outcomes in period one. We assume two states, wet state (when sufficient rainfall for crop production is received) and dry state (when insufficient rainfall for crop production is received). In the wet state, the farmer receives $F(f(x_w) \cdot g(\phi))$, while in the dry state receives $F(f(x_d) \cdot g(\phi) + i)$. Financial literacy affect production investment, since farmers that have better financial literacy are better able to do benfit cost assessment of the production investment decisions. Th return function is sensible and closely similar return function is assumed in Feder and Slade (1984). Throughout, we assume price taking farmers in which the input and output price as well as premium are given. The agent has to decide how much to invest on inputs x, insurance i and financial literacy ϕ at the beginning. The constrained maximization problem in period one is given

as in (3):

$$\max_{x,i,\phi} u(c_1) + \beta[\pi_w u(c_w) + \pi_d u(c_d)] \tag{3}$$

subject to:

$$\begin{aligned} c_1 &= w_0 - x - pi - f\phi && (4)\\ c_w &= F(x_w, \phi) = f(x_w) \cdot g(\phi) && (5)\\ c_d &= F(x_d, \phi) = f(x_d) \cdot g(\phi) + i && (6)\\ & x \geq 0, \quad \phi \geq 0 && (7) \end{aligned}$$

where c_w and c_d are the farmer's consumption in period two, respectively, under wet and dry state. The consumption in period one is the initial wealth (w_0) less cost of inputs and cost of gaining financial literacy (ϕ). The consumption in period two under wet state equals to returns in production investment, while under dry state equals to returns in production investment plus the payouts from insurance. Realistically, we also assume that $f(x_w) > f(x_d)$. Our interest is to see how demand for insurance (i) respond to investment in financial literacy (ϕ). We show this using a comparative statistics result from the first order conditions below. The three first order conditions are:

$$\begin{aligned} \frac{\partial u(.)}{\partial x} &= -u'(c_1) + \beta\pi_w u'(c_w)(g(\phi) \cdot f'(x_w)) + \beta\pi_d u'(c_d)(g(\phi) \cdot f'(x_d)) = 0 && (8)\\ \frac{\partial u(.)}{\partial i} &= -p \cdot u'(c_1) + \beta\pi_d u'(c_d) = 0 && (9)\\ \frac{\partial u(.)}{\partial \phi} &= -f \cdot u'(c_1) + \beta\pi_w u'(c_w)(g'(\phi) \cdot f(x_w)) + \beta\pi_d u'(c_d)(g'(\phi) \cdot f(x_d)) = 0 && (10) \end{aligned}$$

We can rewrite the first order condition in (9), as an implicit function as follows (11 and 12):

$$\begin{aligned} F(x, i, \phi, w_0, p) &= \beta\pi_d u'(c_d) - p \cdot u'(c_1) = 0 && (11)\\ &= \beta\pi_d u'(f(x_d) \cdot g(\phi) + i^*) - p \cdot u'(w_0 - x - pi^* - f\phi) = 0 && (12) \end{aligned}$$

By totally differentiating the implicit function (11), we get (15):

$$
\begin{aligned}
dF &= d\{\beta\pi_d u'(c_d)\} - \{p \cdot u'(c_1)\} = 0 && (13)\\
&= d\{\beta\pi_d u'(f(x_d) \cdot g(\phi) + i^*)\} - d\{p \cdot u'(w_0 - x - pi^* - f\phi)\} = 0 && (14)\\
&= \begin{aligned}[t] &\{\beta\pi_d u''(c_d) f'(x_d) - pu''(c_1)(-1)\}dx + \{\beta\pi_d u''(c_d) - pu''(c_1)(-p)\}di + \\ &\{\beta\pi_d u''(c_d) g'(\phi) - pu''(c_1)(-f)\}d\phi + .. = 0 \end{aligned} && (15)
\end{aligned}
$$

Holding, other variables constant, the change in demand for insurance due to change in financial literacy investment is given by (16):

$$
\frac{di^*}{d\phi} = \frac{\{\beta\pi_d u''(c_d) g'(\phi) - pu''(c_1)(-f)\}}{\{\beta\pi_d u''(c_d) - pu''(c_1)(-p)\}} \tag{16}
$$

Since $u''() < 0, g'() > 0, \beta > 0, f > 0, 0 < \pi_{(w,d)} < 1$ and $p \geq 1$; then $\frac{di^*}{d\phi} > 0$. Hence, an increase in investment in financial literacy lead to increased demand for index insurance. We test this relationship in our empirical setting (see section 6).

5 Empirical strategy

5.1 Endogeneity and identification issue

Our objective is to investigate the effect of risk preference and financial literacy on index insurance demand while controlling for other socio-economic factors. The dependent variable, purchase decision of index insurance is binary. We adopt a probit specification.

Consistent estimates for such framework require that all the right hand side variables should be exogenous. That is, there should be no unobserved factor that affect both an explanatory variables and the dependent variable. However, the burgeoning financial literacy literature point the possible endogeneity of the financial literacy variable (Van Rooij et al., 2011a). Hence, financial literacy can be a suspect of endogeneity, since some unobserved factors may influence both financial literacy and participation in insurance market. For instance, unobserved factor such as innate ability that directly affect financial literacy and also positively influence participation decision in insurance. Hence, probit estimates of financial literacy would be upward biased that overestimate the role of financial literacy in insurance uptake. In addition to the possibility of omitted variable, financial literacy is often subject to measurement errors that attenuate the probit estimates. In such cases, there are several approaches to address the problem such as linear probability model with instrument variable (IV-LPM), maximum likelihood (ML), control function (CF) and special regressor, among others. The variants of estimators from these approaches differ depending on the assumption they impose on the endogenous regressor and its relation with other regressors in the model (Lewbel et al., 2012).

In the IV-LPM, the endogenous regressor can be continuous, discrete or limited. The instruments, z, should satisfy the usual conditions. The isnturment should be correlated with the endogenous vari-

able and not correlated with the error term. There should be at least equal number of instruments as the number of endogenous regressor . It also imposes a linear functional form for the relationship between the exogenous regressors and the endogenous variable. Similarly, ML also allows for continuous as well as limited endogenous regressors, however requires the relationship between the endogenous regressor and the IVs as well as the joint distribution of the errors in the first and second stage should be fully parametrized and correctly specified. Control function requires continuous endogenous regressor and correct specification of the relation between the endogenous and the IVs. Special regressor imposes least restrictions allowing the endogenous regressor to be continuous, limited or discrete. It only requires that the instruments satisfy the usual conditions.

We choose the special regressor approach given the limitations of the other approaches. In the LPM, ζ can not be independent of any regressor (even the exogenous regressors) by construction. Further, it provides fitted probabilities below zero or above one. It requires the regressors not have infinite support otherwise risk having fitted probabilities below zero or above one. Importantly, it may provide wrong sign of the coefficient (Lewbel et al., 2012). In our case, the ML as well as control function requires a complete set of instruments not just any set of instruments, otherwise the estimates will be inconsistent. This is due to the fact that omitting one of the instruments leads to misspecification of the model. The control function requires continuous endogenous regressor, which is not the case in ours. The endogenous regressor, financial literacy is an index that takes limited values. In view of limited endogenous regressor and only a few set of instruments, we apply special regressor approach (Lewbel, 2000; Lewbel et al., 2012). This allows us to address the endogeneity issue and isolate the causal effect of financial literacy and risk preference on index insurance demand.

To find instruments for financial literacy variable, we utilize information from our survey. Specifically, we use two instruments: i) household's extension contact during *dry season* and ii) access to information proxied by ownership of radio. These two instruments indicate information access that could affect financial literacy of the household. Households that had frequent contact with extension agents during dry season are more likely to access information that is most likely to be correlated with their financial literacy (during dry season, it is less likely they discuss about farming issue rather most likely converse about the crop markets and related commercial issue that would rise their financial literacy). However, their contact with the extension agents is less likely to be correlated with insurance uptake, since the insurance product is also new and complex for the extension agents themselves. Further, the training, marketing and sales of the insurance policy was handled by the staffs of the insurance company, the involved NGOs and other partners. We presume a difference in the information flow between wet and dry seasons. During wet season, their contact is often in relation with advices in farming practices (like fertilizer use, high yield varieties, different conservation strategies, and so on). Likewise, households that own radio have high propensity to acquire information (listening to the media) about different financial issues hence better financial literacy. On the other hand, these access to information will not effect on insurance take-up, since the insurance policy is sold in their village. The higher information access is less likely to offer them

an opportunity to learn about insurance given the low level of insurance knowledge in developing society like Ethiopia both from their contacts and media (for instance, insurance penetration rate in the Ethiopia is less than 1%, besides there are hardly any health, unemployment or other social insurance schemes in place). The perception on the importance of insurance is heavily inclined towards auto insurance. Other types (life, property, etc) do not attract much insurance coverage. We test in section 6 the validity and strength of our instruments.

5.2 Special regressor approach

Formally, the special regressor model is specified as below:

$$I_i^* = fl_i\beta_f + \mathbf{x_i}\gamma + L + \zeta_i \tag{17a}$$

$$L = fl_i\beta_v + \mathbf{x_i}\Pi_1 + \mathbf{z_i}\Pi_2 + U_i \tag{17b}$$

where I^* is the latent variable of decision to buy insurance or not. An individual decide to buy insurance if the utility from purchasing insurance is at least equal to not purchasing. $I_i = 1$ if and only if $I^* > 0$, 0 otherwise. $i = 1, 2, ..., n$, fl_i measures financial literacy (possibly endogenous variable), $\mathbf{x}_i$ is vector of exogenous variables; L is the special regressor-land owned; $\mathbf{z_i}$ is vector of instruments (frequency of extension contacts during dry season and access to information (radio ownership)). The equation for L is in reduced form. We assume $E(z\zeta) = 0, E(L) = 0, U \perp (x, fl, z, \zeta)$. β and γ are vectors of parameters, Π_1 and Π_2 are matrices of reduced form parameters.

Special regressor approach assumes that the model includes a regressor, say L that satisfies the following three properties (Lewbel, 2000; Lewbel et al., 2012). First, L is exogenous (conditionally independent of ζ) and appears in the model additively to the error. In the demand model of ours, ζ represents unobserved preferences, ability and other socio-economic factors. The special regressor, land owned, affects the demand for insurance but not ability. Land in Ethiopia is state owned and in the rural villages of our context is distributed by the government three decades ago. Naturally, it satisfies the necessary restriction. Second, L is continuously distributed and has a large support, taking a wide range of values. This satisfies the second condition as well. In fact, any normally distributed regressor would automatically satisfy this condition. Third, though not strictly necessary, L has a thick tailed distribution (see figure 3).

Practically, we estimate the model as follows. First, we estimate Π for equation (17b) using OLS and get the residuals for each observation: $\hat{U}_i = L_i - S_i'\hat{\Pi}$, making sure that L_i takes both negative and positive values with mean zero. The special regressor can easily be demeaned to satisfy this condition. Second, we estimate the density function for $\hat{U}_i$, $f(\hat{U}_i)$ using kernel density estimator. Third, for each observation, i, we construct data $\hat{T}_i = [D_i - I(L_i \geq 0)]/f(\hat{U}_i)$. Last, we run a linear 2SLS of $\hat{T}_i$ on fl, x, L and z using the instruments to get estimate of the coefficients $\hat{\beta}$. Since the construction of $\hat{T}_i$ involves division by the density function that may generate extreme outliers in

the last step leading to high standard errors, Lewbel et al. (2012) advise trimming the outliers.

The estimated coefficients based on special regressor are not directly comparable to estimates based on standard probit, IV-LPM or CF. Rather, direct comparison is possible through marginal effects from each model. The marginal effects for special regressor model is based on Average Index Function (AIF) derived and shown in Lewbel (2000) and Lewbel et al. (2012).

Finally, it is noteworthy to mention the possible drawbacks of special regressor. The main limitation is the restriction on L that require conditional independence from ζ, conditioning on z and x. Even if L is exogenously determined, this conditional independence assumption may be violated, since L may affect the endogenous regressor. In our context, this is not the case since land ownership is a proxy for wealth that affects the demand for insurance but is unlikely to affect the financial literacy after conditioning on other regressors. Another limitation is L needs to be continuously distributed after conditioning on the other regressors. The second limitation is also unlikely to hold since land ownership is continuously distributed.

6 Estimation results

In this section, we discuss our main estimate and compare the results with alternative estimation results (control function, IV-LPM and probit estimates). Then, we report robustness checks based on alternate risk preference and financial literacy measures as well as additional covariates.

6.1 Special regressor estimates

Table 7 shows the regression results based on probit and endogeneity corrected approaches. We use a variable, contact with extension during dry season, in the first stage regression to instrument for financial literacy. We check for the relevance and strength of our instrument. The last row in Table 10 reports the IV tests both for homoscedastic and non-i.i.d errors. In terms of relevance, Angrist-pischke F-test, Anderson canonical correlation LM test and Kleibergen-papp LM test show that the IV is statistically significantly correlated with the endogenous regressor. The instrument pass the rule of thumb weak instrument test of Staiger and Stock (1997). Both Cragg-Donald F-statistics (15.690) and Kleibergen-papp Wald statistics (15.775) are high. This shows that our instruments are strong predictor of financial literacy. We also estimate the special regressor using two instruments (frequency of contact with extension agents during dry season and radio ownership). We do not discuss the results here (see Table 11), since the IVs do not perform well in the weak IV test.

All the estimates in Table 7 are marginal effects that ease comparison across different models. Column (1) first presents special regressor estimates. Column (2) and (3) give the control function and linear probability model with IV (IV-LPM) estimates. The last column report the standard probit estimates.

The special regressor result shows negative but insignificant effect of risk preference on the purchase of index insurance. The sign is inconsistent with predictions from classical models of

insurance (Giné et al., 2008). The negative relationship between risk aversion and demand for WII is rationalized due to the fact that WII is new and complex product that may be perceived to be risky product than a product to manage risk. More importantly, the basis risk in WII may further make it a risky product hence low demand for WII by those with high risk aversion (Clarke, 2011; Giné et al., 2008). Our result is consistent to findings in Hill et al. (2011). Further, we find positive and significant association between time preference and insurance purchase. This is perhaps due to our hypothetical measure that could erroneously measure the discount rate of the individuals. Similar findings are given in Hill et al. (2011) and Cole et al. (2012c). Overall, preference seems to have no significant role in the purchase of index insurance.

Consistent to the predictions in our conceptual framework in Section 4, financial literacy found to have positive and significant effect on purchase of WII. With rise in financial literacy level of an individual, WII purchase increases. Individuals with about 10 more points on the basic financial literacy test are about 6 percentage points more likely to buy insurance. The result is significant at 1% level of significance. This result is consistent with previous studies, among others, Cole et al. (2012b); Cai (2012); Giné et al. (2011) and Cole et al. (2011).

We have also examined the role of wealth as proxied by land owned by the household. Recall that the theory on wealth effect on WII is ambiguous. On the one hand, an increase in welath could relax financial constraint and lead to demand for insurance. On the other hand, the increase in wealth could affect risk aversion and change the demand for insurance. We find positive and significant effect of wealth on the propensity to buy index insurance. This is similar to previous findings (Cole et al., 2012c; Gaurav et al., 2011; Hill et al., 2011).

Participation in PSNP has large and statistically significant positive effect on WII purchase. This is due to the possibility that participants in this scheme have an option to work extra days and their remuneration can be used for paying the premium. In a way, households that participate in PSNP have relaxed liquidity constraint. Similar effects of liquidity constaint are reported in Cole et al. (2012b); Norton et al. (2011) and Giné et al. (2008). We find the effect of participation in *eqqub* and *iddir* to have no significant effect on the purchase decision. Similarly, we find no evidence of recent shock experience on the decision to buy WII.

Demographic characteristics (age and elementary education) do not significantly affect the likelihood of WII take-up. Somewhat surprisingly, we find negative association of secondary education and propensity to buy insurance. We find statistically significant negative effect of household size on uptake of WII at 1%. One explanation is those with large household size have more labor that can be used as other risk management strategies hence demand less insurance. Female headed households are more likely to demand WII than their counterpart male headed households. This is plausible since farming is more riskier for female headed households, since they often sharecrop or hire farm labor for their production that could be another source of production risk.

We have also used a full set of location dummies (tabias) to account for other geographic disparities. For instance, we do not have a measure of basis risk, but both empirical and theoretical literature claim significant effect of basis risk on index insurance demand. In some of the villages

the weather stations are far away from most of the plots in the village. Thus, using location dummies could control for these effects. Our special regressor estimates for location dummies are not statistically significant except for residence in village Genetie. Residents in village Genetie compared to the base village (Hadushadi) are less likely to purchase WII which is statistically significant at 5% level of significance.

We present estimates based on control function and IV-LPM in column (2) and (3) for sake of comparison with special regressor results. We find both risk preference and financial literacy to be insignificant factors in influencing the take-up of insurance. In contrast, we find positive and significant effect of participation in PSNP, *eqqub* and *iddir*. In the IV-LPM, residence in Genetie is significant correlate of WII as shown in column (3). Finally, we report the standrad probit estimates assuming all the covariates are exogenous. We do not find significant effect of risk preference and financial literacy on propensity to buy WII. The results are very close to estimates based on control function and IV-LPM.

6.2 Robustness checks

In order to investigate the robustness of our results, we estimate the main specification in several variants. First, we estimate the special regressor model using alternate risk preference and financial literacy measures. Second, we re-estimate the main specification using additional set of covariates. Detailed results are provided in Table 8.

6.2.1 Alternative measures of risk preference and financial literacy

In Table 8, we use alternate risk preference measures based on hypothetical investment question as in Dohmen et al. (2011). See the wording of the question at the Appendix A.1. The result is similar insignificant effect of risk preference on demand for index insurance. Almost the other coefficients are same as in the baseline results.

Column (1)-(4) in Table 8 provide estimates based on different financial literacy measures. In column (1), we standardize the basic financial literacy index and find positive and strong effect on WII purchase. A standard deviation rise in the basic financial literacy level improves that up-take of WII by about 18 percentage points. In column (2), we use 5 additional and somehow difficult questions to construct our advanced financial literacy measure. Using advanced measure of financial literacy, we still find slightly significant and positive effect on insurance purchase at 10 %. Further, we reconstruct both the basic and advanced financial literacy measures using PRIDIT score. Instead of each questions getting similar weight, we follow Lieberthal (2008) and assign different weights for each questions based on their difficulty. Questions that are correctly answered by most of the respondents will get lower weights and missing such question even penalize. Answering those hard questions based on the frequency of the correctly answered gives higher weight in the PRIDIT score. Such measures are used in insurance literature (Brockett et al., 2002), health (Lieberthal, 2008) and recent financial literacy literature (Behrman et al., 2010; Jappelli and Padula, 2013). Using a sophisticated measure of financial literacy based on PRIDIT score, we find significant positive effect

of the PRIDIT score for basic and advanced financial literacy. Most of the other covariates have qualitatively similar results to our baseline specification. Overall, the results suggest significant impact of financial literacy on insurance demand.

Using altogether the alternate risk preference and financial literacy measures, we find no significant effect of risk preference on insurance demand. The alternate measure indicates insignificant effect of risk aversion on insurance purchase decision. The alternate financial literacy measures show strongly significant and positive effect on WII demand.

In general, the robustness checks suggest the risk preference effects are not sensitive to change in specification. Similarly, the financial literacy effects are strong and less sensitive to alternate measures. Considering only the basic and advanced measures of financial literacy only, the results suggest strong evidence of financial literacy on insurance decision. In a society with low level of literacy and financial practices, simple measurements based on series of questions could effectively capture the difference in financial literacy level. Hence, we argue that the basic and advanced financial literacy measures are very good measures in our setting. Overall, financial literacy is a key non-price factor that affect the up-take of index insurance.

6.2.2 Additional covariates

Table 9 reports the special regressor estimates where we include more covariates (credit, formal saving, remittance and understanding about WII). Some of these covariates could possibly be endogenous. We show that our main specification results are almost similar to further controlling to these additional variables. These additional regressors are not statistically significant. A possible explanation may be that these variables are proxies that err to correctly measure the respective variables hence low power to detect the relationship between the variables and WII purchase. Or, they actually do not have any effect on WII purchase. Though insignificant, the sign of coefficient for formal saving and credit indicate complementarity with WII respectively. With the additional covariates, participation in *eqqub* and experiencing shock are positively correlated with index insurance demand. Finally, we note that the results in Table 9 should be taken with the necessary caution as they are based on cross-sectional evidence and perhaps endogenous regressor as well.

7 Conclusion and policy implications

Weather risk poses a constant threat to economic well being, especially for agrarian economy. Households found to use different risk management strategies to overcome cost of risk, though studies document ineffectiveness of the strategies especially for covariate risk. Hence, a large agrarian population is uninsured of weather risk. An element of risk reduction strategy is to expand household's risk management options. Recently, an innovative insurance product (weather index insurance) is on roll-out in several developing countries with aim of relaxing the insurance constraints and providing them with additional risk management strategy. However, the actual

uptake for the product is rather low. This necessitate for empirically understanding who buys and do not buy the product, in order to effectively target the program and make it viable risk management option. In this paper, we empirically assess the key non-price factors that affect demand of index insurance for a largely traded commercial weather index insurance in Ethiopia. We focus on non-price factors that influence demand owing to lack of variation in price for the product.

Unlike most previous studies, we focus on commercially traded large weather index insurance in Africa. Besides, we elicit risk preference using lottery choice game and measure financial literacy using battery of questions. Furthermore, we uncover the causal factors that influence demand for index insurance using special regressor approach. Indeed, the result hinges on the validity of our special regressor and the instrument variables we use. However, the IV tests, our robustness checks and the consistent results of the variants of specifications render our causal claim valid.

The positive effect of financial literacy on insurance uptake imply for strengthening efforts in provision of financial literacy programs. There are claims that offering training in financial education could be expensive (Matul et al., 2013). However, there are evidence elsewhere that financial literacy has a wider implication for household welfare (Behrman et al., 2010) and participation in finance (Cole et al., 2011; Van Rooij et al., 2011b,a; Jappelli and Padula, 2013). Thus, the provision of financial literacy have even a wider impact than raising demand for index insurance. Furthermore, financial literacy programs can possibly be integrated at lower cost in an innovative way with already running agricultural extension programs.

The positive effect of relaxing liquidity constraint also implies to further work on better designs that account for liquidity constraint of the households. For instance, during good harvest season, sales of the insurance policy could be done immediately after the harvest season when the farmers have less cash constraint than at the beginning of production season. A closely similar evidence is provided in Duflo et al. (2011) though for different product, fertilizer. On the flip side, effecting payouts as immediately as possible once the index triggers the payment. Such design would enhance demand for index insurance accounting for the liquidity constraint of the household and building the quality of the product that increases the trust of the households on the product.

The negative association between risk aversion and participation decision perhaps imply riskiness of the product. Hence, it has an implication for product design and distribution. One, the product design should focus on ways that reduce the riskiness depiction. The product should be presented clearly reducing ambiguity, efforts should be made to reduce possible basis risk of the product. Two, insurers should leave up to their promises to increase trust and promptly make payouts when the index triggers. Three, the marketing strategies should also account for the psychology of human behavior (Dalal and Morduch, 2010).

The evidence in this paper focuses on the non-price factors that affect early uptake of index insurance in a cross-section of households. With continued roll-out of the product, further research is needed to understand the dynamics of uptake for the product and the factors behind so as to sustain demand.

Table 1: Sampled Households by District (Woreda) and Village (Tabia)

District	Village	Insurance Status		Total
		Purchasers	*Non-purchasers*	
Raya Azebo	Genetie	16	31	47
	Hadealga	24	29	53
Kola Tembien	Adiha	46	11	57
	Awet bikalsi	30	18	48
Sase'a Tsa'adaemba	Hadush Adi	53	17	70
Total		169	106	275

Table 2: Lottery Choice Game

Task	Safe Option	Risky option			
		p_l	R_l	p_h	R_h
A	2	0.5	0	0.5	5
B	2	0.5	0	0.5	10
C	2	0.5	0	0.5	15

Table 3: Summary Statistics of Variables Used in Estimation

	Mean	Sd	Min	Max
Dependent variable				
Weather Index Insurance	0.615	0.488	0.000	1.000
Preference				
Risk aversion parameter	0.381	0.191	-0.224	0.802
Risk attitude: hypothetical inv't question (in '000s)	4.854	2.488	0.000	10.000
Time preference (1 if dr >= 30 percent)	0.545	0.499	0.000	1.000
Financial literacy				
Basic financial literacy index	48.691	22.092	0.000	90.000
Advanced financial literacy index	44.848	17.787	6.667	86.667
Basic financial literacy PRIDIT score	0.000	6.041	-12.213	10.289
Advanced financial literacy PRIDIT score	0.000	6.041	-12.583	12.124
Understand WII	0.665	0.473	0.000	1.000
Wealth				
Land owned in timad	2.606	2.507	0.000	12.000
Demographic characteristics				
Age of household head	44.771	12.885	20.000	85.000
Sex of household head	0.396	0.490	0.000	1.000
Household size	5.280	2.027	1.000	12.000
Illiterate (1=yes)	0.651	0.478	0.000	1.000
Elementary education (1=yes)	0.284	0.452	0.000	1.000
Secondary education (1=yes)	0.065	0.248	0.000	1.000
Alternative risk management strategies				
PSNP Participation (1=yes)	0.629	0.484	0.000	1.000
Eqqub participation (1=yes)	0.080	0.272	0.000	1.000
Iddir participation (1=yes)	0.156	0.364	0.000	1.000
Remittance and other gifts received	0.124	0.330	0.000	1.000
Credit (1=accessed)	0.425	0.495	0.000	1.000
Formal saving (1=yes)	0.105	0.308	0.000	1.000
Shock				
Shock dummy (1= experienced shock last 3 years)	0.527	0.500	0.000	1.000
Instrument variables				
Extension contact frequency-dry season	1.848	1.640	0.000	9.000
Household own mobile (1=yes)	0.378	0.486	0.000	1.000
Household own radio (1=yes)	0.207	0.406	0.000	1.000
Location dummies				
Adiha (1=yes)	0.207	0.406	0.000	1.000
Awetbikalsi (1=yes)	0.175	0.380	0.000	1.000
Genetie (1=yes)	0.171	0.377	0.000	1.000
Hadealga (1=yes)	0.193	0.395	0.000	1.000
Hadushadi (1=yes)	0.255	0.436	0.000	1.000
# of observations	275			

Table 4: Descriptive Statistics by Insurance Status

	WII non-buyer		WII buyer		Total	
Preference						
Risk aversion parameter	0.441	(0.184)	0.341	(0.188)	0.380	(0.193)
Risk attitude: hypothetical inv't question	4.515	(2.562)	5.059	(2.460)	4.847	(2.509)
Time preference (1 if dr >= 30 percent)	0.515	(0.502)	0.574	(0.496)	0.551	(0.498)
Financial literacy						
Basic financial literacy index	44.272	(24.479)	51.543	(19.705)	48.717	(21.930)
Advanced financial literacy index	39.612	(18.967)	48.148	(16.126)	44.830	(17.747)
Basic financial literacy PRIDIT score	-1.116	(6.517)	0.691	(5.480)	-0.012	(5.959)
Advanced financial literacy PRIDIT score	-1.294	(6.509)	0.804	(5.493)	-0.011	(5.985)
Understand WII	0.641	(0.482)	0.698	(0.461)	0.675	(0.469)
Wealth						
Land owned in timad	3.091	(2.982)	2.371	(2.116)	2.651	(2.508)
Demographic characteristics						
Age of household head	47.126	(14.094)	43.111	(11.882)	44.672	(12.911)
Sex of household head	0.369	(0.485)	0.414	(0.494)	0.396	(0.490)
Household size	5.320	(2.310)	5.253	(1.869)	5.279	(2.048)
Illiterate (1=yes)	0.767	(0.425)	0.586	(0.494)	0.657	(0.476)
Elementary education (1=yes)	0.204	(0.405)	0.321	(0.468)	0.275	(0.448)
Secondary education (1=yes)	0.029	(0.169)	0.093	(0.291)	0.068	(0.252)
Alternative risk management strategies						
PSNP participation (1=yes)	0.515	(0.502)	0.685	(0.466)	0.619	(0.487)
Eqqub participation (1=yes)	0.039	(0.194)	0.111	(0.315)	0.083	(0.276)
Iddir participation (1=yes)	0.107	(0.310)	0.173	(0.379)	0.147	(0.355)
Remittance and other gifts received	0.175	(0.382)	0.099	(0.299)	0.128	(0.335)
Credit (1=accessed)	0.437	(0.498)	0.426	(0.496)	0.430	(0.496)
Formal saving (1=yes)	0.068	(0.253)	0.130	(0.337)	0.106	(0.308)
Shock						
Shock dummy (1= experienced shock last 3 years)	0.650	(0.479)	0.444	(0.498)	0.525	(0.500)
Instrument variables						
Extension contact frequency-dry season	2.097	(1.757)	1.691	(1.562)	1.849	(1.649)
Household own mobile (1=yes)	0.320	(0.469)	0.414	(0.494)	0.377	(0.486)
Household own radio (1=yes)	0.155	(0.364)	0.241	(0.429)	0.208	(0.406)
Location dummies						
Adiha (1=yes)	0.107	(0.310)	0.278	(0.449)	0.211	(0.409)
Awetbikalsi (1=yes)	0.175	(0.382)	0.179	(0.385)	0.177	(0.383)
Genetie (1=yes)	0.291	(0.457)	0.099	(0.299)	0.174	(0.379)
Hadealga (1=yes)	0.272	(0.447)	0.142	(0.350)	0.192	(0.395)
Hadushadi (1=yes)	0.155	(0.364)	0.302	(0.461)	0.245	(0.431)

mean coefficients; sd in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Mean Difference Test by Insurance Status

	Mean Difference: Non-buyers vs buyers	
Risk aversion parameter	0.102***	(4.45)
Risk attitude: hypothetical inv't question	-0.570*	(-1.85)
Basic financial literacy index	-7.388***	(-2.73)
Advanced financial literacy index	-9.015***	(-4.21)
Basic financial literacy PRIDIT score	-1.830**	(-2.47)
Advanced financial literacy PRIDIT score	-2.162***	(-2.93)
Age of household head	3.811**	(2.41)
Household size	0.0663	(0.26)
Land owned in timad	0.755**	(2.45)
Extension contact frequency-dry season	0.390*	(1.91)
# of observations	275	

t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Proportion Difference Test by Insurance Status

	Proportion Difference: Non-buyers vs buyers	
Time preference (1 if dr >= 30 percent)	-0.0586	(-0.95)
Understand WII	-0.0543	(-0.92)
Sex of household head	-0.0463	(-0.77)
Illiterate (1=yes)	0.184***	(3.29)
Elementary education (1=yes)	-0.124**	(-2.31)
Secondary education (1=yes)	-0.0605**	(-2.23)
PSNP participation (1=yes)	-0.164***	(-2.73)
Eqqub participation (1=yes)	-0.0688**	(-2.29)
Iddir participation (1=yes)	-0.0549	(-1.27)
Remittance and other gifts received	0.0751*	(1.75)
Credit (1=accessed)	0.0292	(0.48)
Formal saving (1=yes)	-0.0641*	(-1.81)
Shock dummy (1= experienced shock last 3 years)	0.217***	(3.62)
Household own mobile (1=yes)	-0.0934	(-1.58)
Household own radio (1=yes)	-0.0763	(-1.58)
Adiha (1=yes)	-0.168***	(-3.72)
Awetbikalsi (1=yes)	-0.00770	(-0.16)
Genetie (1=yes)	0.198***	(3.99)
Hadealga (1=yes)	0.132***	(2.58)
Hadushadi (1=yes)	-0.153***	(-3.04)
# of observations	275	

t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: Marginal Effects: Determinants of Insurance Take-up

	Special regressor	Control function	IV-LPM	Probit
Preference				
Risk aversion parameter	-0.152	-0.154	-0.102	-0.208
	(0.192)	(0.369)	(0.363)	(0.376)
Time preference (1 if dr >= 30 percent)	0.099**	0.034	0.038	0.048
	(0.041)	(0.056)	(0.059)	(0.057)
Financial literacy				
Basic financial literacy index	0.006***	0.005	0.005	-0.001
	(0.002)	(0.005)	(0.007)	(0.001)
Wealth				
Land owned (in timad)	0.078***	0.008	0.005	0.006
	(0.026)	(0.014)	(0.014)	(0.014)
Alternative risk management strategies				
PSNP participation (1=yes)	0.099***	0.138**	0.135**	0.111*
	(0.032)	(0.060)	(0.068)	(0.061)
Eqqub participation (1=yes)	0.064	0.303***	0.285***	0.314***
	(0.048)	(0.115)	(0.104)	(0.114)
Iddir participation (1=yes)	-0.004	0.152*	0.172**	0.137*
	(0.051)	(0.081)	(0.082)	(0.079)
Shock				
Shock dummy (1= experienced shock last 3 years)	0.062	0.034	0.019	0.003
	(0.047)	(0.120)	(0.122)	(0.121)
Demographic characteristics				
Age of household head	-0.001	-0.001	-0.002	-0.004*
	(0.002)	(0.003)	(0.003)	(0.002)
Sex of household head	0.102***	0.074	0.077	0.046
	(0.035)	(0.070)	(0.076)	(0.069)
Household size	-0.025***	0.005	0.009	0.017
	(0.009)	(0.017)	(0.018)	(0.015)
Elementary education (1=yes)	-0.015	-0.006	0.010	0.095
	(0.047)	(0.109)	(0.119)	(0.072)
Secondary education (1=yes)	-0.149*	0.051	0.039	0.172
	(0.087)	(0.169)	(0.171)	(0.135)
Location dummies				
Adiha (1=yes)	0.007	0.071	0.077	0.035
	(0.066)	(0.103)	(0.107)	(0.105)
Awetbikalsi (1=yes)	-0.024	-0.005	-0.012	-0.060
	(0.050)	(0.102)	(0.110)	(0.093)
Genetie (1=yes)	-0.173*	-0.219	-0.291**	-0.338***
	(0.104)	(0.145)	(0.136)	(0.100)
Hadealga (1=yes)	-0.045	-0.115	-0.171	-0.229**
	(0.074)	(0.152)	(0.151)	(0.107)
Observations	245	268	268	274

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Special Regressor Estimates-Alternate Risk Aversion and Financial Literacy measures

	(1)	(2)	(3)	(4)	(5)
Preference					
Risk aversion parameter	-0.305	-0.173	-0.088	-0.130	
	(0.230)	(0.232)	(0.237)	(0.184)	
Risk attitude: hypothetical inv't question					0.002
					(0.009)
Time preference (1 if dr >= 30 percent)	0.125**	0.036	0.069	0.092*	0.025
	(0.052)	(0.039)	(0.053)	(0.051)	(0.031)
Financial literacy					
Basic financial literacy index					0.006***
					(0.002)
Standardized basic financial literacy index	0.182***				
	(0.069)				
Advanced financial literacy index		0.009*			
		(0.005)			
Basic financial literacy PRIDIT score			0.021**		
			(0.008)		
Advanced financial literacy PRIDIT score				0.026***	
				(0.009)	
Wealth					
Land owned (in timad)	0.107***	0.063**	0.055*	0.072**	0.034**
	(0.030)	(0.030)	(0.031)	(0.032)	(0.013)
Alternative risk management strategies					
PSNP participation (1=yes)	0.160*	0.109**	0.083**	0.105**	0.096**
	(0.083)	(0.051)	(0.042)	(0.045)	(0.044)
Eqqub participation (1=yes)	0.092**	-0.002	0.039	0.048	0.035
	(0.042)	(0.063)	(0.086)	(0.065)	(0.057)
Iddir participation (1=yes)	0.001	0.034	0.002	0.012	0.041
	(0.048)	(0.034)	(0.051)	(0.045)	(0.036)
Shock					
Shock dummy (1= experienced shock last 3 years)	0.144	0.095	0.068	0.091**	0.027
	(0.088)	(0.078)	(0.060)	(0.046)	(0.032)
Demographic characteristics					
Age of household head	-0.001	-0.001	-0.000	-0.001	0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
Sex of household head	0.117***	0.028	0.082***	0.099***	0.052***
	(0.040)	(0.048)	(0.026)	(0.030)	(0.019)
Household size	-0.038***	-0.026**	-0.021	-0.026***	-0.017*
	(0.014)	(0.012)	(0.013)	(0.009)	(0.010)
Elementary education (1=yes)	-0.026	-0.062	-0.037	-0.045	-0.089**
	(0.086)	(0.059)	(0.036)	(0.028)	(0.045)
Secondary education (1=yes)	-0.221*	-0.169	-0.133*	-0.174**	-0.116
	(0.124)	(0.150)	(0.071)	(0.074)	(0.084)
Location dummies					
Adiha (1=yes)	0.031	0.068	0.026	0.021	0.030
	(0.054)	(0.080)	(0.056)	(0.037)	(0.034)
Awetbikalsi (1=yes)	-0.079	-0.053	0.001	-0.018	-0.019
	(0.065)	(0.061)	(0.047)	(0.026)	(0.040)
Genetie (1=yes)	-0.245**	-0.056	-0.136	-0.162*	-0.049
	(0.115)	(0.089)	(0.110)	(0.097)	(0.077)
Hadealga (1=yes)	-0.076	0.116	-0.037	-0.029	0.058
	(0.103)	(0.098)	(0.056)	(0.048)	(0.054)
Observations	248	253	245	245	256

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Marginal Effects: Correlates of Insurance Take-up

	Special regressor
Preference	
Risk aversion parameter	-0.070
	(0.207)
Time Preference (1 if dr >= 30 percent)	0.097*
	(0.057)
Financial literacy	
Basic financial literacy index	0.007**
	(0.003)
Understand WII	0.014
	(0.029)
Wealth	
Land owned (in timad)	0.082**
	(0.039)
Alternative risk management strategies	
PSNP participation (1=yes)	0.141**
	(0.068)
Eqqub participation (1=yes)	0.061*
	(0.035)
Iddir participation (1=yes)	0.005
	(0.051)
Credit (1=accessed)	0.004
	(0.028)
Formal saving (1=yes)	0.006
	(0.035)
Remittance and other gifts received	-0.009
	(0.061)
Shock	
Shock dummy (1= experienced shock last 3 years)	0.086*
	(0.046)
Demographic characteristics	
Age of household head	-0.001
	(0.002)
Sex of household head	0.068
	(0.047)
Household size	-0.028**
	(0.012)
Elementary education (1=yes)	-0.052
	(0.076)
Secondary education (1=yes)	-0.173
	(0.108)
Location dummies	
Adiha (1=yes)	0.077
	(0.058)
Awetbikalsi (1=yes)	-0.051
	(0.073)
Genetie (1=yes)	-0.211*
	(0.108)
Hadealga (1=yes)	-0.081
	(0.058)
Observations	250

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 10: First Stage Estimates

	Dependent variable: Basic financial literacy index
Preference	
Risk aversion parameter	-13.425
	(13.81)
Time preference (1 if dr >= 30 percent)	-0.161
	(2.259)
Wealth	
Land owned (in timad)	-0.126
	(0.551)
Alternative risk management strategies	
PSNP participation (1=yes)	-3.618
	(2.434)
Eqqub participation (1=yes)	1.642
	(4.000)
Iddir participation (1=yes)	-1.532
	(3.165)
Shock	
Shock dummy (1= experienced shock last 3 years)	-5.424
	(4.491)
Demographic characteristics	
Age of household head	-0.339***
	(0.090)
Sex of household head	-4.292
	(2.654)
Household size	1.116*
	(0.611)
Elementary education (1=yes)	14.853***
	(2.722)
Secondary education (1=yes)	17.643***
	(4.718)
Location dummies	
Adiha (1=yes)	-6.309
	(3.986)
Awetbikalsi (1=yes)	-8.585***
	(3.730)
Genetie (1=yes)	-16.445***
	(4.223)
Hadealga (1=yes)	-17.729***
	(4.330)
Instrument/Excluded variable	
Frequency of extension contact-dry season	3.009***
	(0.760)
Observations	250
Underidentification test	
Angrist-Pischke multivariate F test of excluded instrument	15.690
	0.000
Anderson canonical correlation LM statistics	15.83
	0.000
Kleibergen-paap rk LM statistics	15.588
	0.000
Weak IV test	
Cragg-Donald Wald F-statistics	15.690
Kleibergen-paap rk Wald F statistics	15.775

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 11: Special Regressor Estimates: Determinants of Insurance Take-up

	Main estimates	First stage estimates
Basic financial literacy index	0.008***	
	(0.002)	
Risk aversion parameter	-0.128	-13.578
	(0.295)	(13.924)
Time preference (1 if dr >= 30 percent)	0.137***	-0.176
	(0.036)	(2.266)
Land owned (in timad)	0.104**	-0.123
	(0.045)	(0.552)
PSNP participation (1=yes)	0.152	-3.649
	(0.104)	(2.446)
Eqqub participation (1=yes)	0.092**	1.670
	(0.047)	(4.011)
Iddir Participation (1=yes)	-0.009	-1.528
	(0.064)	(3.172)
Shock dummy (1= experienced shock last 3 years)	0.058	-5.350
	(0.071)	(4.526)
Age of household head	-0.001	-0.339***
	(0.004)	(0.090)
Sex of household head	0.102	-4.328
	(0.101)	(2.670)
Household size	-0.037**	1.119*
	(0.016)	(0.613)
Elementary education (1=yes)	-0.016	14.904***
	(0.042)	(2.748)
Secondary education (1=yes)	-0.180**	17.773***
	(0.083)	(4.804)
Adiha (1=yes)	0.018	-6.269*
	(0.099)	(4.002)
Awetbikalsi (1=yes)	-0.066	-8.548**
	(0.089)	(3.746)
Genetie (1=yes)	-0.232	-16.546***
	(0.161)	(4.284)
Hadealga (1=yes)	-0.057	-17.856***
	(0.146)	(4.418)
Instrument/Excluded variable		
Frequency of extension contact-dry season		3.014***
		(0.762)
Own radio (1=yes)		-.443
		(2.923)
Constant		68.189***
		(8.067)
Observations	245	268
Underidentification test		
Angrist-Pischke multivariate F test of excluded instrument	7.830	0.000
Anderson canonical correlation LM statistics	15.850	0.000
Kleibergen-paap rk LM statistics	15.810	0.000
Weak IV test		
Cragg-Donald Wald F-statistics	7.830	
Kleibergen-paap rk Wald F statistics	8.110	

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

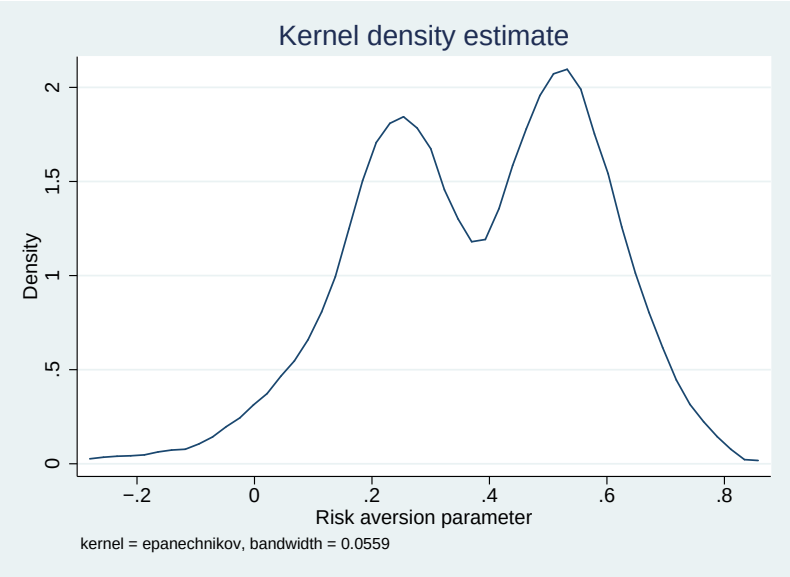

Figure 1: Kernel density of risk aversion parameter

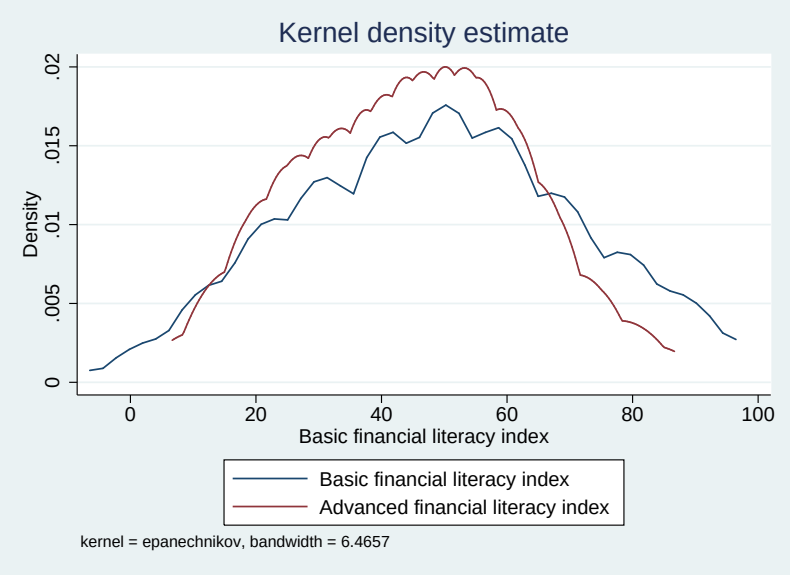

Figure 2: Kernel density of basic and advanced financial literacy index

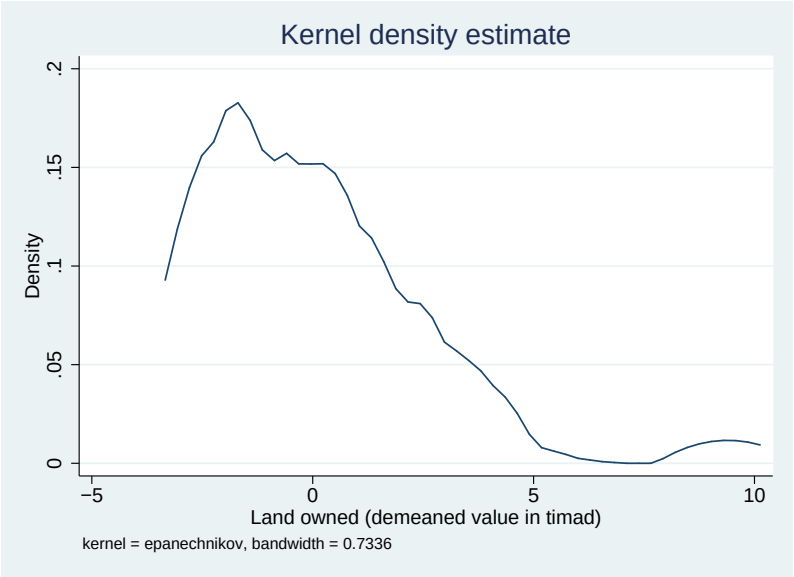

Figure 3: Kernel density of land owned(demeaned value in timad)

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SUPPLEMENTARY MATERIALS

A Risk attitude elicitation using survey experiments

A.1 Hypothetical investment question

Please consider what you would do in the following situation: Imagine that you had won 10,000 Birr in the lottery. Almost immediately after you collect the winnings, you receive the following financial offer from reputable bank (firm), the conditions of which are as follows:

There is a chance to double the money within two years. It is equally possible that you could lose half of the amount invested. You have the opportunity to invest the full amount or reject the offer. What share of your lottery winnings would you be prepared to invest in this financially risky yet lucrative investment? [ ] [ ] 10,000 [ ] 8,000 [ ] 6,000 [ ] 4,000 [ ] 2,000 [0] Nothing, I would decline the offer

A.2 Risk experiment

Interviewer Readout: Now we would like to ask you some questions that are questions about what you would do in certain circumstances. To compensate you for participating and to further understand your decisions, we will also pay some games in which you will have chance to earn a small amount of money. Please pay careful attention and ask if a question is not clear.

1. Consider a game of chance, in which a coin is tossed. If a head appears, you will be paid Birr 5. If a tail appears, you will not be paid anything. You have a choice. You can receive Birr 2 or you may play this game. If you decide to play this game, you will get Birr 5 if a head appears and 0 if a tail appears. We will pay you immediately. Which action do you prefer? [1] Birr 2 with certainty [2] Play the game

2. Interviewer: Toss the coin. If head occurs, give respondent Birr 5. [5]Head [0] Tail

3. Consider a game of chance, in which a coin is tossed. If a head appears, you will be paid Birr 10. If a tail appears, you will not be paid anything. You have a choice. You can receive Birr 2 or you may play this game. If you decide to play this game, you will get Birr 10 if a head appears and 0 if a tail appears. We will pay you immediately. Which action do you prefer? [1] Birr 2 with certainty [2] Play the game

4. Interviewer: Toss the coin. If head occurs, give respondent Birr 10. [10]Head [0]Tail

5. Consider a game of chance, in which a coin is tossed. If a head appears, you will be paid Birr 15. If a tail appears, you will not be paid anything. You have a choice. You can receive Birr 2 or you may play this game. If you decide to play this game, you will get Birr 20 if a head appears and 0 if a tail appears. We will pay you immediately. Which action do you prefer? [1] Birr 2 with certainty [2] Play the game

6. Interviewer: Toss the coin. If head occurs, give respondent Birr 15. [15]Head [0] Tail

B Structural estimation of risk aversion parameter using survey experiments

Each individual (head of the household) given choices between safe and risky option. Assuming individuals exhibit based an expected utility theory (EUT) and using the standard Constant Relative Risk Aversion (CRRA) utility function commonly used (Harrison and Rutström, 2008; Kim and Lee, 2012; Binswanger, 1980) we structurally estimate the risk aversion parameter as discussed below.

Let us denote R and S, respectively, the risky and safe choice. Given the safe and risky choices with equal probabilities ($p = 0.5$), an individual will compare EU of both choices as given by the following index function $\nabla E(U)$ in (A1).

$$\nabla E(U) = E[U(R)] - E[U(S)] \tag{B.1}$$

where $E(U_k) = \Sigma p_k U(k)$ denotes the expected utility of option $k = \{R, S\}$. This index function can be linked to the observed choices using a standard cumulative normal distribution function $\Phi(\nabla E(U))$. Thus, the probability of choosing risky option can be given using the probit link function as in (A2) below:

$$P(R) = \Phi(\nabla E(U)) \tag{B.2}$$

Under EUT, given the CRRA utility function and vector of demographic characteristics $\mathbf{x}$ of the individual, we construct the conditional log-likelihood function for the respondents' choice for each of the three lottery questions.

$$\ln L(r; y, X) = \sum_{i=1}^{n} \sum_{j=1}^{3} ((\ln \Phi(\nabla E(U))|y_i = 1) + (\ln \Phi(1 - \nabla E(U))|y_i = 0)) \tag{B.3}$$

We use the log-likelihood function to estimate the parameter, r. To allow for heterogeneity of the risk aversion parameter, we estimate the function with and without $\mathbf{x}$. Finally, we predict r given $\mathbf{x}$ for each individual and use the predicted value as our regressor in the reduced form insurance demand equation.

C Measuring financial literacy

We have used series of questions to measure financial literacy and to be able to distinguish between financial knowledge and skills. The precise wording of the questions are provided below. The numeracy and literacy questions are adapted from (Cole et al., 2011); while the insurance specific literacy questions are based on (Madajewicz et al., 2010). We constructed our index by summing th correctly answered questions divided by the total number of questions (10 in the case of financial literacy and 5 for insurance literacy).

1. How much is 3+4?
2. If you have 500 Birr and friends give you 200 Birr, how many Birr do you have?
3. How much is 35+82?
4. What is 3 multiplied by 6?
5. What is one-tenth of 400?
6. Suppose you want to buy liter of oil that costs 37 birr and you have 100 Birr note. How much change will you get?
7. Suppose you borrowed Birr 1000 from a money lender and the interest rate was 2% per month. If you made no repayment for three months, how much would you owe? [1] less than Birr 1020 [2] exactly Birr 1020 [3] more than Birr 1020 [-999] DK [-9999] RA
8. Suppose you need to borrow Birr 1000. Two people offer you a loan. One loan requires you pay back Birr 1100 in one month. The second loan requires you to pay back Birr 1000 and 15 percent interest per month. Which loan would you prefer? [1] Birr 1100 in one month [2] birr 1000 and 15 percent interest [-999] DK [-9999] RA
9. Suppose that you saved Birr 1000 in a saving account and were earning an interest rate of 4% per year. If prices were increasing at a rate of 2% per year, after one year, would you be able to buy more than, less than or exactly the same amount as today with the money in the account? [1] less than today [2] exactly as much as today [3] more than today [-999] DK [-9999] RA
10. Do you think the following statement is true or false? For a farmer, planting one crop in a single plot is usually safer than planting multiple crops in a plot. [1] True [0] False [-999] DK [-9999] RA
11. When does insurance give you a payout? [1] When your yields are poor [2] When rainfall is below a certain level according to rain gauge or satellite [3] When rainfall is below a certain level on your field [4] Other please describe [-999] DK [-9999] RA

12. Will you receive a payout every time your yields are poor? [1] Yes [0] No [-999] DK [-9999] RA

13. If you receive an insurance payout, will the payout cover all of your losses or only a part of your losses? [1]The insurance will cover all of my losses [2]Most of the time the insurance will cover only part of my losses [3]Other please describe [-999] DK [-9999] RA

14. Would you ever receive a refund of your premium? [1] Yes [0] No [-999] DK [-9999] RA

15. What is the organization that is offering the insurance? [1] DECSI [2] REST [3] Oxfam America [4] Nyala Insurance Co. [5] Africa Insurance Co. [6]Other please describe [-999] DK [-9999] RA

Table 12: Variable Description

Variables	Type	Description
Dependent Variable		
Weather Index Insurance (WII)	Binary	variable that take 1 if the household bought WII,0 otherwise
Explanatory Variables		
Preference		
Risk aversion parameter	Continuous	variable estimated based on binary lottery choice game as discussed in section 3.3
Risk attitude: hypothetical inv't question	Continuous	variable based on hypothetical investment question as discussed in section A.1.
Time preference	Binary	a variable that takes value 1 if the respondents discount rate based on the set of hypothetical questions is at least 30%, 0 otherwise.
Financial literacy		
Basic financial literacy index	Limited	an index that measure financial literacy based on set of questions as discussed in section 3.5
Advanced financial literacy index	Limited	an index that measure insurance specific literacy based on set of questions discussed in section 3.5
Basic financial literacy PRIDIT score	Continuous	an index that measure financial literacy based on set of questions as discussed in section 3.5 with PRIDIT weights.
Advanced financial literacy PRIDIT score	Continuous	an index that measure insurance specific literacy based on set of questions discussed in section 3.5 with PRIDIT weights.
Understand WII	Binary	self-reported level of understanding about index insurance. It takes value 1 if the respondent replied "I understand WII", 0 otherwise.
Wealth		
Total land	Continuous	a variable measuring the total land size (in timad) owned by the household.
Alternative risk management strategies		
PSNP participation	Binary	measures participation in PSNP. It takes value 1 if the household participates in PSNP, 0 otherwise.
Eqqub participation	Binary	a variable that measures participation in rotating saving arrangement. It takes value 1 if the household is member of eqqub, 0 otherwise.
Iddir participation	Binary	a variable that measures participation in funeral association. It takes value 1 if the household is member of funeral association, 0 otherwise.
Remittance and other gifts	Binary	a dummy variable that takes value 1 if the household received remittance or gifts during this year, 0 otherwise.
Credit	Binary	a dummy variable that takes value 1 if the household has access to credit, 0 otherwise.
Formal saving	Binary	a dummy variable that takes value 1 if the household has formal saving, 0 otherwise.
Shock		
Shock	Binary	a variable measuring the total land size (in timad) owned by the household.
Demographic characteristics		
Age of household head	Continuous	a continuous variable that measures household head's age in years.
Sex of household head	Binary	a dummy variable that takes value 1 if the household head is female, 0 otherwise.
Household size	Continuous	a continuous variable that measure the total number of household members including the household head.
Illiterate	Binary	a variable that takes value 1 if the household head is illiterate, 0 otherwise.
Elementary education	Binary	a variable that takes value 1 if the household head attended some elementary level of education (Grade 1-6), 0 otherwise
Secondary education	Binary	a variable that takes value 1 if the household head attended some secondary level of education, 0 otherwise
Instrument variables		
Extension contact frequency-dry season	Continuous	a variable that measures the frequency of contacts with extension agent during dry season
Household own mobile (1=yes)	Binary	a dummy variable that takes value 1 if the household owns mobile phone
Household own radio (1=yes)	Binary	a dummy variable that takes value 1 if the household owns radio
Location dummies		
Adiha	Binary	It takes value 1 if the household is from the stated village, 0 otherwise.
Awetbikalsi	Binary	It takes value 1 if the household is from the stated village, 0 otherwise.
Genetie	Binary	It takes value 1 if the household is from the stated village, 0 otherwise.
Hadealga	Binary	It takes value 1 if the household is from the stated village, 0 otherwise.
Hadushadi	Binary	It takes value 1 if the household is from the stated village, 0 otherwise.

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