Randomised Control Trial in Kenya – The case of a bundle product of insurance and agricultural inputs

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1. Introduction

According to the *World Development Report* (World Bank 2008), agriculture remains a fundamental instrument for poverty reduction and sustainable development even in the twenty-first century. Further, statistics reveal that in sub-Saharan Africa, agriculture is an essential component of effective development strategies, and employs two-thirds of the labour force while generating about one-third of gross domestic product (GDP) growth (Brune et al 2016). The *2008 World Development Report,* notes that GDP growth associated with agriculture is about four times more effective in reducing poverty than GDP derived from other sectors.

One of the main instruments to improve agricultural development relates to the uptake of new agricultural technologies, including improved seeds. A variety of studies have demonstrated a clear positive correlation between wealth and the adoption of new agricultural technology and the uptake of new seeds. Evidence clearly shows that an increase in improved seeds is associated with a rise in income, plot size, education and access to credit (see, e.g. Besley & Case 1993; Chirwa 2005; Just & Zilberman 1983; Simtowe 2006). Thus, the uptake of productivity-enhancing innovations is of utmost importance for agricultural development of sub-Saharan Africa. However, African farmers turn out to be very reluctant to adopt new technologies, for a variety of reasons.

For instance, according to the Uganda Bureau of Statistics, as of 2006, only 6% Ugandan farmers were using improved seeds while a much lower percentage used inorganic fertilizers (Uganda Bureau of Statistics 2007). Further, dropout rate are high among farmers who initially adopt improved agricultural technologies. For instance, Kijima et al. (2011) provides evidence which shows that about 50% of farmers who adopt improved rice varieties abandon them within two years. Also, pertaining to East Africa in general, statistics reveal that small farm holders with average farm sizes of 2.5 hectares account for about 75% of agricultural outputs and these farmers mainly use traditional technologies. In the broader context of sub-Saharan Africa, while adoption of modern varieties of maize was estimated to be 57% in Latin America and the Caribbean, and 90% in East and South East Asia and the Pacific, adoption for sub-Saharan Africa was estimated to be 17% (Gollin et al 2005).

A major reason for the low uptake is that these new technologies are too risky to adopt (Dercon and Christiaensen 2011; Barrett et al 2008; Anderson 2003). For example, the high variability of crop output inhibits demand for fertilizer (Kelly et al 2007). More generally, uncertainty impedes innovation and induces risk-averse, low-return investments (Zimmerman and Carter 2003). Thus, risk avoidance in various ways inhibits agricultural gains and productivity (Kurosaki & Fafchamps 2002; Antle & Crissman 1990; Feder etal 1985; Fatchamps 1992; Roumasset 1976 and Robison & Brake 1979).

An extensive literature has shown that poor households are able to informally manage risks in the absence of formal financial tools. For instance, it has long been argued that poor farmers in rural areas tend to adopt approaches such as village insurance to protect themselves from specific crises (see, e.g. Breman 1974; Scott 1976). Informal risk sharing mechanisms, which involve reciprocal lending within social networks, have also been used to deal with risk (see, Farrin & Miranda 2015; Townsend 1994; Udry 1990, 1994). However, informal risk sharing arrangements have been argued to be insufficient in dealing with certain risks (Farrin & Miranda 2015).

Thus, the development of formal insurance systems that may help to reduce the vulnerability to risk is crucial to induce an increase in adoption (Giné & Yang 2009). However, the precise relationship between insurance and uptake of new technologies is still ambiguous, due to a lack of rigorous studies. While several questions remain unanswered about the relationship between insurance and the uptake of new technologies, only few studies attempt to explore the demand for and the effects of insurance (see, e.g., Brick and Visser 2015; Cole et al 2017; Hill et al 2017; Karlan et al 2014; Mobarak & Rosenzweig 2013). Cole et al (2017), for instance, conduct a randomised field experiment in India and found that the provision of rainfall insurance policies significantly increases the production of crops with higher expected returns. Similarly, in a randomised controlled trial, Karlan et al (2014) offer small-scale farmers in Ghana rainfall insurance, cash grants or both and found evidence that rainfall insurance results in riskier production choices and greater investments in agriculture compared to cash grants.

We seek to provide new evidence on the relevance of insurance for the uptake of new technologies. Specifically, we conduct a randomised controlled trial to measure whether and to what extent providing free insurance, conditional on adoption of a pre-specified set of improved inputs, affects uptake of new technologies. The specific context of the study was the adoption of improved seeds, which were linked to or served as the condition for which rural farmers in Kenya could benefit from insurance. We assign free crop insurance to a random sub-set of 803 farmers belonging to 40 farmer groups in the Meru county of Kenya. Two studies comparable to ours are Giné and Yang (2009) and Hill et al (2017). Giné and Yang (2009) focus on how bundling insurance with a loan intended to promote the adoption of new crop technology could affect demand for the loan. In contrast to their study, we directly bundle insurance with the uptake of specific improved seeds. Hill et al (2017) introduced discounts and rebates in a treatment to encourage insurance take-up and to allow for the estimation of the price-elasticity of insurance demand. We, on the other hand, completely relaxed the credit constraint associated with insurance take-up by offering free insurance to the treatment group conditional on the adoption of specific improved seeds.

To the best of our knowledge this is the first study that tests the relevance of bundling insurance and inputs for adopting new technologies. A specific feature of our study is that we explicitly consider whether the bundling of insurance and inputs crowds in adoption of inputs not directly linked to the product. Crowding-in effects may be important as is suggested by Emerick et al (2016), who find that introducing a new rice variety that reduces downside risk by providing flood tolerance has positive effects on usage of labour-intensive planting methods and fertilizer usage.

First, our results indicate that when insurance is significantly subsidised it could increase uptake. This result is consistent with the findings from the empirical literature and with theory, which suggests that insurance results in increased investment in risk-increasing agricultural inputs (see, e.g. Hill et al 2017; Karlan et al 2014; McIntosh et al 2013). For instance, drawing on evidence from Ethiopia, McIntosh et al (2013) found that 25 per cent of those randomly allocated to an insurance group took up insurance but demand might have been non-existent in the absence of significant subsidy. Karlan et al (2014) also find that about 40 to 50 per cent of farmers in Ghana purchase insurance when prices are actuarially fair, however, these rates drop significantly to about 10 to 20 per cent when farmers are charged prices about double the actuarially fair price.

Second, we find substantive evidence for crowding-in and the adoption of improved inputs. Our intervention of free insurance increases the uptake of improved seeds regardless of whether the seeds are linked with the insurance uptake or not. Thus, since the returns from the insured plots or insurance is guaranteed, farmers are confident to experiment with other improved seed types, which is an important positive externality. This suggests that farmers prefer a certain amount of risk and are willing to make riskier investments if they have some insurance. Put differently, the provision of insurance to encourage the demand for specific improved seeds boosts the demand for other improved seeds, fertilizer, and other inputs. These positive externalities strongly suggest that in order to improve adoption of new technologies and kick-start a process of agricultural development, subsidising insurance may be very important.

Our paper, thus, sheds light on the slow adoption of insurance and new technologies, for instance improved seeds (see, Cai & Song 2017; De Janvry et al 2014; Giné & Yang 2009; Karlan et al 2014). Relaxing credit constraints by providing free insurance, farmers tend to adopt more improved seeds. Consistent with the literature (see, e.g. Antle & Crissman 1990; Feder et al 1985), the avoidance of such seeds may be an approach farmers adopt to diffuse risk and minimise their level of risk exposure since formal insurance is expensive.

Accordingly, policy aimed at easing formal insurance costs can increase the diffusion of formal insurance and the uptake of improved technologies.

The remainder of the paper is organised as follows. In section 2 we explain the insurance product and details of the study design. Section 3 explains the identification and the main outcome variables. Section 4 presents the empirical results while Section 5 draws the main conclusions.

2. Experimental design and balance tests

We assign free crop insurance to a random sub-set of 803 farmers belonging to 40 farmer groups in the Meru county of Kenya. After a lottery randomly assigning participants either to a treatment (45%) or to a control group, treatment farmers were awarded free insurance proportional to the amount of certified improved seeds demonstrably purchased, among four crops: maize, sorghum, soya and sunflower.

The insurance is conditional, i.e. if treatment farmers do not buy any certified seeds they will not be insured, even if they have won the lottery. The insurance offered is hybrid, i.e. partially index based and partially indemnity based. Weather index insurance (WII) includes both rainfall deficits (covering three stages, i.e. germination, vegative and flowering) and rainfall excess during the entire growth season. Weather data are ground-based rainfall measurements. The Multi-Peril Crop Insurance (MPCI) part provides coverage against flooding, hail, frost, fire, windstorm, and uncontrollable pests and diseases. Incept of MPCI starts after a successful crop stand count inspection is carried out by a field inspector. Furthermore, risk is monitored during the cover period through periodic farms visits in sampled farms within defined insurance units. Claims are not admissible under WII if the appraisal made under MPCI indicates no loss. In case of total loss necessitating replanting payments, these may be made to facilitate on time replanting if the season permits. Otherwise, at harvest an indemnity is paid guaranteeing 65% of the long-term production average (i.e., deductible of 35% of the insured amount). The market price of the hybrid crop insurance product paid by the experimenters amounted 570 Kenyan Shillings per acre.

Table 1 shows that the randomization worked as expected, i.e. there are no significant differences between winners and losers of the lottery across a variety of controls at time of the baseline survey.[1]

[1] Table 1 excludes 23 farmers that were not available at the endline. Appendix Table A1 shows that there is no evidence of selective attrition in our sample. Moreover, all variables remain not significant across treatment and control if the attrition is added to Table 1. In addition, in all 40 groups the leader received the insurance if they had purchased certified seeds. This was to ensure that in all cases the leader would be motivated to participate and follow up on the project. For this reason, the group leaders that participated in the project were excluded from the analysis from the start. Note that 34 lottery losers insured (8%) anyway. Likewise, 20 lottery winners eventually did not receive free insurance even though qualifying for it (8%). Also for this reason, in what follows we will analyse intention to treat effects (conservative).

Table 1. Summary statistics by lottery outcome

Variables	Lost		Won		Δ
	N	Mean	N	Mean	
Insured	434	0.08	346	0.53	0.46***
Age	434	46.37	346	45.99	-0.38
Male	434	0.09	346	0.09	-0.00
Education	434	6.21	346	6.38	0.17
Catholic	434	0.31	346	0.36	0.05
Household Size	434	5.60	346	5.73	0.13
Wealth index	434	0.02	346	-0.03	-0.05
Food insecurity index	434	-0.04	346	0.04	0.08
Livestock (Tropical Livestock Units)	434	3.71	346	3.51	-0.20
Land available (previous year)	434	3.75	346	3.85	0.10
Produced maize (previous year)	434	0.99	346	0.97	-0.01
Produced sorghum (previous year)	434	0.06	346	0.08	0.02
Produced soya (previous year)	434	0.01	346	0.01	0.00
Produced sunflower (previous year)	434	0.02	346	0.01	-0.01
Drought expected	434	0.43	346	0.41	-0.02
Excessive rain expected	434	0.25	346	0.31	0.06*
Pest expected	434	0.69	346	0.67	-0.02
Farm shock index (this season)	434	0.44	346	0.45	0.01
M-pesa account	434	0.80	346	0.84	0.03
Bank account	434	0.24	346	0.29	0.04
Any credit (previous year)	434	0.02	346	0.03	0.01
Credit size desired	434	12,330	346	12,653	322
Share invested in risk game	434	0.29	346	0.32	0.02
Openness	434	-0.00	346	-0.01	-0.01
Conscientiousness	434	-0.02	346	0.03	0.05
Extraversion	434	0.01	346	-0.06	-0.06
Agreeableness	434	-0.01	346	0.00	0.01
Neuroticism	434	0.03	346	-0.03	-0.06

* $p < .05$, ** $p < .01$, *** $p < .001$.

3. Identification

We will present simple post-treatment intention to treat (ITT) estimates to measure the impact of being offered free insurance on different groups of outcome variables. The ITT reads as follows:

$$Y = C + \alpha T + \beta$$

Where Y refers to an index of outcome variables, T the treatment (i.e. being offered free insurance) and X a vector of controls. In terms of outcome variables, we focus on land use, selection and share of certified seeds, certified seeds value, unconditional inputs, credit and productivity. We report p-values adjusted for multiple hypothesis testing (Sankoh et al., 1997). [2] Moreover, we control for Unit

[2] Sankoh et al (1997) perform a Bonferroni adjustment which also adjusts for correlation between outcomes. Their p(adj) =1- (1- p(k))^(M^(1-r(.k)), where M is the number of outcomes being tested within a family of outcomes, p(k) the unadjusted p-value for the kth outcome, and r(.k) the mean correlation among the outcomes other than outcome k.

Area of Insurance (UAI) fixed effects. UAI comprises a set of five dummies reflecting the spatial division of farmer groups in different geographical units for the index-based part of the hybrid crop insurance.

Finally, farmers were asked to state their willingness to pay for an insurance coverage identical to that of the intervention. We use an incentive-compatible BDM-type method (Becker et al., 1964), offering to insure 1 acre of maize for the ensuing short-rain season. Farmers were offered four envelopes containing different prices; if their stated willingness to pay was higher than the price in the selected envelope they were insured against the price in the envelope, otherwise not.

4. Empirical results

4.1 Crowding-in effects

Table 2 summarizes the intention to treat effects of the intervention over a variety of outcome variables, through a simple t-test—for overview purposes. Treatment seems to have increased the land devoted to farming the four crops of interest, the likelihood of purchasing certified seeds and the expenditure on non-conditional inputs (all inputs that were not a necessary condition to be insured for free), and demand for credit. The effect on farm output an income is far weaker, even though both income expectations in a bad year and willingness to pay for insurance are significantly greater.

Table 2. Overview of intention to treat effects

Variables	Lost		Won		Δ	s.e.
	N	Mean	N	Mean		
LAND USE						
Total land farmed	434	2.52	346	2.80	0.27	0.18
Maize acreage	434	1.25	346	1.42	0.17*	0.09
Sorghum acreage	434	0.13	346	0.24	0.12***	0.04
Soya acreage	434	0.01	346	0.06	0.05**	0.02
Sunflower acreage	434	0.03	346	0.08	0.05***	0.02
CONDITIONAL INPUTS						
Purchased certified seeds	434	0.45	346	0.59	0.14***	0.04
Value certified maize seeds	434	1,747	346	1,889	142	121
Value certified sorghum seeds	434	46	346	85	39**	15
Value certified soya seeds	434	7	346	17	10*	6
Value certified sunflower seeds	434	9	346	16	7	5
UNCONDITIONAL INPUTS						
Fertilizer costs	434	3,569	346	3,908	340	258
Other chemicals costs	434	1,119	346	1,226	108	121
Mechanization costs	434	2,164	346	2,745	582***	188
Labour hiring costs	434	5,732	346	6,289	557	523
Total non-seed inputs costs	434	12,579	346	14,145	1,566*	811
CREDIT						
Actively tried to obtain credit	434	0.41	346	0.49	0.08**	0.04
Obtained credit (formal)	434	0.40	346	0.47	0.07*	0.04
Total credit (at season start)	434	4,543	346	5,145	601	767
Total credit (any at peak)	434	5,073	346	5,791	718	838
OUTPUT						
Maize harvest (kg)	434	218.65	346	218.35	-0.30	33.26
Sorghum harvest (kg)	434	6.04	346	15.99	9.95**	5.01
Soya harvest (kg)	434	0.28	346	0.62	0.33	0.40

Sunflower harvest (kg)	434	1.42	346	1.42	0.00	0.67
INCOME						
Realised crop income	434	8,551	346	8,935	383	1280
Realised total farm income	434	14,727	346	14,014	-713	1865
Expected total farm income (this season)	434	14, 300	346	13,415	-885	3612
Expected total farm income (bad year)	434	7,356	346	10,907	3,552***	-3552
Willingness to pay for maize insurance	434	498	346	541	43**	21

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 3 summarizes the ITT effects on land use. We find a small but significant increase in the total land farmed by about 0.28 acres (0.1 s.d.), as well as for the acreage of the four crops involved in the study. This indicates that farmers respond to the presence of the insurance by increasing their farming efforts at the extensive margin.

Table 3: Land use

	(1) Total land farmed	(2) Maize acreage	(3) Sorghum acreage	(4) Soya acreage	(5) Sunflower acreage
ITT	0.279**	0.186***	0.109**	0.050*	0.043***
	(0.109)	(0.065)	(0.045)	(0.025)	(0.016)
[adj. p-value]	[0.057]	[0.027]	[0.064]		[0.029]
Additional controls	Yes	Yes	Yes	Yes	Yes
UAI fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	780	780	780	780	780
# of Clusters	40	40	40	40	40
R-squared	0.46	0.26	0.096	0.031	0.073

OLS regressions. Robust standard errors in parentheses clustered at the farmer group level. In square brackets we report the p-value adjusted for multiple hypothesis testing (5) if the unadjusted p < 0.05. Additional controls include age, age squared, male respondent dummy, years of education, household size, catholic dummy, asset index, livestock TLU, share invested in risk preferences game, number of fields having access to, bank account dummy, value of total bank savings, and a dummy for if the farmer group was supplied by only one input supplier. * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 4 presents the outcome of a linear probability model on using certified inputs (a prerequisite to being insured). We find an increase in the likelihood of purchasing any certified inputs among the four crops to increase by 14.8 percentage points (0.3 s.d.). Columns 2 to 5 present instead Heckman selection models of uptake and share of certified seeds used. We find no effect on the uptake or share of certified maize used. Instead, we find large and significant effects on the uptake of certified sorghum, soya and sunflower. Nonetheless, conditional on uptake, the average share of these crops farmed using certified seeds does not increase. Admittedly, however, the second stage may suffer from low power due to very low uptake rates: exemplary of this is certified soy—purchased by 6% of treatment farmers against only 3% control farmers. In total only 37 farmers purchased certified soy, making it difficult to gauge any significant differences. Overall the results show significant increases in the uptake of certified seeds, except for maize, and virtually no effect on the share of certified seeds on the total. This outcome may have a twofold explanation. First, even in the control group the vast majority of certified seed purchasers purchased only certified seeds, a share that can hardly be increased. Second, farmers that purchased more certified seeds simultaneously purchased more uncertified seeds (i.e., a possible risk pooling strategy).

Table 4: Selection and share of certified seeds

	(1) Certified inputs	(2) Certified Maize		(3) Certified Sorghum		(4) Certified Soya		(5) Certified Sunflower	
		select	share	select	share	select	share	select	share
ITT	0.148***	0.155	0.006	0.358***	-0.040	0.313*	0.377	0.438***	0.108
	(0.045)	(0.186)	(0.020)	(0.115)	(0.120)	(0.171)	(0.250)	(0.157)	(0.111)
[adj. p-value]	[0.008]			[0.008]				[0.022]	
Produced crop last year		0.896**		0.367*		0.678		0.847**	
		(0.456)		(0.197)		(0.607)		(0.402)	
Additional controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
UAI fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	780	780	751	780	134	780	37	780	64
# of Clusters	40	-	-	-	-	-	-	-	-
R-squared	0.11								

LPM regression with robust standard errors clustered at the farmer group level in (1). Columns (2)-(5) are estimated using a Heckman two stage selection model with a dummy on whether the farmer had produced this crop at all in the previous season as excluded variable in the first stage. In square brackets we report the p-value adjusted for multiple hypothesis testing (5) if the unadjusted $p < 0.05$. Additional controls include age, age squared, male respondent dummy, years of education, household size, catholic dummy, asset index, livestock TLU, share invested in risk preferences game, total land, number of fields having access to, bank account dummy, value of total bank savings, and a dummy for if the farmer group was supplied by only one input supplier. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

We further explore the intention to treat effects on the absolute value of certified seeds purchased in Table 5. Columns 1-6 report Tobit regression outcomes to account for the large lower limit censoring at zero (farmers not purchasing any certified seeds). While the intention to treat effects for each crop are positive, we can only reject the null hypothesis of no effect for certified sorghum (Columns 1-4). Column 5 reports the value of all certified seeds purchased; while the total value in Kenyan Shillings increases by over 10% at the mean prevalence of the control group (0.12 s.d.), the increase is again not significant. Excluding certified maize – by far the most common crop farmed (98%), for which we found not effect on uptake in Table 5 – the estimated increase in certified seeds purchased almost doubles, and becomes significant at the 1% level (Column 6).

Table 5: Certified seeds value

	(1) Value certified maize	(2) Value certified sorghum	(3) Value certified soya	(4) Value certified sunflower	(5) Value all certified seeds (incl. maize)	(6) Value all certified seeds (ex. maize)
ITT	142.488	254.081***	221.088*	107.007	191.352	355.143***
	(114.253)	(84.265)	(117.492)	(70.380)	(116.413)	(98.786)
[adj. p-value]		[0.013]				[0.001]
Additional controls	Yes	Yes	Yes	Yes	Yes	Yes
UAI fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	780	780	780	780	780	780
# Clusters	40	40	40	40	40	40
Pseudo R-squared	0.02	0.06	0.05	0.10	0.02	0.06

Tobit regressions censored at the lower limit. Robust standard errors in parentheses clustered at the farmer group level. In square brackets we report the p-values adjusted for multiple hypothesis testing (6) if the unadjusted p < 0.05. Additional controls include age, age squared, male respondent dummy, years of education, household size, catholic dummy, asset index, livestock TLU, share invested in risk preferences game, number of fields having access to, bank account dummy, value of total bank savings, and a dummy for if the farmer group was supplied by only one input supplier. * p < 0.10, ** p < 0.05, *** p < 0.01.

Tables 4 and 5 focus on the uptake of inputs (certified seeds) that were a precondition for benefitting from the crop insurance offered to the treatment group. However, we are also interested in observing the effects that the promise of a free insurance may have had on investment decisions of farmers that did not carry such conditionality. In Table 6 we set to explore the intention to treat effect on unconditional inputs. A decrease in expenditures would suggest that insurance has crowding-out effects, in line with classic principal agent models. In our experiment the risk reduction is two-fold. First, through the existence of the hybrid insurance, which is partly based on a weather index-based insurance protecting against drought and excessive rainfall, and partly indemnity based. Second, the purchase of certified seeds may reduce downside risk if farmers purchase higher drought-tolerant varieties. In fact, we find that of the 710 farmers reportedly having purchased certified maize, 82% purchased the Duma-43 maize variety, purposely developed for farming in semi-arid areas.

We find mild and generally insignificant effects on chemical and fertilizer expenditures, but large and robust effects on the investments into hiring external labourers for planting, weeding, and harvesting, as well as hiring tractors and other machinery to prepare the land (Table 6). Overall the intention to treat effect on unconditional input costs is over 1400 Kenyan Shillings (circa 15 US$), almost twice the average insurance price waived (circa 8 US$). Importantly, these results are obtained controlling for the area of land actually farmed, and are therefore to be considered, like the results for certified seeds, at the intensive margin. Overall this constitutes a robust indication of crowding-in of investments as a result of being offered a hybrid crop insurance, with strong implications for the use of conditional insurance as policy instrument to reduce risk and increase the adoption of farming practices potentially increasing output and productivity (more on this below).

Table 6: Unconditional inputs

	(1)	(2)	(3)	(4)	(5)
	Fertilizer costs	Chemical costs	Mechanization costs	Labour costs	Total non-seed input costs
ITT	491.526*	90.402	742.368***	761.183***	1448.239***
	(258.857)	(122.363)	(201.111)	(265.052)	(452.666)
[adj. p-value]			[0.001]	[0.010]	[0.003]
Additional controls	Yes	Yes	Yes	Yes	Yes
UAI fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	780	780	780	780	780
Number of Clusters	40	40	40	40	40
Pseudo R-squared	0.01	0.01	0.02	0.03	0.03

Tobit regressions censored at the lower limit. Robust standard errors in parentheses clustered at the farmer group level. In square brackets we report the p-values adjusted for multiple hypothesis testing (5) if the unadjusted p < 0.05. Additional controls include age, age squared, male respondent dummy, years of education, household size, catholic dummy, asset index, livestock TLU, share invested in risk preferences game, number of fields having access to, bank account dummy, value of total bank savings, and a dummy for if the farmer group was supplied by only one input supplier. * p < 0.10, ** p < 0.05, *** p < 0.01.

Increased expenditure can take the form of reduced saving, reduced consumption, or increased borrowing from formal and informal sources. Farmers in our sample have limited access to formal credit (from banks or microfinance institutions), a fact that is confirmed by the extremely low prevalence of respondents having obtained a loan in the year prior to the intervention.[3] Nonetheless, Column 1 of Table 7 shows a 9 percentage point increase in the likelihood that treated farmers actively try to obtain credit from a bank (a 23% increase with respect to the control mean). This also translates in greater chance of obtaining any credit, either formal or informal (Column2), although the amount borrowed is only weakly higher, mostly due to high data heterogeneity (Columns 3 and 4).

Table 7: Credit

	(1) Tried to obtain formal credit	(2) Obtained credit (formal and informal)	(3) Total credit (at season start)	(4) Total credit (at peak)
ITT	0.088**	0.076**	2655.826*	2903.037**
	(0.037)	(0.036)	(1435.802)	(1444.566)
[adj. p-value]	[0.037]	[0.052]		[0.071]
Additional controls	Yes	Yes	Yes	Yes
UAI fixed effects	Yes	Yes	Yes	Yes
Observations	780	780	780	780
Number of Clusters	40	40	40	40
R-Squared	0.05	0.04		
Pseudo R-squared			0.01	0.01

LPM regressions in (1) and (2). Tobit regressions censored at the lower limit in (3) and (4). Robust standard errors in parentheses clustered at the farmer group level. In square brackets we report the p-values adjusted for multiple hypothesis testing (4) if the unadjusted p < 0.05. Additional controls include age, age squared, male respondent dummy, years of education, household size, catholic dummy, asset index, livestock TLU, share invested in risk preferences game, number of fields having access to, bank account dummy, value of total bank savings, and a dummy for if the farmer group was supplied by only one input supplier. * p < 0.10, ** p < 0.05, *** p < 0.01.

We proceed to test the intention to treat effects on productivity. To ease comparisons we first convert output weight into output value, multiplying by the average selling price indicated by farmers for a certain crop. Next, we divide the output value for the number of acres produced under the crop. Moreover this time we exclude the UAI fixed effects as due to the low uptake of non-maize seeds, in combination with a severe drought, 3 out of 6 UAI present no non-zero harvest of at least one of the crops. Table 8 shows a negative non-significant change in productivity for maize (Column 1). The other crops all show an increase in productivity (Columns 2-4), significant for both sorghum and soya. This is a net effect of a variety of changes that our intervention may have determined. On the one side, the increase in productivity may reflect increased investments and improved seed varieties. On the other, we cannot rule out a certain degree of moral hazard and lower effort at play, without which the productivity gains would have been even bigger. This is particularly the case for

[3] At early stages we had wished to introduce a factorial variation into our experimental design, offering facilitated access to a formal loan to a random sub-sample of farmers. Evidence of the difficulty in convincing formal lenders to offer credit to the farmers in our sample is strengthened by the absence of such intervention in our final design.

maize, for which we know from previous analysis that the intervention did not increase the uptake nor the share of certified varieties; the negative sign may be driven by reduced effort or strategic underreporting, but is not large enough to result in a significant decrease of production per acre.

Table 8: Productivity

	(1) Maize productivity (KSH/acre)	(2) Sorghum productivity (KSH/acre)	(3) Soya productivity (KSH/acre)	(4) Sunflower productivity (KSH/acre)
ITT	-1535.534	2970.113**	3833.916**	2268.113
	(1646.601)	(1366.794)	(1499.593)	(3125.963)
[adj. p-value]		[0.107]	[0.043]	
Additional controls	Yes	Yes	Yes	Yes
UAI fixed effects	No	No	No	No
Observations	780	780	780	780
Number of Clusters	40	40	40	40
Pseudo R-squared	0.01	0.05	0.06	0.06

Tobit regressions censored at the lower limit. Robust standard errors in parentheses clustered at the farmer group level. In square brackets we report the p-values adjusted for multiple hypothesis testing (4) if the unadjusted p < 0.05. Additional controls include age, age squared, male respondent dummy, years of education, household size, catholic dummy, asset index, livestock TLU, share invested in risk preferences game, number of fields having access to, bank account dummy, value of total bank savings, and a dummy for if the farmer group was supplied by only one input supplier. * p < 0.10, ** p < 0.05, *** p < 0.01.

Lastly, we take to test the intention to treat effects on income and expectations. Column 1 in Table 9 shows the sum of all crop revenues estimated indirectly by us by summing the revenues of each individual crop. The null of no effect on income cannot be rejected. Similarly, we find no evidence of effect when we ask the farmers directly to estimate their total farming income for this season.[4] In Column 3 we asked instead to report on the expected income in a "worst case scenario" bad year. We find a significantly greater expected income for farmers in the treatment group. We interpret this as farmers internalizing reduced downside risk as a result of their investment decisions and possibly insurance payout. This interpretation is confirmed by the reduced variance of this season's expected farming income ($F = 3.86$, $p < 0.01$).

4.2 Willingness to pay

Willingness to pay for an insurance coverage identical to that of the intervention is presented in Table 9. Column 4 shows that treatment farmers are willing to pay significantly more for a new round of insurance. The average willingness to pay for insurance of both control farmers and treatment farmers is below the market price of the insurance product paid by the experimenters (570 Kenyan Shillings per acre), but farmers who actually got insured revealed an average willingness to pay not statistically different from the true price—even though the

[4] We use the self-estimated farming income here (including animal products such as eggs, milk, etc.), but a very similar result comes out when using our computed estimate of total farming income (see Table 2 for a comparison).

product's market price had not been revealed at any stage. This is in line with ambiguity averse farmers acquainting with the expected benefits of insurance, and highlights that offering discounted insurance products to people unfamiliar to them may positively affect their future unsubsidized uptake and impact.[5]

Table 9: Income, expectations, and willingness to pay for insurance

	(1) Total crop income (4 crops)	(2) Expected farming income (this season)	(3) Expected farming income (bad year)	(4) Willingness to pay for maize insurance
ITT	1416.577	-139.212	3172.348**	49.761**
	(1403.869)	(4253.725)	(1545.508)	(23.948)
Additional controls	Yes	Yes	Yes	Yes
UAI fixed effects	Yes	Yes	Yes	Yes
Observations	780	780	780	780
Number of Clusters	40	40	40	40
Pseudo R-Squared	0.02	0.01	0.01	0.00

Tobit regressions censored at the lower limit in (1)-(3), censored at the upper limit in (4). Robust standard errors in parentheses clustered at the farmer group level. Additional controls include age, age squared, male respondent dummy, years of education, household size, catholic dummy, asset index, livestock TLU, share invested in risk preferences game, number of fields having access to, bank account dummy, value of total bank savings, and a dummy for if the farmer group was supplied by only one input supplier. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5. Conclusion

We use a randomized experiment in Kenya to show that smallholder farmers respond to receiving a free hybrid crop insurance conditional on purchase of certified seeds, by increasing farming efforts both at the extensive margin – farming more land – and intensive margin. Not only are they more likely to adopt certified seeds, but also invest more overall in "unconditional inputs", especially in hiring farm-machinery and labour outside the household.

To finance these additional expenses they are more likely to actively try to obtain formal credit, and are more likely to borrow. However, we find no clear evidence that farmers increase or decrease their productivity or income as a consequence of these increased investments. We do find that the variance of the expected farming income in the current season is significantly reduced, as is the expected income in a hypothetical "worst case scenario" bad year. We interpret this as farmers internalizing reduced downside risk as a result of their investment decisions and possibly insurance payout. Moreover, farmers respond to treatment by increasing their own willingness to pay for insurance in the future—tested using an incentive-compatible BDM method.

The lessons learned are threefold. First, farmers respond to a conditional insurance offer by increasing the uptake of conditional inputs. Insurance thus

[5] In Table 9 we do not present the p-values adjusted for multiple hypothesis testing. This is because only the first two columns test the same hypothesis (i.e. a change in farm revenues), and are insignificant; the other two are independent.

reveals its potential to be used as a policy instrument to increase the adoption of desirable farming practices. Second, insurance also crowds-in borrowing and investments in other farm inputs, potentially engendering more intense cultivation practices. Third, given the increased interest of treated farmers in the insurance product, temporarily offering discounted insurance may well be a sustainable policy tool to enhance future unsubsidized uptake and impact.

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Appendix

Table A1. Balance tests for attrition

Variables	Sample	Mean	Attrition	Mean	Δ
Lottery won	780	0.44	23	0.52	-0.08
Insured	780	0.28	23	0.26	0.02
Age	780	46.21	23	46.48	-0.27
Male	780	0.09	23	0.17	-0.09
Years of education	780	6.29	23	6.78	-0.49
Household size	780	5.66	23	6.35	-0.69*
Land available (previous year)	780	3.79	23	3.13	0.66
Produced maize (previous year)	780	0.98	23	1.00	-0.02
Produced Sorghum (previous year)	780	0.07	23	0.09	-0.02
Produced soya (previous year)	780	0.01	23	0.00	0.01
Produced sunflower (previous year)	780	0.02	23	0.00	0.02
Drought expected	780	0.42	23	0.52	-0.10
Excessive rain expected	780	0.28	23	0.30	-0.03
Pest expected	780	0.68	23	0.57	0.12
Mpesa account	780	0.82	23	0.74	0.08
Bank account	780	0.26	23	0.22	0.04
Any credit (previous year)	780	0.03	23	0.00	0.03
Credit size desired (x1000)	780	12.47	23	13.59	-1,113.49
Share invested in risk game	780	0.30	23	0.41	-0.11

* $p < .05$, ** $p < .01$, *** $p < .001$.