Longer run effects of one-time subsidy on adoption of a new agricultural technology:

Evidence from a randomized control trial in Uganda

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Abstract

This article investigates the impact of one-time subsidy for a completely new agricultural technology, hermetic storage bags, on its adoption by smallholder farmers in Uganda the longer run i.e. four years after the subsidy was provided. We study the longer-run effect of the subsidy in an open market system, where we did not control the supply of the bags in the years following the intervention, as the market was allowed to develop. Thus, our intervention models the actual diffusion of an innovation over time. We used data on 1190 small holder maize growers in rural Uganda from three waves of randomized control trial conducted in 2014, 2016, and 2019. While previous research showed that subsidy recipients were more likely to purchase the technology commercially in the short run, the empirical results from this article show that the short-run effect of subsidy did not persist in the longer-run and this limited adoption was driven by the access (supply-side) constraints faced by the farmers. Hence, this article shed light on how market conditions such as search frictions, which are common in rural developing economies, could inhibit the gains from a one-time subsidy in the longer run.

JEL classification: C23, C93, O33, Q12, Q18

Keywords: Subsidy, hermetic technology adoption, post-harvest, RCT, longer-run effects, access constraint, Uganda, sub-Saharan Africa.

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Technological advances that help solve problems in agriculture are essential to improve the welfare of poor farmers in the developing world. While a new agricultural technology might help increase productivity for farmers, rural smallholder farmers in developing countries might not be willing to pay the market price of the technology if they are uncertain about the benefits. As such, price subsidies are often proposed as a solution to help smallholder farmers overcome this uncertainty and in turn spur adoption. This is because subsidies can help in reducing the cost of experimentation and give an opportunity to learn the benefits of the technology first-hand. At the same time, information about the benefits of the agricultural technology may spill over to the households in the social network of the subsidy recipients and can thus increase the adoption of other households (Foster & Rosenzweig, 1995). However, obtaining the technology at the subsidized price might anchor the willingness to pay of the farmer in the future due to behavioral phenomenon known as reference dependence (Kőszegi & Rabin, 2006).The tradeoffs between these opposing mechanisms coupled with the large fiscal burden on governments and donors from implementing large-scale agricultural subsidies has drawn economists to evaluate the impact of subsidies on agricultural technology adoption. Ricker-Gilbert et al. (2011) found that providing 1 kg of subsidized fertilizer crowds out i.e. reduces commercial purchases by 0.22 kg in Malawi. Using a randomized control trial, Omotilewa et al. (2019) found that providing one free hermetic storage bag increases likelihood of commercial purchase in following year i.e. short run by 5.1% in Uganda. In Mozambique, Carter et al. (2020) find that providing one time input subsidy increases the adoption of fertilizer by 6.6 percentage points in the subsequent unsubsidized season but do not find such persistence for improved hybrid seeds. These varying outcomes suggests that the technology, time-frame, and system play an important role in understanding the impact of subsides on technology adoption.

With this in mind, the present study estimates the impact of one-time subsidy for a completely new agricultural technology on its adoption by smallholder farmers in Uganda four years after the subsidy was provided. The technology was a hermetic (airtight) storage bag that preserves grain quality without the use of chemical insecticides. Additionally, our study was conducted in an open market system where we did not control the supply of the agricultural technology and households in our study who did not receive the initial subsidy could also purchase the bags at market price over time. Our study is built upon the work of Omotilewa et al. (2019) who find positive evidence of short run effect of subsidy on the commercial purchase of the technology. We extend their work by answering the following questions: i) Does the short run effect of one-time subsidy persist in the longer run in an open market system? Specifically, we look at three outcomes four years after the intervention: (a) awareness of the technology, (b) continued use of the technology, and (c) sustained demand for the technology (i.e. commercial purchase of the technology). ii) What are the mechanisms that led to persistent effects or possible constraints that hindered the persistent effects?

The data used in this study come from three waves of household surveys we conducted among 1,190 maize producers in Uganda. The first, second, and third waves of data were collected from October to December 2014, 2016 and 2019 respectively. In 2015, we randomly distributed hermetic storage bags amongst 240 households. All households, whether they received the subsidize bag or not, were free to purchase the bags from the private market. This allows us to examine if receiving subsidy had an impact on the awareness and adoption of the household in the future time periods.

We make the following contributions to the literature on impact of temporary subsidies on agricultural technology adoption. First, we study the effects of one-time subsidy on the use and commercial purchase in the longer run, specifically four years after subsidy intervention. Previous literature studying the effect of agricultural subsidy on commercial purchase have focused mainly on programs which provided the subsidy every year (Jayne et al., 2013; Mason & Ricker-Gilbert, 2013; Ricker-Gilbert & Jayne, 2017; Xu et al., 2009). While these studies show that agricultural input subsidies crowds out commercial demand, the anchoring effect in these unending subsidy programs may be stronger than the one-time subsidy implemented in our study. In fact, as mentioned earlier, based on the sample used in this study Omotilewa et al. (2019) find that providing one-time subsidy crowds-in commercial demand one year after the subsidy was provided. We seek to understand if this result persists in the longer run i.e. 4 years after subsidy intervention. This is important as treatment effects of subsidy on adoption can change over time as households learn about the value of the technology and subsequently change their usage rates. This is particularly crucial in studies such as ours where the technology under investigation is durable in nature and can be used for multiple periods. A notable exception is Carter et al. (2020) who found that providing one-time input subsidy increases the adoption of fertilizer in the subsequent unsubsidized season but do not find such persistence for improved hybrid seeds in Mozambique. It is also worth noting that previous literature on agricultural subsidies have focused mainly on fertilizer and improved seeds which are well known to the smallholders. The technology used in our study was completely new where the awareness and adoption were virtually zero before subsidy intervention.

Secondly, our study was conducted in an open market system where we did not control the supply of the agricultural technology and let it develop naturally. In the past, economists investigating persistent effects of short term subsidy often control the supply to ensure the availability of technology during the study period to the participants (Carter et al., 2020; Dupas, 2014). However, rural markets for new technologies in developing countries might not be so resilient in presence of search friction between farmers and suppliers. Dupas (2014) and Carter et al. (2020) showed that positive effects of a relatively unknown technology can be sustained over time. But both studies do so while maintaining strong coordination with the suppliers to connect the households with the supply. While the evidence of success of one-time subsidy in presence of coordinated supply chain are encouraging, it is important to understand how persistent the effects of one time subsides are in an open market system where supply chain is not controlled. Such conditions are more realistic to the actual supply chain for a technology, thus providing an important comparison to earlier studies measuring longer-term impacts of subsidies with a coordinated supply chain. The natural development of the supply chain also allows us to explore the heterogeneity in the longer run effect of the subsidy based on whether the households reported facing access constraint or not.

Results from our study indicate that the one-time subsidy on hermetic bags in 2015 had a significant positive effect on the awareness and use of technology four years later. However, the subsidy did not have a significant longer-run impact on the market participation (i.e. commercial purchases for the recipients of the subsidy). Exploratory analysis indicates that the subsidy recipients that did not report facing constraints to access the technology were about 11 percentage points more likely to purchase the technology than households that that did not receive the subsidy nor faced access constraint (statistically significant at 10% level). Moreover, treatment effect of subsidy on longer run commercial purchases is significantly lower amongst subsidy recipients that reported facing access constraints than those subsidy recipients that did not encounter them. This suggests that the limited adoption of hermetic bags in 2019 was mainly due to constraints on the supply side. In fact, of those aware of the hermetic bags in 2019, 89% reported that they did not know where to buy them. This indicates that over time the disconnect between smallholders and bag suppliers affected availability and adoption. We may not have captured this effect, had the supply been controlled rather than being allowed to develop (or not develop) naturally. This result coupled with the fact that Omotilewa et al. (2019) found a positive effect of the subsidy in the short term adoption (one year later in 2016) among the same sample, reveals that the absence of longer-run supply-chain development can erase the gains from adopting a technology in the short term.

Background:

Annually, Sub Saharan Africa (SSA) accrues post-harvest grain losses of nearly $4 billion. A major contributor to post-harvest grain losses is related to on-farm storage, which accumulates to 63% of the losses in Uganda. (World Bank 2011). Smallholders are often left with two choices; either sell the harvest early or apply the synthetic chemicals, on the grains to store them for longer periods. It is critical to reduce the on-farm storage losses to improve the food and income security. One way to reduce storage losses is to use chemical free storage technology, such as hermetic bags. At baseline in 2013, 73% of the smallholder households in rural Uganda were found to use a regular woven plastic bag to store their grain. These bags are single-layered and thus, are vulnerable to insect and pest infestation. On the other hand, the hermetic bags used in this study are triple layered and prevent oxygen to enter in the bags and thus kills the insects by the lack of oxygen (Murdock et al., 2012). Hermetic bags have shown promising results in reduction of losses, reducing damages up to 71%. Between conventional storage practices and hermetic bags, Ndegwa et al. (2016) estimated a grain damage drop from 14% to 4%. Specifically in Uganda, Omotilewa et al. (2018) found that households that use smallholders that used hermetic bags to store maize were significantly less likely to report post-harvest losses compared to households that did not use the hermetic bags. In Tanzania, Chegere et al., (2021) found that hermetic bags have a positive effect on the qualitative characteristics of the stored maize. Additionally, given the cultural similarity between hermetic and traditional bags, acceptability is not expected to be a barrier to adoption (Rogers 1995). The hermetic bags distributed in this study had a capacity to store 100 kilograms (kg) of shelled maize. The cost of one hermetic bag is $2.50 about 7000 Ugandan Shillings (UGX) compared to a price of mere $0.50 per bag for the traditional woven bags.

Data and experimental design:

The data used in this study come from three waves of household surveys we conducted among 1,190 maize producers in Uganda. The first, second, and third waves of data were collected from October to December 2014, 2016 and 2019, respectively, as baseline, midline and endline surveys. Each wave of data covers two cropping cycles. The baseline survey covers second cropping season of 2013 and first cropping season of 2014. The midline survey covers the same seasons in 2015 and 2016 respectively and the endline survey covers the same season in 2018 and 2019. The study time line is presented in figure 1.

[Insert Figure 1 here]

A two-level experimental design was used in this study (see Figure 2 for schematic representation). After the sampling and baseline survey in 2014 (see Omotilewa et al. (2019) for details), local area ones (LC1s) were randomly distributed between treatment and control groups, for the first experiment at the village level. From two LC1s in each sub-county, we randomly assigned one into a treatment group and the other into a control group, in our sampling framework. As a result, equal number of LC1s, with approximately equal number of households, were assigned into both groups (24 each), the treatment and control groups. The LC1s in treatment group received awareness demonstrations showing how to use the technology and its effectiveness, compared to LC1s of the control group which did not receive any information. A second experiment, which is the main focus of this study, was conducted in 2015. At this time, a single 100kg-capacity PICS hermetic storage bag was given to 10 randomly selected households within each of the treatment LC1s that had received information about the technology. The 10 households were selected from a sample size of 25 per LC1, based on the baseline sampling (Figure 2). The reasoning behind providing the subsidy was to alleviate demand constraints by increasing awareness and giving an opportunity for recipients to evaluate the technology first-hand which would generate positive learning experiences and in turn lead to increased market demand. Additionally, the supply side of the market was developing naturally around the time treatment interventions were conducted wherein we did not control the location of the sellers nor did we ensure the availability of the technology. The participants in our study would need to scout the markets around them in order to purchase the technology. The sole distributor of the hermetic bag was one of the largest distributors of fertilizer and chemical protectants in the country. Thus, the main retail points for the hermetic bags were the agro-dealers who sold fertilizers and protectants. However, the baseline descriptive statistics in Table 2 indicate that only 15% of the households purchased fertilizers at the agro-dealers and similarly only 14% purchased chemical protectant at the agro-dealers. This suggests that vast majority of the study sample could face constraints in accessing the technology due to search frictions. On the other hand, the retailers might stop selling the technology if the search frictions lead them to prematurely conclude that there is no demand. These market dynamics makes our study more representative of the real-life supply constraints that exist in rural markets of developing economies.

To summarize, three categories of households were generated in our experimental design. The first category comprises the households located in randomly assigned treatment villages and received the subsidy (group 1 in Figure 2). The second category (of exposed household) comprises the households located in randomly assigned treatment villages but received no subsidy. (group 2 in Figure 2). The third category (of pure control households) comprises the households which received neither information nor subsidy (group 3 in Figure 2). In this study, we will focus on the household in the treatment villages i.e. the subsidized and exposed group. The baseline sample consisted of 240 households in the subsidy group and 356 households in the exposed group. As with any study with longer follow up period, there are chances of attrition. In our endline survey in 2019, we were able to re-interview 222 (out of 240) subsidized households and 316 (out of 356) exposed households leading to a re-interview rate of 90.3%. To understand if there was attrition bias we regressed the attrition binary indicator on subsidy treatment indicator. Results in table 1 shows that the attrition was balanced across the two groups.

[Insert Figure 2 here]

Verification of experimental validity:

Table 1 examines if the randomization was successful in the second experiment i.e. between group 1 and 2 in figure 2. To do so, we regress baseline characteristics and outcome variables on the treatment of receiving the hermetic bag in 2015 controlling for regional fixed effects and clustering standard errors at LC1 level. We find that the baseline characteristics are balanced across the subsidized and exposed groups. In particular, both the groups have similar expected storage loss, quantity of maize stored, household revenue and maize revenue.

[Insert Table 1 here]

Descriptive statistics:

Baseline sample characteristics:

Table 2 shows the mean and standard deviations for baseline characteristics and outcomes. Average age of the household head in our sample was 45 years and households on an average had about 6 members. 18% of the households were female headed and 89 % of the household head had some form of education. Furthermore, 77% of households had access to information through radio and 70 % had access through mobile phone. The annual household revenue was 2.3m Ugandan Shillings and annual maize revenue was 0.27m Ugandan Shillings. On an average the households in the sample dedicated 0.53 ha for maize cultivation and harvested on an average 883 kg of maize. This suggests that the households in our sample represented smallholder farmers in Uganda. Moreover, an average household stored 625 kg of maize thus requiring about 6 bags for storage. This indicates there was a potential to generate demand beyond the one free hermetic bag provided during the subsidy intervention. Importantly, the awareness and commercial purchase of hermetic bags was virtually zero thus providing us with a clean baseline to understand the adoption of a completely new technology.

[Insert Table 2 here]

Longer run outcomes:

Figure 3 shows the awareness of the household about hermetic storage technology during baseline (2013), midline (2016), and endline (2019) surveys. All of the subsidized households indicated that they were aware of hermetic technology 1 year after the subsidy was provided. More importantly, this high level of awareness persisted four years after subsidy was provided in 2019. In the exposed group, 65 % of the households were aware of hermetic technology in 2016 and the awareness increased to 84% in 2019. This increase might be partly due to information diffusion from subsidized households.

While the increasing awareness of the technology is an important role of subsidy, it is vital that farmers use the technology. Figure 4 shows that the 77% of the subsidized households use the hermetic storage technology in the 2015/16 (i.e. the agricultural season after the subsidy intervention was conducted). However, the usage rate in the subsidized group dropped to 25 % in the 2018/19 agricultural season, four years after the subsidized bag was provided to the households. Similarly, the usage rate in exposed group dropped from 13% in 2015/16 to 4% in 2018/19. In the endline survey (four years after the treatment), 84% of the households indicated that the main reason they stopped using the hermetic bag was because it was broken. This is understandable as the expected life span of the hermetic bag is three years and thus this product lifecycle should generate demand if the farmers had positive experience with the technology and value it. Amongst those who used the hermetic technology at least once between 2014 and 2019, 99% of the households consider hermetic storage bag effective and 96% of the households prefer hermetic storage bag over storage chemicals. This provides a strong indication that households that used the technology had a positive learning experience.

Figure 5 shows that the positive experiences did not translate to increase in longer run commercial purchases. About 11% of the subsidized households purchased the hermetic bag commercially in between 2nd agricultural season of 2015 and 1st agricultural season of 2016. However, only 7% of the subsidized households purchased the bag commercially in the longer run i.e. between 2nd season of 2016 and 1st season of 2019. The commercial purchases followed similar pattern for the exposed groups where market participation fell from 6% in short run to 4% in the longer run. In order to understand decrease in market participation in the longer run, during the endline survey in 2019 we asked the households the reason behind not purchasing the bags after midline. Figure 6 shows that amongst those aware of the technology, 75% reported the primary reason for not buying the bags commercially in the longer run was not knowing where to buy them. Thus, this provides an indication that the access constraint could have led to dampening of the market participation in the longer run.

[Insert Figure 3 here]

[Insert Figure 4 here]

[Insert Figure 5 here]

[Insert Figure 6 here]

Empirical framework:

Longer-run impact of subsidy

To understand the longer run effect of one-time free distribution of hermetic bags on awareness and adoption decision of subsidy recipients we estimate equation (1) using sample consisting of groups 1 and 2 i.e. subsidy and exposed groups.

$$y_{ij} = \alpha + \tau Subsidy_{ij} + \boldsymbol{\beta X_i} + \sigma_r + \varepsilon_{ij} \quad (1)$$

Where y_{ij} represents three binary outcome variables: $Awareness_{ij}$, Use_{ij}, and PC_{ij}. The variable $Awareness_{ij}$= 1 if household is aware of the hermetic bag in the endline survey and zero otherwise; Use_{ij} = 1 if the household used hermetic bag in 2018/19 agricultural season; PC_{ij} =1 if household *i* in village *j* bought hermetic bag commercially after midline i.e. from 2^{nd} agricultural season of 2016 to 1^{st} agricultural season of 2019. We include this larger period instead of season before the end line survey i.e. 2018/19 agricultural season due to the durable nature of the bags that have an expected lifespan of three years.

The binary variable $Subsidy_{ij}$ equals to one if households received the treatment of a free hermetic bag in 2015 and zero otherwise. Parameter τ is the effect of the one-time subsidy on the longer run awareness and adoption of the subsidized households. In addition, σ_r are the regional fixed effects, $\boldsymbol{X_i}$ is the vector of household characteristics such as household size, and age, gender, and education level of household head to improve precision and ε_{ij} is the idiosyncratic error term.

Heterogeneous impacts

We use households' responses to why they did not purchase the technology commercially to classify them into two groups: one which faced binding access constraint (*AC = 1*) and other that did not *(AC=0)*. Specifically, AC = 1 if household indicated that reason they did not purchase the bag commercially was that they did not know where to buy the bags or that the vendor was too far Similarly, AC=0 if household reported the reason for not purchasing the hermetic bag was: a) hermetic bag is too expensive, b) the hermetic bag is not effective, c) they do not store maize/sell maize immediately or d) the current technology they use is effective. We then analyze if the treatment effects of receiving one-time subsidy differed if the households reported facing access constraints or not. We estimate the heterogenous impacts of one-time subsidy using the following model:

$$PC_{ij} = \alpha + \rho Subsidy_{ij} + \gamma AC_i + \delta Subsidy_{ij} * AC_i + \boldsymbol{\beta X_i} + \sigma_r + \varepsilon_{ij} \quad (2)$$

where PC, Subsidy, and X are as described in Eq. (1). Variable AC = 1 if household reported facing access constraint to purchase technology and zero otherwise. In addition, σ_r are the regional fixed effects and ε_{ij} is the idiosyncratic error term. The coefficient estimates of δ

indicates whether the longer-run impact of the subsidy on market participation differed if the subsidy recipient faced access constraint and ρ captures longer run effect of the subsidy amongst households that did not report facing access constraint. Since the responses to construct the variable AC were captured post treatment, the estimates from equation (2) may lead to biased estimates if receiving subsidy had an impact on whether the household reported facing access constraint. To test this we regressed the binary variable AC on subsidy treatment indicator. Results in table 1 shows that the coefficient on subsidy treatment indicator is not significant and access constraint variable is balanced across the subsidy and exposed group. Equation (2) could still yield to biased estimates if *AC* is correlated with the error term. Thus, we regress baseline characteristics on AC_i to check if there is a systematic difference between households that faced access constraint and those that did not. Table 3 shows that there is no statistically significant difference on nearly all baseline household variables within the two groups. Further, we exploit the panel nature of our data to control for any time-invariant unobserved heterogeneity at the household level. To do so we use the fixed effects estimator to estimate the treatment and interaction effects using equation (3):

$$PC_{it} = \alpha + \rho_{FE} Subsidy_i + \gamma_{FE} AC_{it} + \delta_{FE} Subsidy_{it} * AC_{it} + \boldsymbol{\beta X_{it}} + \eta season_t + c_i + \varepsilon_{it} \quad (3)$$

Where the variables retain their definitions as described in equation (2). Additionally, we also include c_i which is the time-invariant individual heterogeneity and season fixed effects, $season_t$, which are binary dummies for three out of four seasons used in the analysis.

[Insert Table 3 here]

Results:

Columns (1) and (2) of table 4 present results for effect of one time subsidy on the longer run market participation of recipients. We do not find evidence that receiving a free bag increases probability of subsidized households to purchase the hermetic bag commercially in the longer run compared the exposed households which did not receive the subsidy. However, heterogeneity analysis presented in table 5 indicates that the subsidy recipients that did not report facing constraints to access the technology were about 11 percentage points more likely to purchase the technology than households that that did not receive the subsidy nor faced access constraint (statistically significant at 10% level). Moreover, the coefficient on the interaction term (***δ)*** indicates that treatment effect of subsidy on longer run commercial purchases is significantly lower amongst subsidy recipients that reported facing access constraints than those subsidy recipients that did not encounter them. Finally, Table 6 and 7 show that the subsidized households were about 12.8% more aware and 12.5% more likely to use the bag in the longer run i.e. four years after the subsidy intervention. The fact that life of the subsidized bag is three years coupled with supply chain failure provides evidence of household's positive experience with the technology.

[Insert Table 4 here]

[Insert Table 5 here]

[Insert Table 6 here]

[Insert Table 7 here]

Conclusions:

This article evaluates the impact of one-time subsidy on the adoption of new agricultural technology, a hermetic storage bag, among smallholder farmers in Uganda. Omotilewa et al. (2019) using data from this study, collected one year after the subsidy intervention, find that subsidy has a positive effect on the commercial purchase for the subsidy recipients. However, the results in this study indicate that while the one-time subsidy had a positive effect on the awareness and use of the hermetic bag four years after the treatment, the short run effect on commercial purchase of hermetic does not extend to the longer run. This is contrary to the findings of Carter et al. (2020) and Dupas (2014) who provide evidence on persistent effect of temporary subsidies. Our results reveal that absence of persistent effect of subsidy on longer run commercial purchase is likely due to access constraints faced by the smallholders. In fact, Carter et al. (2020) and Dupas (2014) studies ensure a strong coordination between the suppliers and participants to make the technology readily available. In all, evidence from article coupled with the findings from Omotilewa et al. (2019), Dupas (2014) and Carter et al. (2020) suggests that while one-time subsidies can reduce the information constraints by providing positive experiential experience, last mile supply chain development is important for sustainable adoption. This is especially true for rural smallholder farmers in developing economies. Thus, decision makers while designing policies to induce adoption of new technologies should take a holistic approach rather than just focusing on alleviating either demand or supply constraints.

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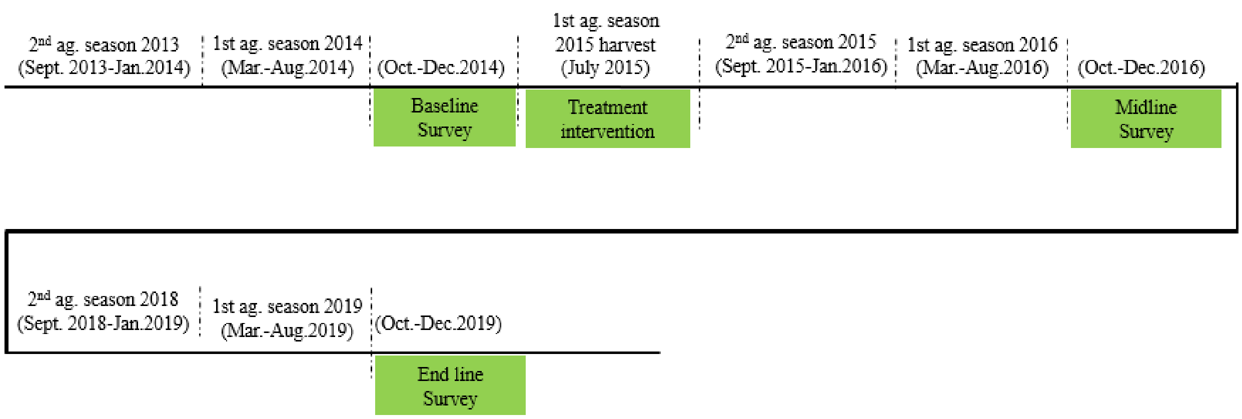

Figure 1: Study Timeline

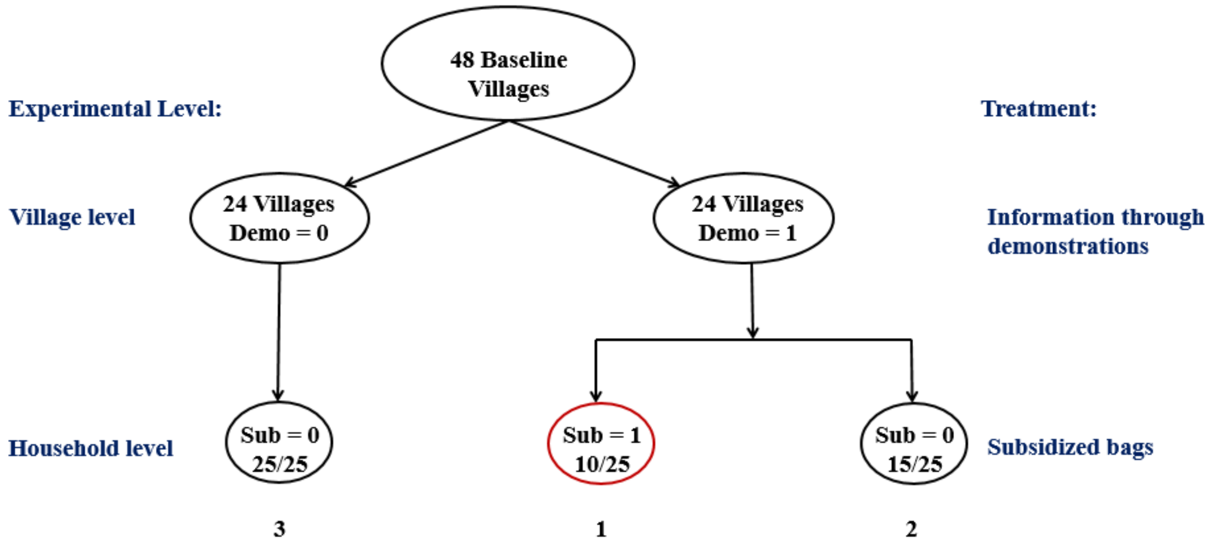

Figure 2: Experimental design. Source: Omotilewa et al. (2019)

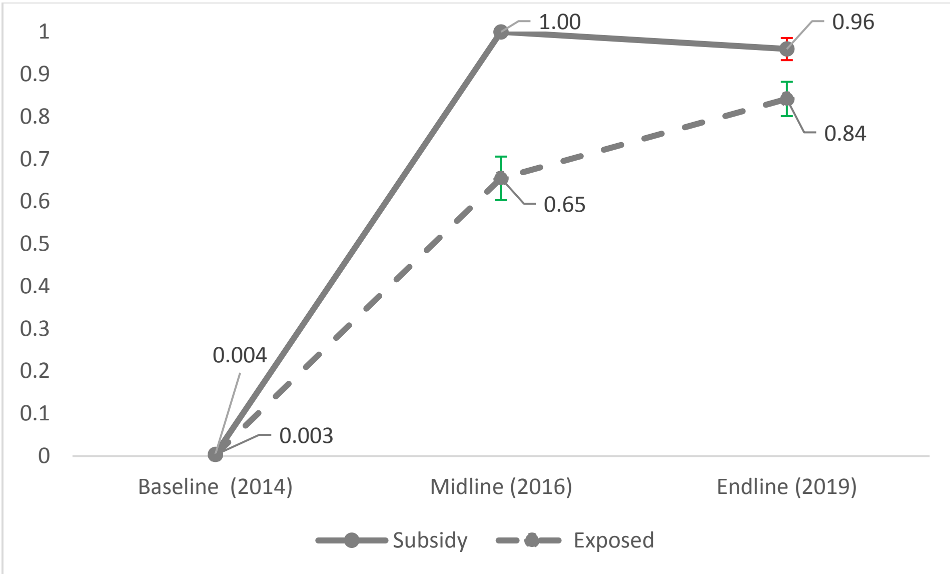

Figure 3: Mean awareness about hermetic technology amongst subsidy and exposed groups

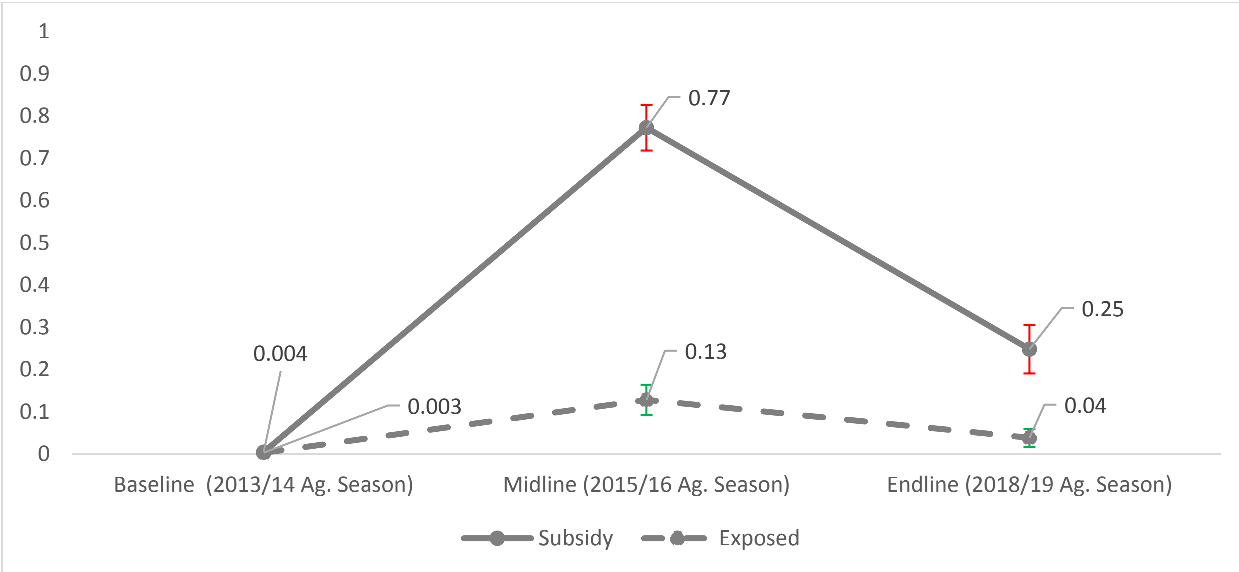

Figure 4: Mean use of hermetic technology amongst subsidy and exposed groups

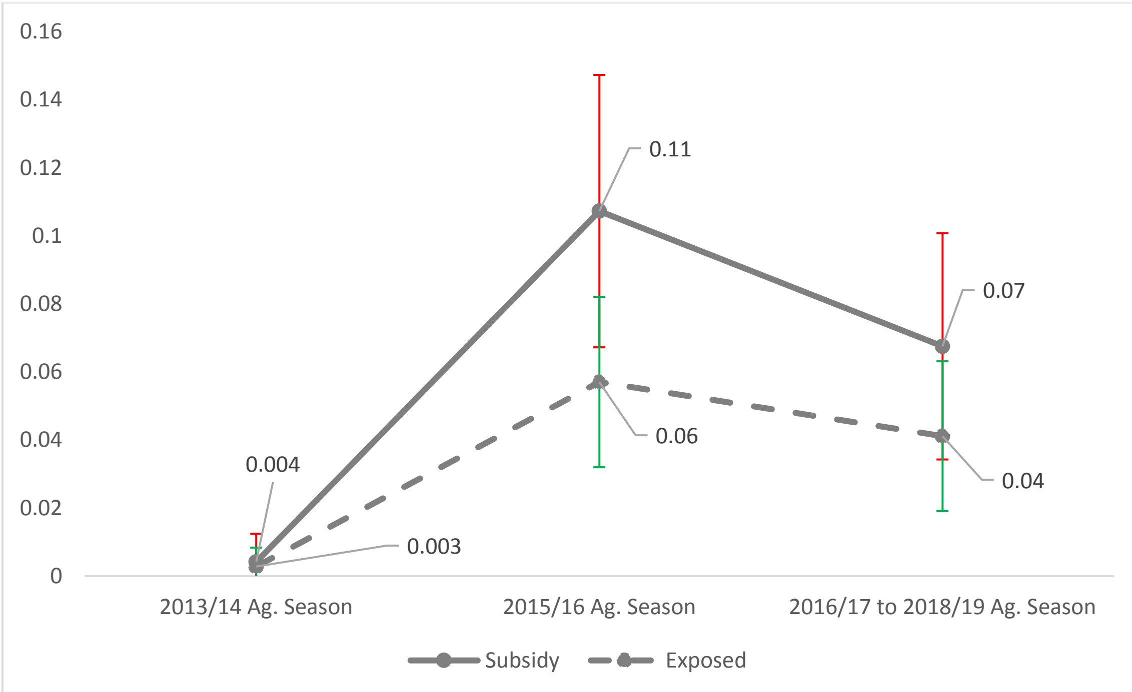

Figure 5: Market participation rates amongst subsidy and exposed groups.

Note: Market participation is defined as a binary variable equal to one if household purchased hermetic bag commercially.

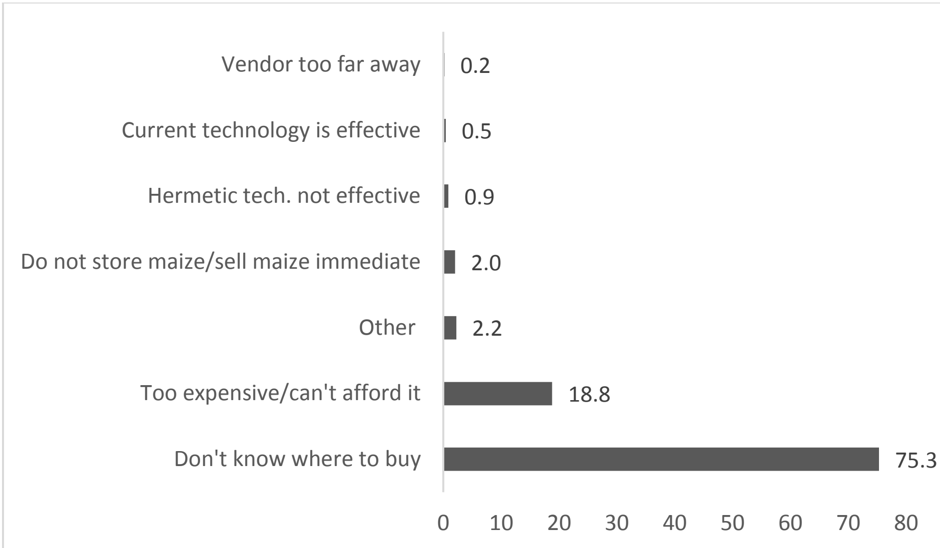

Figure 6: Reason for not purchasing hermetic bag in the longer run if aware.

Table 1: Baseline characteristics and balance check between subsidized households and exposed households in treatment LC1s

	Exposed		Treated		
	Mean	SD	OLS Coeff.	p-value	N
Variables	(1)	(2)	(3)	(4)	(5)
Outcome Variable(s)					
=1 if HH bought hermetic bag (adopter) at baseline	0.003	0.053	0.001	0.333	1186
=1 if HH is aware of hermetic bag at baseline	0.001	0.038	-0.001	0.332	1186
Household Characteristics					
Age of household head (years)	45.36	15.09	0.35	0.768	1192
Household size	6.38	3.11	0.168	0.521	1192
=1 if female-headed household	0.18	0.38	-0.005	0.859	1192
=1 if Polygamous	0.16	0.36	0.016	0.572	1192
=1 if HH head has any form of education	0.89	0.31	-0.008	0.721	1192
Total household revenue (‘000 UGX)[a]	2280	4923	-8	0.985	1190
=1 if HH has radio	0.78	0.42	-0.008	0.800	1188
=1 if HH has mobile phone	0.70	0.46	-0.019	0.689	1188
=1 if HH has a bicycle	0.61	0.49	-0.043	0.244	1188
Production and storage practices					
Total maize area (ha.)	0.52	0.44	-0.003	0.947	1115
Total quantity harvested-maize (kg)	840	1071	45	0.645	1115
Total quantity of maize stored (kg)	571	956	62	0.461	1186
Maize revenue(‘000 UGX)	223	543	66	0.356	1192
Expected storage loss (%)	4.42	8.65	-0.706	0.178	1069
=1 if Traditional storage technology use	0.84	0.37	-0.001	0.976	1186
=1 if hermetic storage technology use	0.007	0.08	-0.005	0.170	1186
Attrition					
=1 if attritted household	0.112	0.31	-0.038	0.178	1192
Access constraint					
=1 if HH reported facing access constraint	0.747	0.436	0.0087	0.819	1076

Notes: Columns 1 and 2 report baseline means and standard deviations for exposed households. Columns 3 through 5 report baseline results from OLS regressions comparing subsidized households with exposed households within demonstration LC1s. The robust standard errors are clustered at the LC1 level. *** p<0.01, ** p<0.05, * p<0.1 [a] 1USD = 2800 UGX at baseline.

Table 2 : Baseline characteristics of households in treatment LC1s (subsidized and exposed group)

	Mean		SD		N
Variables	(1)		(2)		(3)
Outcome Variable(s)					
=1 if HH bought hermetic bag (adopter) at baseline	0.003		0.058		593
=1 if HH is aware of hermetic bag at baseline	0.003		0.058		593
Household Characteristics					
Age of household head (years)	45.49		14.55		596
Household size	6.45		3.22		596
=1 if female-headed household	0.18		0.38		596
=1 if Polygamous	0.16		0.38		596
=1 if HH head has any form of education	0.89		0.32		596
Total household revenue ('000 UGX)[a]	2297		5066		595
=1 if HH has radio	0.77		0.42		594
=1 if HH has mobile phone	0.70		0.46		594
=1 if HH has a bicycle	0.60		0.49		594
Production and storage practices					
Total maize area (ha.)	0.53		0.46		570
Total quantity harvested-maize (kg)	883		1283		570
Total quantity of maize stored (kg)	625		1174		594
Maize revenue('000 UGX)	273		803		596
Expected storage loss (%)	4.72		9.92		552
=1 if Traditional storage technology use	0.87		0.34		594
=1 if hermetic storage technology use	0.005		0.07		594
=1 if purchased fertilizer at agro-dealer	0.154		0.362		595
=1 if purchased chemical protectant at agro-dealer	0.136		0.343		595

Notes: Columns 1 and 2 report baseline means and standard deviations for sample consisting of subsidized and exposed households.

Table 3: Results from regressing baseline characteristics on binary indicator of access constraint.

	Access constraint		
	OLS Coeff.	p-value	N
Variables	(1)	(2)	(3)
Household Characteristics			
Age of household head (years)	1.346	0.385	1,076
Household size	0.242	0.500	1,076
=1 if female-headed household	-0.010	0.788	1,076
=1 if Polygamous	0.009	0.838	1,076
=1 if HH head has any form of education	0.032	0.482	1,076
Total household revenue (‘000 UGX)[a]	-34.330	0.943	1,074
=1 if HH has radio	-0.045	0.167	1,072
=1 if HH has mobile phone	-0.025	0.574	1,072
=1 if HH has a bicycle	-0.008	0.881	1,072
Production and storage practices			
Total maize area (ha.)	-0.024	0.564	1,032
Total quantity harvested-maize (kg)	47.117	0.758	1,032
Total quantity of maize stored (kg)	29.897	0.833	1,072
Maize revenue (‘000 UGX)	-117.7	0.345	1,076
Expected storage loss (%)	0.384	0.636	998

Note: Columns 1 through 3 report baseline results from regressing baseline characteristics on binary indicator of accesss constraint. The robust standard errors are clustered at the LC1 level. Columns 1 and 2 report the OLS coefficient and p-value corresponding to the access constraint dummy and column 5 reports the sample size for each regression. *** p<0.01, ** p<0.05, * p<0.1 [a] 1USD = 2800 UGX at baseline.

Table 4: Effect of subsidy on longer run commercial purchase of hermetic bag

Outcome: =1 if HH purchased bag between 2nd season of 2016 and 1st season of 2019		
VARIABLES	(1)	(2)
=1 if HH received subsidized bag in 2015 ($\boldsymbol{\tau}$)	0.026	0.027
	(0.020)	(0.020)
Age of household head		0.000
		(0.000)
=1 if HH head has any form of education		0.020
		(0.033)
Household size		-0.004
		(0.004)
=1 if female headed household		0.001
		(0.024)
LC1 fixed effects?	Yes	Yes
Season binary indicators?	Yes	Yes
Constant	0.035	-0.010
	(0.022)	(0.044)
Observations	1,076	1,076
R-squared	0.059	0.062

Notes: Columns (1) and (2) show the direct subsidy effect without and with covariates, respectively. Robust standard errors, clustered at the LC1 level, are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 5: Heterogeneity analysis of effects of subsidy on longer run commercial purchase.

Outcome: =1 if HH purchased bag between 2nd season of 2016 and 1st season of 2019	OLS		FE	
VARIABLES	(1)	(2)	(3)	(4)
Subsidy=1 if HH received subsidized bag in 2015 (**ρ**)	0.113*	0.116*	0.115*	0.117*
	(0.061)	(0.060)	(0.061)	(0.060)
AC=1 if HH faced access constraint (γ)	-0.162***	-0.164***	-0.162***	-0.161***
	(0.046)	(0.045)	(0.043)	(0.041)
*Subsidy*AC* (**δ**)	-0.113*	-0.115*	-0.115*	-0.117*
	(0.061)	(0.060)	(0.061)	(0.059)
Age of household head		0.001		-0.000
		(0.001)		(0.000)
=1 if HH head has any form of education		0.043		-0.014
		(0.030)		(0.022)
Household size		-0.004		0.002
		(0.004)		(0.001)
=1 if female headed household		-0.000		0.015
		(0.022)		(0.022)
=1 if HH used traditional storage technology		-0.023		-0.004
		(0.029)		(0.021)
LC1 fixed effects?	Yes	Yes		
Season binary indicators?	Yes	Yes	Yes	Yes
Constant	0.137***	0.115	0.000	0.003
	(0.041)	(0.090)	(0.004)	(0.037)
Observations	1,076	1,076	2,266	2,266
R-squared	0.215	0.221	0.224	0.225

Notes: Columns (1) and (2) show the OLS estimates of subsidy effect controlling for access constraints without and with other covariates, respectively. Columns (3) shows the Fixed effect estimates of subsidy effects controlling for access constraints with other covariates. Robust standard errors, clustered at the LC1 level, are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 6 : Direct effect of subsidy on awareness of hermetic technology in 2019

Outcome: =1 if HH aware of PICS in 2019		
VARIABLES	(1)	(2)
=1 if HH received subsidized bag in 2015	0.128***	0.127***
	(0.032)	(0.032)
Age of household head		0.000*
		(0.000)
=1 if HH head has any form of education		0.046
		(0.060)
Household size		0.005
		(0.004)
=1 if female headed household		-0.094*
		(0.050)
Regional fixed effects?	Yes	Yes
Season binary indicators?	Yes	Yes
Constant	0.853***	0.785***
	(0.029)	(0.086)
Observations	1,076	1,076
R-squared	0.051	0.070

Notes: Columns (1) and (2) show the subsidy effect on longer run awareness without and with covariates, respectively. Robust standard errors, clustered at the LC1 level, are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 7: Effect of subsidy on use of hermetic technology in 2018/19

Outcome: =1 if HH used PICS in 2018/19		
VARIABLES	(1)	(2)
=1 if HH received subsidized bag in 2015	0.125***	0.129***
	(0.031)	(0.031)
Age of household head		-0.000
		(0.000)
=1 if HH head has any form of education		0.101***
		(0.032)
Household size		-0.001
		(0.003)
=1 if female headed household		0.079**
		(0.034)
Regional fixed effects?	Yes	Yes
Season binary indicators?	Yes	Yes
Constant	0.086*	-0.022
	(0.042)	(0.062)
Observations	1,076	1,076
R-squared	0.076	0.090

Notes: Columns (1) and (2) show the subsidy effect without and with covariates, respectively. Robust standard errors, clustered at the LC1 level, are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1