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# Does bundling crop insurance with certified seeds crowd-in investments? Experimental evidence from Kenya

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ABSTRACT

We use a randomised experiment in Kenya to analyse how smallholder farmers respond to receiving a free hybrid crop insurance product, conditional on purchasing certified seeds. We find that farmers increase effort—increasing total investments and taking more land in production. In addition to adopting more certified seeds, they also invest more in complementary inputs such as fertilizer and hired-in farm-machinery and non-farm labour. We find limited evidence of a change in farming intensity. For example, there is no evidence of 'crowding-out' of effort or inputs on a per-hectare basis, even if the indemnity-based component of the insurance product potentially gives rise to asymmetric information problems (moral hazard). We also document that *ex post* willingness to pay for the insurance product has increased for the treatment group. This suggests that learning about the benefits of (subsidized) insurance outweighs any anchoring effects on the zero price during the pilot study.



## 1. Introduction

Agriculture is the key sector for poverty reduction and sustainable development in Africa in the twenty-first century, and remains an essential component of most development strategies (World Bank, 2008). It employs approximately two-thirds of the labour force and generates on average one-third of gross domestic product (GDP) growth (Brune et al., 2016).

In order to kick-start a process of agricultural development farmers should increase usage 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. Just and Zilberman, 1983). However, it is well-known that adoption of modern inputs among African farmers remains incomplete due to lack of information, lack of liquidity to purchase inputs, and (perceived) risks associated with adoption (Feder et al., 1985).[1] More recent explanations for low adoption rates

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[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 rates are high among farmers who initially adopt improved

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are based on insights from behavioral economics (Foster and Rosenzweig, 2010) or the existence of low-quality counterfeit inputs (Bold et al., 2017).

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 pose a threat to their livelihoods if they live close to subsistence levels. While poor households may be able to informally manage risks via community-based insurance (e.g., Breman, 1974; Scott, 1976) or reciprocal lending within social networks, such strategies are unlikely to adequately deal with systemic risks such as weather shocks (e.g., Townsend, 1994; Udry, 1990, 1994). Hence it is no surprise that many African smallholders opt for (traditional) inputs promising low expected yields but little variability in returns (Mobarak and Rosenzweig, 2013, Karlan et al., 2014; Kurosaki and Fafchamps, 2002).

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, pointing to potential *ex ante* (investment) and *ex post* (income constraint) effects (e.g., Cai and Song, 2017; De Janvry et al., 2014; Karlan et al., 2014; Hill et al., 2019).[2] However the evidence on potential welfare gains remains ambiguous, and policy choices regarding 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 rates typically do not exceed ten per cent of the population. Ahmed et al. (2018, p.32) write "... *there are literally no examples of developing-country index insurance pilot programs leaping to scale as market-based products*." Also refer to Cole and Xiong (2017) and Carter et al. (2017) for recent overviews of experiences with index insurance.[3]

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' the use of 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 set of improved inputs, achieves the following: 1) increase the uptake of improved seeds; 2) affect the uptake of complementary modern inputs; and 3) provide a vehicle facilitating learning about the benefits of agricultural 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, labor 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. That is; insurance increases the risk-adjusted rate of return of investments in inputs. Crowding-out effects may also occur. This could happen if the indemnity-based component of our insurance product invites moral hazard among farmers. The effect of insurance on input use is therefore theoretically ambiguous.

Our work is related to several other studies. Very little work has been done on the 'bundling' of insurance. Giné and Yang (2009) find that bundling insurance with credit 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. Karlan et al. (2014) also argue against bundling credit and insurance, arguing that microfinance organisations should focus on providing the latter if the aim is to generate an investment response.[4] We are not aware of any work on the bundling of insurance and agricultural inputs. One difficulty is that, compared to credit, agricultural inputs are far from homogenous. Studying insurance bundled with a specific seed variety, for instance, will be inherently dependent on the very characteristics of that variety, and thus have limited external validity. We address this generalisability issue by allowing farmers to bundle the insurance to 'any' seed variety certified by the Kenya Plant Health Inspectorate Service (KEPHIS), for the four most commonly farmed crops in the area of study. This includes virtually any certified improved seeds our sample of smallholder farmers would have access too. The paper also speaks to the issue of subsidizing inputs. According to behavioural economic theory, short-term subsidies may invite opposing effects on long-term adoption. Short-term subsidies may facilitate learning about the benefits of new technologies, but also invite 'anchoring' on low (or zero) prices which would reduce future demand (e.g. Dupas, 2014a,b). The net effect is again theoretically ambiguous.

agricultural technologies (Kijima et al., 2011). Gollin et al. (2005) estimate that adoption of modern varieties of maize was limited to 17% of the maize farmers, which may be compared to 57% in Latin America and the Caribbean, and 90% in East and South East Asia and the Pacific.

[2] 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 labor-intensive planting methods and fertilizer.

[3] Cole et al. (2014), Casaburi and Willis (2018) and Belissa et al. (2019) demonstrate that demand for index insurance can be increased by complementary interventions aimed at generating trust in the insurance product or overcoming liquidity constraints when premiums are due. Karlan et al. (2014) also provide evidence for considerable demand for index insurance.

[4] Theoretical work by Carter et al. (2016) also emphasizes potentially ambiguous welfare effects of combining credit and insurance, depending on the nature of the risk and the presence of collateral.

We report three main results. First, bundling modern inputs with free insurance results in some extra uptake of improved seeds. This suggests positive willingness to pay for the insurance product. However, it also 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 use a Becker–DeGroot–Marschak auction design (BDM) to elicit willingness-to-pay (WTP) for the same insurance product during the following year in an incentive-compatible fashion. We document greater willingness to pay among the treated, which we interpret as evidence of a positive learning effect.

The remainder of the paper is organised as follows. In Section 2 we explain the insurance product, and randomisation procedure. We show that randomisation worked by presenting balance tests. Section 3 sketches our identification strategy and presents the main outcome variables. 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

We offer free multi-peril insurance (see below) to a random group of Kenyan smallholders who purchase improved seeds for specific crops. The improved seed varieties were locally available at market prices, and certified by KEPHIS—the national authority monitoring seed quality. The study was motivated by two observations regarding the behaviour of smallholders in our study region: (i) uptake of unsubsidized farming insurance products is very limited (nearly absent) in our study area,[5] and at current rates is unlikely to provide an impetus to local agricultural development; and (ii) the adoption of improved crop varieties is low, levelling at less than 50% of farmers in our study region and covering less than 25% of land. The majority of farmers prefer to grow traditional varieties with lower expected yield. Farmers adopting modern varieties are typically growing traditional varieties alongside the modern ones.[6]

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 a very rough proxy for the latent demand for insurance. The price paid for improved inputs now enables the farmer to kill two birds with one stone: she effectively purchases both insurance as well as modern inputs. If the promise of free insurance does not increase the adoption of modern seed, the implied value of insurance must be very low. By comparing the uptake of improved crop varieties between the treated and control group we obtain a measure of willingness to pay for formal insurance.

However, while our estimated treatment effect provides a proxy for the value of insurance, it is not straightforward to interpret its exact meaning without making additional assumptions. This can be shown with a very simple model. Suppose that people are homogeneous in their WTP for insurance ($v$) but heterogeneous in their WTP for improved varieties ($i$). Assume a cumulative distribution function for the distribution of WTP for improved varieties, $i \sim G(\cdot)$, and that farmers have to choose whether to buy improved varieties or not (binary choice). The price of the improved variety is fixed, at price $p$. Farmers from the control group will buy if $i > p$ and farmers from the treatment group will buy if $i + v > p$. The difference in uptake between the two groups is simply $G(p) - G(p - v)$, and depends on the shape of $G$ as well as on the variable of interest ($v$),

The main hypothesis that we test:

***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 non-seed modern inputs. As mentioned, production complementarities and the elimination (or reduction) of downside risk may crowd in additional inputs, but moral hazard may have the opposite effect. Since the indemnity-based component of the hybrid product is relative small, however, we expect that problems due to asymmetric information will be relatively unimportant in this context.

***Hypothesis 2:*** *Farmers induced to buy a bundle with improved seeds and formal insurance are more likely to also invest in the use of complementary inputs.*

Finally we predict that offering a free insurance product may facilitate learning about the benefits of insurance and contribute to building trust in the product and insurance company. In theory, reference-dependent utility may depress WTP after short-term subsidization of goods and services, but the literature suggests that the learning effect tends to dominate the anchoring effect. Hence we expect willingness to pay for insurance in follow up periods to increase.

***Hypothesis 3:*** *Subsidized access to insurance increases future demand for insurance.*

[5] While we cannot exclude that other farmers in the area purchased insurance, none of the participants in our study bought crop or weather insurance in the previous year.

[6] However, there is some ambiguity as to the exact meaning of the concept 'traditional varieties'. Much of the traditional maize seed used by farmers everywhere in Africa is a mix of old and modern.

**Table 1**
Premiums of MPCI per acre for different crops.

| | Soya bean | Sorghum | Sunflower | Maize |
|---|---|---|---|---|
| Cost of production per acre | 11,300 | 11,500 | 4900 | 14,500 |
| Expected yield (kg/acre) | 1800 | 2000 | 1000 | 1500 |
| Insured at 65% guarantee Sum insured (KSh/acre) | 7345 | 7475 | 3185 | 9425 |
| 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** |

### *2.1. The insurance product*

We consider an unusual insurance product. The insurance product is made available for free but obtaining it is conditional on the purchase of certified seeds. The insurance is underwritten individually by farmers and not transferable. The insurance coverage is specifically designed and provided by APA Insurance Ltd and Acre Africa Ltd for the purpose of the experiment.[7] Our hybrid insurance product combines index-based insurance for some risks and indemnity-based insurance for others. It therefore falls in the category of Multi-Peril Crop Insurance (MPCI).

The weather index insurance (WII) component includes both rainfall deficits (covering three stages: germination, vegetative and flowering) and excess rainfall during the entire growth season. Weather data are ground-based rainfall measurements. The effective date of inception starts when a minimum of 10 mm of rain within a five-day period (as captured by the respective weather stations) is recorded. The indemnity component 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 inspection. Furthermore, risk is monitored during the cover period through periodic farm visits in sampled farms within defined insurance units. In case of a ‘total loss’ necessitating replanting, payments are 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. the product uses a deductible of 35% of the insured amount).

The study team subsidized the full insurance premium for adopting farmers. The premium paid to the insurance company varied depending on the crop—from 232 KSh for Sunflower to 609 KSh per acre for maize (where 100 Ksh ≈ USD 1). Since standard seed packages cover only part of an acre (one acre of maize requires four standard packages), it was also possible to insure part of an acre – the land equivalent of the number of packets purchased. We did not impose any upper bound on the number of acres (packages) that could be purchased. Table 1 breaks down the premium for the four crops as estimated by APA.

Farmers were not informed about the value of the different insurance subsidies, but received two trainings about the workings of the insurance product. Group meetings were held in the period from June to September in 2016, and to increase participation in these sessions we incentivized attendance. During these sessions, concepts like total loss, trigger, long term yield estimates and so on where presented and discussed. All participants in the study were informed that the indemnity-based portion of the insurance would be triggered if actual yield fell below 65% of long-term yield estimates (also discussed and validated locally). They also received information about index insurance and remote sensing of local rainfall. To further increase the understanding of farmers we also organized meetings with group leaders to provide additional explanation about the insurance product. After the sessions farmers participated in a lottery that determined treatment status – whether they qualified for the free insurance conditional on purchase of certified seeds.[8] The lottery assigned 45% (55%) of the farmers to the treatment (control) arm. The purchase of certified seeds and registration of insurance was verified in October 2016, after farmers started clearing land for planting.

### *2.2. Experimental design*

Our initial sample frame consisted of 803 farmers, all of which members of one of the 40 farmer groups in Meru county, Kenya. Treatment farmers received free insurance proportional to the amount of certified improved seeds purchased for selected crops. During the end-line survey we were unable to retrieve 23 of the farmers, so the analysis is based on a sample of 780. Additional analysis (summarized in Appendix Table A1) reveals that attrition is not correlated with treatment status or baseline co-variates. We therefore treat it as random.

There was some non-compliance. Of the control group, 34 farmers purchased the MPCI product anyway, paying the full market price. This amounts to 8% of the subsample. Being absent or unavailable at the time of registration by APA insurance, 20 farmers from the treatment group who purchased improved seeds did not receive free insurance, amounting to 6% of this

[7] The design of the insurance product was done in close collaboration with Shalem Investments – a local aggregator in Meru, Kenya, providing certified inputs and trading (mainly) sorghum.

[8] Leaders of all 40 farmer groups were offered the conditional insurance package, and are not part of the study sample frame. This was to ensure ‘buy-in’ of leaders.

**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). $^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$.

subsample. In addition, many farmers from the treatment group did not purchase improved seed (see below), and therefore also qualify as non-compliers. In the analysis that follows we conservatively, considering all lottery winners as treated and lottery losers as control—regardless of their ensuing insurance status.[9]

### 2.3. Descriptive statistics and balancing tests

We check whether the randomisation worked by regressing the treatment dummy on baseline values of co-variates for the sample of 780 farmers. Table 2 shows that the randomisation procedure worked as expected: at baseline, there are hardly any significant differences between winners and losers of the lottery. Farmers in the treatment group are slightly more likely to have a bank account, significant at the 10%, but the difference is small and we control for in our analysis. Participants are mostly female, on average 46 years old, with 6 years of education, and living in a household with 6 members. About one-third of our respondents is 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 (TLU). Almost every farmer grew maize, and sorghum and sunflower were less important crops (grown by 7% and 2% of the farmers in our sample, respectively). Soya was almost absent in the area.

## 3. Identification

We present simple estimates of the impact of being offered the free insurance, bundled with improved seeds, on different outcome variables.[10] The model we estimate read as follows:

$$Y_i = C + \alpha T_i + \beta \boldsymbol{X_i} + \varepsilon_i \tag{1}$$

Where $Y_{\mathrm{i}}$ refers to a vector of dependent variables for respondent *i*, $T_{\mathrm{i}}$ is the treatment dummy indicating whether respondent *i* was offered free insurance (1 if they won the lottery, 0 otherwise), $X_{\mathrm{i}}$ is a vector of controls at baseline, and $\epsilon_{\mathrm{i}}$ is a random error term. While treatment status is orthogonal to 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* (expressed in TLUs); *Bank account 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 (or 'region' dummies). Eq. (1) is estimated using OLS, and we cluster standard errors at the farmer group level (of which there are 40).

## 4. Results

In this section we present our main regression results, focusing on the impacts of the offer of the free multi-peril crop insurance product on various dimensions of farm management as well as on WTP for the insurance product in the future.

[9] As is often the case with individual-level interventions, it is possible that the treated colluded with control generating unwanted spill-overs. While we cannot exclude this entirely, we are confident that the extent of it is not driving our results. We believe that the combination of an index based component, with and indemnity component requiring field verifications by qualified agronomists – as explicitly stressed by APA insurance – strongly disincentivized opportunistic behaviour across participants.

[10] Note that we do not estimate the effect of having insurance, but the effect of winning the lottery which gives access to free insurance.

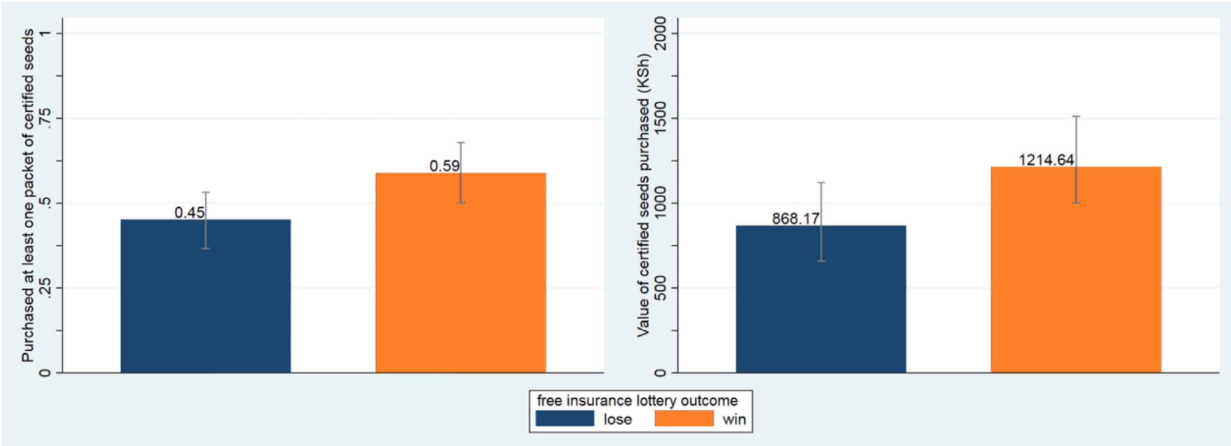


**Fig. 1.** Uptake of certified seeds.

**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 |
|---|---|---|---|---|---|---|
| Free insurance | 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 |
| Clustered s.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 |
| $R^2$ | 0.09 | 0.10 | 0.10 | 0.06 | 0.07 | 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. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

### *4.1. Certified seeds usage*

The link between insurance and the purchase of improved seed is direct and automatic. Fig. 1 shows that the treatment groups has a significantly higher uptake rate of certified seeds as well as a significantly higher total expenditure on seeds (with a 95% confidence interval clustered at the farmer group level).

Using a Linear Probability Model (LPM) we find that the likelihood of purchasing certified seeds increases by 14.6 percentage points (Column 1 of Table 3), suggesting that the farmers have a positive value for insurance. In the control arm, some 45% of the farmers used improved seeds. This number was pushed up to nearly 60% due to the offer of free MPCI.[11] This appears like a sizable treatment effect, of some 0.3 standard deviations from the control mean. However, it is evident that many farmers still decided to *not* purchase any improved seeds. While latent demand for insurance is positive and significant, it is not sufficiently large to sway all farmers to switch from traditional to modern varieties.

***Result 1:*** *Uptake of modern varieties with subsidized insurance is greater than uptake of modern varieties without subsidized insurance, suggesting positive willingness to pay for insurance.*

Columns 2–5 reports on estimates where we break down the analysis at the crop level. Treatment farmers were more likely to purchase improved seeds of the two major crops in the area, sorghum and maize. They did not take the insurance product as an opportunity to experiment with the lesser crops: soya and sunflower.

Column 6 shows the impact on total improved seed expenditures (for all crops). Expenditures on certified seeds increased by about 400 KSh, or by 0.26 standard deviations. This amounts to approximately one additional package of seed per person in the treatment group (improved maize seed costs approximately KSh 400-500 per package), or just enough seed for one quarter of an acre. This is a modest effect, indicating that farmers continue to grow traditional varieties as well.

From Table 1 we know that the market price of the maize insurance product is KSh 609. It is important to observe that for some 40% of the farmers in our sample, the *combined value* of improved seed and the insurance product is less than the

[11] This result is robust to using Probit and Logit estimators, with consistent significance levels and marginal effects.

**Table 4**
Investments in complementary inputs.

| | (1) Fertilizer | (2) Chemicals | (3) Machine rental | (4) Farm labor | (5) Total non-seed |
|---|---|---|---|---|---|
| Free insurance | 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 |
| Clustered s.e. | Yes | Yes | Yes | Yes | Yes |
| Mean control group | 3568.518 | 1118.825 | 2163.733 | 5732.316 | 12,579.34 |
| Observations | 780 | 780 | 780 | 780 | 780 |
| $R^2$ | 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. $^*p < 0.10$, $^{**}p < 0.05$, $^{***}$ $p < 0.01$.

**Table 5**
Land farmed.

| | (1) Maize acres | (2) Sorghum acres | (3) Sunflower acres | (4) Soya acres | (5) Total land farmed | (6) Certified acres |
|---|---|---|---|---|---|---|
| Free insurance | 0.181** | 0.107** | 0.040** | 0.049** | 0.293** | 0.332*** |
| | (0.070) | (0.045) | (0.015) | (0.024) | (0.132) | (0.096) |
| Additional controls | Yes | Yes | Yes | Yes | Yes | Yes |
| UAI f.e. | Yes | Yes | Yes | Yes | Yes | Yes |
| Clustered s.e. | Yes | Yes | Yes | Yes | Yes | Yes |
| Mean control group | 1.25 | 0.13 | 0.04 | 0.01 | 2.55 | 0.55 |
| Observations | 780 | 780 | 780 | 780 | 780 | 780 |
| $R^2$ | 0.20 | 0.08 | 0.07 | 0.03 | 0.24 | 0.14 |

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. $^*p < 0.10$, $^{**}$ $p < 0.05$, $^{***}p < 0.01$.

market price of seed (400 KSh) and therefore a priori (much) less than the market price of insurance. This suggests that offering MPCI is unlikely to succeed as a market-based solution without subsidies (among inexperienced farmers).

Additional regression results, including the full vector of control variables, are reported in Appendix Table A2. We find that, in addition to the subsidy treatment, uptake of certified seed is also associated with education and wealth (both a wealth index and livestock holdings). There are also significant differences between regions, reflecting differences in agro-ecological conditions or culture.

### *4.2. Crowding-in complementary investments*

Does the increase in uptake of certified seeds, and the additional security offered by insurance, affect total investments in complementary inputs *not subject to* the conditionality of improved seeds? In our experiment, risk reduction may come from two sources – income stabilization due to the MPCI as well as reduced production risk due to the (drought-tolerant) seed varieties. In addition, agronomic research suggests there may be production complementarities. Specifically, hybrid varieties have a higher harvest index and put more of the nitrogen in added fertilizer into the grain.

Table 4 shows a positive impact of the treatment on fertilizer use (Column 1), but not on pesticides and other chemicals (Column 2). We also find a large effect on investments in off-farm labour for planting, weeding, and harvesting (Column 3) and machinery such as hired tractors (Column 4). Overall, the treatment effect on unconditional input investment amounts to almost 1700 Ksh (0.15 standard deviations), significant at the 1% level. These data suggest 'crowding-in' of complementary inputs, consistent with Karlan et al. (2014) for insurance, and Emerick et al. (2016) for flood-tolerant new rice varieties. Below we speculate about the mechanism linking insurance to enhanced uptake of complementary inputs.

Additional regression results are reported in Appendix Table A3. As before, we find a positive association between uptake of inputs and our wealth proxies, and that the region dummies are significant. In addition we find that household size correlates positively with the use of complementary inputs (perhaps reflecting complementarity in production between these inputs and family labor), and that age is positively correlated with the use of fertilizers.

### *4.3. Land use*

We next explore whether the intervention affected land use. Table 5 reveals positive and significant impacts of the offer on the acreage of the crops involved in the study (Columns 1–4) as well as on total area farmed (Column 5). Additional regression results are presented in Table A4. As before we find that wealth, region dummies and education tend to enter significantly.

**Table 6**
Farm investments per acre (excluding seeds).

| | (1) Fertilizer | (2) Chemicals | (3) Machine rental | (4) Farm labor | (5) Total non-seed |
|---|---|---|---|---|---|
| Free insurance | 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 |
| Clustered s.e. | Yes | Yes | Yes | Yes | Yes |
| Mean control group | 2044.9 | 608.6 | 954.0 | 2317.5 | 5922.9 |
| Observations | 780 | 780 | 780 | 780 | 780 |
| $R^2$ | 0.15 | 0.06 | 0.05 | 0.04 | 0.07 |

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. $^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Our finding of expanded acreage is consistent with extensive margin results reported by Hill et al. (2019) for Bangladesh. It is likely that part of the off-farm labour and machinery hired (Table 4) are used to clear additional land. Column 6 shows that newly-cultivated land was mostly used to plant certified seeds. Certified seeds therefore do not substitute non-certified seeds. Rather, they seem to complement existing land allocation.

But where does this additional land farmed come from? The finding that farmers in the treatment group cultivate an extra one-quarter acre of land, suggests non-binding land constraints. We asked farmers in our sample whether credit, and/or land availability were the main constraint to expanding their farming. While 62.4% responded that credit was a major constraint for them, only 27.7% responded that land availability was a concern. This may be explained by the relatively low population density in the area, with many farmers reporting they only farm a portion of the land they have farming rights upon. It is also possible however that the additional land was farmed at the expense of land set aside for traditional crop rotation. If so, the increase in farmed area may have unintended consequences in later seasons—limiting the land available in the future under traditional rotation practices.

***Result 2:*** *Subsidized insurance increases demand for complementary inputs such as fertilizer, machinery and hired labor, and increases demand for land. Attenuating downside risk invites farm expansion.*

### 4.4. Intensity of land use

How does this increase of land use reflect on the *intensity* of input use? We have documented that variable investments in farm management as well as farm size increased as a result of the subsidized insurance offer. If insurance 'crowds-out' effort due to moral hazard, we should expect investments per unit of land may go down. However, regression results in Table 6, based on investments per acre, are inconsistent with such a perspective. Fertilizer and chemical use intensity is unaffected. This finding allows us to speculate about the earlier finding that insurance crowds-in other inputs (Section 4.2 above). The latter effect might have been driven by two non-exclusive mechanisms: an increase in the risk-adjusted return to investment in modern inputs or production complementarities. Table 6 reveals the crowding-in effects originates from taking additional land in production, rather than intensifying the management of existing land. Modern seed does not cause farmers to apply more fertilizer on the cultivated land, as would have been the logical outcome for a positive cross-term of certified seeds and fertilizer in the production function. We therefore speculate that the risk adjustment effect dominates. However, additional data are necessary to disentangle these effects.

Investments in off-farm labour and machinery are higher than among farmers in the control group. This is not unexpected if there are convex costs associated with taking more land in production. If taking new land in production requires additional effort, then the average (per acre) cost of capital and labour cost for the farm go up. Total non-seed investments per acre increase by about 500 KSh (Column 5)—significant at the 10% level. Very few of the additional covariates, apart from the region dummies, seem to have much explanatory power (Table A5). However it is interesting to note that male-headed households tend to farm their plots less intensively than female-headed households – they use less fertilizer and chemicals per unit of land.

Taking all the evidence on complementary inputs together we conclude the following:

***Result 3:*** *Evidence for the intensity of intensive farm management is mixed, but overall input costs per unit of land increase. There is no support for the claim that insurance invites moral hazard and crowds-out the use of complementary inputs.*

### 4.5. Willingness to pay

Finally we test whether our intervention has affected willingness to pay (WTP) for future insurance—using an incentive compatible BDM method. We presented farmers with an envelope containing a (discount) voucher for the purchase of in-

**Table 7**
Willingness to pay for insurance (Table A6).

| | (1) OLS | (2) Winsorized | (3) Poisson | (4) Tobit |
|---|---|---|---|---|
| Free insurance | 40.451** | 39.127** | 0.078** | 53.384** |
| | (19.124) | (18.188) | (0.037) | (22.863) |
| Additional controls | Yes | Yes | Yes | Yes |
| UAI f.e. | Yes | Yes | Yes | Yes |
| Clustered s.e. | Yes | Yes | Yes | Yes |
| Mean control group | 498.27 | 512.79 | – | – |
| Observations | 780 | 780 | 780 | 780 |
| $R^2$ | 0.04 | 0.04 | – | – |

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, ***$p < 0.01$.

surance for one acre of certified maize land.[12] We offered the same MPCI product as before, but now limited the offer to one acre and only for the most common crop (maize). Respondents were asked their maximum WTP for the voucher. If their bid was higher than the price in the envelope, they could purchase insurance at the given envelope price. If their bid was below the strike price they could not purchase the voucher.

Regression results in Table 7 reveal two important results. First, WTP for the treated group exceeds that of the control group (column 1). This suggests that the learning opportunities offered by subsidized insurance exceed any anchoring effect on the past price of 0 Ksh. This results is robust to winsorizing the most extreme valuations (column 2), running a Poisson specification to take advantage of the count nature of data (column 3), as well as a censored Tobit to take into account censoring of data above 1000 KSh per policy (column 4). All results in Table 7 consistently point to an increase of WTP for the treated of 7–8% compared to control.

The second result is that the WTP of treated farmers is still too low for the market to take off––bids in the BDM are 11 percentage points below the true market value (column 1). According to our data, only 28% of the farmers in the control group, and 33% of the farmers in the treatment group, are willing to pay the full premium of 609 KSh. Additional results in Table A6 reveal a positive correlation between WTP at endline and our wealth index as well as our dummy for catholic faith.

***Result 4:*** *Short-term subsidies for agricultural insurance increase long-term demand for insurance. This suggests that the learning effect of subsidies dominate any anchoring effects.*

## 5. Conclusions

We use a randomised experiment in Kenya to analyse how smallholders respond to subsidized crop insurance conditional on purchasing certified seeds. Our insurance product does not only offer index-type of protection against droughts, it also contains an indemnity-based component offering protection against other shocks including pests and diseases. Basis risk, broadly defined, is therefore lower than with conventional index insurance products, suggesting that we offer a superior product from the farmers' perspective. This is the first paper that looks at the effect of an intervention that 'bundles' insurance with improved inputs.

Our study complements the literature on the role that reducing downward income risks has on farming choices and investments (Emerick et al., 2016). Similar to Karlan et al. (2014) and Hill et al. (2019), we find that when uncertainty constraints are relaxed by insurance coverage, farmers increase their appetite for innovation – in our case improved seed varieties – and are able to find resources to increase farm expenditures. Importantly, we are able to separate the increase in expenditures that is due to increased land use, from intensification. We find that farmers respond by taking more land in production and (hence) increasing expenditures on complementary inputs.

As is well-known, the indemnity-based component of our insurance product may invite moral hazard—farmers claiming damages following from the under-supply of protective effort. However, this is not what we observe in our data. The use of complementary inputs per acre does not go down as a result of treatment. Of course it is possible that verification costs

[12] We had four envelopes with four different strike prices: 480, 360, 240, and 120 KSh.

of the indemnity-based component may impede further development of hybrid insurance products, even in the absence of severe asymmetric information problems.

Another important result of our study is that while farmers value insurance, they do not value it enough to support market-based solutions. Willingness to pay for the hybrid product is positive, but falls short of the real market price for many farmers. Indeed, even the combined value of modern seed and insurance is (far) below the market price of insurance. Short-term subsidization goes some way towards 'bridging the gap' between willingness to pay and market prices, and may help to develop future markets. We document that treated farmers place higher value on the insurance product than farmers from the control group, suggesting the 'learning effect' of subsidies dominates any behavioural 'anchoring effect'. However, even after learning about the benefits of insurance, we still find that willingness to pay for insurance falls short of market prices. Continued subsidization may therefore be necessary in order for this market to take off—which is of course not very different from the way insurance markets in Western countries have developed (Cole and Xiong, 2017).

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## Appendix

Table A1–A6.

**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 |

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

**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 |
|---|---|---|---|---|---|---|
| Free insurance | 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) |

(continued on next page)

**Table A2** (*continued*)

| | (1) Uptake certified seeds | (2) Certified maize | (3) Certified sorghum | (4) Certified Sunflower | (5) Certified soya | (6) Total certified seeds |
|---|---|---|---|---|---|---|
| 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 |
| $R^2$ | 0.09 | 0.10 | 0.10 | 0.06 | 0.07 | 0.11 |

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

**Table A3**
Investments in complementary inputs.

| | (1) Fertilizer | (2) Chemicals | (3) Machine rental | (4) Farm labor | (5) Total non-seed |
|---|---|---|---|---|---|
| Free insurance | 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 farmed.

| | (1) Maize acres | (2) Sorghum acres | (3) Sunflower acres | (4) Soya acres | (5) Total land farmed | (6) Certified acres |
|---|---|---|---|---|---|---|
| Free insurance | 0.181** | 0.107** | 0.040** | 0.049** | 0.293** | 0.332*** |
| | (0.070) | (0.045) | (0.015) | (0.024) | (0.132) | (0.096) |
| Age | 0.015 | 0.008 | 0.002 | 0.006* | 0.020 | 0.024* |
| | (0.017) | (0.007) | (0.002) | (0.003) | (0.042) | (0.014) |
| $Age^2$ | −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* | 0.326 |
| | (0.188) | (0.217) | (0.031) | (0.037) | (0.627) | (0.226) |
| Education years | 0.004 | 0.012** | 0.005* | 0.006 | 0.033 | 0.037*** |
| | (0.012) | (0.005) | (0.003) | (0.005) | (0.031) | (0.013) |
| Household size | 0.052** | 0.018 | 0.001 | 0.000 | 0.090*** | 0.022 |
| | (0.022) | (0.013) | (0.005) | (0.003) | (0.032) | (0.020) |
| Catholic | −0.126 | 0.081 | −0.033 | 0.014 | −0.018 | −0.017 |
| | (0.093) | (0.083) | (0.020) | (0.028) | (0.233) | (0.113) |
| Wealth index | 0.204*** | −0.008 | 0.011 | 0.012 | 0.355*** | 0.136** |
| | (0.058) | (0.031) | (0.012) | (0.026) | (0.118) | (0.059) |
| Livestock units | 0.112*** | 0.008 | −0.000 | 0.005 | 0.209*** | 0.055*** |
| | (0.026) | (0.005) | (0.002) | (0.003) | (0.028) | (0.020) |
| Bank account | 0.105 | 0.096* | 0.000 | −0.035 | 0.400* | 0.142 |
| | (0.101) | (0.056) | (0.025) | (0.022) | (0.203) | (0.093) |
| One supplier | 0.209* | −0.092 | 0.102*** | 0.008 | 0.245 | −0.036 |
| | (0.113) | (0.082) | (0.028) | (0.017) | (0.274) | (0.127) |
| Imenti | −0.424*** | −0.150* | −0.050 | 0.003 | −1.054*** | −0.271** |
| | (0.113) | (0.075) | (0.037) | (0.024) | (0.272) | (0.103) |
| Kaare | −0.146* | 0.086 | 0.164*** | 0.144*** | 0.656*** | 0.103 |
| | (0.076) | (0.079) | (0.016) | (0.011) | (0.164) | (0.086) |
| Lailuba | −0.295** | −0.263** | −0.019 | −0.013 | −0.922*** | −0.151 |
| | (0.118) | (0.097) | (0.016) | (0.019) | (0.192) | (0.106) |
| Tharaka | −0.078 | −0.124 | −0.019 | 0.040** | −0.425 | −0.141 |
| | (0.139) | (0.080) | (0.014) | (0.017) | (0.286) | (0.153) |
| Constant | 0.135 | −0.267* | −0.096 | −0.201 | 0.411 | −0.627* |
| | (0.396) | (0.153) | (0.065) | (0.120) | (1.001) | (0.344) |
| Observations | 780 | 780 | 780 | 780 | 780 | 780 |
| Clusters | 40 | 40 | 40 | 40 | 40 | 40 |
| $R^2$ | 0.20 | 0.08 | 0.07 | 0.03 | 0.24 | 0.14 |

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

**Table A5**
Farm investments per acre (excluding seeds).

| | (1) Fertilizer | (2) Chemicals | (3) Machine rental | (4) Hiring of labour | (5) Total non-seed |
|---|---|---|---|---|---|
| Free insurance | 44.467 | −11.293 | 154.919* | 320.002*** | 505.880* |
| | (157.010) | (74.618) | (78.044) | (100.284) | (259.953) |
| Age | −71.524 | −30.468 | −26.768 | −62.041* | −190.726* |
| | (73.868) | (20.913) | (16.638) | (36.316) | (104.616) |
| $Age^2$ | 0.626 | 0.374 | 0.216 | 0.438 | 1.652 |
| | (0.815) | (0.232) | (0.157) | (0.361) | (1.116) |
| Male | −1019.997*** | −313.925** | 141.191 | 34.784 | −1157.635* |
| | (353.901) | (121.732) | (199.910) | (253.115) | (586.219) |
| Education years | 5.969 | 9.066 | −20.005 | −29.119 | −33.671 |
| | (26.815) | (18.301) | (16.100) | (27.452) | (51.345) |
| Household size | −40.736 | −35.506 | 10.949 | 2.515 | −62.880 |
| | (36.493) | (22.736) | (20.376) | (34.165) | (71.746) |
| Catholic | −372.071** | 141.646 | −64.536 | −130.197 | −424.314 |
| | (169.403) | (142.961) | (70.377) | (165.482) | (329.194) |
| Wealth index | −104.058 | 64.756 | 47.644 | 164.835* | 174.931 |
| | (115.899) | (42.390) | (57.746) | (91.150) | (205.306) |
| Livestock units | −41.382** | −11.312 | 0.501 | 40.627* | −12.006 |
| | (15.920) | (10.176) | (8.616) | (22.092) | (36.368) |

(continued on next page)

**Table A5** (*continued*)

| | (1) Fertilizer | (2) Chemicals | (3) Machine rental | (4) Hiring of labour | (5) Total non-seed |
|---|---|---|---|---|---|
| Bank account | 35.053 | −108.096 | 38.159 | −5.487 | −36.655 |
| | (154.124) | (73.505) | (127.495) | (200.567) | (428.140) |
| One supplier | −345.519 | −51.777 | −25.715 | −190.797 | −613.637 |
| | (317.300) | (86.685) | (136.197) | (235.094) | (583.976) |
| Imenti | 861.697* | 204.718** | −385.828 | 370.253 | 1049.235 |
| | (504.102) | (82.387) | (235.053) | (307.424) | (704.515) |
| Kaare | −1010.940*** | 336.859*** | −272.078** | −268.129 | −1335.486** |
| | (223.380) | (98.963) | (133.311) | (264.162) | (555.301) |
| Lailuba | 1062.314*** | −171.332** | −637.666*** | 116.378 | 371.713 |
| | (390.093) | (75.012) | (182.199) | (198.397) | (671.288) |
| Tharaka | 1121.200*** | 412.672*** | −326.932** | −101.230 | 1106.669* |
| | (373.275) | (138.669) | (138.968) | (297.116) | (621.194) |
| Constant | 4125.239** | 1252.568*** | 1973.955*** | 4331.092*** | 11,679.670*** |
| | (1653.317) | (422.874) | (435.538) | (807.817) | (2500.683) |
| Observations | 780 | 780 | 780 | 780 | 780 |
| Clusters | 40 | 40 | 40 | 40 | 40 |
| $R^2$ | 0.15 | 0.06 | 0.05 | 0.04 | 0.07 |

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

**Table A6**
Willingness to pay.

| | (1) OLS | (2) Winsorized | (3) Poisson | (4) Tobit |
|---|---|---|---|---|
| Free insurance | 40.451** | 39.127** | 0.078** | 53.384** |
| | (19.124) | (18.188) | (0.037) | (22.863) |
| Age | −6.440 | −6.830 | −0.012 | −9.146 |
| | (4.598) | (4.513) | (0.009) | (5.877) |
| $Age^2$ | 0.067 | 0.069 | 0.000 | 0.095 |
| | (0.051) | (0.049) | (0.000) | (0.064) |
| Male | 42.625 | 49.383 | 0.076 | 48.580 |
| | (40.819) | (38.597) | (0.069) | (54.879) |
| Education years | 0.374 | −0.733 | 0.001 | 0.158 |
| | (3.760) | (3.497) | (0.007) | (4.461) |
| Household size | −2.238 | −1.406 | −0.004 | −2.278 |
| | (6.079) | (5.791) | (0.012) | (7.542) |
| Catholic | 48.885** | 47.064** | 0.093** | 62.750** |
| | (21.578) | (20.258) | (0.039) | (27.323) |
| Wealth index | 29.056* | 28.030** | 0.056** | 37.058** |
| | (14.641) | (13.351) | (0.027) | (17.481) |
| Livestock units | 4.817 | 4.396 | 0.008 | 5.991 |
| | (3.804) | (3.600) | (0.006) | (4.845) |
| Bank account | 11.311 | 10.194 | 0.022 | 11.331 |
| | (26.108) | (24.753) | (0.049) | (32.547) |
| One supplier | 41.842 | 33.970 | 0.081 | 43.956 |
| | (27.424) | (25.629) | (0.054) | (33.392) |
| Imenti | 7.261 | 11.863 | 0.015 | 18.049 |
| | (31.190) | (28.622) | (0.060) | (37.375) |
| Kaare | −15.541 | −14.276 | −0.030 | −11.074 |
| | (22.149) | (21.242) | (0.044) | (26.957) |
| Lailuba | −15.896 | −16.155 | −0.035 | −14.988 |
| | (43.298) | (39.548) | (0.084) | (52.846) |
| Tharaka | 1.368 | −4.292 | 0.003 | −0.929 |
| | (24.164) | (23.300) | (0.049) | (30.839) |
| Constant | 595.999*** | 631.970*** | 6.400*** | 671.283*** |
| | (103.449) | (102.064) | (0.193) | (131.866) |
| Observations | 780 | 780 | 780 | 780 |
| Clusters | 40 | 40 | 40 | 40 |
| $R^2$ | 0.04 | 0.04 | – | – |

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

## References


Ahmed, S., McIntosh, C., Sarris, A., 2018. The Impact of Commercial Rainfall Index Insurance: Experimental Evidence from Ethiopia UCSD Working paper.

Belissa, T., Bulte, E., Cecchi, F., Gangopadhyay, S., Lensink, R., 2019. Liquidity constraints, informal Institutions, and the adoption of weather insurance: a randomized controlled trial in Ethiopia. J. Dev. Econ. 140, 269–278.

Breman, J., 1974. Patronage and Exploitation. University of California Press, Berkeley, CA.

Bold, T., Kaizi, K., Svensson, J., Yanagizawa-Drott, D., 2017. Lemon technologies and adoption: measurement, theory, and evidence from agricultural markets in Uganda. *Q. J. Econ.* 132, 1065–1100.

Brune, L., Giné, X., Goldberg, J., &, Yang, D., 2016. Facilitating savings for agriculture: field experimental evidence from Malawi. *Econ. Dev. Cult. Change* 64 (2), 187–220.

Cai, J., Song, C., 2017. Do disaster experience and knowledge affect insurance take-up decisions? *J. Dev. Econ.* 124, 83–94.

Carter, M.R., Cheng, L., Sarris, A., 2016. Where and how index insurance can boost the adoption of improved agricultural technologies. *J. Dev. Econ.* 118, 59–71.

Carter, M., de Janvry, A., Sadoulet, E., Sarris, A., 2017. Index insurance for developing country agriculture: a reassessment. *Annu. Rev. Resour. Econ.* 9, 10.1–10.18.

Casaburi, L., Willis, J., 2018. Time versus state in insurance: experimental evidence from contract farming in Kenya. *Am. Econ. Rev.* 108 (12), 3778–3813.

Cole, S., Gine, X., Tobacman, J., Topalova, P., Townsend, R., Vickerey, J., 2014. Barriers to household risk management: evidence from India. *Am. Econ. J.* 5, 104–135.

Cole, S., Xiong, W., 2017. Agricultural insurance and economic development. *Annu. Rev. Econ.* 9, 235–262.

De Janvry, A., DeQuidt, V., Sadoulet, E., 2014. The demand for insurance against common shocks. *J. Dev. Econ.* 106, 227–238.

Dupas, P., 2014a. Getting essential health products to their end users: subsidize, but how much? *Science* 345, 1279–1281.

Dupas, P., 2014b. Short-run subsidies and long-run adoption of new health products: evidence from a field experiment. Econometrica 82, 197–228.

Emerick, K., de Janvry, A., Sadoulet, E., Dar, M.H., 2016. Technological innovations, downside risk, and the modernization of agriculture. *Am. Econ. Rev.* 106 (6), 1537–1561.

Feder, G., Just, R.E., Zilberman, D., 1985. Adoption of agricultural innovations in developing countries: a survey. *Econ. Dev. Cult. Change* 33 (2), 255–298.

Foster, A.D., Rosenzweig, M., 2010. Microeconomics of technology adoption. *Annu. Rev. Econ.* 2, 395–424.

Giné, X., Yang, D., 2009. Insurance, credit, and technology adoption: field experimental evidence from Malawi. *J. Dev. Econ.* 89 (1), 1–11.

Gollin, D., Morris, M., Byerlee, D., 2005. Technology adoption in intensive post-green revolution systems. *Am. J. Agric. Econ.* 87 (5), 1310–1316.

Hill, R.V., Kumar, N., Magnan, N., Makhija, S., de Nicola, F., Spielman, D.J., Ward, P.S., 2019. Ex ante and ex post effects of hybrid index insurance in Bangladesh. *J. Dev. Econ.* 136, 1–17.

Just, R.E., Zilberman, D., 1983. Stochastic structure, farm size and technology adoption in developing agriculture. *Oxf. Econ. Pap.* 35 (2), 307–328.

Karlan, D., Osei, R., Osei-Akoto, I., Udry, C., 2014. Agricultural decisions after relaxing credit and risk constraints. *Q. J. Econ.* 129 (2), 597–652.

Kijima, Y., Otsuka, K., Sserunkuuma, D., 2011. An inquiry into constraints on a green revolution in Sub-saharan Africa: the case of NERICA rice in Uganda. *World Dev.* 39 (1), 77–86.

Kurosaki, T., Fafchamps, M., 2002. Insurance market efficiency and crop choices in Pakistan. *J. Dev. Econ.* 67 (2), 419–453.

Mobarak, A.M., Rosenzweig, M.R., 2013. Informal risk sharing, index insurance, and risk taking in developing countries. *Am. Econ. Rev.* 103 (3), 375–380.

Scott, J.C., 1976. The Moral Economy of the peasant: Subsistence and Rebellion in Southeast Asia. Yale University Press, New Haven, CT.

Townsend, R.M., 1994. Risk and insurance in village India. Econometrica 62 (3), 539–591. doi:10.2307/2951659.

Udry, C., 1990. Credit markets in Northern Nigeria: credit as insurance in a rural economy. *World Bank Econ. Rev.* 4 (3), 251–269.

Udry, C., 1994. Risk and insurance in a rural credit market: an empirical investigation in northern Nigeria. *Rev. Econ. Stud.* 61 (3), 495–526.

Uganda Bureau of Statistics. 2007. *Uganda National Household Survey 2005-2006: Social Economic Report*, Kampala: Uganda Bureau of Statistics.

World Bank, 2008. World Development Report: Agriculture for Development. World Bank, Washington, DC.