Do Crop Insurance-Certified Seed Bundles Crowd-in Investments? Experimental Evidence from Kenya

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Abstract

We use a randomised 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 at the extensive margin—farming more land and increasing total investments. Not only are they more likely to adopt certified seeds, but also invest more complementary inputs, especially fertilizer, and in hiring farm-machinery and labour outside the household. These effects are somewhat muted at the intensive margin, but we do not find strong evidence of crowding-out of effort, except for spending more on hired labour and machinery. Finally, for the treatment group we find significantly greater willingness to pay, as well as higher income expectations in bad years—both in absolute terms and relative to average years.

1. Introduction

Agriculture remains the key sector for poverty reduction and sustainable development in Africa in the twenty-first century (World Bank 2008). Agriculture is an essential component of effective development strategies, employing two-thirds of the labour force while generating about one-third of gross domestic product (GDP) growth (Brune et al 2016). Moreover, evidence suggests that GDP growth associated with agriculture is about four times more effective in reducing poverty than GDP derived from other sectors (World Bank 2008). Hence, improving performance in the agricultural sector remains of utmost importance for sub-Saharan Africa.

In order to kick-start a process of agricultural development it seems crucial that farmers increase their use of modern agricultural techniques, including improved seeds and chemical inputs such as fertilizer. For example, improved seeds have the potential to increase income and improve rural livelihoods (e.g. Besley & Case 1993; Chirwa 2005; Just & Zilberman 1983; Simtowe 2006). However, adoption of modern inputs among African farmers is very incomplete.[1] Possible reasons for this according to the literature are lack of information, lack of liquidity to purchase inputs, and (perceived) risks associated with adoption (Dercon and Christiaensen, 2011; Barrett et al., 2008; Anderson, 2003).

Since agricultural output in rain-fed African agriculture varies with the vagaries of the weather, potential yield benefits associated with modern inputs are not guaranteed. Indeed, adopting smallholders may lose their "investment" which may impose a real threat to their

[1] 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).

livelihoods if they live close to subsistence levels. While poor households may be able to informally manage risks in the absence of formal financial tools, via community-based insurance (see, e.g. Breman 1974; Scott 1976) or reciprocal lending within social networks, it is unlikely that such strategies are appropriate to deal with systemic risks such as weather shocks (e.g., Farrin & Miranda 2015; Townsend 1994; Udry 1990, 1994). Hence it is no surprise that many African smallholders opt for inputs promising low expected yield but little variability in returns (Zimmerman and Carter 2003).[2]

What scope is there for formal insurance systems to reduce farmers' vulnerability to risk, and induce an increase in adoption of new technologies and improved seeds? A small literature is now developing to explore these issues (e.g., Cai & Song 2017; De Janvry et al 2014; Giné & Yang 2009; Karlan et al 2014), but the evidence remains ambiguous.[3] Policy choices, such as whether or not to subsidize insurance products, remain debated. Part of the lack of progress is explained by the simple fact that uptake of (unsubsidized) insurance remains very limited among African smallholders. This is true even for recent innovative products based on index insurance, where pay-outs are linked to local rainfall or vegetation growth (as opposed to individual damages). While the transaction costs associated with index-based insurance are much lower than with traditional indemnity-based insurance products, uptake rate typically do not exceed ten per cent of the population.

In this study we probe the latent demand for formal insurance among a population that heretofore had no access to insurance, and aim to analyse whether formal insurance "crowds-in" modern inputs. We present evidence based on a randomized controlled trial to measure whether providing free multi-peril crop insurance, conditional on adoption of a pre-specified

[2] See, for example, Kurosaki & Fafchamps (2002); Antle & Crissman (1990); Feder et al. (1985); Fafchamps (1992); Roumasset (1976) and Robison & Brake (1979).

[3] Relatedly, but focusing on a non-financial approach to reducing downside risk, Emerick et al. (2016) document that a flood-tolerant new rice variety positively affects usage of labour-intensive planting methods and fertilizer usage.

set of improved inputs: 1) increases the uptake of improved seeds, 2) affects the uptake of complementary modern inputs, 3) provides a learning platform from which to increase the taste for (non-subsidised) insurance. In our treatment arm, smallholders receive multi-peril insurance at zero cost if they purchase improved seeds of (one of) the following four crops: maize, sorghum, soya and sunflower. Our insurance product combines elements of index insurance and indemnity-based insurance (see below). We distinguish between effects on the targeted seeds (a direct effect) and effects on complementary inputs such as fertilizer, herbicides, labour and machinery (an indirect effect). Crowding-in effects may occur due to production complementarities (synergy effects), or because risk averse smallholders are shielded from particularly "bad outcomes" with near-zero returns in which they run the risk of losing some of their assets. Crowding-out effects may also occur. This could happen if the indemnity-based component of our insurance product invites moral hazard among farmers.

Several studies are related to ours. For example, Giné & Yang (2009) focus on how bundling insurance with a loan intended to promote the adoption of new crop technology adversely affected demand for the loan. The reason, they argue, is that limited liability with respect to credit implicitly provides insurance, so that adding a formal insurance component simply adds to the cost of obtaining credit. In the absence of such effects, Karlan et al. (2014) found that adoption of insurance did crowd-in the uptake of modern inputs. Various other papers have probed the scope for subsidizing insurance. For example, Hill et al. (2017) introduce discounts and rebates in a treatment to encourage insurance take-up and to estimate the price-elasticity of insurance demand. McIntosh et al. (2013), drawing on evidence from Ethiopia, found that 25 per cent of smallholders randomly allocated to a subsidy treatment took up insurance.

We report three main results. First, bundling modern inputs with free insurance results in some extra uptake of the targeted improved seeds. This suggests positive willingness to pay for the insurance product. However, it appears as if the latent demand for formal insurance is modest: uptake of the improved seeds does increase, but by less than the implicit value of the subsidy for one acre of land. Second, the bundle (improved seed and free insurance) enhanced the uptake of additional modern inputs and increased the area people cleared for farming. This suggests there are either production complementarities, or that extra demand can be leveraged by reducing downside production risk. Third, we follow the Becker–DeGroot–Marschak method (BDM) to elicit an incentive compatible willingness-to-pay for the same insurance product during the following year. We find significantly greater willingness to pay, as well as higher income expectations in bad years—both in absolute terms and relative to average years. We interpret this as farmers being less distrustful of the insurance product and internalizing the reduced downward risk.

The remainder of the paper is organised as follows. In Section 2 we explain the insurance product, and the randomisation procedure. We will show that the randomisation worked by presenting balance tests. Section 3 sketched identification strategy and presents the main outcome variables we consider. The empirical results are presented in Section 4. Section 5 summarises the main conclusions, discusses the main limitations, and provides avenues for further research.

2. Context and experiment

The main idea

We offer free multi-peril insurance (see below) to Kenyan smallholders who purchase improved seed varieties for specific crops. The improved seed was locally available at market prices. The study was motivated by two observations regarding the behaviour of smallholders in our study region. First, the uptake of unsubsidized farming insurance products is very limited, in not absent in the area of study,[4] and at current intensities of use insurance is therefore unlikely to provide a serous impetus to local agricultural development. Second, the adoption of improved crop varieties is low, levelling at less than 50% of the farmers in our study region, and less than 10% of land usage. The great majority of farmers prefers to grow traditional varieties instead (with low expected yield, and low variability), and even those farmers adopting modern varieties are typically growing traditional varieties alongside the modern ones.

We wish to explore whether there is latent demand for formal insurance products. By offering free insurance, but making it conditional on purchasing improved seed, we can obtain an upper bound for the latent demand for insurance. The price paid for improved inputs now enables the farmer to kill two birds with one stone: he effectively purchases both insurance as well as modern inputs. If the promise of free insurance does not affect the adoption of modern seed, the implied value of insurance must be low. In other words, by comparing the uptake of improved crop varieties between the treated and control group we obtain a crude measure of willingness to pay for formal insurance. The main hypothesis that we test:

[4] While we cannot exclude that other farmers in the area did insure, none of the participants to our study purchased any crop/weather insurance in the year previous to our study. At the time of the study there were two insurance companies present in the county capital city that can offer such insurance products.

Hypothesis 1: There is positive willingness to pay for formal insurance, so compared to the control group uptake of modern varieties in the treatment group will be higher.

We also wish to explore whether uptake of the improved seed plus insurance bundle affects the uptake of modern inputs. We hypothesize that production complementarities and the elimination (or reduction) of downside risk will crowd in additional inputs.

Hypothesis 2: Farmers who are induced to buy a bundle with improved seeds and formal insurance are more likely to also invest in the use of complementary inputs. Both the extensive and intensive margin may be shifted as a result.

Finally we predict that offering a free insurance product may increase the familiarity of farmers to the product itself, reducing the reservations and possibly shifting the willingness to pay for it closer to its true market value.

Hypothesis 3: Farmers who are given the possibility of trying out the bundle will have a higher willingness to pay for crop insurance in the following year.

The insurance product

We consider an unusual insurance product. Specifically, the insurance product is made available for free but obtaining it is conditional on the purchase of certified seeds. The insurance coverage is specifically designed and provided by APA Insurance Ltd and Acre Africa Ltd for the purpose of the experiment.[5] We offered a hybrid insurance product that combined index-based insurance for some risks and indemnity-based insurance for others. The Multi-Peril Crop Insurance (MPCI) part provides coverage against flooding, hail, frost, fire, windstorm, and uncontrollable pests and diseases. Inception of MPCI starts after a field inspector carries out a crop stand count inspection. Furthermore, risk is monitored during the cover period through periodic farm visits in sampled farms within defined insurance units. In

[5] The design of the insurance product was done in close collaboration with Shalem Investments, which is a local aggregator in Meru, Kenya, that provides certified inputs and acts as output trader of mainly sorghum.

case of total loss necessitating replanting, payments 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 weather index insurance (WII) component includes both rainfall deficits (covering three stages being germination, vegetative and flowering) and rainfall excess during the entire growth season. Weather data are ground-based rainfall measurements. The effective date of inception of this cover starts when a minimum of 10 mm of rain within a five-day period (as captured by the respective weather stations) is recorded. The total price of the hybrid crop insurance product that the experimenters paid to the insurance company varied depending on the crop—the highest being 609 KSh per acre for maize, the lowest 232 for Sunflower. However, as seed packets cover only a portion of an acre – for example each acre planted with maize needs four packets – it was also possible to insure portions of an acre, proportional to the precise amount of packets purchased and to their land equivalent. We did not impose any upper bound to the number of acres/seed pakets that could receive the fully subsidized insurance—on average farmers in our sample farmed 2.5 acres of land. Table 1 breaks down the premium for the four crops as estimated by APA.

Table 1. Premiums (waived) per acre

	Soya bean	**Sorghum**	**Sunflower**	**Maize**
Cost of production per acre	11,300	11,500	4,900	14,500
Expected yield (kg/acre)	1,800	2,000	1,000	1,500
Insured at 65% guarantee				
Sum Insured (KSh/acre)	7,345	7,475	3,185	9,425
Gross Premium 6%	441	449	191	566
Levies	1.98	2.02	0.86	2.54
Stamp duty	40	40	40	40
Net premium (Ksh)	**483**	**491**	**232**	**609**

Farmers were not informed about the value of the different insurance subsidies, but received two trainings about the workings of the insurance itself, in which the concepts of total loss, trigger, long term yield estimates and so on where presented and discussed. All participating groups were made aware that the indemnity based portion of the insurance would only trigger if the actual yield would be below 65% of long-term yield estimates (also discussed and validated locally). They also gained more understanding in the concept of index insurance and remote sensing of local rainfall. The first group meetings were held in June 2016. At the end of these sessions farmers also participated to a lottery that determined whether they would qualify for the free insurance conditional on purchase of certified seeds. The second round took place between August and September of the same year, one month prior to the verification of purchase of certified seeds and registration of the insurances. It served as a reminder to all participants of their status of winners or not of the subsidised insurance, and it refreshed their understanding of the insurance product at the time in which they typically start clearing land for planting. We incentivised the presence to the meetings to make sure all group members would be present, but did not verify the extent to which participants understood the insurance product. Anecdotally we have evidence that at least some of the farmers did not fully understand its working even after the second meeting round. To further their understanding we decided to have a separate meeting with group leaders in which the insurance was explained once more, and in which group leaders were offered the conditional insurance, regardless of their treatment status. We hoped that this would increase the interest of group leaders in the product and that they would be able to explain the concepts with more detail and time to the farmers in their group that may have had more difficulties in understanding them. For this reason, however, we had to exclude group leaders from the analysis that follows.

Experimental design

Our initial sample frame consists of 803 farmers, all of which are members of one out of 40 farmer groups in the Meru county of Kenya. After a lottery randomly assigning individual participants to a treatment (45%) or control group (55%), treatment farmers were awarded free insurance proportional to the amount of certified improved seeds demonstrably purchased, among either of these four crops: maize, sorghum, soya and sunflower.[6] During the endline survey we were unable to retrieve 23 of the farmers. Therefore the analysis is based on a sample of 780 farmers. Additional analysis (summarized in Appendix Table A1) reveals that attrition not correlated with treatment status or baseline co-variates.

Out of the control group, 34 farmers purchased insurance anyway, unprompted by the experimenters but perhaps induced . This amounts to 8% of that subsample. Likewise, 20 farmers from the treatment group did not receive free insurance (6%), even though they had purchased certified seeds in time, as they were unavailable at the time of distribution/registration. In what follows we will estimate intention to treat (ITT) effects, so the presence of non-compliers implies an underestimation of the true effect for the treated.

Descriptives and balancing tests

We check whether the randomisation worked by regressing the treatment dummy on baseline values of co-variates for the full sample of 780 farmers. Table 2 shows that the randomisation procedure worked as expected: there are no significant differences between winners and losers of the lottery at the baseline. Only the availability of a bank account is slightly higher for the treatment group, significant at the 10%, which we control for in our analysis. Participants are mostly female 46 years old on average, with 6 years of education, and live in a household with 6 members. About a third of our respondents are Catholic, the rest is from other Christian denominations. In the previous season they farmed on average almost 4 acres of land, and owned almost 4 tropical livestock units. In the previous year almost every farmer farmed maize, while sorghum, and sunflower were only farmed by 7%

[6] In all 40 groups, the group leader received free insurance if she/he 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.

and 2% of the farmers in our sample, respectively. Soya is almost absent in the area and is only farmed by a handful of respondents.

Table 2. Balance tests

Variables	Control	Treatment	difference
Male	0.085	0.089	0.004
Age	46.373	45.994	-0.379
Years of education	6.214	6.381	0.167
Household size	5.599	5.725	0.126
Catholic	0.313	0.358	0.045
Wealth index	0.022	-0.027	-0.049
Livestock tropical units	3.708	3.6885	-0.0195
Bank account	0.242	0.286	0.044*
Land farmed previous season	3.749	3.85	0.101
Maize previous season	0.988	0.974	-0.014
Sorghum previous season	0.065	0.081	0.016
Sunflower previous season	0.021	0.015	-0.006
Soya previous season	0.007	0.012	0.005

Notes: OLS regressions of on Treatment and Constant. Constant reflects average baseline value of Control group; Constant plus Treatment reflects average baseline value of treatment group. Number of observations: 780 for all regressions. p-values based on cluster robust standard errors with farmer group as cluster(40). *p<0.10; **p<0.05; ***p<0.01.

3. Identification

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

$$Y_i = C + \alpha T_i + \beta \boldsymbol{X_i} + \varepsilon_i \quad (1)$$

Where Y_i refers to a vector of dependent variables for respondent *i*, *T* is the treatment dummy (i.e. indicates whether respondent i has won the lottery and was offered free insurance), *X* is a vector of controls at baseline, and ϵ is a random error term. While strictly speaking it is not necessary to include baseline controls to reduce estimation bias (as treatment status is orthogonal to all baseline variables), controls are added to improve the precision of our estimates. In all models we include the following controls: Age; Square of age; Male; Years of Education; Household size; Catholic; Wealth index (based on assets);

Livestock (converted into 'tropical units'); Bank account open at baseline; and whether the farmer has access to only one input supplier (i.e. Shalem). We also include Unit Area of Insurance fixed effects ("region" dummies): Kaare; Lailuba; Marere; Tharaka and Imenti.[7] We estimate (1) with OLS, and cluster standard errors at the farmer group level (40).

4. Results

Certified seeds usage

We first consider the impact of the intervention on certified seeds usage, and focus on ITT effects on using certified inputs (a prerequisite of being insured). Column 1 of Table 3 shows that the likelihood of purchasing any certified seeds increases by 14.6 percentage points. In the control, on average some 45% of the farmers used improved seeds. This number was pushed up by almost 15 percentage points (0.3 standard deviations from the control mean). While this increase is statistically significant at the 1% level, it is also evident that the effect is rather modest in economic terms. Even when offered free insurance for their crops, many farmers decide to not purchase the any improved seeds. While the latent demand for insurance is positive and significant, it is not sufficiently large to sway farmers to switch from traditional to modern varieties.

Columns 2-5 estimate the value of certified seeds purchased for each crop, and Only the purchase of certified sorghum and maize, the two most common crops, increased significantly. Soya and Sunflower, did not, meaning that farmers did not take the insurance as an opportunity to experiment with new crops. Column 6 shows the total for all four crops. The purchase of certified seeds increases by about 400 KSh (equivalent to 4 USD), or to 0.26 standard deviations. Consistent with the findings in Column 1 we therefore find that farmers

[7] 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. The constant in the regressions reflects Marere, which comprises 406 of the 780 respondents.

are willing to spend more money on improved seed if these are accompanied by free insurance. But the magnitude of the gain is modest given that a typical maize packet costs between 400 and 600 KSh, and covers about a quarter of an acre. In other words, farmers increased their certified maize purchase by less than one packet of maize increasing the land area planted with it only marginally. Moreover, this increase is modest if related to the price of the insurance product Taking maize as reference, and attributing all the gains from the modern seed purchase to the value of insurance (an overestimate, for sure), we find that farmers are willing to insure less than an acre of their land (349/609=0.57 acres), out of the 1.33 acres that they cultivated with maize on average—less than 43%.

Table 3. Certified seed usage

	(1) Uptake certified seeds	(2) Certified maize	(3) Certified sorghum	(4) Certified Sunflower	(5) Certified soya	(6) Total certified seeds
ITT	0.146***	349.190***	40.713**	3.822	7.746	401.471***
	(0.045)	(122.020)	(16.450)	(4.635)	(5.816)	(129.991)
Additional controls	Yes	Yes	Yes	Yes	Yes	Yes
UAI f.e.	Yes	Yes	Yes	Yes	Yes	Yes
Mean control group	0.449	855.414	24.021	4.234	6.509	890.179
Observations	780	780	780	780	780	780
Clusters	40	40	40	40	40	40
R^2	0.094	0.099	0.10	0.058	0.065	0.11

Robust standard errors in parentheses clustered at the farmer group level (40). Additional controls include Age, Age^2, Male, Education years, Household size, Catholic, Wealth index, Livestock units, Bank account, One supplier only, and UAI fixed effects. See Appendix Table A2 for a full detail of the control variables and their coefficients. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Crowding-in complementary investments

Does the increase in uptake of certified seeds, and the additional security offered by the insurance coverage, affect investments in additional inputs that did not carry the conditionality of improved seeds? Moral hazard may induce crowding out, and production complementarities and risk reduction may induce crowding in. In our experiment, risk reduction may come from two sources. First, through the existence of the hybrid insurance and, second, through the purchase of drought-tolerant seed varieties reducing downside production risk.

Table 4 shows a positive impact on fertilizer use (Column 1), but not on pesticides and other chemicals (Column 2). Moreover, there is a large and robust effect on investments in terms of hiring external labourers for planting, weeding, and harvesting (Column 3), as well as hiring tractors and other machinery to prepare the land (Column 4). Overall, the ITT effect on the cost of unconditional input (Column 5) amounts to almost 1700 Ksh (circa 17 USD)—0.15 standard deviations. Even if the effect size is not very large, taken together our data suggest considerable crowding-in of complementary inputs as a result of the certified seed-crop insurance bundle. Once expected downward risks are reduced farmers increase their farm investments. This evidence is consistent with Karlan et al. (2014) for insurance, and Emerick et al. (2016) for a flood-tolerant new rice varieties.

Table 4. Farm investments (excluding seeds)

	(1) Fertilizer	(2) Chemicals	(3) Machine rental	(4) Hiring of labour	(5) Total non-seed
ITT	459.397**	89.282	556.721***	601.490**	1690.651***
	(222.405)	(107.539)	(173.599)	(295.429)	(475.321)
Additional controls	Yes	Yes	Yes	Yes	Yes
UAI f.e.	Yes	Yes	Yes	Yes	Yes
Mean control group	3568.518	1118.825	2163.733	5732.316	12579.34
Observations	780	780	780	780	780
Clusters	40	40	40	40	40
R^2	0.13	0.12	0.16	0.22	0.23

Robust standard errors in parentheses clustered at the farmer group level (40). Additional controls include Age, Age^2, Male, Education years, Household size, Catholic, Wealth index, Livestock units, Bank account, One supplier only, and UAI fixed effects. See Appendix Table A3 for a full detail of the control variables and their coefficients. * p < 0.10, ** p < 0.05, *** p < 0.01.

Land use

We further explore whether the intervention affected land use. Table 4 presents the next set of results. It shows positive and significant impacts of adoption on the acreage of the four crops involved in the study (Columns 1 to 4), as well as on the total (Column 5), resulting in over a quarter acre more land farmed. While we did not collect this information specifically, we speculate that part of the additional labour and machinery hired by treated farmers has been used to clear additional land. Column 6 shows that the additional land farmed was not always used to plant certified seeds: only 0.8 additional acres are cultivated with certified seeds. The remainder is instead cultivated with non-certified seeds (0.21 acres, not statistically significant).[8] Once again, this indicates that farmers respond to the presence of insurance by increasing farming efforts at the extensive margin, consistent with non-binding land constraints.

Table 5. Land farmed

	(1) Maize acres	(2) Sorghum acres	(3) Sunflower acres	(4) Soya acres	(5) Total land farmed	(6) Certified seed acres
ITT	0.181**	0.107**	0.040**	0.049**	0.293**	0.081***
	(0.070)	(0.045)	(0.015)	(0.024)	(0.132)	(0.029)
Additional controls	Yes	Yes	Yes	Yes	Yes	Yes
UAI f.e.	Yes	Yes	Yes	Yes	Yes	Yes
Mean control group	1.25	0.13	0.04	0.01	2.55	0.17
Observations	780	780	780	780	780	780
Clusters	40	40	40	40	40	40
R^2	0.20	0.082	0.067	0.026	0.24	0.071

Robust standard errors in parentheses clustered at the farmer group level (40). Additional controls include Age, Age^2, Male, Education years, Household size, Catholic, Wealth index, Livestock units, Bank account, One supplier only, and UAI fixed effects. See Appendix Table A4 for a full detail of the control variables and their coefficients. * p < 0.10, ** p < 0.05, *** p < 0.01.

Intensive margin

How does this increase of land use reflect on the *intensity* of input use? It is plausible that the aforementioned increase in investments went in parallel with the increase in land used—resulting in stable investments per acre. However, if insurance has crowding-out effects at the intensive margin, we would expect that investments per acre go down as a result of our intervention. Table 5 shows that, while some of the significant effects we observed at the extensive margin disappear (Columns 1 to 3), we do not find robust evidence of crowding-out. In fact, total non-seed investments per acre increase by about 500 KSh (Column 5)—

[8] Notice nonetheless that the share of certified land over total land farmed does increase, by about 3.7%.

significant at the 10% level. Interestingly, this result hinges mostly on the significant increase in expenditures for the rental of tractors and other machinery dedicated to land preparation. While we do not have information on the total number of hours spent by the household preparing the land, we conjecture that some crowding-out of effort may have been taking place in this context, substituted by the use of hired inputs.

Table 6. Farm investments per acre (excluding seeds)

	(1) Fertilizer	(2) Chemicals	(3) Machine rental	(4) Hiring of labour	(5) Total non-seed
ITT	32.663	-12.743	154.925*	326.130***	498.638*
	(152.283)	(75.573)	(77.449)	(101.578)	(253.546)
Additional controls	Yes	Yes	Yes	Yes	Yes
UAI f.e.	Yes	Yes	Yes	Yes	Yes
Mean control group	2114.33	629.37	986.66	2399.38	6127.57
Observations	778	778	778	778	778
Clusters	40	40	40	40	40
R^2	0.15	0.055	0.045	0.035	0.070

Robust standard errors in parentheses clustered at the farmer group level (40). Additional controls include Age, Age^2, Male, Education years, Household size, Catholic, Wealth index, Livestock units, Bank account, One supplier only, and UAI fixed effects. See Appendix Table A5 for a full detail of the control variables and their coefficients. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Willingness to pay and expectations

Finally we test whether our intervention has had effects on expectation under bad weather and on the willingness to pay (WTP) for insurance—using an incentive compatible BDM method. For expectations we simply asked farmers to tell us what they would expect their farm income to be next year under normal and under bad conditions. For the willingness to pay we presented farmers with four envelopes, each one containing a voucher for the purchase of insurance at discount for one acre of land farmed under certified maize (i.e. the same insurance product but constrained to one acre and only for the most common crop). We told respondents that they should first let us know what would be the maximum they would be willing to pay to insure one acre of certified maize under the same conditions as the previous year. If that maximum was above the price in the selected voucher/envelope, then they could purchase insurance at the price in the selected envelope. If the price they would set as limit was lower than that in the voucher they would not receive the voucher (which would not be a problem since they would be willing to pay only less than that). The four vouchers offered insurance at either 480, 360, 240, or 120 KSh. Column 1 of Table 7 shows that while the WTP does go up as a consequence of the intervention (and of the bad harvest looming over the 2017 farming season), the average WTP of farmers is still about 11 percentage points below the true market value for the treatment group. This means that only 28% of control and 33% of treatment group farmers would be willing to pay 609 KSh. Column 2 instead shows that in a hypothetical bad year treatment farmers expect to receive a slighly higher income than control (by about 0.3 standard deviations. This is robust to taking bad year income as a fraction of average year income (Column 3). Taken together we speculate that these results points towards treated farmers partially internalizing the income effect of insurance in bad years.[9]

Table 7. Willingness to pay and income expectations

	(1) Willingness to pay	(2) Expected income bad year	(3) Bad year income as fraction of average
ITT	40.451**	4420.875***	0.027**
	(19.124)	(1504.024)	(0.012)
Additional controls	Yes	Yes	Yes
UAI f.e.	Yes	Yes	Yes
Mean control group	498.27	9120.89	0.37
Observations	780	618	618
Clusters	40	40	40
R^2	0.041	0.11	0.035

Robust standard errors in parentheses clustered at the farmer group level (40). Additional controls include Age, Age^2, Male, Education years, Household size, Catholic, Wealth index, Livestock units, Bank account, One supplier only, and UAI fixed effects. See Appendix Table A6 for a full detail of the control variables and their coefficients. * p < 0.10, ** p < 0.05, *** p < 0.01.

[9] However, an insurance product such as the one on offer, given its true price and an estimated likelihood of trigger (i.e. in bad years) of 5%, should expect to smoothen the income shock by over 12000 KSh to be worth buying.

5. Conclusions

We use a randomised 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 at the extensive margin—farming more land and increasing total investments. Not only are they more likely to adopt certified seeds, but also invest more complementary inputs, especially fertilizer, and in hiring farm-machinery and labour outside the household. We speculate that this effect may be driven by two non-exclusive mechanisms. First, insurance takes away an additional portion of downward risks, not only with respect to weather but also pests and diseases. This in turn may reduce the expected cost of modern inputs (in marginal utility terms). Second, improved seed varieties may be more responsive to complementary inputs than traditional ones. If the cross term of certified seed and other inputs (e.g. fertilizer) is positive, by incentivising the purchase of certified seeds we also increase the value of the marginal product of other inputs.

At the intensive margin these effects are somewhat muted, meaning that it is unlikely that productivity will be enhanced by our intervention. However we show that farmers do not reduce investments per acre in the presence of the multi-peril crop insurance. What could explain this lack of evidence for moral hazard? One explanation could be that farmers value the sunk cost related to the condition for activation of the insurance: they need to purchase certified seeds in order to receive the bundled insurance product, and may be willing to invest more in complementary inputs to safeguard that initial investment. Another explanation could be that the hybrid nature of the insurance (partly index-based) reduces the temptation to shirk. Finally, it could be that farmers increase investments in the fields that are not covered by the insurance, therefore hiding the reduced investments on average. Our design does not allow us to disentangle these or other mechanisms at play. Further research is needed to better understand the extent to which crop insurance and certified seed bundles can help reduce the investment gap in African agriculture. This said, our study points once again to the importance of reducing downward risks to unleash smallholder investments, and offers new insights into potential synergies between different risk management strategies.

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Appendix

Table A1. Balance tests for attrition

Variables	Sample	Mean	Attrition	Mean	Δ
Lottery won (treatment group)	780	0.44	23	0.52	-0.08
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
Bank account	780	0.26	23	0.22	0.04

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

Table A2. Certified seed usage

	(1) Uptake certified seeds	(2) Certified maize	(3) Certified sorghum	(4) Certified Sunflower	(5) Certified soya	(6) Total certified seeds
ITT	0.146***	349.190***	40.713**	3.822	7.746	401.471***
	(0.045)	(122.020)	(16.450)	(4.635)	(5.816)	(129.991)
Age	0.001	31.287	2.127	0.905*	0.188	34.508
	(0.007)	(21.610)	(2.445)	(0.522)	(1.042)	(21.551)
Age^2	0.000	-0.275	-0.020	-0.007	-0.002	-0.304
	(0.000)	(0.224)	(0.029)	(0.005)	(0.011)	(0.222)
Male	0.009	-21.283	160.069**	10.613	20.074	169.473
	(0.082)	(249.477)	(77.247)	(12.358)	(20.263)	(257.109)
Education years	0.026***	46.624**	2.041	1.289**	0.974	50.927***
	(0.007)	(18.129)	(1.781)	(0.521)	(1.138)	(18.753)
Household size	-0.010	20.233	3.543	-1.252	1.261	23.785
	(0.010)	(30.333)	(4.073)	(1.239)	(0.863)	(30.246)
Catholic	-0.018	-169.774	28.567	-6.544	-11.461**	-159.212
	(0.042)	(128.175)	(23.150)	(5.688)	(5.306)	(131.696)
Wealth index	0.030	224.918**	2.412	7.073***	4.852	239.254**
	(0.024)	(87.942)	(9.244)	(2.589)	(4.385)	(89.266)
Livestock units	0.004	63.076***	2.966	-0.821	0.007	65.228***
	(0.005)	(17.432)	(2.227)	(0.539)	(0.631)	(18.836)
Bank account	0.079*	190.136	-1.565	2.304	2.174	193.048
	(0.044)	(154.068)	(18.831)	(4.357)	(6.180)	(155.072)
One supplier	-0.120*	-359.790	-17.819	15.965***	5.427	-356.218
	(0.063)	(218.194)	(22.822)	(5.696)	(4.442)	(213.856)
Imenti	0.032	-447.342**	3.802	-17.234***	-9.012	-469.787**
	(0.057)	(214.203)	(20.532)	(5.422)	(6.113)	(212.244)
Kaare	-0.016	-612.022***	1.311	31.734***	111.445***	-467.533**
	(0.044)	(211.192)	(18.753)	(3.321)	(6.474)	(203.159)
Lailuba	0.016	-123.802	-60.545*	-5.111	0.774	-188.683

	(0.051)	(250.940)	(31.607)	(5.204)	(8.602)	(221.161)
Tharaka	-0.040	-284.246	-10.950	-3.133	6.962*	-291.367
	(0.078)	(273.896)	(20.458)	(2.188)	(3.864)	(272.782)
Constant	0.227	-312.274	-79.437	-18.620	-14.561	-424.891
	(0.182)	(502.027)	(47.331)	(12.265)	(26.473)	(514.471)
Observations	780	780	780	780	780	780
Clusters	40	40	40	40	40	40
R^2	0.094	0.099	0.10	0.058	0.065	0.11

Robust standard errors in parentheses clustered at the farmer group level. * p < 0.10, ** p < 0.05, *** p < 0.01.

Table A3. Complementary inputs

	(1)	(2)	(3)	(4)	(5)
	Fertilizer	Chemicals	Machine rental	Hiring of labour	Total non-seed
ITT	459.397**	89.282	556.721***	601.490**	1690.651***
	(222.405)	(107.539)	(173.599)	(295.429)	(475.321)
Age	93.486**	-7.986	-7.585	11.755	87.701
	(45.187)	(27.894)	(33.560)	(82.152)	(125.010)
Age^2	-1.146**	0.181	0.014	-0.442	-1.379
	(0.461)	(0.314)	(0.342)	(0.854)	(1.334)
Male	-719.098	392.807	536.833	2189.794	2409.062
	(545.757)	(357.514)	(545.338)	(2129.088)	(2842.945)
Education years	30.246	35.411	9.620	20.374	96.545
	(35.195)	(23.746)	(25.257)	(99.683)	(141.851)
Household size	118.686*	3.900	155.553**	192.777*	470.387***
	(63.229)	(28.303)	(60.140)	(95.689)	(165.745)
Catholic	-615.346**	90.886	-83.723	-453.462	-1048.019
	(283.012)	(238.012)	(221.304)	(406.076)	(802.511)
Wealth index	633.854**	266.279***	382.334***	758.697**	2049.348***
	(264.135)	(94.708)	(132.580)	(332.815)	(570.758)
Livestock units	135.876**	46.535	121.237***	744.641***	1044.770***
	(58.405)	(30.855)	(23.195)	(175.476)	(153.454)
Bank account	491.169	171.942	101.588	1285.739	2057.729
	(453.260)	(194.275)	(291.092)	(815.727)	(1380.547)
One supplier	-845.509	-92.285	172.595	3.861	-750.498
	(739.684)	(210.248)	(404.788)	(711.595)	(1701.895)
Imenti	-157.463	-70.704	-1693.314***	-1355.786	-3276.391*
	(942.176)	(190.556)	(446.614)	(882.579)	(1702.325)
Kaare	-2494.881***	1501.881***	432.188	2178.225**	1143.764
	(559.717)	(209.138)	(319.146)	(827.084)	(1646.069)
Lailuba	414.054	-662.894***	-1615.579***	-1591.792**	-3442.487**
	(627.726)	(184.456)	(359.854)	(601.480)	(1410.469)
Tharaka	799.949	358.334	-1025.915***	-628.163	-485.178
	(614.088)	(280.881)	(358.931)	(861.889)	(1544.120)
Constant	770.099	540.003	1592.762**	2330.593	5286.170*
	(1107.687)	(601.948)	(757.374)	(1950.820)	(2803.346)
Observations	780	780	780	780	780
Clusters	40	40	40	40	40
R^2	0.13	0.12	0.16	0.22	0.23

Robust standard errors in parentheses clustered at the farmer group level. * p < 0.10, ** p < 0.05, *** p < 0.01.

Table A4. Land use

	(1) Maize acres	(2) Sorghum acres	(3) Sunflower acres	(4) Soya acres	(5) Total land farmed	(6) Certified seed acres
ITT	0.181**	0.107**	0.040**	0.049**	0.293**	0.081***
	(0.070)	(0.045)	(0.015)	(0.024)	(0.132)	(0.029)
Age	0.015	0.008	0.002	0.006*	0.020	0.004
	(0.017)	(0.007)	(0.002)	(0.003)	(0.042)	(0.004)
Age^2	-0.000	-0.000	-0.000	-0.000*	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Male	0.224	0.350	0.012	-0.046	1.173*	0.066
	(0.188)	(0.217)	(0.031)	(0.037)	(0.627)	(0.057)
Education	0.004	0.012**	0.005*	0.006	0.033	0.011**
years	(0.012)	(0.005)	(0.003)	(0.005)	(0.031)	(0.005)
Household size	0.052**	0.018	0.001	0.000	0.090***	-0.002
	(0.022)	(0.013)	(0.005)	(0.003)	(0.032)	(0.006)
Catholic	-0.126	0.081	-0.033	0.014	-0.018	-0.060**
	(0.093)	(0.083)	(0.020)	(0.028)	(0.233)	(0.026)
Wealth index	0.204***	-0.008	0.011	0.012	0.355***	0.050*
	(0.058)	(0.031)	(0.012)	(0.026)	(0.118)	(0.026)
Livestock units	0.112***	0.008	-0.000	0.005	0.209***	-0.003
	(0.026)	(0.005)	(0.002)	(0.003)	(0.028)	(0.003)
Bank account	0.105	0.096*	0.000	-0.035	0.400*	0.038
	(0.101)	(0.056)	(0.025)	(0.022)	(0.203)	(0.035)
One supplier	0.209*	-0.092	0.102***	0.008	0.245	0.037
	(0.113)	(0.082)	(0.028)	(0.017)	(0.274)	(0.046)
Imenti	-0.424***	-0.150*	-0.050	0.003	-1.054***	-0.058
	(0.113)	(0.075)	(0.037)	(0.024)	(0.272)	(0.040)
Kaare	-0.146*	0.086	0.164***	0.144***	0.656***	0.132***
	(0.076)	(0.079)	(0.016)	(0.011)	(0.164)	(0.025)
Lailuba	-0.295**	-0.263**	-0.019	-0.013	-0.922***	-0.039
	(0.118)	(0.097)	(0.016)	(0.019)	(0.192)	(0.030)
Tharaka	-0.078	-0.124	-0.019	0.040**	-0.425	-0.031
	(0.139)	(0.080)	(0.014)	(0.017)	(0.286)	(0.036)
Constant	0.135	-0.267*	-0.096	-0.201	0.411	0.017
	(0.396)	(0.153)	(0.065)	(0.120)	(1.001)	(0.116)
Observations	780	780	780	780	780	780
Clusters	40	40	40	40	40	40
R^2	0.20	0.082	0.067	0.026	0.24	0.071

Robust standard errors in parentheses clustered at the farmer group level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A5. Intensive margin

	(1) Fertilizer	(2) Chemicals	(3) Machine rental	(4) Hiring of labour	(5) Total non-seed
ITT	32.663	-12.743	154.925*	326.130***	498.638*
	(152.283)	(75.573)	(77.449)	(101.578)	(253.546)
Age	-69.436	-29.606	-25.632	-58.177	-182.788*
	(74.220)	(20.851)	(16.608)	(36.045)	(104.730)
Age^2	0.606	0.364	0.207	0.399	1.574
	(0.819)	(0.232)	(0.156)	(0.359)	(1.118)
Male	-1043.173***	-318.637**	142.897	23.508	-1195.084**

	(355.040)	(124.482)	(199.558)	(258.937)	(589.656)
Education years	8.313	9.552	-18.255	-27.851	-27.790
	(26.860)	(18.050)	(16.268)	(28.225)	(52.388)
Household size	-42.354	-35.609	12.309	1.584	-64.162
	(36.584)	(22.525)	(20.451)	(34.402)	(71.557)
Catholic	-363.395**	143.024	-64.410	-133.806	-417.662
	(168.726)	(145.614)	(69.116)	(165.298)	(331.292)
Wealth index	-122.314	60.719	42.074	149.228	131.455
	(117.919)	(40.746)	(58.134)	(92.027)	(207.367)
Livestock units	-40.104**	-11.210	0.487	41.327*	-9.943
	(15.969)	(10.190)	(8.639)	(21.842)	(36.046)
Bank account	35.466	-107.679	34.162	-4.010	-38.329
	(154.431)	(73.912)	(127.743)	(203.037)	(430.658)
One supplier	-342.066	-50.438	-22.377	-184.010	-598.748
	(316.754)	(87.030)	(136.221)	(234.984)	(581.246)
Imenti	913.820*	211.987**	-381.535	407.861	1150.495
	(497.014)	(81.131)	(236.388)	(311.739)	(688.286)
Kaare	-1008.601***	334.220***	-275.389**	-287.060	-1357.970**
	(220.571)	(99.659)	(133.491)	(263.006)	(550.812)
Lailuba	1057.522**	-173.921**	-644.525***	100.682	341.742
	(391.025)	(75.110)	(181.276)	(199.107)	(674.151)
Tharaka	1156.481***	423.427***	-320.848**	-72.171	1187.625*
	(369.196)	(144.430)	(137.950)	(305.953)	(629.992)
Constant	4070.213**	1234.460***	1931.488***	4250.677***	11483.551***
	(1663.970)	(414.126)	(440.290)	(810.377)	(2515.641)
Observations	778	778	778	778	778
Clusters	40	40	40	40	40
R^2	0.15	0.055	0.045	0.035	0.070

Robust standard errors in parentheses clustered at the farmer group level. * p < 0.10, ** p < 0.05, *** p < 0.01.

Table A6.

	(1) Willingness to pay	(2) Expected income bad year	(3) Bad year proportional to average
ITT	40.451**	4420.875***	0.027**
	(19.124)	(1504.024)	(0.012)
Age	-6.440	71.667	-0.001
	(4.598)	(306.040)	(0.003)
Age^2	0.067	-0.809	0.000
	(0.051)	(2.816)	(0.000)
Male	42.625	2411.386	-0.028
	(40.819)	(4422.748)	(0.042)
Education years	0.374	96.731	0.000
	(3.760)	(375.073)	(0.003)
Household size	-2.238	323.818	-0.007*
	(6.079)	(363.159)	(0.004)
Catholic	48.885**	1903.653	-0.003
	(21.578)	(1849.131)	(0.022)
Wealth index	29.056*	3801.196***	0.021*
	(14.641)	(1016.665)	(0.011)

Livestock units	4.817	742.914***	0.001
	(3.804)	(216.451)	(0.002)
Bank account	11.311	3749.877**	0.001
	(26.108)	(1771.199)	(0.017)
One supplier	41.842	2163.653	0.017
	(27.424)	(1639.765)	(0.024)
Imenti	7.261	-1350.528	0.014
	(31.190)	(2242.921)	(0.028)
Kaare	-15.541	9139.060***	0.031
	(22.149)	(1596.290)	(0.019)
Lailuba	-15.896	3800.570	0.076**
	(43.298)	(4481.081)	(0.037)
Tharaka	1.368	4102.700**	0.057*
	(24.164)	(1818.446)	(0.030)
Constant	595.999***	-1982.084	0.395***
	(103.449)	(7604.689)	(0.093)
Observations	780	618	618
Clusters	40	40	40
R^2	0.041	0.11	0.035

Robust standard errors in parentheses clustered at the farmer group level. * p < 0.10, ** p < 0.05, *** p < 0.01.