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Adoption of Weather Index Insurance

Learning from Willingness to Pay among a Panel of Households in Rural Ethiopia

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ABSTRACT

In this paper we examine which farmers would be early entrants into weather index insurance markets in Ethiopia, were such markets to develop on a large scale. We do this by examining the determinants of willingness to pay for weather insurance among 1,400 Ethiopian households that have been tracked for 15 years as part of the Ethiopia Rural Household Survey. This provides both historical and current information with which to assess the determinants of demand. We find that educated, rich, and proactive individuals were more likely to purchase insurance. Risk aversion was associated with low insurance take-up, suggesting that models of technology adoption can inform the purchase and spread of weather index insurance. We also assess how willingness to pay varied as two key characteristics of the contract were varied and find that basis risk reduced demand for insurance, particularly when the price of the contract was high, and that provision of insurance through groups was preferred by women and individuals with lower levels of education.

Keywords: risk, index-insurance, willingness to pay, Ethiopia

1. INTRODUCTION

Uninsured risk is pervasive in developing countries, often with pernicious consequences. Shocks such as floods, droughts, price shocks, market collapses, or civil strife can lead directly to a loss of livelihoods by destroying assets, as when a flood washes away a farmer's topsoil, or by reducing current returns to existing assets, as when a drought causes harvests to fail. A large shock or a series of repeated shocks in quick succession can force households to sell off assets to the point where they find themselves in a poverty trap. For example, farmers in Ethiopia who suffered livestock and other losses in the droughts of the 1980s found it difficult to recover and experienced considerably slower income growth in the decades that followed (Dercon 2004). Shocks, even if they are temporary, can also reduce investment in human capital with long-lasting consequences. In Zimbabwe, children exposed to the civil war preceding independence and the droughts that occurred in the early 1980s were more likely to be stunted as preschoolers, had reduced stature by late adolescence, and completed less formal schooling. These circumstances translate into a reduction in lifetime earnings on the order of 14 percent (Alderman, Hoddinott, and Kinsey 2006).

Even if shocks do not reduce asset holdings, the threat of shocks discourages innovation and risk taking. The expectation that something bad may happen affects household behavior, causing households that are unprotected to avoid expending effort on risky activities (Morduch 1991; Dercon 1996; Hill 2009), and to avoid putting their money into irreversible investments, keeping liquid assets instead (Rosenzweig and Binswanger 1993; Fafchamps and Pender 1997). Walker and Ryan (1990) found that in semiarid areas of India, households may sacrifice up to 25 percent of their average incomes to reduce exposures to shocks. The threat of shocks can make households reluctant to access credit markets because they fear the consequences of an inability to repay. There are a number of means by which households can be protected against the income shocks that arise as a result of deficient rainfall. Informal risk-sharing networks, savings, and credit markets can provide some protection against smaller shocks that do not affect all households in an area. However, these tools can prove ineffective in the face of widespread covariate weather shocks or weather shocks that occur in quick succession.

Given the malign effects of uninsured risk, innovations that reduce the adverse consequences of shocks would seem to hold considerable welfare benefits. Recent developments in index-based weather insurance provide one such possibility. These products base insurance on local rainfall indexes that are closely correlated with yields in the region where the farmer lives. When the index falls below a certain level, farmers automatically get a payment with no requirement of costly estimation of their potential yield losses and no need to address moral hazard. While index insurance offers much potential, there is still work to be done in perfecting its design—in particular in reducing basis risk, improving understanding, and reducing costs of provision. Although provision of index insurance on a small scale has been observed in a number of countries (Giné and Yang 2007; Cole et al. 2009; Hess and Hazell 2009), including Ethiopia (Meherette 2009; Hill and Robles 2011), it has not yet been brought to scale.

In this paper we examine which farmers would be early entrants into weather index insurance markets in Ethiopia. We do this by examining the determinants of willingness to pay for weather insurance among 1,400 Ethiopian households. In contrast to other willingness-to-pay studies, the respondents in this study are households that have been tracked for 15 years as part of the Ethiopian Rural Household Survey. Analysis of previous survey rounds has shown that climatic shocks are widespread (Dercon, Hoddinott, and Woldehanna 2005) and have severe and persistent welfare effects (Dercon 2004). In the final round of this panel survey, conducted in 2009, households were asked about their willingness to pay for a stylized weather index insurance product. We are thus able to use both current characteristics and historical data to assess the determinants of their response. This provides us with a rich dataset with which we can test some of the hypotheses commonly suggested as constraints on demand for index insurance. By randomly selecting the price at which the insurance contract was offered to the respondents, we are also able to examine the price sensitivity of stated willingness to pay.

A primary focus of our analysis is to study the variations in stated willingness to pay across individuals and to use that information to identify who would be the likely first adopters of insurance contracts, were they to be offered. We find that insurance markets will likely be entered into by educated, rich, and proactive individuals. Those facing higher rainfall risk are more likely to respond that they would choose to purchase insurance, while those who behaved in a less risk-averse manner in a Binswanger-style lottery (1980) were found to be more likely to purchase insurance. This pattern has also been found for households in India and Kenya (Cole et al. 2009; Lybbert et al. 2010) and suggests that models of technology adoption can inform the purchase and spread of weather index insurance.

We extend this analysis in two ways. We consider whether willingness to pay would vary were the insurance to be offered through a local risk-sharing group that acts as an insurance broker. Understanding determinants of preferences for insurance offered through different modalities can help inform us about the drivers of demand. Marketing to groups rather than individuals may have a number of advantages. Not only does it reduce the cost of marketing and increase group members' trust in the insurance being offered, but when it is combined with informal risk sharing within the group, it can allow individuals to manage small levels of risk within the group and use group insurance purchases to insure larger or more covariate risks (Clarke and Dercon 2009; Dercon et al. 2010). The groups we consider are traditional funeral associations called *iddirs* that are widespread in Ethiopia. Second, we examine how willingness to pay would be affected were a household to experience downside basis risk, in particular if its members were to pay for an insurance contract, realize a year of bad weather, and not receive a payout (due to the difference between the index and the rainfall on their field). Weather index insurance is characterized by basis risk, and understanding how downside basis risk affects demand—and whether there are some individuals who may be particularly affected—is important to assessing the long-term sustainability of an index insurance market.

Within the Ethiopian context this study also has specific relevance. Weather index insurance has been provided on a small scale in a number of pilot studies in Ethiopia (Meherette 2009; Chen et al. 2010; Hill and Robles 2011). The majority of these pilots have research agendas embedded within them to understand how best to design, price, and deliver weather insurance to farmers. An analysis of demand using long-run panel data provides a broader assessment than is possible within shorter run pilots, and as such is a useful complement to these activities.

Section 2 discusses our conceptual framework on determinants of demand. Section 3 explains the data and descriptive statistics. Section 4 discusses the main findings, and Section 5 concludes.

2. CONCEPTUAL FRAMEWORK

Weather insurance is not the same as standard indemnity insurance. As Clarke (2010) emphasized, because of the presence of basis risk—the probability that the index records a good state of the world when the individual experiences a bad state of the world—it is better thought of as a hedging contract. With this in mind, Clarke (2010) set out a model of demand for weather index products.[1] He assumed that consumers are well-informed, pricetaking, risk-averse utility maximizers with decreasing absolute risk aversion. He showed that demand for index products will be

1. decreasing in basis risk;
2. decreasing in the loading factor (the ratio of the price to the actuarially fair price of the insurance contract);
3. increasing then decreasing with risk aversion when the loading factor is greater than 1 (Very risk-averse individuals will choose to purchase less index insurance on account of the weight they give to the worst-case scenario—the probability that they might realize a bad event when the index realizes a good event. To the extent that risk-averse individuals are also likely to be poorer, this suggests that at some ranges of wealth, wealthier individuals may be more likely to purchase insurance than poorer individuals, even though poorer individuals have more to gain from an insurance product that would indemnify them against their losses.); and
4. ambiguous with respect to wealth. (If index insurance is an inferior good, demand will fall as wealth rises; as a normal good, demand will rise with wealth.)

A critical feature of Clarke's model is the assumption of well-informed agents. However, weather insurance is a new financial product in rural Ethiopia. There is much that is unknown about this financial product. For farmers who do not have bank accounts or borrow from microfinance institutions (MFIs), an insurance purchase would represent the first time they engage with a formal financial institution, and they may have some uncertainty about how the transaction would work and how much such an institution can be trusted. The benefits of the insurance contract itself may also not be immediately clear, since there is much to learn about the probability distribution of the rainfall at the weather station as well as the joint probability between rainfall at the weather station and a farmer's yields. A farmer's perception of the benefits of the perceived distribution may be highly uncertain.

As such, the decision of whether or not to purchase insurance is akin to the decision of whether to adopt a new technology (Giné, Townsend, and Vickery 2008; Lybbert et al. 2010). An example consistent with this view is the tendency of farmers to purchase one or two units of insurance—much less than would be required for full insurance—perhaps to experiment with how well it works. This is similar to the observation that farmers experiment with new technologies or practices on small portions of their land as would be predicted by a Bayesian model of learning about a new technology (O'Mara 1980; Feder and O'Mara 1982).

Competitively priced insurance that is designed to be risk reducing may not be perceived as such, as a result of uncertainty around returns and the probability that it will pay out when needed. Consequently, although insurance is a financial product for which we would expect a positive coefficient on risk aversion for some if not all of the distribution of risk preferences, this relationship may not be observed to hold. Technology adoption studies have long reported that risk-averse households are less likely to be early adopters of new technologies. Empirical analyses of demand for insurance have shown that demand for insurance may decrease with risk aversion across the range of risk aversion (Giné, Townsend, and Vickery 2008; Lybbert et al. 2010).

In addition to suggesting an alternate relationship between risk aversion and adoption, conceptualizing insurance as a technology adoption decision highlights the importance of subjective

[1] Clarke's (2010) model is a generalization of Doherty and Schlesinger's (1990) model of insurance contracting, wherein the provider has a nonzero probability of defaulting on the insurance contract.

expectations (Adesina and Baidu-Forson 1995). Higher levels of trust in financial firms or the financial sector, built as a result of previous interactions through access to formal savings and credit markets, may increase the perceived probability that the insurance contract will pay. We may thus find that even though individuals who have access to formal financial markets have a larger array of risk management tools at their disposal, demand for insurance may increase with financial inclusion. This is also consistent with the hypothesis that ambiguity aversion constrains insurance demand. Bryan (2010) used data collected in Malawi to test the hypothesis that ambiguity aversion reduces demand for insurance and found evidence consistent with this hypothesis.

Further, a large body of literature shows that wealthier households are more likely to be early adopters of new technologies; this implies that adoption will be increasing in wealth. Technology adoption studies have also highlighted the importance of education and entrepreneurial ability in encouraging early adoption. Education increases the ability of farmers to "perceive, interpret, and respond to new events in the context of risk" (Schultz 1981, 25). A number of theoretical and empirical studies have shown that farmers with higher levels of education are more likely to be early adopters of modern technologies (Feder, Just, and Zilberman 1985).

Finally, weather insurance is but one element in households' portfolio of risk management activities. Others include actions that ex-ante smooth income, examples being deciding to grow a mix of crops that embody differing levels of susceptibility to climatic shocks, delaying planting until rainfall patterns are more certain, or diversifying into off-farm activities (Alderman and Paxson 1994; Morduch 1995, 1999; Townsend 1995). These ex ante actions often come at high cost—Bliss and Stern (1982) showed that a two-week delay in planting following the onset of seasonal rains is associated with a 20-percent reduction in rice yields. Consumption-smoothing strategies including the use of savings and borrowing, transfers within networks to spread risk, and accumulation and decumulation of physical assets are other examples of risk management.

Households with good networks and access to savings and borrowing instruments may have lower demand for insurance than those without access to these activities if the cost of engaging in these activities is lower than the cost of purchasing insurance, if insurance reduces consumption variability, and if insurance is perceived as a substitute for these. The demand for weather index insurance will be increasing with the presence of these risk management activities where it is seen to complement existing mechanisms.

These approaches to conceptualizing the demand for insurance—as a stand-alone hedging instrument, as a (financial) innovation to be adopted, or as an element of a portfolio of risk management activities—highlight the different effects of covariates of stated demand for indexed insurance. The three strands of literature also provide different predictions on how demand would change in response to insurance being offered through a group and in response to realizations of basis risk. We summarize these predictions in Table 2.1.

Table 2.1—Contrasting predictions of demand for indexed insurance

	Prediction of direction of correlation of covariate with demand		
Covariate	**Basic model**	**Adoption of an unknown financial product**	**One of many risk management strategies**
Price	Negative	Negative	Negative
Weather risk	Positive	Positive	Positive
Basis risk	Negative	Negative	Negative
Risk aversion	Inverse U	Negative	Inverse U
Wealth	Ambiguous	Positive	Ambiguous
Access to informal risk-sharing tools	None	None	Negative (if risk management tools are cheap), none (if tools are costly)
Access to formal financial markets	None	Positive	Negative (if risk management tools are cheap), none (if tools are costly)

Source: Authors' classifications.

3. DATA AND DESCRIPTIVE STATISTICS

Our data are drawn from the Ethiopian Rural Household Survey (ERHS), a multipurpose panel survey of approximately 1,400 households located in 15 Ethiopian villages that have been interviewed seven times since 1994. While these data are not nationally representative, the survey included the main agroclimatic zones of the country. Each round collected data on demographic characteristics, assets, occupation, cropping patterns, nonagricultural income, consumption, and experiences with shocks.[2] Certain survey rounds also included specialized modules. The 2009 round included a module on willingness to pay for weather insurance, risk preferences, and discount rates. These, along with data describing these households, are discussed below.[3]

Willingness to Pay for Weather Insurance

The willingness-to-pay module began by describing the closest weather station to the respondents' home and the amounts of rain observed at that station over the last 10 years. A hypothetical insurance contract was then described in terms of a "well-known Ethiopian insurance company" offering a payment of 1,500 Ethiopian birr (ETB) when rainfall at the closest weather station fell below a certain level.[4] It was emphasized that the rainfall amount *s*, while possibly similar, would not be identical to the amount that would have fallen on the respondent's own fields and that if this hypothetical contract was accepted, the respondent would be exposed to basis risk. To get a sense of whether the respondents understood the insurance contract properly, a series of questions was asked about when the contract would and would not pay. We also tried to capture understanding of basis risk by asking whether the contract would pay on the basis of rain in their fields or at the nearby weather station, and whether the rainfall at the weather station was similar to the rainfall on their fields. We also asked simple questions on mathematics (addition, multiplication, division, and proportions) and probability to measure their mathematical skill level.

Most respondents could correctly identify when the payouts would and would not occur (89 and 78 percent, respectively) and understood that the payouts were based on the rainfall station, not what fell on their own fields (Table 3.1). These values are skewed by a high number of incorrect responses in the most northerly villages. Excluding these, correct identification of when payouts would and would not occur rises to 92 and 84 percent, respectively. Basic mathematical skills such as addition and multiplication were reasonably good, but many respondents had difficulty correctly answering questions about division, proportions, and probabilities.

Respondents were then asked if they would be willing to buy this insurance for a monthly premium that was randomly selected to lie (in increments of ETB 5) between ETB 10 and ETB 40. This interval was chosen so as to encompass the actuarially fair price of this insurance (ETB 25 monthly), a markup of up to 60 percent on the fair price (that would account for costs associated with marketing, administering, and reinsuring the insurance product), as well as the possibility that this insurance might be subsidized.

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[2] Dercon, Hoddinott, and Woldehanna (2005) provide further details on sampling and implementation of the ERHS.

[3] In addition to the ERHS data, we used rainfall data from Livelihood, Early Assessment, Protection (LEAP, Hoefsloot Spatial Solutions 2009) for the 18 weather stations in our sample. Since the LEAP data are at the *woreda* level, we used (GPS) coordinates of the weather stations nearest to our sample villages to measure rainfall from the LEAP data at those coordinates.

[4] There were no gradual reductions in payments as the millimeters of rainfall increased as there would be in many weather index-based insurance contracts. There was also no payment for late rains or rains that fell at inopportune times during the growing season.

Table 3.1—Understanding insurance contracts and general mathematical skills

	Proportion providing correct response
Understanding of the insurance contract	
No payout for (cutoff rainfall) + 20 mm at weather station	0.78
Payout for (cutoff rainfall) - 50 mm at weather station	0.89
Insurance pays on basis of weather station, not their fields	0.76
Insurance would have paid twice in last 10 years	0.71
Farm by weather station does not always have the same rainfall as you	0.82
Mathematical skills	
Flip a coin, equal probability of getting heads and tails	0.45
Bag with 4 red and 1 white balls, 1 in 5 chance of getting a white ball	0.83
4 + 3 is 7	0.92
3 x 6 is 18	0.71
1/10 of 400 is 40	0.39
15% of 200 is 30	0.28

Source: Ethiopian Rural Household Survey 2009.
Note: Sample size is 1,355.

Respondents were also asked about their willingness to buy insurance after having bought it and experiencing the following hypothetical outcomes:

- Suppose you bought insurance this year. The rains were fine this year and no payout was made to you. Would you buy insurance again next year?
- Suppose you bought insurance each year for five years. You paid the premium each year and the rains were fine five years in a row, so no payout was made to you. Would you still buy insurance the next year?
- Suppose you bought insurance this year. The rains fail on your field but were sufficient at the weather station, so no payout was made to you this year. Would you buy insurance again next year?

Respondents were also asked if they would be willing to purchase the identical insurance product through groups called *iddirs*. Outside of the northern region of Tigray, *iddirs*—burial societies or funeral associations—are ubiquitous, with nearly 90 percent of ERHS respondents belonging to at least one *iddir*. These associations are self-governing and are striking in their degree of formality; often there are written rules and records of contributions and payouts (Dercon et al. 2006). They are inclusive. In the ERHS sample, two-thirds of *iddirs* have no restrictions on membership beyond paying the necessary dues[5] and attending meetings, and all villages (except in Tigray) had at least one *iddir* that was open to anyone. In addition to providing payouts when a member dies—in effect a form of life insurance—a third of the *iddirs* these households belong to provide cash payouts to their members when they experience other types of adverse shocks such as fires or illness; and a quarter of *iddirs* offer loans.

Across the full sample, 42 percent of respondents were willing to purchase an individual weather insurance contract; approximately the same proportion was willing to do so through an *iddir* (Table 3.2). The most common reason given for not purchasing was "I would like to buy it but cannot afford it," with slightly more than 50 percent of non-purchasers giving this answer. Approximately 30 percent stated that they did not need it and 16 percent thought the price was too high, given what was provided. Less than 3 percent of respondents stated that the rainfall on their fields was too different from that at the weather station, that they did not trust the insurance company to pay, or that they really did not understand the contract.

[5] The average monthly contribution for *iddirs* of a household is about ETB 4, which is less than one percent of the average real consumption expenditure.

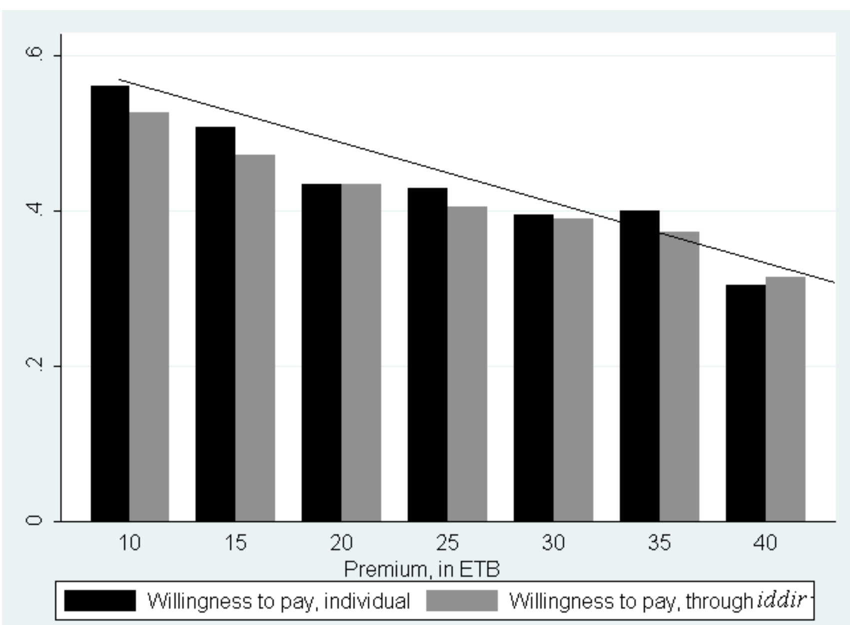
Table 3.2—Willingness to purchase weather insurance

	Proportion willing to purchase
Willingness to purchase individual contract	
At randomly selected price	0.42
Conditional on being willing to purchase initially, willingness to purchase individual contract	
After one year and no payout	0.88
After five years and no payout	0.79
After one year when rains fail on own farm but there is no payout	0.70
Willingness to purchase individual or iddir contract[a]	
Individual contract	0.42
Iddir contract	0.41

Source: Ethiopian Rural Household Survey 2009.
Note: [a] Excludes two villages in Tigray.

The unconditional demand for insurance fell as the price rose (Figure 3.1). Conditional on being willing to purchase insurance, most (88 percent) of respondents were willing to purchase it for a second year even if there were no payout in the first year, and 79 percent were still willing to purchase after five years of good rains and no payout. However, there is a suggestion that willingness to continue purchasing is affected by basis risk, since 30 percent of respondents would not continue purchasing the product if rains failed on their own farms but there was no payout. Respondents were evenly split between preferring an individual contract or one administered through an *iddir*. The main reason for preferring the individual contract was that individuals preferred to make their own payments, whereas those preferring insurance through the *iddir* felt that it was more equitable if everyone had the same insurance and easier if the *iddir* leaders managed payments.

Figure 3.1—Demand for weather insurance



Source: Author's creation.

Risk Aversion and Time Preference

To measure individual risk preferences we administered Binswanger-style lottery choices to each individual in the survey (Binswanger 1980). Two questions were asked. The first represented a real choice with real (monetary) payouts while the second was framed as a hypothetical decision regarding the amount of price risk an individual would choose when it came to selling surplus grain output. Using responses to these questions, we calculated a measure of risk aversion using a constant partial risk aversion utility function (as in Binswanger 1980). Table 3.3 shows the distribution of risk aversion in our sample for both the real and the hypothetical payouts. Interestingly, 42 percent became more risk averse when presented with the hypothetical example, while only 25 percent moved to a riskier option. The tendency to move to a safer option could have been driven by a number of factors. The hypothetical stakes in the hypothetical lottery were much higher than the stakes played for in the real lottery, and higher stakes are often associated with more risk-averse behavior (Holt and Laury 2002). The hypothetical question was framed as a choice of price risk for a crop being sold in a market, and as such was much more integral to an individual's livelihood than a choice over abstract monetary gambles. Given that the gamble was presented as a game, individuals may have been trying to win as much money as possible rather than revealing a true preference for risk.

Table 3.3—Distribution of risk aversion, percent households

		Distribution of sample (percent) when	
Degree of risk aversion	Coefficient of partial risk aversion	Real payouts were used	Hypothetical payouts were used
Severe	3.26–∞	9.0	20.9
Intermediate	1.2–3.26	14.8	15.9
Moderate	0.68–1.2	24.6	22.1
Slight-to-neutral	0.33–0.68	19.0	13.7
Neutral-to-preferred	0–0.33	32.6	27.3

Source: Ethiopian Rural Household Survey 2009.

We use data from both measures of risk preference in our analysis. We use the predicted coefficients, but we also enter the choices directly without assuming any functional form. Harrison, Humphrey, and Verschoor (2010) have shown that for Ethiopia, some households make decisions under uncertainty that are consistent with cumulative prospect theory rather than with expected utility theory. Risk preference parameters estimated assuming a specific functional form for the utility function will thus not be correct for all households. As a result, in the analysis we also directly estimate the relationship between willingness to pay for insurance and lottery choices.

Purchasing insurance requires an individual to set aside money in the present for an event that may occur in the future. As such, an individual's discount rate is also likely to influence the decision of whether or not to buy. We collected data on time preferences by asking individuals to consider a situation in which they were about to receive a gift. They could choose to receive the gift of ETB 100 today or could instead choose to receive a gift of ETB 100 + X one month from now, where X was increased from ETB 25 to the point at which the household chose to wait. Discount rates are calculated using this information on how much an individual requires to be paid to choose to wait. Discount rates are presented in Table 3.4. However, as Andersen, Harrison, Lau, and Rutstrom (2008) show, these are likely to be higher than estimates that take into consideration the inherent uncertainty present in agreeing to take a future payment. In the analysis, we use these calculated discount rates only in regressions in which we also control for an individual's risk preferences.

Table 3.4—Distribution of time preference

Monthly discount rate	Distribution of sample (%)
0 to 0.25	22.5
0.25 to 0.50	17.2
0.50 to 1	24.2
1 to 2	16.1
More than 2	19.9

Source: Ethiopian Rural Household Survey 2009.

Weather Risk and Welfare

The ERHS was designed to capture how households cope with shocks. Dercon, Hoddinott, and Woldehanna (2005) used data from the two previous rounds of the survey to document the nature, frequency, and severity of shocks experienced by the ERHS households. Almost half of these households were affected by drought sometime between 1999 and 2004, and the consumption levels of those reporting a serious drought were found to be about 20 percent lower than the levels of those who did not experience drought. Dercon (2004) also showed that drought shocks had long-run impacts on welfare and growth for these households. He showed that experiencing drought in the 1980s caused both lower levels of consumption and lower growth rates in the 1990s.

ERHS respondents are not passive in the face of these shocks. They were asked how many people they could call on “in time of need” and to describe the five most important people in this network. On average, households indicated that there were nine people they could call on and virtually all households had at least one person in this support network. The most important sources of support came from those residing in the same village, relatives, or members of the same *iddir*. Very often they were members of labor-sharing groups (53 percent) and had adjacent plots of land (63 percent). While there is evidence that these are functioning support networks—support is both given and received—their close physical proximity suggests that they may be more effective in coping with idiosyncratic shocks such as illness rather than covariate environmental shocks that they all may be exposed to.

Most households (73 percent) reported that given an emergency, they could obtain ETB 100 within seven days. They indicated that they would draw on a variety of sources, most notably credit (33 percent) and sale of livestock (23 percent). Consistent with these findings, 32 percent indicated that they had borrowed money in the last 12 months for consumption purposes or in response to a shock, while only 6 percent reported holding savings in a bank account. Across the full sample, 83 percent of households reported belonging to at least one *iddir* (and as noted above, this rose to nearly 90 percent when the Tigray villages were excluded). In addition to providing assistance when a member dies, 38 percent of households belong to an *iddir* that would make cash grants in response to certain idiosyncratic shocks, such as fires or illness, and 43 percent would make loans. Finally, just over half the households surveyed in 2009 had received a remittance in the previous 12 months.

An indication of how well these mechanisms protect households from shocks is found in Table 3.5. In the 2009 round of the ERHS, respondents were asked, “Has this household been affected by a serious shock—an event that led to a serious reduction in your asset holdings, caused your household income to fall substantially, or resulted in a significant reduction in consumption? We would like to learn more about the worst shocks in the last five years.” The prevalence of the four most commonly reported shocks—drought, pest infestations affecting crops, death, and illness—are reported in Table 3.5. There is a noticeable difference between the consequences of illness and death shocks and drought shocks. The former tend to have income effects, consumption effects, or both, but not asset losses, while drought is much more likely to lead to asset losses in conjunction with income and consumption losses. This is consistent with our suggestion that informal mechanisms serve to reduce the impact of idiosyncratic but not covariate shocks.

Table 3.5—Prevalence and impact of selected shocks

	Shock in the previous five years			
	Drought	Pests that affected crops	Death of household member	Illness of household member
Percent affected	40.2	22.0	22.8	30.2
Consequence (percent)				
Loss of household income	13.2	20.2	26.5	34.5
Reduction in household consumption	15.2	16.6	6.8	6.0
Income loss and reduced consumption	15.2	24.4	6.2	9.2
Loss of income, reduced consumption, or both	43.6	61.2	39.5	49.7
Loss of productive assets	17.8	20.2	8.7	13.3
Asset and income loss	1.9	2.3	15.2	10.8
Asset loss and reduced consumption	3.2	1.3	1.3	2.9
Asset loss, income loss, and reduced consumption	32.7	11.7	9.4	10.4
Asset loss	55.6	35.5	34.6	37.4
Other	0.8	3.3	25.9	12.9

Source: Ethiopian Rural Household Survey 2009.

Looking forward, respondents viewed the likelihood of rainfall shortages in the coming season as quite high. Their perceptions of rainfall risk were elicited by asking them to place beans between two squares, rain failure and sufficient rain, in accordance with how likely they thought rain failure in the upcoming season was (see Hill [2009] for use of a similar method to elicit perceptions of price risk). On average, farmers thought rain would fail with a probability of 0.41. We also calculated a measure of rainfall vulnerability that indicated the proportion of years out of the last 10 that the rainfall was below average for a household. This proportion was about half for our sample households (not reported).

Sample Characteristics

Table 3.6 presents a variety of descriptive statistics on ERHS households observed in 2009. On average, the head of household was a 53-year-old male with less than two years of schooling. Since in our analysis the respondent's characteristics also matter, we report these as well. On average, the respondent was younger and more educated than the household head. The average household size was about six members, with the highest education level being just below six grades.

Average landholding was 1.9 hectares, higher than the national average of 0.9 hectares. There was considerable variation in these holdings. Average landholding of a household in the lowest landholding quartile in its peasant association (PA, the smallest administrative unit usually comprising some 2-5 villages) was less than a hectare, and for those in the highest quartile. It was just under 4 hectares. Half of surveyed households owned livestock. Households typically obtained about 80 percent of their income from agriculture, and nearly all (94 percent) were reliant on the main *Kiremt* (June–September) rains for crop production. However, the principal crop grown varied by location. This is not surprising, given the marked agroecological differences that exist across Ethiopia. Households in drier localities grew barley or sorghum. Those in the south grew maize, while those in the higher-potential villages to the west grew teff. About half of the households had oxen.

Table 3.6—Household descriptive statistics

	Mean	Std. dev.
Demographic characteristics		
Household size	5.67	2.55
Highest grade attained by a household member	5.63	3.71
Household head		
Age	53.1	15.1
Gender (male = 1, female = 0)	0.66	0.47
Grades of schooling	1.48	2.83
Respondent		
Age	50.6	15.7
Gender (male = 1, female = 0)	0.73	0.44
Grades of schooling	2.01	3.00
Assets and agriculture		
Total land operated, hectares	1.90	2.90
Fraction of households that have oxen	0.50	0.50
Kiremt rains important for crops	0.94	0.25
Used fertilizer during last cropping season	0.50	0.50
Used fertilizer purchased on credit during last cropping season	0.21	0.41
Main crop is		
Maize	0.25	0.44
Wheat	0.08	0.27
Teff	0.19	0.39
Barley	0.23	0.42
Sorghum	0.14	0.35
Enset	0.08	0.28
Selected risk management mechanisms		
Number of people that can be called on in time of need	9.54	7.69
Proportion of households that could obtain ETB 100 in seven days	0.73	0.45
Borrowed money to maintain consumption or respond to shocks	0.32	0.47
Has bank account	0.06	0.23
Belongs to an *iddir*	0.83	0.38
Number of *iddirs* that household belongs to	2.08	2.47
Iddir provides grants in addition to funeral payments	0.38	0.49
Iddir provides loans to members	0.43	0.49
Proportion of households that have received a private transfer in previous 12 months	0.55	0.50

Source: Ethiopian Rural Household Survey 2009.

4. RESULTS

The descriptive data indicate that most respondents understood the hypothetical insurance product on offer and that they were generally risk averse. While they did have access to mechanisms for coping with adverse shocks, these mechanisms tended to be better suited to managing idiosyncratic shocks. Therefore, drought shocks seemed to have adverse effects that these mechanisms did not address. In this section we examine the determinants of reported willingness to pay for weather insurance in light of the models described in Section 2. We extend this to assess how demand might vary if insurance were provided through a local risk-sharing network and how demand would be affected by realization of downside basis risk.

A Basic Model of Insurance Demand

Table 4.1 contains the results of a basic model of demand for insurance where the included covariates—price, risk aversion, basis risk, and wealth—are those outlined in Table 2.1. We estimate the willingness to purchase this hypothetical product using a probit and present the results in terms of the marginal effects of the covariates. In all specifications we account for village fixed effects. Within each PA households are clustered in small settlements, and we correct standard errors for clustering at the settlement level.

Column (1) shows that demand is decreasing in price. An ETB 10 increase in the premium reduces demand by 7.9 percentage points. Demand for insurance, a risk-reducing asset, should increase with risk aversion. In column (1), however, the coefficient on the risk aversion measure constructed from the money game is negative, although not statistically significant. To assess whether the relationship is quadratic, we include squared risk aversion as an additional covariate, shown in column (2). Based on Table 2.1, we expect the coefficient on the linear term to be positive and the quadratic negative, but in fact we observe the opposite. Given that the risk aversion covariate takes on only a small number of values and that these are estimated assuming that expected utility theory holds for all households, we check this result by including dummy variables for different lottery responses with risk neutrality being the omitted category, as shown in column (3). We wondered if this result was driven by the nature of the game used, so as a check, we repeated these specifications using the risk aversion measure derived from the hypothetical market game in columns (4), (5), and (6). We find the same pattern as before—increased risk aversion reduces the likelihood of selecting this insurance product—but with improved precision. With the caveat that these results are based on willingness to purchase a hypothetical product, the negative relationship between willingness to pay and risk aversion is not consistent with the predictions of the basic model.

Table 4.1—A basic model of weather insurance demand

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Price	-0.0079***	-0.0079***	-0.0079***	-0.0078***	-0.0077***	-0.0078***	-0.0078***	-0.0086***	-0.0039*	-0.0106***
	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0017)	(0.0023)	(0.0021)
Risk aversion (1)	-0.0152	-0.0868*					-0.0400**	-0.0363**	-0.0289	-0.0492**
	(0.0153)	(0.0511)					(0.0169)	(0.0178)	(0.0317)	(0.0238)
Risk aversion (1) squared		0.0227								
		(0.0159)								
= 1 if slight risk aversion (1)			0.0174							
			(0.0390)							
= 1 if moderate risk aversion (1)			-0.0281							
			(0.0414)							
= 1 if intermediate risk aversion (1)			-0.0795*							
			(0.0432)							
= 1 if severe risk aversion (1)			-0.0246							
			(0.0513)							
Risk aversion (2)				-0.0309***	-0.0810					
				(0.0118)	(0.0579)					
Risk aversion (2) squared					0.0147					
					(0.0163)					
= 1 if slight risk aversion (2)						0.0292				
						(0.0599)				
= 1 if moderate risk aversion (2)						-0.1027***				
						(0.0396)				
= 1 if intermediate risk aversion (2)						-0.0353				
						(0.0498)				
= 1 if severe risk aversion (2)						-0.1055***				
						(0.0396)				
Risk aversion (1)-risk aversion (2)							-0.0302**	-0.0302**	-0.0026	-0.0424***
							(0.0122)	(0.0136)	(0.0250)	(0.0135)

(continued)

Table 4.1—Continued

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Number of years consumption fell and was below average	0.1400**	0.1430**	0.1416**	0.1433**	0.1446**	0.1473**	0.1419**	0.1865**	0.2061*	0.0910
	(0.0597)	(0.0599)	(0.0599)	(0.0584)	(0.0585)	(0.0587)	(0.0583)	(0.0781)	(0.1105)	(0.0759)
Household would have been paid in years it reported lack of rain	-0.0030	-0.0033	-0.0048	-0.0093	-0.0098	-0.0069	-0.0091	-0.0199	-0.0050	-0.0194
	(0.0394)	(0.0394)	(0.0395)	(0.0396)	(0.0396)	(0.0402)	(0.0396)	(0.0431)	(0.0662)	(0.0513)
Distance to weather station (km)	0.0084	0.0090	0.0087	0.0090	0.0092	0.0088	0.0087	0.0031	0.0101	0.0202
	(0.0140)	(0.0140)	(0.0140)	(0.0140)	(0.0141)	(0.0141)	(0.0141)	(0.0151)	(0.0232)	(0.0200)
Distance to weather station squared	-0.0004***	-0.0004***	-0.0004***	-0.0004***	-0.0004**	-0.0005**	-0.0004**	-0.0004**	-0.0009	-0.0004*
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0006)	(0.0002)
Land, 2nd quartile	0.1613***	0.1630***	0.1643***	0.1563***	0.1572***	0.1600***	0.1616***	0.1472***	0.1145**	0.1731***
	(0.0361)	(0.0360)	(0.0364)	(0.0371)	(0.0370)	(0.0368)	(0.0365)	(0.0413)	(0.0576)	(0.0475)
Land, 3rd quartile	0.1262***	0.1265***	0.1255***	0.1267***	0.1284***	0.1291***	0.1295***	0.1204***	0.2134***	0.0538
	(0.0398)	(0.0395)	(0.0398)	(0.0411)	(0.0408)	(0.0402)	(0.0402)	(0.0413)	(0.0566)	(0.0482)
Land, top quartile	0.2067***	0.2059***	0.2068***	0.2051***	0.2064***	0.2063***	0.2064***	0.1718***	0.2566***	0.1558***
	(0.0362)	(0.0361)	(0.0364)	(0.0364)	(0.0366)	(0.0367)	(0.0363)	(0.0410)	(0.0572)	(0.0406)
Observations	1,272	1,272	1,272	1,274	1,274	1,274	1,271	1,200	494	777

Source: Ethiopian Rural Household Survey 2009.
Notes: Risk aversion (1) is based on money lottery. Risk aversion (2) is based on hypothetical market lottery. Peasant association dummy variables are included but not reported. In column (8), interviewer dummy variables are included but not reported. Columns (9) and (10) are restricted to the subsamples of respondents who could partially (9) or completely (10) correctly identify when the insurance contract would pay out. Marginal effects are reported with standard errors in parentheses. Standard errors account for clustering at the village level. *, **, and *** indicate significance at the 10, 5, and 1 percent levels, respectively.

Recall, however, that risk aversion was higher when the hypothetical risk question was posed. With this in mind, we include as an additional regressor the difference in risk aversion as measured in the monetary and hypothetical games. This coefficient is negative and statistically significant, implying that individuals who became more risk averse when playing the hypothetical risk game (which was always asked after the monetary game and had higher stakes) were more likely to purchase weather insurance.

To measure an individual's exposure to risk, we use the long-run data on consumption levels available for these households on six different occasions from 1994 to 2009 to estimate consumption risk. We record the number of times a household's consumption was below average. The results show that this is a significant predictor of demand for insurance: an additional year in which consumption fell below average increases demand for insurance by 14 percent.[6]

We cannot directly measure the degree of basis risk a household would face in purchasing this insurance. Instead, we include two proxies. We use self-reported rainfall shocks over the last 10 years to determine how many times the rain was reported to have failed in a year in which the insurance would have paid. Second, we include distance to the weather station on which the insurance would be offered. Since we may expect a nonlinear relationship between distance and basis risk, we also add a quadratic term. The first representation of basis risk has no effect. While the linear term on distance is positive but not significant, the quadratic term is negative and significant. Given that the reported coefficients are expressed in terms of marginal effects, we can use these to assess how this measure of basis risk affects the demand for insurance. For example, increasing the distance from 5 to 15 kilometers reduces the demand for insurance by 8.6 percentage points (given that 40 percent of the sample are willing to purchase insurance), a reduction in demand of about 20 percent.

In the conceptual models described above, the impact of wealth on the demand for weather index insurance was ambiguous. Across all specifications, we find that wealth, as proxied by landholding quintile, increases demand for insurance.

Considerable effort was expended when training the enumerators to implement the questions on weather insurance, risk aversion, and time preference to ensure that they all would present these topics to respondents in a close-to-identical fashion. Invariably, however, with more than 40 enumerators working in dispersed locations, there will have been differences in presentation, responses to questions, and so on. In column (8), we re-estimate the basic model, controlling for interviewer characteristics, which are entered as dummy variables. Doing so, however, does not change the results found in Table 4.1. In columns (9) and (10), we assess the robustness of our findings by splitting the sample into those respondents who could only partially (column [9]) or completely (column [10]) correctly state when the insurance contract would pay out. There are two striking differences across these subsamples. First, respondents who better understood the contract exhibited greater price sensitivity to the purchase of this product. Second, they were more sensitive to basis risk as shown by the larger (in absolute terms) coefficient on the square of distance to weather station.[7]

Extensions to the Basic Model

As noted earlier, a growing empirical literature provides some evidence consistent with the idea that the decision to purchase insurance is akin to a technology adoption decision (Giné, Townsend, and Vickrey 2008; Lybbert et al. 2010). The negative coefficient on risk aversion reported in Table 4.1 is consistent with this view. In this subsection we report results from an expanded regression that includes other variables that may become relevant if we treat insurance as an innovation that households are deciding

[6] Other measures of consumption risk were also tried—the number of times an individual's consumption fell by more than one standard deviation, the number of times an individual's consumption was below average, the coefficient of variation of consumption, and the number of times an individual reported that consumption was below average—and in all cases the coefficient was positive, but it was not significant for all measures.

[7] Two other robustness checks are also worth noting. We assessed whether the results were robust to including dummy variables indicating the month when the interview took place. Doing so did not substantively change our findings. In Section 3 we noted that nearly all respondents relied on the *Kiremt* rains. Excluding the small (6 percent) of households for whom these rains were not important or controlling for reliance on these rains did not change these results.

whether or not to adopt. To do so, we begin with the model used in column (7) of Table 4.1.[8] We add the following variables: respondent age, sex, and highest grade of schooling attained; measures of self-efficacy[9]; time preference; log household size; and access to financial institutions. While this extended set of regressors includes variables whose salience arises from considering insurance as a technology adoption decision, we also note that it includes variables that we may have already expected to be important in explaining insurance. Access to finance captures not only familiarity with financial products but also ability to finance insurance purchases.

Table 4.2, Column (1) presents results for this extended set of regressors. The coefficients on the original set of regressors remain unchanged and many of the additional regressors have significant explanatory power. The age, gender, and education of the respondent are important in determining response: women, older individuals, and less educated individuals are less likely to be willing to pay for insurance. In fact, women are 12 percent less likely to respond that they would be willing to pay for insurance. Having access to financial services (defined as either possessing a bank account or having access to formal-sector loans) makes an individual 11 percent more likely to purchase insurance. Perhaps most striking are the coefficients on the measures of power a respondent reports. Individuals who somewhat agreed they had power to make decisions that change the course of their life are 15 percent more likely to respond that they would like insurance. Individuals who strongly agreed with this statement are 19 percent more likely to respond in the affirmative. These results indicate that early adopters of insurance products are likely to be households that are wealthy, educated, and with more access to credit and formal financial markets. They are also likely to be those households that most strongly believe they can improve the welfare of their own lives and individuals who are not averse to taking risks.

Table 4.2, Column (2) considers willingness to pay as part of a household's overall portfolio of risk management strategies. Specifically, we assess whether weather insurance is seen as a complement to or a substitute for other means of dealing with weather shocks. We focus on two measures: the number of people an individual perceives he or she can "call on in time of need" (log network size) and whether the household could, in case of emergency, obtain ETB 100 in less than one week. These variables have statistically significant effects, but their direction differs. As log network size increases, so does the demand for index insurance, while households who perceive that they already have some degree of self-insurance are less willing to purchase a weather index product.

In addition to asking a household about its demand for insurance bought directly from an insurance company and its demand for insurance purchased through its *iddir,* we also directly asked respondents about their preference for insurance purchased through the *iddir.*[10] We asked households whether, in general, they would prefer to have insurance through an individual contract with the insurance company or through a contract between their *iddir* and the insurance company. Although the majority of households reported that they would prefer a contract through their *iddir,* there is substantial regional variation. We describe these results here; full results are available on request.

Including the covariates found in Table 4.2, column (2), individuals with more schooling are less likely to prefer group insurance. Less educated individuals may prefer to purchase insurance through the group because of the complex nature of these products, which causes direct contracting to have high transaction costs for those individuals with lower levels of education. Changes in the price of insurance do not affect the preference for group insurance nor does availability of other networks of support. In a further specification, we find that those who report higher degrees of trust in their neighbors (measured by whether or not individuals would trust their neighbors to look after their house while they are away) prefer purchasing insurance through the group. This indicates the important role that trust plays in enabling local institutions to increase market access for their members.

[8] There is one slight change: we drop linear distance to nearest weather station but keep its quadratic.

[9] This is measured on a Likert scale in response to the statement, "I have the power to make important decisions that change the course of my life."

[10] When using reported willingness to pay for insurance purchased through the *iddir*, we drop the two Tigray villages included in the sample, as *iddirs* are not present in Tigray.

Table 4.2—Expanded models of willingness to pay

Variables	(1) Willingness to pay as technology adoption	(2) Willingness to pay as component of risk management portfolio
Price	-0.0084*** (0.0016)	-0.0087*** (0.0016)
Risk aversion (1)	-0.0294 (0.0187)	-0.0265 (0.0189)
Risk aversion (1)-risk aversion (2)	-0.0301** (0.0128)	-0.0268** (0.0128)
Number of years consumption fell and was below average	0.1032 (0.0639)	0.0991 (0.0664)
Household would have been paid in years it reported lack of rain	-0.0181 (0.0414)	-0.0110 (0.0412)
Distance to weather station squared	-0.0004** (0.0002)	-0.0003* (0.0002)
Land, 2nd quartile	0.1416*** (0.0418)	0.1212*** (0.0421)
Land, 3rd quartile	0.0984** (0.0435)	0.0750* (0.0439)
Land, top quartile	0.1128*** (0.0409)	0.0795* (0.0406)
Respondent age	-0.0025** (0.0011)	-0.0022** (0.0011)
Respondent is male	0.1176*** (0.0393)	0.0998** (0.0394)
Respondent, highest grade obtained	0.0157** (0.0062)	0.0144** (0.0060)
Somewhat agree with statement about power to improve life	0.1547** (0.0646)	0.1456** (0.0641)
Strongly agree with statement about power to improve life	0.1934*** (0.0644)	0.1809*** (0.0639)
Time preference	0.0684* (0.0403)	0.0666* (0.0396)
Log household size	0.0529 (0.0364)	0.0381 (0.0375)
Access to formal financial institutions	0.1073** (0.0449)	0.0915** (0.0459)
Log network size		0.0347* (0.0193)
Can obtain ETB 100 within one week		-0.1376*** (0.0371)
Observations	1,174	1,174

Source: Ethiopian Rural Household Survey 2009.
Notes: Risk aversion (1) is based on money lottery. Risk aversion (2) is based on hypothetical market lottery. Peasant association dummy variables are included but not reported. Marginal effects are reported with standard errors in parentheses. Standard errors account for clustering at the village level. *, **, and *** indicate significance at the 10, 5, and 1 percent levels, respectively.

As outlined in the descriptive section, respondents were asked to undertake the following thought experiments to assess the persistence of demand for insurance:

1. Suppose you bought insurance this year. The rains were fine this year and no payout is made to you. Would you buy insurance again next year?
2. Suppose you bought insurance each year for five years. You paid the premium each year and the rains were fine five years in a row so no payout was made to you. Would you still buy insurance the next year?
3. Suppose you bought insurance this year. The rains fail on your field but are sufficient at the weather station so no payout is made this year to you. Would you buy insurance again next year?

In general, the sign and pattern of coefficients are similar to those reported in Table 4.2. (Full results are available on request.) It is interesting to compare the responses to questions (1) and (3). In both cases individuals are asked to consider their demand in a situation in which they had bought insurance and the insurance did not pay. In one case the insurance did not pay and it was not needed; in the other case the insurance did not pay and it was needed, that is, the household experienced the downside of basis risk. Differencing the responses to question (1) and question (3) allows us to consider determinants of the impact of downside basis risk on insurance. Only those households that reported they would be willing to buy insurance in case (1) are included. We find a negative relationship between price and basis risk, suggesting that for a product that is cheaply priced, the impact of basis risk on demand will be less.

5. CONCLUSIONS

In this paper we examined the determinants of willingness to pay for weather insurance among rural Ethiopian households to assess the characteristics of households that would be likely early entrants into weather index insurance markets in Ethiopia. In contrast to other willingness-to-pay studies, the respondents in this study are households that have been tracked for 15 years as part of the Ethiopian Rural Household Survey, providing information on both historical experiences and current characteristics with which to assess willingness to pay. We find that, at least initially, insurance markets will likely be entered into by educated, rich, and proactive individuals.

One major drawback of willingness-to-pay studies that are not backed by an actual insurance product is that they do not necessarily represent actual behavior. In fact, households may behave very differently when faced with an actual insurance product (Breidert, Hahsler, and Reutterer 2006). Even though they do not replicate real situations, there are certain benefits from these willingness-to-pay studies. First, they help inform what kind of households may be interested in purchasing a similar product. Second, they can also provide a first assessment of the price elasticity of insurance demand and welfare implications, thereby informing a decision on whether to subsidize insurance (Sarris, Karfakis, and Christiaensen 2006). Third, they can guide implementation modalities of provision of the insurance product.

While those who faced higher rainfall risk are more likely to respond that they would choose to purchase insurance, those who behaved in a less risk-averse manner in a Binswanger-style lottery were found to be more likely to purchase insurance. This, in combination with the importance of education and a measure of individual agency, suggests that models of technology adoption can inform the purchase and spread of weather index insurance. This finding is consistent with assessments of weather insurance purchases in India (Giné, Townsend, and Vickery 2008). An important question is whether the dynamics of demand also behave as suggested in studies of technology adoption such as those by Griliches (1957) and Conley and Udry (2004). While insurance is, for many farmers, an innovative financial product, it differs from crop technologies in that it is a conceptual rather than a physical product and has observed benefits only in some years. Understanding the dynamics of insurance demand and the interventions needed to encourage sustained demand remains an interesting area of research.

A second component of this paper was to assess how willingness to pay varied as two key characteristics of the contract were varied. We examined how demand may vary depending on whether weather insurance is offered as an individual contract or whether it is offered through a traditional risk-sharing group. While groups offer advantages for females who are less educated, perhaps on account of the lower transaction costs faced in accessing insurance, low levels of trust in one's neighbors constrain demand for insurance offered through groups for some individuals. In situations where trust is high enough, it does seem that offering insurance through groups may ensure that insurance is provided to some individuals who would otherwise not purchase insurance (women and those with low levels of education).

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