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The Impact of Agricultural Insurance on the Demand for Supplemental Irrigation: A Randomized Controlled Trial Experimental Evidence in Northern Ghana

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9.1 Introduction

The vast majority of smallholder farmers in sub-Saharan Africa (SSA) are dependent on rainfed agriculture for their livelihoods, and they are more often afflicted by the vagaries of drought risk (Elagib 2014; Shiferaw et al. 2014). In fact, rainfed agriculture provides about 95 percent of SSA's food and feed (FAO 2007) and it is the principal source of livelihood for more than 70 percent of the population (Hellmuth et al. 2007). Therefore, for millions of poor smallholder farmers, drought poses a major challenge that can critically restrict options, limit development and pull farmers into poverty trap.

Given the underlined threats of drought on smallholder farmers' livelihoods in SSA, drought preparedness and adaptation become a key priority for any policy intended to help smallholder farmers. In developed countries,

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risk-transfer approaches such as insurance have played a role in mitigating drought risk but they have generally not been available in developing countries where insurance markets are limited and are not oriented toward the poor. Recent advances in climate science help in the development of a new type of insurance called weather index insurance¹ that offers new opportunities for managing drought risk in areas where such services were difficult to deliver due to high transaction costs related to poor infrastructure and the classical adverse selection and moral hazard problems in providing financial services. Index insurance is a type of insurance that is linked to an index, such as rainfall, temperature, humidity or crop yields rather than actual loss which is difficult to observe. Access to these risk-transfer services can help protect poor farmers against climate variability while promoting the uptake of productivity enhancing technologies.

While the potential benefits of index insurance are great, its implementation can be difficult (Miranda 1991). The results of most index insurance pilot programs however have been disappointed, with the demand disappearing as soon as the subsidy is eliminated (Farrin and Miranda 2015). Also, because of the more pronounced infrastructural and technology gaps in developing countries, there is the disadvantage that the payoff of the weather derivative does not perfectly correlate to the actual shortfall in the underlying exposure. This is the so-called basis risk. Basis risk refers to the potential mismatch between the index trigger and actual on-farm losses. Besides that, the true benefit of index insurance at the smallholder farmers' level is very puzzled as the insurance does not replace the crop loss. And because of the systemic nature of the event, when it occurs it affects the whole community, the local market included. So, price of staple food goes up and that reduces the value of the insurance pay out and reduces the ability of smallholder farmers to smooth their consumption. Index insurance policies rarely issue indemnity payments due to high deductibles and low-coverage levels.

Investment in water management in rainfed agriculture is another side of novel drought adaptation strategy, particularly in SSA where rainfed agriculture plays such an important economic role. Supplemental irrigation (SI) is one possible water management investment that can help overcoming the challenge of water deficit of rainfed crops in semiarid areas (Rockström et al. 2010).

SI is defined as the application of additional water to otherwise rainfed crops, when rainfall fails to provide essential moisture for normal plant growth, to improve and stabilize productivity (Fox and Rockström 2000; Oweis and Hachum 2006, 2012). SI is a simple but highly effective technology that allows farmers to plant and manage crops at the optimal time, without being at the mercy of unpredictable rainfall. All sources of water can be used for SI systems, including runoff harvested water, surface water, underground water, treated industrial waste water. SI contributes to smallholder farmers' livelihoods in three ways: (1) improves yield, (2) stabilizes production from year to year, and (3) provides suitable conditions for economic use of higher technology inputs. The critical importance of SI lies in its capacity to bridge dry spells and thereby reduce risks of drought in rainfed agriculture in SSA. By reducing risk, SI provides smallholder farmers with the necessary incentive for investments in improved production technologies.

Despite the underlying contributions toward farmers' livelihood, SI is still a rare innovation among smallholder farmers in SSA.

While both drought index insurance and SI address the risk of drought, they do so in very different fashions. As such, smallholder farmers potentially view drought index insurance and SI as either substitutable or complementary drought risk management instruments, depending on various factors such as farmers' experience with drought, whether the risks are related to crop failure or to the additional costs of SI during dry spells or the structure of the insurance contract.

This chapter makes use of the randomized controlled trials experiment to shed light on the existing debate whether drought index insurance and SI as two novel drought risk management instruments are substitute or complementary.

9.2 Weather Index Insurance and Supplemental Irrigation: Previous Studies

SI appears to offer more benefit to farmers than drought index insurance. However, in the recent literature in developing countries, attention have been majoritarially directed toward drought index insurance. The question is why is it so? Do farmers prefer most drought index insurance compared

to SI? The literature does not adequately answer this question. Very few studies have looked at the interaction between SI and index insurance. Studies that jointly analyzed SI and weather index insurance are Foudi and Erdlenbruch (2012) in France, Buchholz and Musshoff (2014) in Germany, Barham et al. (2011), Dalton et al. (2004), Lin et al. (2008), and Mafoua and Turvey (2003) in the USA.

Foudi and Erdlenbruch (2012) in analyzing the way French farmers manage drought risk found that SI serves as a self-insurance to farmers. They further found that a farmer's decision whether to irrigate (or not) depends on his decision to purchase insurance (or not). Insurance decreases the probability of adopting irrigation. Thus, the offered yield insurance, as they further conclude, may serve to decrease the amount of water used for irrigation.

Buchholz and Musshoff (2014) investigate the potential of index insurance to cope with the economic disadvantages for farmers resulting from a reduction in water quotas and increased water prices. They do that by comparing crop portfolios without and with index insurance and they found that the use of weather index insurance offsets the loss in the farmer's certainty equivalent resulting from moderate reductions in water quotas and water price increases. They also found that weather index insurance has the potential to substantially alter farm plans and the optimal irrigation water demand. Barham et al. (2011) compare discrete combinations of multiple-peril crop insurance and varying levels of irrigation in a stochastic simulation setting for a cotton farm in Texas. Their findings show that crop insurance is particularly beneficial at lower irrigation levels.

Dalton et al. (2004) evaluate the benefits of multiple-peril crop insurance and the investment in SI for potato production in Maine. Using a biophysical simulation model, the authors derived the risk management benefits of SI and crop insurance over nonirrigated uninsured production. The authors found that crop insurance programs are inefficient at reducing producer exposure to weather-related production risk in humid regions. They also found the risk management benefits from SI to be scalable and technology dependent. Increasing the scale of technology adoption increases the risk management benefits of SI. Lin et al. (2008) investigate irrigation strategies for maize production in Georgia in case of varying water prices and the availability of a precipitation-based weather

derivative. Their results reveal that the derivative performs relatively poorly in terms of increasing the estimated certainty equivalent revenues and has no impact on the amount of irrigation water used.

Mafoua and Turvey (2003) provide a conceptual regression model using annual cross-sectional data from New Jersey. They demonstrate that precipitation-based weather derivatives may enable farmers to hedge against irrigation costs in drought years.

The literature does not make it clear whether drought index insurance and SI are substitutes or complementarity risk management tools. The first line of research shows that SI and drought index insurance are substitutes in the sense that drought index insurance may be used to reduce the amount of water used. The second line of research demonstrates the benefit of SI over drought index insurance as drought index insurance is inefficient at reducing farmers' exposure to drought, performs poorly in terms of increasing farmers' revenues and has no impact on the amount of irrigation water used. The last line of literature considered drought index insurance and SI as complementary risk management tools because drought index insurance can be used to offset the high cost of SI during drought years.

It appears therefore worthy to contribute to this interesting debate by assessing the impact of drought index insurance on the demand for SI in developing countries.

9.3 Methodology

9.3.1 Experimental Design

In 2014, with the support of USAID-BASIS fund a randomized control trials (RCT) study was undertaken by the Ohio State University and the African Center for Economic Transformation, in collaboration with the University of Ghana, in order to investigate the impact of drought index insurance on the adoption of agricultural technology including SI among smallholder farmer in Northern Ghana.²

Following a list of farmers provided by the Rural Community Banks (RCB), a rural inclusive financial service provider in charge of all the three Northern regions of the study area, and based on a preliminary field visit with this institution and their farmers, a selection of 279 farmer

groups out of 791 groups was made. A baseline survey was then conducted in early 2015 in order to gather household's demographic and socioeconomics characteristics necessary to assure similarity among potential assigned treatments and control groups. During the baseline survey an experimental field survey was also undertaken to elicit smallholder farmers' willingness to pay (WTP) for SI.

For the baseline survey, six farmers were randomly selected from each of the 279 farmer groups using a uniform distribution with the intent to interview the first three farmers and the second three farmers as backup in case the first three farmers were unavailable for the interview. A total of 777 farmers were interviewed. Table 9.1 presents the composition of the sample size by region and gender.

Based on the information collected from the baseline survey, the 279 farmer groups were randomly assigned into three groups: (1) Control: smallholder farmers were offered conventional loans, no drought index insurance; (2) Treatment 1: smallholder farmers were offered insured loans where the farmers themselves were policy holders and any payouts are made directly to them; (3) Treatment 2: smallholder farmers were offered insured loans where bank was the policy holder and payouts were to be made to bank and credited toward the outstanding debt of farmer groups. Randomization took place within two strata; region and loan status of the farmers to ensure balance impact across region and loan status. Table 9.2 presents the preliminary number of farmers within region and treatment. Farmer groups were then invited to apply for loans (control) or insured loans (treatment 1 and 2).

The intervention took place during the 2015 farming season followed by a follow-up survey of the same farmers who were included in the baseline survey and we also repeated the WTP for SI experiment.

Table 9.1 Sample size by region and gender

Region	Male	Female	Total
Northern	156	142	298
Upper West	64	20	84
Upper East	182	213	395
Total	402	375	777

Table 9.2 Preliminary farmers in treatment and control categories by regions [2]

Treatment	Northern	Upper West	Upper East	Total
Control	103	27	131	261
Treatment 1	96	33	132	261
Treatment 2	99	24	132	255
Total	298	84	395	777

9.3.2 Data

We use the demand for SI outcomes to assess the impact of index insurance. The demand for SI and socioeconomic characteristics were collected before and after the intervention.

To elicit the demand for SI, a Contingent Valuation Method (CVM) was employed. Since SI systems are not yet available in Ghana, the CVM method is convenient for this study. Following Arrow et al. (1993) recommendations which lead to maximize the reliability of the CVM, we employed a single-bounded dichotomous choice questions. Designing contingent valuation questions in the form of hypothetical referenda in which respondents are told how much they would have to pay for each product before asking them to respond by a simple yes or no answer was used in this study first, to imitate the real world market where a price is given and the consumer chooses to purchase or not to purchase the product at the stated price. Second, to avoid bias induced by asking follow-up WTP questions as with double bounded dichotomous choice questions (Chantarat et al. 2009). The seasonal subscription charged fee per acre is one of seven values which were determined based on the estimated mean fee per acre of GHC 20.00, charged for similar services in Ghana, Burkina Faso, Kenya and India (Alhassan et al. 2013; Chandrasekaran et al. 2009; Zongo et al. 2015). The seven bid values used in the study include the estimated mean fee with six additional values that are ± 5 percent, ± 15 percent, and ± 25 percent of the estimated means fee (Bids: GHC 15, 17, 19, 20, 21, 23, & 25). Each of this bid was randomly assigned to each respondent.

9.3.3 Sample Size, Power Calculations and Minimum Detectable Effect

Choosing an appropriate sample size in experimental research matter as it increases the probability to detect an effect, assuming there is a genuine effect which is to be detected. This is the so-called power of the experiment. It measures the ability of a test to reject the null hypothesis when it should be rejected. Duflo et al. (2008) define power of an experiment as the probability that, for a given effect size and a given statistical significance level, one can reject the hypothesis of zero effect. The power of the experiment is affected by the sample size, the statistical significant level and other design choices. The minimum accepted level of power is considered to be 80 percent in the literature, which signifies that there is an eight in ten chance of detecting a difference of the specified effect size (Bloom 1995; Duflo et al. 2008). The statistical significant level (p value) is the probability of a type I error (that is the probability we reject the null hypothesis when it is in fact true). Usually 5 percent is used.

The sample size for our experiment is at group level since each of our farmers belongs to a farmer-based organization (and more often are member of the same household). This is to reduce potential spillover effect. We then need to pick our sample size such as to minimize the effect size taken into consideration power 80 percent and statistical significant level 5 percent. For this purpose, it is useful to measure precision in terms of minimum detectable effects (Bloom 1995, 2006). A minimum detectable effect is the smallest true treatment effect that a research design can detect with confidence.

As we intend to test the hypothesis whether drought index insurance has effect on the demand for SI at farmer level, our sample size is at individual level. Our outcome variable is a binary “yes” or “no” WTP. Following Duflo et al. (2008), the minimum detectable effect (MDE) for this binary outcome given power (κ), significance level (α), sample size (N) of identical size (n), and portion of subjects allocated to treatment group (P) is given by:

$$\text{MDE} = \frac{1}{c} \frac{M_{N-2}}{\sqrt{p(1-p)N}} \sqrt{\rho + \frac{1-\rho}{n} \pi (1-\pi)}$$

where $M_{j-2} = t_{\alpha/2} + t_{1-k}$, for a two-sided test;

C is the compliance rate for the treatment; P is the proportion of treated sample; σ is the variance in the outcome variable; ρ is the intra-class correlation of the farmers within each group; π is the proportion of the study population that would have a value of one for the binary variable in the absence of the program (Bloom 1995).

In order to calculate the MDE for our experiment, we use the baseline survey to estimate the variance for the outcome variable. Table 9.3 presents the value of the parameters we used to estimate the MDE. The results of the MDE estimations are presented in Table 9.4.

Table 9.3 Parameter assumptions for MDE calculations

Number of members per group (n)	3
Proportion of sample in treatment (P)	0.5
$t_{\alpha/2}$	1.65
t_{1-k}	0.84
Power (k)	0.8
Significance level (α)	0.05
Share of treatment group actually treated (C)	0.5

Table 9.4 MDEs calculations for binary outcome variables

Intra-class correlation	WTP for Canal SIES	WTP for drip SIES
<i>Sample group size 100</i>		
0.05	0.089	0.092
0.2	0.1	0.104
0.4	0.114	0.118
0.6	0.126	0.131
<i>Sample group size 150</i>		
0.05	0.072	0.075
0.2	0.082	0.085
0.4	0.093	0.096
0.6	0.103	0.107
<i>Sample group size 180</i>		
0.05	0.067	0.069
0.2	0.075	0.078
0.4	0.085	0.088
0.6	0.094	0.097
$\pi(1 - \pi)$	0.148	0.153

The MDE is sensitive to the sample size. It is lower when the sample size is bigger. We choose our sample size to be 279 roughly equally divided among the groups. That corresponds to an individual total size of 837.

9.3.4 Study Area

This study took place in the Northern Savannah zone of Ghana (Northern, Upper East and Upper West) to assess potential drought risk management tools among smallholder farmers. The choice of the study area is based on its agricultural contribution to the entire country and the great threat of drought that warms agriculture, the main activity in the zone. The Northern Savannah zone is the largest agriculture zone in Ghana. Most of the nation's supply of maize, rice, millet, sorghum, yam, tomatoes, cattle, sheep, goat and cotton are grown in Northern Savannah. This is because the Northern Savannah zone carries two-thirds of the nation's grassland.

The Northern Savannah agro-ecological zone of Ghana is characterized by unimodal rainfall of short duration, high incidence of droughts and excessive evapotranspiration³ allowing only 4 to 5 months of farming and 7 to 8 months of extended dry season. Yet agriculture in the zone is predominantly rainfed with less than 0.4 percent of the agricultural land irrigated. As a result, droughts often impact severely on livelihoods in the area (Dietz et al. 2004; Laube et al. 2008; Van de Giesen et al. 2010). The effects of drought on food production in the area are greater than anywhere else in the country (MOFA 2007; EPA 2012). Rainfall variability in the zone is exacerbated by climate change, resulting in a rise in the frequency of droughts (EPA 2007; Hesselberg and Yaro 2006). Adaptation policies with regard to drought in this region have, however, been insufficient (EPA 2012; Yaro 2013). Figure 9.1 presents the map of the study area. Figure 9.1 further presents the groupment of farmers and the distance between their household and a nearby river. GPS were recorded and those were used to estimate the distance between the household and the nearby river.

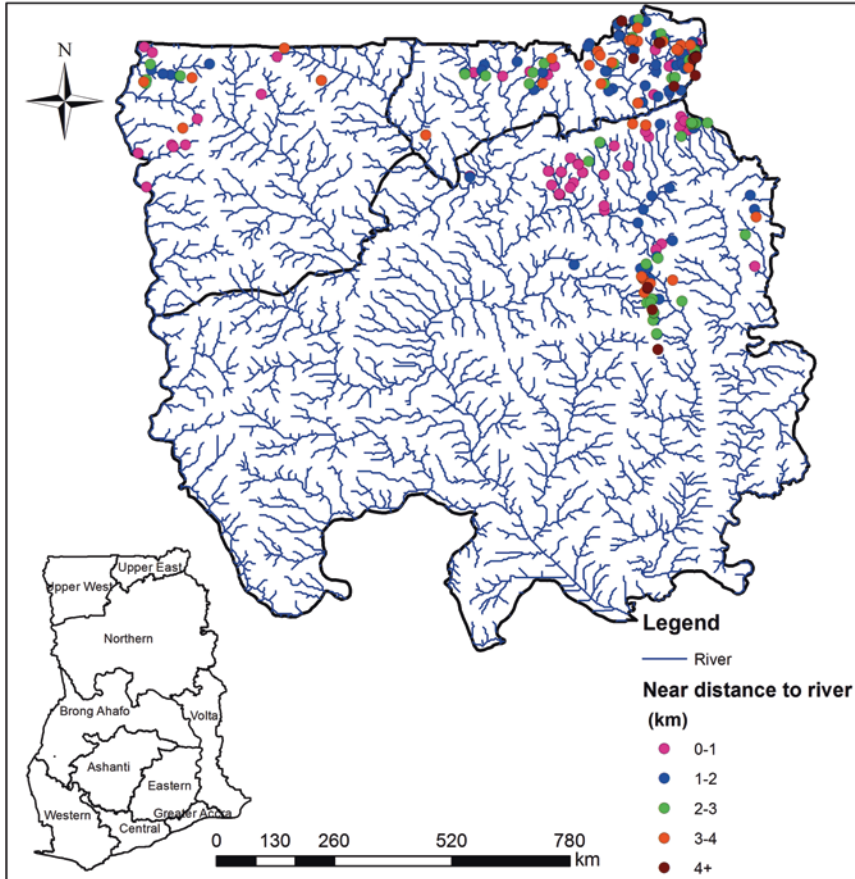


Fig. 9.1 Map of the study area. Source: Author

9.3.5 Statistical Methods

Deke (2014) in a Mathematica Policy Research brief suggested the Linear Probability Model (LPM) as appropriate compared to logistic model in calculating the impact of a binary outcomes in a randomized controlled trial setting.

The LPM has the ultimate advantage that the estimators can be directly interpreted as the marginal effect of covariates on the binary outcome. The

main disadvantage of the LPM in the textbooks is that the true relationship between a binary outcome and a continuous explanatory variable is inherently nonlinear. That is, the functional form of the LPM is generally not correctly specified, which can lead to biased estimates of some parameters of interest. The reason is that the LPM assumes a constant marginal effect of covariate X for all values of X , but the marginal effect of X almost always varies with respect to X . This misspecification of the functional form often leads to predicted probabilities that are less than 0 or greater than 1 (Deke 2014). However, as Deke (2014) demonstrated, it turns out that the disadvantage of the LPM highlighted above does not apply to the context of randomized controlled trial experiment. The reason why LPM works well to estimate experimental impacts is that the treatment status is a binary variable, not a continuous variable, which would be subject to the potential bias described above. This means that the functional form concerns about LPM do not apply to estimating impacts under RCT, since all that is required is to estimate two prevalence rates; one for the treatment group and one for the control group (as opposed to estimating a different prevalence rate for every unique value of a continuous variable). A second reason that the LPM provides accurate estimates of experimental impacts is that any other covariates included in the impact model are uncorrelated with treatment status, which means that the impact estimate is unbiased regardless of whether the correct functional form is used to adjust for other (possibly continuous) covariates.

The LPM is simply the application of ordinary least squares to binary outcomes instead of continuous outcomes as follows:

$$\text{WTP}_i^{\text{OLS}} = \beta_0 + \beta_{\text{bid}} \text{Bid}_i + \beta_X X_i + \beta_T T_i + \beta_D D_i + \varepsilon_i$$

WTP_i is the binary response to the willingness to pay question for farmer i ; Bid_i is the proposed price of the SI to farmer i ; X_i is the vector of household characteristics; T_i is a vector of binary variables representing whether the respondent was issued drought index insurance last season or not; β_T and β_X are parameters representing mean marginal effects; D_i is the vector of district dummies and ε_i is the error term.

9.4 Results

9.4.1 Experimental Integrity: Balance Tests on Variables at Baseline

Table 9.5 presents the summary statistic and the balance test for the whole sample and for control and treatments groups with simple mean comparison t -tests at baseline and Table 9.6 presents the balance test for the WTP variable at baseline without and with compliance.

On average, the respondents are 46 years old and 83 percent of them do not have any formal education (Table 9.7). Male represents 52 percent of the sample. The household is composed of predominantly inactive members. The average household size is about 11 members with a dependency ration of 1.4. That is every active member of the household is in charge of more than one inactive members. On average, about six members of the household participate in agricultural labor. Households on average earn GHC 1334.00 from agriculture compared to the average total income of GHC 2889.00. Households typically obtain about 60 percent of their income from agriculture (compared to less than 6 percent on remittances). As shown in Table 9.8, nearly all (96 percent) are reliant on rainfall for crop production. Also, 97 percent of household own livestock. The average livestock endowment measured by tropical livestock units (TLU) is 3.43 (Table 9.5).

Landholdings in Ghana are typically small. Small farms predominate throughout the country, although they tend to be larger on average in the savannah zones, with land distribution more skewed closer to the coast. Average landholding in our sample is 6.20 acres (with more than 62 percent holding less than five acres) which is considerable higher than the national average of 5.6 acres (Chamberlin 2008). Household is reached by extension service officer about two times per season and the average walking time to the market is one hour.

On average, 53 percent of farmers experienced drought the previous cropping season and about 47 percent experienced at least three times and 91 percent experienced at least two times drought in the previous five cropping seasons. On average, 53 percent of farmers believe there will be

Table 9.5 Experimental integrity: balance tests on variables at baseline [3]

Variables	Whole Control Treatment 1 Treatment 2				t-statistic	
	(1)	(2)	(3)	(4)	(2) # (3)	(2) # (4)
Age	45.80 (12.73)	45.93 (13.15)	46 (12.01)	45.48 (13.04)	-0.07	0.45
Male	0.52 (0.50)	0.55 (0.50)	0.50 (0.50)	0.50 (0.50)	0.04	0.05
Household size	10.71 (6.65)	10.92 (5.73)	11.11 (8.05)	10.10 (5.86)	-0.19	0.81
Dependency ratio	1.39 (2.73)	1.24 (1.90)	1.25 (2.49)	1.68 (3.54)	-0.01	-0.44*
Total income (100)	23.89 (15.30)	25.03 (16.12)	22.63 (15.11)	24.02 (14.58)	2.41*	1.01
Agricultural income (100)	13.34 (8.86)	13.93 (9.18)	13.10 (9.19)	12.96 (8.69)	0.86	0.99
Remittance (100)	1.24 (2.23)	1.38 (2.35)	1.01 (2.17)	1.34 (2.34)	0.38**	0.04
Saving (100)	0.79 (0.41)	0.77 (0.41)	0.79 (0.40)	0.78 (0.42)	-0.02	-0.01
Loan received (100)	2.18 (2.72)	2.16 (2.89)	2.06 (2.64)	2.33 (2.64)	0.10	-0.17
TLU	3.43 (3.47)	3.52 (3.57)	3.30 (3.38)	3.48 (3.45)	0.22	0.39
Distance nearest market	1.05 (0.77)	1.00 (0.70)	1.03 (0.74)	1.11 (0.87)	-0.02	-0.10
Extension_ service	1.81 (1.64)	1.89 (1.71)	1.70 (1.52)	1.84 (1.69)	0.18	0.05
Drought 2014, Dummy	0.51 (0.50)	0.50 (0.50)	0.50 (0.50)	0.53 (0.50)	0.01	-0.05
Years of drought experiences	2.48 (0.82)	2.48 (0.81)	2.47 (0.81)	2.49 (0.86)	0.01	0.01
Drought_ perception	0.53 (0.50)	0.51 (0.50)	0.53 (0.50)	0.55 (0.50)	-0.02	-0.04
Help during drought	2.40 (2.39)	2.52 (2.49)	2.18 (2.14)	2.49 (2.50)	0.34*	0.03
Risk preferences						
Risk averse	0.39 (0.49)	0.36 (0.48)	0.44 (0.50)	0.36 (0.48)	-0.08*	0.003
Risk neutral	0.13 (0.34)	0.12 (0.32)	0.15 (0.36)	0.13 (0.34)	-0.03	-0.01
Risk loving	0.16 (0.37)	0.17 (0.38)	0.13 (0.33)	0.18 (0.39)	0.05	-0.01
Time preference	0.06 (0.06)	0.06 (0.05)	0.06 (0.45)	0.06 (0.07)	0.002	-0.003

(continued)

Table 9.5 (continued)

Variables	Whole Control Treatment 1 Treatment 2				t-statistic	
	(1)	(2)	(3)	(4)	(2) # (3)	(2) # (4)
Household labor	5.76 (4.01)	5.76 (3.84)	6.02 (4.87)	5.49 (3.39)	-0.26	0.27
Plots	3.95 (2.22)	4.01 (2.40)	3.82 (2.10)	3.91 (2.15)	0.28	0.19
Riceland	0.67 (1.76)	0.60 (1.36)	0.71 (1.68)	0.69 (2.16)	-0.11	-0.09
Landholding	6.20 (6.24)	6.09 (4.71)	6.51 (8.00)	5.99 (5.54)	-0.42	0.11
Observations	777	261	261	255		

Note: Standard deviation in parentheses. *Significant at 10 percent; **Significant at 5 percent; ***Significant at 1 percent

Table 9.6 Experimental integrity: WTP at baseline [4]

Variables	Whole sample Control Treatment 1 Treatment 2				t-statistic	
	(1)	(2)	(3)	(4)	(2) # (3)	(2) # (4)
WTP canal CSA	78.64 (0.41)	80.01 (0.4)	76.25 (0.4)	79.61 (0.4)	3.76	0.41
WTP drip CSA	80.69 (0.39)	84.29 (0.36)	78.16 (0.41)	79.61 (0.4)	6.13	4.68
Observations	777	261	261	255		
With compliance						
WTP canal CSA	77.4 (0.42)	77.95 (0.42)	73.53 (0.44)	80.55 (0.40)	4.42	-2.6
WTP drip CSA	79.36 (0.4)	80.31 (0.4)	77.21 (0.42)	80.55 (0.4)	3.1	-0.24
Observations	407	127	136	144		

Note: Standard deviation in parentheses. *Significant at 10 percent; **Significant at 5 percent; ***Significant at 1 percent

Table 9.7 Household level of education [5]

Level of education	Freq.	Percent
No education	648	83.40
Primary school	40	5.15
Middle school	46	5.92
High school/university	43	5.53
Total	777	100.00

Table 9.8 Access to irrigation [6]

Access to irrigation	Freq.	Percent
No	743	95.62
Yes	34	4.38
Total	777	100.00

drought next coming cropping season. Farmers could call upon two to three members for help if there is drought.

9.4.2 Impact of Drought Index Insurance on the Demand for Supplemental Irrigation

We report the results of the effect of drought index insurance on SI in three steps: first, the relationship between demand of SI and treatments is presented via simple mean comparison. Second, we report the result of the LPM. Third, we analyze whether the impact differs when allowing for respondents heterogeneity.

Farmers who actually received the treatment represent 79.22 percent of farmers initially assigned to the treatment. Treatment was contingent on the receiving of loans. Therefore, farmers initially assigned to control and treatments who could not get credit from the banks were taken out of the analysis. This does not have any major implication in the power of our analysis as we considered 50 percent of compliance in the calculation of the sample size. Besides, as presented in the Table 9.9, compliance is almost equally distributed across groups.

To test whether demand for SI was higher or lower among treatments, we first looked at simple mean outcomes post-intervention. The randomization and the fact that the control and treatment samples are well balanced in the observed characteristics imply that a simple comparison of mean outcomes post-intervention will likely provide an unbiased estimate of intervention impacts. However, we also control for other observed socioeconomic characteristics in order to reduce idiosyncratic variation and to improve the power of the estimates.

Table 9.10 presents the results of a simple comparison of mean outcomes post-intervention. We observe that the two treatment groups have higher demand for SI compared to the control group. In treatment 1 (drought index insurance with farmer as policy holder), the demand of SI

increased by 7.8 percent for canal irrigation and by 12.8 percent for drip irrigation. In treatment 2 (drought index insurance with bank as policy holder), the demand for SI increased by 13.5 percent for canal irrigation and by 18.4 percent for drip irrigation. The differences between control and treatments groups are all significant. Although treatment 2 appears to have greater effect than treatment 1 in both canal and drip irrigation, their differences are not significant. Also, we could not find any significant difference of impact between canal and drip irrigation, except in the control group where the difference is significant at 5 percent level.

For the impact with covariates, we estimated a LPM of WTP for SI with the treatment variable being a dummy indicating whether the individual was in one of the treatment groups or in the control group. The covariates are socioeconomic characteristics measured during the follow-up survey which took place just after the intervention. The specific variables included in the model were those highly correlated with the dependent variables (dummy WTP) in the control group (Gertler 2004).

We first considered only the WTP bid as the only covariate. Table 9.11 provides the result of the treatments effect using LPM specification.

Finally, we added the other covariates as presented in Table 9.12. We find similar magnitude effects of drought index insurance on the WTP for SI as those found in Table 9.11.

Table 9.9 Actual (preliminary) farmers into treatment and control groups by regions [7]

Treatment	Northern	Upper West	Upper East	Total
Control	57 (103)	12 (27)	69 (131)	138 (261)
Treatment 1	75 (96)	30(33)	78 (132)	183 (261)
Treatment 2	66(99)	15(24)	90 (132)	171 (255)
Total	198 (298)	57 (84)	237 (395)	407 (777)

Table 9.10 Mean treatment effect [8]

	Control Treatment 1 Treatment 2			Impact (t-statistic)		
	(1)	(2)	(3)	(1) # (2)	(1) # (3)	(2) # (3)
Canal SI	72.5	80.3	86.0	-7.8*	-13.5***	-5.7
Drip SI	68.1	80.9	86.5	-12.8***	-18.4***	-5.6
Diff (t-statistic)	4.4**	-0.6	-0.5	5	4.9	-0.1

The observations are percentage. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 9.11 Treatment effect with bid WTP LPM [9]

	Canal SI			Drip SI		
	(1)	(2)	(3)	(4)	(5)	(6)
WTP_bid	-0.058*** (0.007)	-0.054*** (0.007)	-0.043*** (0.007)	-0.057*** (0.007)	-0.056*** (0.007)	-0.037*** (0.007)
Insurance_farmer	0.069* (0.043)			0.118*** (0.044)		
Insurance_bank		0.121*** (0.042)			0.170*** (0.043)	
Insurance_farmer_bank			0.052 (0.037)			0.053 (0.037)
Constant	1.867*** (0.135)	1.787*** (0.141)	1.646*** (0.127)	1.812*** (0.133)	1.792*** (0.142)	1.526*** (0.123)
Observations	321	309	354	321	309	354
R-squared	0.205	0.196	0.133	0.205	0.223	0.101
Log likelihood	-141.1	-122	-130	-148.2	-125.6	-131.6

The observations are percentage. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

These results cohere with the complementarity effect hypothesis of the effect of drought index insurance on SI. The complementarity nature of drought index insurance and SI that we found can be comprehended in two ways. First, farmers with drought index insurance might think of implicitly insuring the cost of irrigation. Drought index insurance have been widely studied in the past two decades in developing countries, yet its take up is still very poor with demand disappearing as soon as the subsidy is removed or the pilot project is terminated. Second, farmers probably do not find drought index insurance as stand-alone drought risk management instrument interesting enough especially that drought index insurance does not cover the actual loss and also the famous basis risk problem. The indemnity also appears very small to allow farmers to smooth their consumption during drought time especially that the trigger of the insurance is likely to be associated with the rise of the price of stable food in the local market. Farmers usually have high incentive to protect their yield compared to any other objective. This is because farmers heavily rely on their own production for consumption and usually express very strong resistance to buy any stable foods that they think they should have had from their farms. Therefore, insurance in this case only provides farmers with the opportunity to afford SI which is the drought risk management tools that they really prefer because it helps increase their production. Also, there is a strong correlation between the cost of irrigation or the disruption of irrigation and the likelihood of insurance being triggered. As the severity of drought increases, the cost of irrigation, the disruption of allocation of water for SI and the probability of insurance payout increase as well.

Mafoua and Turvey (2003) found similar result. The authors employed an economic model to analyze the tradeoff between the loss in revenues from unirrigated crops during drought and the cost of irrigation to preserve yields in periods of drought and simulate drought index insurance in both scenarios. They then came to the conclusion that rainfall insurance can be used to insure against the cost of irrigation.

Table 9.12 Treatment effect with covariate LPM

	Canal SI			Drip SI		
	(1)	(2)	(3)	(4)	(5)	(6)
WTP_bid	-0.059*** (0.007)	-0.054*** (0.007)	-0.044*** (0.006)	-0.058*** (0.007)	-0.056*** (0.007)	-0.037*** (0.006)
Age	-0.000 (0.002)	0.001 (0.002)	0.001 (0.002)	-0.001 (0.002)	0.001 (0.002)	0.002 (0.002)
Education	0.038* (0.021)	0.044** (0.020)	0.023 (0.015)	0.061*** (0.020)	0.042* (0.023)	0.024 (0.017)
Agricultural income	0.008*** (0.002)	0.006** (0.003)	0.007*** (0.002)	0.006*** (0.002)	0.004 (0.003)	0.006*** (0.002)
Loan received	0.007 (0.007)	-0.001 (0.007)	0.023*** (0.006)	0.005 (0.007)	-0.002 (0.007)	0.018*** (0.006)
Remittance	-0.011 (0.010)	0.004 (0.009)	-0.004 (0.008)	-0.012 (0.010)	0.005 (0.009)	0.003 (0.007)
Drought last season	0.127*** (0.041)	0.021 (0.042)	0.070* (0.037)	0.130*** (0.042)	0.015 (0.043)	0.054 (0.037)
Nearer river	-0.043 (0.045)	-0.049 (0.049)	-0.030 (0.045)	0.021 (0.047)	0.006 (0.049)	0.021 (0.044)
Extension services	0.036** (0.014)	0.013 (0.012)	0.001 (0.011)	0.025* (0.014)	0.012 (0.013)	-0.002 (0.011)
Landowned	0.005** (0.002)	0.000 (0.005)	0.004** (0.002)	0.004 (0.002)	0.000 (0.005)	0.003 (0.003)
Share rice land	-0.020** (0.009)	-0.001 (0.011)	-0.006 (0.007)	-0.012 (0.010)	0.004 (0.011)	-0.001 (0.007)
Insurance_farmer	0.088** (0.042)			0.136*** (0.043)		
Insurance_bank		0.119*** (0.042)			0.167*** (0.043)	

Insurance_farmer_bank				0.026 (0.036)				0.025 (0.037)
Canal asked 1st		0.013 (0.041)		0.018 (0.036)				-
Drip asked 1st					0.044 (0.043)	0.019 (0.042)		0.015 (0.037)
Constant	1.628*** (0.157)	1.635*** (0.164)	1.402*** (0.149)		1.586*** (0.160)	1.627*** (0.167)		1.253*** (0.141)
Observations	321	309	354		321	309		354
R-squared	0.309	0.232	0.224		0.292	0.249		0.173
Log likelihood	-118.6	-115	-110.5		-129.8	-120.2		-116.9

The observations are percentage. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

9.5 Conclusions

Index insurance and SI have the potential to hedge drought risk and as such they offer risk-averse farmers the opportunity to invest more on their farms. This study assess via a three-year randomized controlled trial experiment the effect of index insurance on the demand for SI among smallholder farmers. The study found the demand for SI canal (drip) among farmers who received insurance as policy holders to be 7.8 (12.8) percent greater than in the control group, and the demand for SI canal (drip) among farmers who received insurance with their banks as policy holders to be 13.5 (18.4) percent greater than in the control group.

It is, therefore, worthy investing in SI technology because it improves the overall profile of the profit distributions of farmers. But the only inconvenience is the risk of no allocation of water and the high cost of alternative solutions involved during severe drought years. Hence, coupled SI with drought index insurance for long dry spell or severe drought might help reduce the high cost of irrigation during severe drought and reduce the cost of insurance and basis risk that undermine the take up of insurance in developing countries.

Notes

1. Throughout this chapter, we focus our attention on a specify case of weather index insurance called rainfall or drought index insurance.
2. Many other outcome variables were investigated including: agricultural loan defaults; access to credit; interest rates charged and uptake of improved production technologies.
3. Annual potential evapotranspiration is about 2000 mm in the north.

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