Journal of Development Economics 134 (2018) 1–15

Contents lists available at ScienceDirect

Journal of Development Economics

journal homepage: www.elsevier.com/locate/devec

Grain today, gain tomorrow: Evidence from a storage experiment with savings clubs in Kenya☆

Shilpa Aggarwal[a], Eilin Francis[b], Jonathan Robinson[b,c,*]

[a] Indian School of Business, India
[b] University of California, Santa Cruz, USA
[c] NBER, USA

ARTICLE INFO

JEL Codes:
O12
O13
O16
D14

Keywords:
Intertemporal price fluctuations
Storage
Savings
ROSCAs
PICS bags

ABSTRACT

Many farmers in the developing world lack access to effective savings and storage devices. Such devices might be particularly valuable for farmers since income is received as a lump sum at harvest but expenditures are incurred throughout the year, and because grain prices are low at harvest but rise over the year. We experimentally provided two saving schemes to 132 ROSCAs in Kenya, one designed around communally storing maize and the other around saving cash for inputs. About 56% of respondents took up the products. Respondents in the maize storage intervention were 23 percentage points more likely to store maize (on a base of 69%), 37 percentage points more likely to sell maize (on a base of 36%) and (conditional on selling) sold later and at higher prices. We find no effects of the individual input savings intervention on input usage, likely because baseline input adoption was higher than expected.

1. Introduction

Over one billion people are employed in agriculture worldwide (World Development Report, 2008), and like many of the world's poor, the vast majority of these farmers lack access to good savings instruments (Demirgüç-Kunt et al., 2015).[1] A spate of recent research studies has shown that providing households with savings accounts can increase cash savings, particularly among micro-enterpreneurs who generate cash income.[2] In contrast, research on the effect of providing savings services to farmers has been sparse.

However, there are several potential reasons to believe that farmers' saving challenges are unique and deserve attention. First, most farmers receive the bulk of their income as a single lump sum soon after harvest, and then need to gradually draw on this over the rest of the year to meet anticipated and unanticipated cash needs. This is a particularly daunting task in the absence of financial instruments and many farmers struggle. For instance, Mullainathan and Shafir (2014) document that sugarcane farmers in India have a 4% likelihood of having pawned something to meet cash needs in the month after harvest, and that this likelihood climbs up to 78% in the month just before harvest. Second, rural farmers, particularly in Africa, are part of kinship networks with

☆ We are grateful to Ashwini Chhatre, Maitreesh Ghatak and Dahyeon Jeong for useful discussions, and to 2 anonymous referees and seminar participants at IIM Bangalore, the Indian School of Business, and the Naval Postgraduate School for helpful comments. We thank Claudia Casarotto for research support. We thank ATAI and the University of California, Santa Cruz for funding, and IPA Kenya for administrative support. We thank Michael Dalious, Kathryn Dutile, Maira Reimao, and Dario Sidhu of Evidence Action for their collaboration. This research protocol was approved by the IRBs of Maseno University, UCSC, ISB, and IPA. The project operated under a research permit granted by the Kenyan National Commission for Science, Technology, and Innovation. This trial is registered in the American Economic Association's registry for randomized controlled trials (AEARCTR–0002188).

* Corresponding author. University of California, Santa Cruz, USA.
E-mail addresses: shilpa_aggarwal@isb.edu (S. Aggarwal), elfranci@ucsc.edu (E. Francis), jmrtwo@ucsc.edu (J. Robinson).

[1] According to the 2014 Global Findex Report, about half of the world's farmers lack access to a basic bank account or mobile money account. In our study context of western Kenya, less than a quarter of the farmers in our sample have a bank account and two-thirds have a mobile money account.

[2] See Prina (2015) and Dupas et al. (2017,2018 for a review of recent savings studies.

https://doi.org/10.1016/j.jdeveco.2018.04.001
Received 28 July 2017; Received in revised form 6 March 2018; Accepted 1 April 2018
Available online 6 April 2018

deeply embedded sharing norms (Collier and Garg, 1999; Baland et al., 2011), which can make saving challenging (Dupas and Robinson, 2013a; b).[3] Third, unlike cash, agricultural commodities display large price fluctuations over the season, from post-harvest lows to pre-harvest peaks,[4] implying that farmers would be better off saving grain instead of selling output at low prices soon after harvest. However, storing grain brings the additional challenge that it may be spoiled by pests or consumed.

In this paper, we evaluate the effect of a savings experiment geared towards addressing the special savings needs of farmers, and administered via farmers' existing savings clubs (Rotating Savings and Credit Associations or ROSCAs) in Kenya. The experiment was designed around two ideas. First, we designed a product to make it easier to store maize after harvest, which we called the Group Savings and Reinvestment Account (GSRA). We encouraged randomly selected ROSCAs to set aside maize together in communal bags, stored at a single member's house (usually the ROSCA treasurer). In order to facilitate this, we provided GSRA ROSCAs with storage supplies, namely triple-layered plastic bags capable of being hermetically sealed and designed specifically for the purpose of grain storage,[5] and a heavily subsidized wooden stand to keep the maize elevated from the ground (and less susceptible to pests and water damage). In order to enable record-keeping of maize deposits and withdrawals, we supplied a ledger book to log transactions, to be maintained by the ROSCA treasurer. We also provided encouragement that the stored maize be used for later sale, and the proceeds from the sale be used for reinvestment in the farm via input purchases. We hypothesized that moving the maize out of farmers' homes would make it less prone to being claimed by others or falling prey to temptation. Moreover, separating this portion of their maize-holding from the rest of the stock, and mentally allocating it to the purpose of "later sale for buying inputs" (i.e., labeling) might increase savings.[6] The GSRA intervention is thus an amalgam of the physical technology (bags and stand) aimed at minimizing spoilage, the mental accounting aspect from labeling, and the social or interpersonal channel due to the ROSCA storing grain as a collective.[7] The ultimate goal of this combined technology is to increase the amount of maize stored for later use and to increase cash income from maize sales at a time when maize prices have risen.

Second, we designed a cash savings product which was meant to take advantage of mental accounting through allocating the saved money to a pre-specified purpose. We called this the Individual Savings and Reinvestment Account (ISRA). This product was inspired by the health savings accounts held at ROSCAs in Dupas and Robinson (2013a), but was configured towards inputs. A recent paper by Carter et al. (2013) is also based on a similar idea of utilizing mental accounting for saving up for inputs, but through individual mobile money accounts, and therefore, does not harness the social commitment aspects of saving with the ROSCA. In each ROSCA, we provided guidance to people to set up an account with the ROSCA in which they could save cash towards a goal, and similar to the GSRA, we encouraged that the goal be farm reinvestment, i.e., input purchases. The treasurer kept a ledger of all transactions.

The final feature of the experimental design was the provision of coupons for discounts on inputs at the local agricultural input retailer. In every ROSCA, enumerators distributed coupons which could be redeemed at their local shop. The price of the coupon was randomized (from 10 to 90% discount), at the ROSCA level. The rationale for this intervention was to spur fertilizer investment, and to be able to examine the effect of the savings interventions on input usage through administrative data on redemption alone.[8]

We have five main findings. First, take-up of both the GSRA and the ISRA was high: records kept by the ROSCA treasurers suggest that 57 percent of respondents in the GSRA treatment and 56 percent of respondents in the ISRA treatment made at least 1 deposit.[9] Second, individuals in the GSRA were 23 percentage points more more likely to store maize (which we defined as saving maize for at least a month after harvest), compared to a base of 69 percent in the control group. Third, GSRA farmers were 37 percentage points more likely to have sold maize in the market by endline, compared to only 36% in the control group. Conditional on selling, treatment farmers sold later: sales in the GSRA group were on average 1 month later than in the control group, and fetched 6 percent higher prices. Fourth, though respondents used the ISRA, we find no consistent effects of the ISRA on downstream outcomes. Since the ISRA was not designed around maize storage, we did not expect to find effects on storage or on sales. Surprisingly, however, we find an increase in maize stored at home in our main specification. This result is surprising and not entirely robust and so we do not wish to read too much into it, but we conjecture that it may be possible that the savings intervention triggered respondents to think about savings more generally, and to choose to save maize. However, we find no effect on other outcomes like sales, nor on our expected outcome of input usage. This last result may be attributable to the fact that baseline input usage was already surprisingly high (89% of control farmers used hybrid seeds and fertilizer, much higher than earlier studies in this part of Kenya, i.e. Duflo et al., 2011).

Fifth, using our coupon redemption information, we are able to plot a demand curve for agricultural inputs. We find near-universal coupon redemption among those who received a 90% discount, but redemption rate falls to 10% for those who receive a 10% discount. However, in this context in which baseline input usage is high, much of this redemption was simply reshuffling of purchases that would have happened anyway. We do not find differential rates of coupon redemption between the treatment and control groups.

Our paper makes several contributions. First, it is an addition to the literature which examines the reasons due to which large intertemporal arbitrage gains are not exploited. So far, this literature has mainly focused on financial constraints, namely credit constraints (Stephens and Barrett, 2011; Bergquist et al., 2017), or liquidity constraints (Lee and Sawada, 2010; Sun et al., 2013; Dillon, 2016), or high alternative returns to capital (Nash and McCloskey, 1984). An older literature has looked at price risk as a potential explanation

[3] Saving may also be difficult if farmers are present-biased (see Duflo et al., 2011).

[4] See Gilbert et al. (2017) and Bergquist et al. (2017) for recent evidence summarizing price gaps across multiple countries. This phenomenon is particularly severe in rural areas of developing countries due to the spatially fragmented nature of markets.

[5] Specifically, we provided them with the Purdue Improved Crop Storage (PICS) bags: https://ag.purdue.edu/ipia/pics/Pages/home.aspx. These bags have been found so effective at arresting post-harvest losses that a USAID initiative in Kenya has projected that if a million farmers in Kenya adopt them by 2019, domestic supply of maize would increase by 450,000 tons (https://www.fintrac.com/sites/default/files/HST_A3_11.16.pdf).

[6] See Thaler (1999) on mental accounting, and Dupas and Robinson (2013a) for evidence on labeling savings in Kenya.

[7] While the idea of harnessing mental accounting and peer pressure through communal grain storage is novel, storing grain communally has precedent. Historically, many communities have had such systems, largely to ensure food security for everyone. In the 1970s, several NGOs sponsored the setting up of communal grain storage geared towards weathering poor market conditions, especially in West Africa and the Sahel. More recently, the Millennium Villages project also supported cereal banks with a similar objective (World Bank, 2011).

[8] Participants were not told beforehand that they would receive coupons as part of this study. Further, coupons were distributed much later in the season, so the coupon discount amounts were not known to participants at the time when storage decisions were being made (see Web Appendix Fig. A1 for the full timeline of events).

[9] The take-up of the GSRA at the ROSCA-level was nearly universal – 96 percent of treatment ROSCAs agreed to participate in the study and paid the subsidized price for the wooden stand.

(Saha and Stroud, 1994; Barrett and Dorosh, 1996); however, the current consensus among academics as well as policy-makers is that this is largely implausible given how predictable and regular these price increases are. We further this literature by showing that part of the explanation might be that farmers do not have access to the appropriate storage technology for food grains.

Second, by evaluating the effect of a novel savings scheme, but one that is focused around saving harvest grain, we contribute to the voluminous savings literature, which has almost exclusively focused on cash savings, especially among microentrepreneurs.[10] The closest paper to ours is Basu and Wong (2015), in which farmers were offered free weather-sealed storage drums and storage sacks or lean-season consumption loans to be repaid after harvest, and which finds that the storage interventions increased an index of consumption and income, in both the harvest and lean seasons. Our paper is complementary in several ways. First, we provide another data point in favor of storage as an effective intervention and validate their findings in a different setting. Second, our data allows us to look at mechanisms through which storage is effective. We find that it is not only the technological improvement of reduced harvest losses which was effective, but also the mental accounting of setting aside maize. In particular, while a majority (53%) said that the GSRA was effective because it reduced spoilage, large minorities also said it helped them consume less (38%) or give away less to others (24%).[11] Lastly, we show that income gains were also not solely from reducing spoilage, but occurred because farmers were more likely to sell maize, and sold maize later in the season at higher prices. Another related paper is Bergquist et al. (2017) which worked with an NGO to offer loans to farmers in the post-harvest period and observed that farmers sold less maize immediately after harvest and more in the lean season. Since that study did not change storage technology, the interpretation is that conditional on the existing storage technology, farmers sell some maize due to liquidity needs.[12]

Third, we contribute to the literature on agricultural technology adoption by estimating an experimental demand curve for agricultural inputs. There is a very large literature in development that examines the various demand- and supply-side factors that may depress adoption of these inputs. These include credit, liquidity, and insurance constraints (Karlan et al., 2015; Maitra et al., 2017), social learning and experience (Conley and Udry, 2010; Emerick, 2017; Foster and Rosenzweig, 1995), and behavioral biases (Duflo et al., 2011; Hanna et al., 2014) on the demand side; and the role of quality uncertainty (Bold et al., 2017) and infrastructural bottlenecks (Aggarwal, 2018; Aggarwal et al., 2018; Shamdasani, 2016; Suri, 2011) on the supply side.[13] However, simply documenting the sensitivity of demand to price is important, especially for sub-Saharan Africa because many countries in the region have sizeable and expensive input subsidy programs.[14] Estimating the price sensitivity is also important because there is significant spatial heterogeneity in input prices due to limited road infrastructure in developing countries, particularly when accounting for travel costs (Aggarwal et al., 2018).

Finally, our project is related to the nascent literature on ASCAs/VSLAs, which has tended to show large positive effects from such groups (see Ksoll et al., 2016; Beaman et al., 2014; Greaney et al., 2015; Karlan et al., 2017). The key distinction with financing agricultural inputs is that all participants are on the same agricultural cycle, making within-group lending for agricultural loans difficult. Communal storage can help facilitate intertemporal transfer of resources from harvest to later in the agricultural cycle.

The rest of the paper proceeds as follows. Section 2 lays out the basic experimental design and data. We present our results in Section 3, and briefly discuss the cost and benefit implications of the GSRA intervention. Section 4 concludes with a discussion.

2. Experimental design and data

2.1. Background on seasonal price changes

This project took place in Busia District of Western Kenya. The staple crop in this area is maize and there are two main growing seasons: a longer, more productive "long rains" season with a harvest occurring around August; and a shorter season which harvests around December or January. Prices typically reach a peak around June, just before the long rains harvest, and fall to a low during the harvest period, increasing steadily thereafter.

Many previous papers have documented large seasonal price variations for grains in rural Africa. Price increases as high as 100 percent have been observed in some countries like Madagascar (Moser et al., 2009), Malawi (Dillon, 2016), Southern Tanzania (van Campenhout et al., 2015), and Zambia (Ricker-Gilbert et al., 2013). These cases are likely in the right tail of the seasonality distribution, however (for example, because road networks are very poor in these countries, limiting trade between rural locations with differing harvest schedules).[15] Price fluctuations in countries with somewhat better road networks are more modest, though still meaningful. For example, Bergquist et al. (2017) document an average price increase of 25–50% in 5 countries in East Africa using data from RATIN; similarly, Gilbert et al. (2017) document an average price increase of 33 percent for maize in 7 African countries.

We have two sources of data to document price increases: (1) reported prices from maize sales made by our respondents during the study period; and (2) responses to questions about month-by-month prices from retailers located in the study area. Both sources show increases of about 30–40% (see Fig. 1). Though we lack historical price data in Busia, we look at prices in the nearby city of Kisumu using several public data sources in Table 1. We find an average price increase of 46% in the 2006–16 period (33% if 2011, a major famine year, is removed).[16]

[10] Our design has similarities to studies such as Brune et al. (2014) and Duflo et al. (2011), though our focus is on realizing seasonal gains in prices rather than in setting aside income for future input use.

[11] Multiple responses were allowed. People also cited as reasons the ability to share costs and that they were able to allocate money to agricultural inputs.

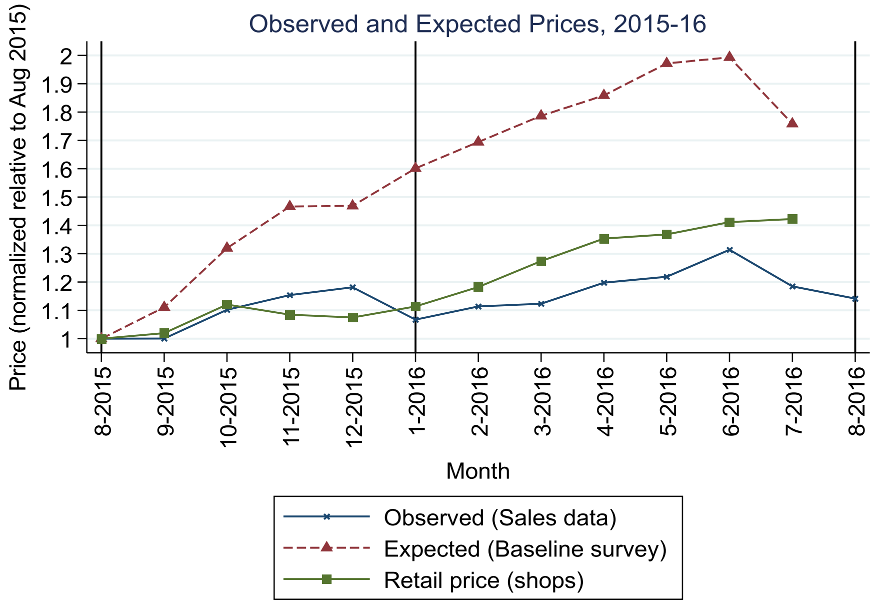
[12] This paper also adds to a niche literature about how cooperatives help farmers improve their incomes. The bulk of these papers are about agricultural marketing cooperatives (Fischer and Qaim, 2012; Wollini and Zeller, 2007; Bernard et al., 2008), but there is also some evidence suggesting that farmers' cooperatives might be able to improve access to financial services and inputs (Desai and Joshi, 2014). The results from this paper suggest that the cooperative structure can be useful even in the absence of intermediation benefits that are central to marketing or input acquisition efforts. In the case of storage, collective action not only provides commitment benefits as described above, but can also help defray costs. Specifically, when asked about why the GSRA was helpful, 38 percent of the respondents reported the sharing of costs as a reason.

[13] See Foster and Rosenzweig (2010) and Jack (2013) for reviews.

[14] In Malawi, for example, 170,000 tons of fertilizer, costing about 4% of the GDP, was distributed to smallholder farmers in 2008–09 (Chibwana and Fisher, 2011).

[15] According to the CIA *World Factbook*, the density of roads in Madagascar, Malawi, Tanzania, and Zambia is respectively 0.06, 0.13, 0.09, and 0.05 km per square kilometer of land area. Kenya, by contrast, has 0.28 km of roads per square kilometer area. As benchmark, the United States has 0.67 km of roads per square kilometer area.

[16] A final point worth making regarding seasonality in this context is about price expectations. During our baseline survey, people reported expecting much larger price changes (the average expected price change was 100 percent – see Fig. 1). Given the results in Table A1, we take this as suggestive that people overestimated increases in the survey. Interestingly, Bergquist et al. (2017) also find that farmers expect a doubling of prices, compared to actual prices increase of 20–30 percent.



Notes: The vertical axis shows the price, normalized to August 2015. Vertical loans show the long rains harvest (around August) and the short rain harvest (around January). Expectations data comes from the baseline survey; observed sales data comes from sales data collected from respondents during surveys; data for shops comes from interviews with shop-owners conducted in the primary markets for our respondent farmers (10 markets in all).

Fig. 1. Prices over season.

Table 1
Peak-trough variation in maize prices in Kisumu, 2006–2016.

(1) Year	(2) Dataset	(3)	(4)	(5) Average across datasets
	FAO	RATIN	WFP	
Panel A. Year by year				
2006	1.42	1.48	1.40	1.43
2007	1.17	1.18	1.15	1.17
2008	1.50	1.44	2.07	1.67
2009	1.22	1.21	1.18	1.20
2010	1.61	1.62	1.54	1.59
2011	2.81	2.88	2.36	2.69
2012	1.40	1.44	1.45	1.43
2013	1.14	1.16	1.13	1.14
2014	1.30	1.44	1.38	1.37
2015	1.28	1.16	1.15	1.20
2016	1.20	0.00	1.04	1.12
Panel B. Average, 2006–16				
Mean peak/trough ratio	1.46			
Standard deviation	0.45			

Notes: Based on maize price data reported for Kisumu (the nearest major city to Busia). The reported statistic is the highest monthly price as a percentage of the lowest monthly price for that year. The year 2011 was a famine in the horn of Africa.

2.2. *Experimental design*

2.2.1. *Sampling and randomization*

In July 2015, we conducted a door-to-door census of 552 individuals in 17 villages spread across three counties in Western Kenya. The census asked people for a list of all ROSCAs in which they participated and collected basic identifying information about each ROSCA, as well as contact information for ROSCA officials. A total of 497 ROSCAs were identified in this way. After collecting this list, we randomly sampled 274 ROSCAs for project inclusion. Enumerators called the treasurers of selected ROSCAs to schedule an initial meeting (at one of the normally scheduled ROSCA meetings).

We randomized ROSCAs into 3 treatment groups: (1) the Group Savings and Reinvestment Account (GSRA), (2) the Individual Savings and Reinvestment Account (ISRA), and (3) control. Details of the experimental design are included in Web Appendix Fig. A1.

Of the 274 sampled ROSCAs, 163 were successfully reached.[17] Since non-participation occurred before treatment was announced, it should not be possible that treatment affected project participation. However, due to random chance, more GSRA ROSCAs were reachable by phone than the other groups (of the 163 ROSCAs that were traced, 60 were GSRA, 52 were control, and 51 were ISRA). An additional 24 attrited before the intervention, leaving 139 ROSCAs.[18] Of these, 132 were traced for the endline.[19] For the reason listed above, there are therefore more GSRA ROSCAs (51) than ISRA (43) and control (38). Web Appendix Table A1, Column 1, shows compliance by treatment status, finding no evidence of differential compliance.

Web Appendix Table A2 shows some statistics on ROSCAs. The average ROSCA has existed for about 6 years, has about 21 members, and the average round length is about 1 year. Nearly all ROSCA members farm, and many ROSCAs provide financial services aside from the pot, including credit (66%) and welfare insurance in case of emergencies (83%). ROSCAs also provide loans to members, at high interest rates (the average rate is approximately 13% per month). We find little difference across ROSCAs in these characteristics (Column 2) – one of nine variables is significant at 10%.

2.2.2. GSRA intervention

At the initial meeting, each ROSCA was read a script about the benefits of setting maize aside after the harvest, of using farming inputs such as chemical fertilizer, and of saving. This basic script was augmented for GSRA ROSCAs to also explain the group savings intervention. ROSCA members were encouraged to collectively set aside some portion of their harvest, and hold it to sell when prices had risen. ROSCAs were each given four hermetically sealed storage bags (called Purdue Improved Crop Storage, or PICS bags) [20] Hermetically sealed bags are likely a major technological improvement for farmers: several studies have compared the PICS bags to other techniques such as solarization, fumigation, metal drums, or storage with ash/mud (all of which are likely superior to the technology our farmers use), and have found PICS bags to be more effective at preventing and arresting infestation (for instance, see Williams et al., 2017).[21] Moreover, PICS bags are also less labor-intensive and more cost-effective. Specifically, the prevalent method of on-farm storage in gunny sacks requires pre-storage application of insecticide, with follow-up reapplications every 3 months (Kimenju and DeGroote, 2010). PICS bags, on the other hand, work through cutting off oxygen which causes insects to suffocate, obviating the need for artificial insecticides.

In addition to the bags, ROSCAs were provided a heavily subsidized wooden stand to keep the maize elevated from the ground (and less susceptible to pests and water damage). Finally, ROSCAs were provided ledger books in which the treasurer could keep track of all deposits and withdrawals of maize by individual members. After describing the program, ROSCAs were given a month to think it over. Project staff emphasized that not all members of a participating ROSCA were required to contribute maize for their ROSCA to qualify for the program.[22]

The GSRA could encourage savings through three main channels. First, the GSRA may be a technological improvement on the alternative of storing maize in burlap sacks at home. Second, the fact that the GSRA maize is held outside the home (for all but the treasurer) will limit access to the maize and may discourage withdrawals of maize for unplanned consumption or early sales. Third, the group nature of the intervention may further encourage participation. The experiment was not designed to test between these pathways, but rather was designed to maximize the chances that the intervention might be effective.

2.2.3. ISRA intervention

The individual savings intervention was inspired by the fact that in this part of Western Kenya, average plot sizes are small and many people who farm also do other small businesses on the side to earn cash. The savings intervention was an individual account labeled for agricultural input usage, held at the ROSCA.[23] ROSCA treasurers were provided a ledger to keep track of deposits, and ROSCAs were encouraged to use savings for inputs (though this was not explicitly enforced). The accounts allowed deposits only of cash, not maize, and so provided no direct mechanism to allow arbitrage of harvested maize.

2.2.4. Coupon intervention

The first main growing season after our intervention was the 2016 long rains. ROSCAs were randomly sampled to receive a discount on inputs at a local agricultural retailer on any input (including fertilizer, seeds, herbicide, and pesticide). The value of the coupon randomly varied from 10 to 90% off of the cost of inputs.[24] The logic of this intervention was that farmers who saved money in the individual savings treatment or stored grain in the GSRA might be more likely to redeem the coupons. In retrospect we realize the intervention was not well-timed because prices do not much increase between the long rains harvest (August) and the time inputs are needed for the next season (redemption was in February–March) – this is because the smaller short rains occur in December or January, and thus prices only really rise starting in February. In addition, baseline input usage was much higher than we expected, limiting the possible effect of the coupons.

2.3. Data

We utilize four main data sources for this analysis (see Web Appendix Fig. A2 for the timeline of activities). First, we conducted a baseline survey with all ROSCAs in August–September 2015. During the same time period, we also conducted a baseline survey with a randomly selected subset of respondents at each ROSCA meeting. We targeted 6 members per ROSCA. In addition to basic demographic questions, the survey included questions on harvest amounts, storage, and input usage. Second, we conducted an in-person midline survey in January and February 2016, in which we collected data on storage as well as on take-up of the GSRA. For this survey, we attempted to enroll 3 respondents per ROSCA. We initially attempted to enroll

[17] Ten ROSCAs were identified as duplicates. The remaining 101 were not reachable by phone, either because the treasurer did not pick up the phone when called (field staff called up to 4 times before stopping), or the phone number was incorrect.

[18] This attrition occurred before ROSCAs knew or enumerators knew their treatment status. The 24 ROSCAs who were not enrolled did not participate because they were unable to schedule a meeting time or because they were not interested in the project.

[19] Of the 7 that could not be traced, 4 had disbanded by midline and were not further contacted. No members could be traced in the other 3.

[20] PICS bags are one of several types of hermetically sealed storage bag solutions that have been developed in recent years for the specific purpose of storing grain. Other examples include the IRRI superbag, the AgroZ bag, and the GrainPro SuperGrain bag.

[21] Also see https://www.entm.purdue.edu/PICS2/Abstracts.pdf for a summary of other studies on the efficacy of PICS bags.

[22] Besides initiating a basic set-up with the bags, stand, and ledger books, we did not provide any guidance on the governance of the GSRA, such as decisions on whether everyone contributes equally, finding consensus on the amounts being deposited or withdrawn, distribution of spoilage risk across members, or the timing and price of collective sales by the GSRA. During a phone check-in with GSRA treasurers in November 2015, however, we did ask them about how they anticipated handling this last aspect, and 89% expected that decisions about sales would be made communally by those holding deposits.

[23] The accounts were inspired by the health savings accounts in Dupas and Robinson (2013a,b), but for inputs instead of health emergencies.

[24] The 3 main inputs that people purchased were DAP and CAN fertilizer, and hybrid seeds. The average prices of these inputs was about $37 for a 50 kg bag of DAP, $27 for a 50 kg bag of CAN, and $4.50 for a 2 kg bag of seeds.

Table 2
Baseline characteristics and randomization check.

	(1) Control Mean	(2) Savings treatments	(3)	(4)	(5) Coupon treatment
		Coefficient on GSRA	Coefficient on ISRA	*p-value* for F-test GSRA = ISRA = 0	Coefficient on Log (price)
Panel A. Demographics and asset ownership					
Age	39.59	−0.58	0.39	0.81	0.43
	(13.52)	(1.62)	(1.87)		(0.86)
Years of education	6.89	0.3	0.51	0.42	−0.21
	(3.41)	(0.38)	(0.38)		(0.25)
Home has mud walls	0.90	−0.01	−0.04	0.56	0.03
		(0.04)	(0.04)		(0.03)
Value of durable goods owned (USD)	131.50	2.28	13.22	0.27	−8.50
	(73.86)	(9.67)	(9.62)		(6.98)
Value of animals owned (USD)	211.70	9.81	70.83*	0.15	−1.49
	(240.70)	(26.62)	(37.37)		(15.16)
Has a mobile phone	0.79	0.04	0.10**	0.1*	0.03
		(0.05)	(0.05)		(0.03)
Has a bank account	0.23	0.04	0.17***	0.01***	0.04
		(0.05)	(0.05)		(0.03)
Has a mobile money account	0.66	0.04	0.09	0.24	0.00
		(0.05)	(0.06)		(0.03)
Acres of land owned	1.79	0.35	0.32	0.36	0.17
	(1.99)	(0.28)	(0.30)		(0.23)
Panel B. Harvest output[a]					
Harvest output from 2015 long rains (kg)	480.60	7.47	26.79	0.84	2.06
	(341.50)	(42.71)	(47.04)		(37.18)
Value of harvest output at post-harvest price (60 ks h/goro-goro)	131.10	2.04	7.31	0.84	0.56
	(93.13)	(11.65)	(12.83)		(10.14)
Panel C. Input usage					
Used fertilizer (2015 long rains)	0.81	0.06	0.05	0.24	0.00
		(0.04)	(0.04)		(0.02)
Used hybrid seeds (2015 long rains)	0.74	0.02	0.07	0.28	−0.01
		(0.05)	(0.05)		(0.04)
Kilograms of fertilizer per acre planted	54.04	11.57*	2.98	0.20	−1.11
	(49.04)	(6.62)	(6.64)		(3.92)
Panel D. Maize storage and sales					
Do you ever store maize?	0.88	0.05*	0.05	0.22	−0.02
		(0.03)	(0.03)		(0.02)
Percentage of seasons in which some maize was spoiled (past 5 years)	0.30	0.05	0.04	0.35	−0.01
		(0.04)	(0.04)		(0.02)
In those seasons, average percentage of maize lost	0.32	0.05*	0.00	0.1*	0.00
	(0.20)	(0.02)	(0.02)		(0.02)
Did you sell maize in the 2014 long rains?	0.32	0.13***	0.11**	0.02**	0.00
		(0.05)	(0.06)		(0.03)
Do you buy maize?	0.79	−0.09*	−0.01	0.05**	0.02
		(0.05)	(0.05)		(0.03)
Do you ever feel that you consume "too much" maize when you have bags in the house?	0.28	−0.03	0.02	0.61	0.02
		(0.05)	(0.06)		(0.03)
Number of observations	668				
Number of ROSCAs	135				

Notes: Sample restricted to those that completed a midline or endline survey. Each row shows means and coefficients from a regression of the dependent variable on treatment indicators and the (log) price of inputs after the coupon discount. In Column 1, standard deviations in parentheses; in Columns 2 and 3, standard errors (clustered by ROSCA) in parentheses. *, **, and *** indicate significance at 10%, 5%, and 1%.
[a] Harvest output (Panel B) is from the endline but should be exogenous to the treatment since the intervention began only just before harvest. There are 511 observations for this variable.

baseline respondents; if there were not 3 baseline respondents present at the meeting, a respondent would be replaced by another randomly selected ROSCA member who was present at that meeting. We enrolled a total of 529 respondents in this survey. Third, we conducted an endline survey over the phone from July–November 2016. We attempted to interview those respondents who had previously completed interviews and successfully interviewed 583 respondents. We use the endline as our primary measure of outcomes, since it is more comprehensive and had more refined modules to measure key outcomes of interest. Fourth, we asked all GSRA ROSCAs to keep logs of deposits, withdrawals, and reason for withdrawal. We visited ROSCAs at midline and endline to inspect these records. We successfully collected logbooks with every GSRA ROSCA at midline, and with 47 out of 52 at endline. Of the 5 remaining ROSCAs, 4 were untraceable because the treasurer was out of town at endline and 1 ROSCA never kept records. In addition to doing endline surveys with individual farmers, we also did ROSCA-level endlines with the treasurer of each ROSCA. We were able to do endlines with 93% of the ROSCAs that were in the baseline sample.[25]

Attrition for the midline and endline is shown in Appendix Table A1 (at the ROSCA level) and A3 (at the individual level). We find no evidence of differential attrition between the GSRA and control groups.

[25] We also did a brief take-up survey with GSRA treasurers in November 2015.

Table 3
Take-up.

	(1) All respondents	(2) Respondents in endline survey sample
Panel A. ROSCA Logbooks		
GSRA		
Contributed maize to GSRA (N = 1105)	0.57	0.70
If yes, kilograms contributed	44.45	37.95
	(73.03)	(32.93)
ISRA		
Contributed money to ISRA (N = 910)	0.56	0.76
	(0.50)	(0.43)
If yes, amount deposited (USD)	9.63	9.03
	(9.27)	(8.20)
Panel B. Endline survey		
GSRA		
Contributed maize to GSRA (N = 221)	–	0.84
If yes, kilograms	–	63.43
		(66.52)
ISRA		
Contributed money to ISRA (N = 191)	–	0.90

Notes: Panel A is from logbooks kept by treasurers. Panel B is from the endline survey. Deposits and withdrawals are winsorized at 1%. Standard deviations in parentheses. The exchange rate at the time was approximately 1 dollar to 100 ks h.

2.4. *Summary statistics and balance check*

Table 2 presents summary statistics on our (post-attrition) sample, as well as a test for randomization balance. From Panel A, the average farmer is 39 years old, has close to 7 years of education, owns about $340 in durable good and animal assets, and owns 1.8 acres of land. Ninety percent of farmers live in homes with mud walls. Twenty-three percent of farmers have a bank account, though 67% have a mobile money account.

Panel B shows that farm productivity is very low: the average farmer reported a yield of just 480 kg, which is worth only about $131 at immediate post-harvest prices in 2015 ($180 if held until the peak price reached in 2015). Surprisingly, input usage (Panel C) is fairly high: 81% of farmers used fertilizer in the past year, and 75% used hybrid seeds.[26] Farmers use 54 kg of fertilizer per acre, close to recommended amounts.

Finally, Panel D presents some figures on maize storage. Virtually all households (88%) store some maize for some period of time (since the alternative is to sell the entire output immediately after harvest). However, as we show later, many farmers sell or consume much of this maize within a fairly short period of time. Nearly all households who store maize do so on a raised platform or table in the house, typically in a burlap sack. Storing in this way may be subject to pest and rodent infestation, which is borne out in reported losses: farmers report that at least some maize was lost in 30% of seasons and that these losses were substantial (1/3 of storage in those years). Another issue is that people may be tempted to consume the maize faster than if it were out of sight: a non-negligible minority of households (28%) report that they consume "too much" maize when it is stored in the home. We find that most households are net buyers of maize: only 32% sell maize, while 79% buy.

We check for randomization in Column 4, which shows the p-value from an F-test of equality of the coefficients from regressions of each of these variables on indicators for GSRA, ISRA, and control, as well as the log price after discount, with standard errors clustered by ROSCA. We find five significant differences out of 22 in this table: an indicator for having a bank account, an indicator for having a mobile phone, a measure of spoilage in the past 5 years, and whether a farmer bought or sold maize in the last planting season. Though these are unfortunate outcomes on which to have pre-existing differences, we attempt to address this by controlling for each of these variables in our main specifications. Further, we do not think it is likely that these drive our treatment effects on sales, since the effect on sales is 3 times this baseline difference. Nevertheless, these baseline differences should be kept in mind.

2.5. *Estimation strategy*

To estimate treatment effects, we rely primarily on the endline survey (we use the midline as supportive evidence). For each outcome for individual i in ROSCA r, we run the following Intent to Treat regression

$$Y_{ir} = \alpha_0 + \beta_1 G_r + \beta_2 I_r + \theta X_{ir} + \epsilon_{ir} \quad (1)$$

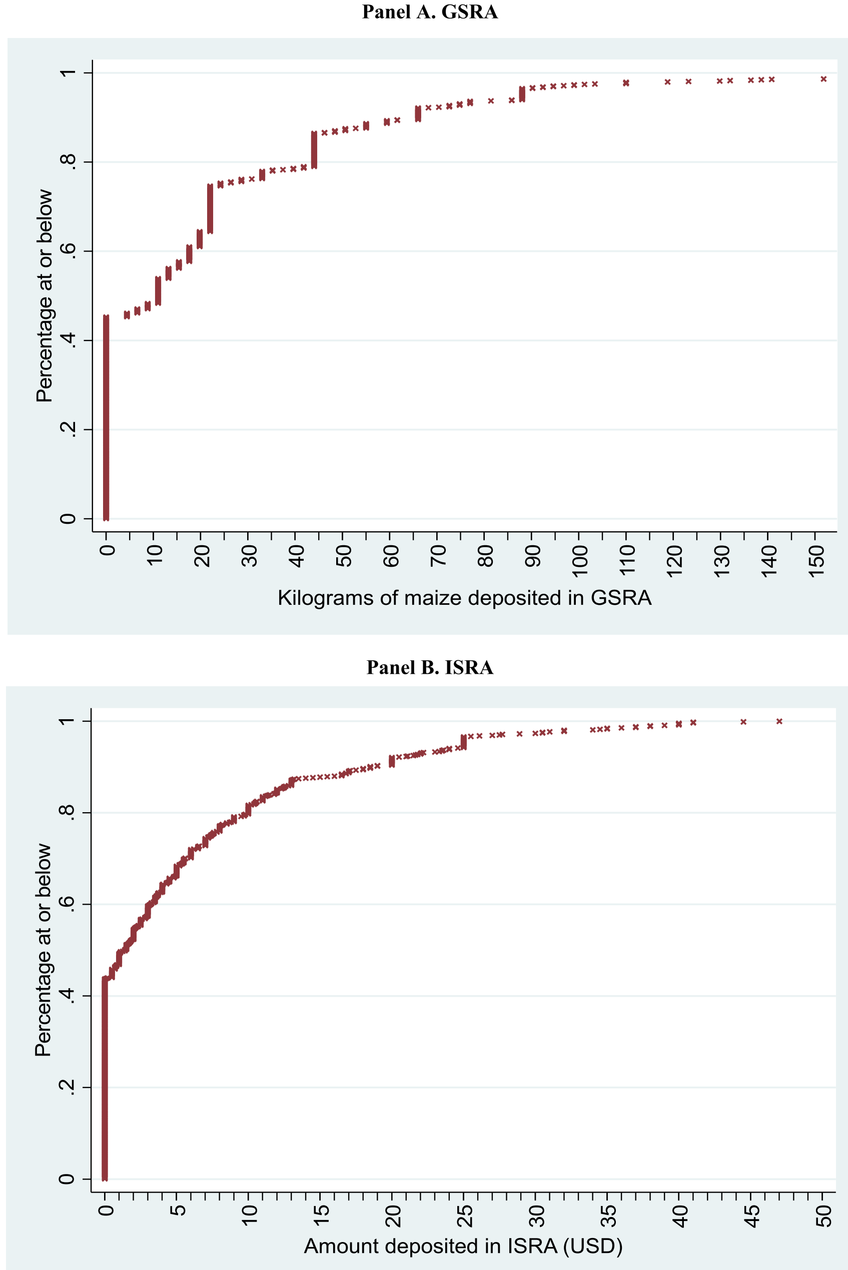
where G_r is a dummy for receiving the GSRA treatment and I_r is a dummy for receiving the ISRA treatment. X_{ir} includes the following controls: the four variables that are significantly different in Table 2, a control for harvest output in August 2015, which is exogenous to treatment since ROSCAs were visited either just before or slightly after harvest (and so there was no opportunity to change investment decisions), and the log of the percentage price payable of inputs, net of the coupon. The harvest output has been included as a control to improve precision since it is the primary determinant of storage behavior. However, this control does not materially change results (see Panel A in Appendix Table A4). We cluster standard errors at the ROSCA level.

3. Results

3.1. *Take up*

Table 3 shows statistics on take-up of GSRA and ISRA, using data from the ROSCA logs and the endline. According to the logs, 57% of

[26] This is much higher than previously reported in this part of Kenya, for example in Duflo et al. (2011), suggesting that input usage has increased in Kenya over time.



Notes: For readability, CDF in Panel A shows values below the 99th percentile. A kilogram of maize was worth about US $0.27 in August 2015, rising to US $0.36 by June 2016. Average total harvest was approximately 480 kilograms (see Table 2). The exchange rate at the time was approximately 1 dollar to 100 Ksh.

Fig. 2. CDFs of deposits.

ROSCA members contributed to the GSRA and 56% contributed to the ISRA. This percentage is higher (70% for GSRA and 76% for ISRA) among respondents who completed the endline survey. We conjecture that the main reason for this is that the respondents who were present at ROSCA meetings were likely to be the more active members of the ROSCA, and were therefore somewhat more likely to use the product than the average respondent. This should not affect the internal validity of our results, however, since the same types of respondents should have been present in treatment and control ROSCAs.[27] Of those who used the savings products, many used it quite a bit – see Fig. 2, Panel A for a CDF of total deposits into the GSRA, and Panel B for the ISRA counterpart. Among GSRA users, the average amount deposited was 44 kg on the logbooks (38 kg among endline respondents), equivalent to roughly 8–9% of average harvest output (480 kg – see Table 2). While this is a small amount in absolute terms (worth about $14-$17 at immediate

[27] In order to allay doubts about overreporting however, we run the storage regressions using the administrative information on ROSCA storage. These results are presented in Panel B of Appendix Table A4.

Table 4
Effects on storage.

	(1) Stored maize to be consumed or sold at least 1 month after 2015 long rains harvest[2]	(2) Quantities	(3)	(4)
		Amount stored outside home (including GSRA)	Amount stored at home	Total amount stored
GSRA	0.23***	50.52***	−21.15	29.37
	(0.05)	(4.06)	(19.54)	(19.47)
ISRA	0.10	0.84	43.22**	44.06**
	(0.06)	(1.56)	(20.66)	(20.63)
Log (price after coupon rebate)	0.04	2.00	8.68	10.69
	(0.04)	(2.02)	(14.28)	(14.42)
2015 Long Rains Harvest[a]	0.24***	0.02***	0.42***	0.44***
	(0.06)	(0.01)	(0.04)	(0.03)
Control mean	0.69	0.00	185.20	185.20
Control sd	0.46	–	196.70	196.70
Number of respondents	583	583	583	583
Number of ROSCAs	132	132	132	132

Notes: All variables measured from the 2015 long rains harvest, from the endline survey. Quantities are winsorized at 5%. All weights in kilograms. In addition to the covariates shown here, all regressions control for variables that are imbalanced in Table 2. Standard errors clustered by ROSCA in parentheses. *, **, and *** indicate significance at 10%, 5%, and 1%, respectively.
[a] Harvest is measured in 1000 kg in Columns 1, and in kilograms in the remaining Columns.

post-harvest prices), it is a sizeable percentage of harvest income (since harvested output is very low). As a percentage, this effect size compares favorably to other papers in the savings literature, most of which are about cash savings. For example, recent studies have found treatment effects for deposits of 11% of income (Dupas and Robinson, 2013b in Kenya), 6% (Prina, 2015 in Nepal), 12% (Dupas et al., 2017,2018 in Kenya), 8% (Dupas et al., 2017,2018 in Malawi) and 18% (Dupas et al., 2017,2018 in Uganda). For the ISRA, the average amount deposited was about $5.50, which is equivalent to about 12% of baseline input purchases in the control group.[28]

3.2. Storage

Table 4 shows results on storage of harvested maize. To measure storage, we asked respondents the following question: “How much maize did you store which you intended to sale or consume more than a month after harvest?” Though the specific cutoff of one month is arbitrary, this question is meant to measure longer-term maize storage, rather than storage of just a few days or weeks. We code an indicator for storage in Column 1, and observe a large, statistically significant treatment effect: while only 69% of control farmers reported yes to this question, this increased by 23 percentage points in the GSRA group.

Columns 2–4 show quantities. Column 2 shows all storage outside the home, pooling GSRA with any other storage outside the home. While individuals in control group ROSCAs did not store any maize outside the home, individuals in GSRA ROSCAs stored an average of 51 kg. Column 3 shows home storage, which was lower in the treatment group (by 21 kg), suggesting that some of the GSRA maize was shifted from home storage. Even in itself, this type of crowd out might be a desirable outcome due to the inefficient nature of home storage. Column 4 sums Columns 2 and 3 into total storage, showing a 29 kg increase in the GSRA group (though statistically insignificant). The point estimate is sizeable compared to the control base of only 185 kg, equivalent to 16%.[29]

Surprisingly, we also find an effect of the ISRA on home storage, which was not the intent of that treatment. This may be noise or, perhaps, it may be the case that getting people to think about saving stimulated an interest in saving up intertemporally even though this was not the intent of the treatment. This is only conjecture however so we do not make too much of this result.

3.3. Sales

Table 5 shows effects on maize sales and farm cash income (note that these measures were only collected at endline). Column 1 shows that GSRA farmers were 37 percentage points more likely to sell maize in the year after the harvest. This is over a doubling in sales, compared to the control group mean of 36%. Though effects on quantities and revenues (Columns 2–3) are not significant, point estimates show increases in sales of about 15-20% on the control group. We examine the timing of the sales in Columns 4 and 5, and find that GSRA farmers are no more or less likely than control to sell within a month of harvest (i.e. in August or September, 2015), but 40 percentage points more likely to sell later in the season. As Fig. 1 shows, prices are already 10% higher than the immediate post-harvest trough by this time. Of people who sold, Columns 6–7 show that GSRA farmers sold later (by about a month, on average, significant at 1%) and received higher prices for output (about 6% on average, significant at 5%). In line with our initial expectations, we do not find any treatment effects of the ISRA on sales. While consistent with the pre-intervention hypothesis, this is slightly

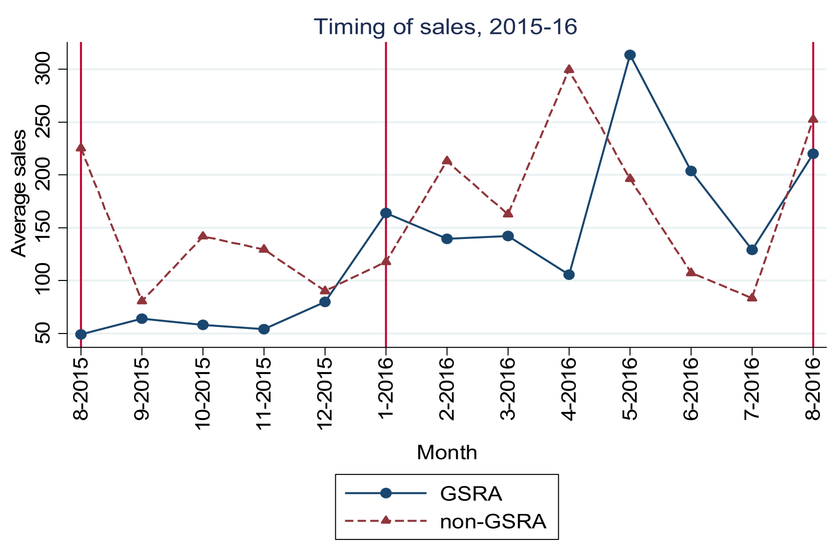
[28] Web Appendix Table A5 shows regressions of take-up of the GSRA on baseline characteristics, showing some weak evidence that more affluent individuals may have been more likely to use the GSRA. However, few covariates are significant, likely due to the limited sample size.

[29] Web Appendix Table A4 shows 4 robustness checks: removing the harvest control (Panel A), using administrative data for GSRA storage (Panel B), and either not winsorizing at all (Panel C) or at 1% (Panel D). Results are robust across all specifications and total storage is actually stronger (and statistically significant) in the untrimmed, the 1% winsorized, as well as the administrative data specifications. Appendix Table A6 shows estimates using only the midline data, finding broadly similar effects. Note, however, that the indicator for storage was defined differently than in the endline – in the midline, we asked about storing maize for any length of time, including maize that was sold or consumed within a month. For this reason, the mean of this measure is much higher and the treatment effect attenuated.

Table 5
Effects on maize sales, prices received, and farm revenue.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Sales between Aug 2015 and Aug 2016			Timing of Sales		For those who sold	
	Indicator for selling any maize	Quantity sold	Total Revenue	Sold within a month of harvest	Sold later in the year	Days between sale and 2015 harvest[b]	Log (average sales price)[c]
GSRA	0.37***	18.32	4.82	0.02	0.39***	36.21***	0.06**
	(0.06)	(21.93)	(7.22)	(0.03)	(0.06)	(13.63)	(0.03)
ISRA	−0.04	14.44	3.09	−0.02	−0.03	−7.21	−0.01
	(0.06)	(21.76)	(7.35)	(0.03)	(0.06)	(18.56)	(0.04)
Log (price after coupon rebate)	−0.08**	−23.99	−7.33	−0.03	−0.07*	12.60	0.00
	(0.04)	(14.98)	(5.00)	(0.02)	(0.04)	(8.81)	(0.02)
2015 Long Rains Harvest[a]	0.31***	0.31***	0.10***	0.05	0.31***	0.01	0.08**
	(0.06)	(0.04)	(0.01)	(0.04)	(0.06)	(0.01)	(0.03)
Control mean	0.36	103.30	33.62	0.07	0.32	169.80	−1.19
Control sd	0.48	196.70	66.78	0.26	0.47	91.60	0.19
Number of respondents	583	583	583	583	583	294	294
Number of ROSCAs	132	132	132	132	132	106	106

Notes: All data is from endline survey. All variables measured from the 2015 long rains harvest. Monetary values in USD. All weights in kilograms. Quantities in columns 2–3 are winsorized at 5%. In addition to the covariates shown here, all regressions control for variables that are imbalanced in Table 2. Standard errors clustered by ROSCA in parentheses. *, **, and *** indicate significance at 10%, 5%, and 1%, respectively.
[a] Harvest quantity is measured in 1000 kg in Columns 1 and 7 and in kg for the remaining columns.
[b] Harvest occurs around August. For people with multiple sales, average is weighted by the quantity of maize sold per transaction.
[c] Average is weighted by quantity.



Notes: y-axis shows average sales (in kilograms), by month. The long rains harvest was in August 2015. The unit of analysis is the average monthly sales by treatment group, where ISRA and Control are pooled. This figure is based on the endline survey (sales were not recorded in the GSRA logbooks).

Fig. 3. Timing of sales, treatment and control groups.

surprising given the large storage effects of the ISRA. It is possible that the GSRA farmers benefited from collective bargaining and intermediation, features that were absent in the ISRA. This is only speculation, however. Finally, we also see a negative effect of the log price on selling. Speculatively, it is possible that those who had to pay more for coupons were compelled to sell sooner in order to finance the remainder of the input purchase amount, while those who had to pay less could hold to their maize for late season consumption.

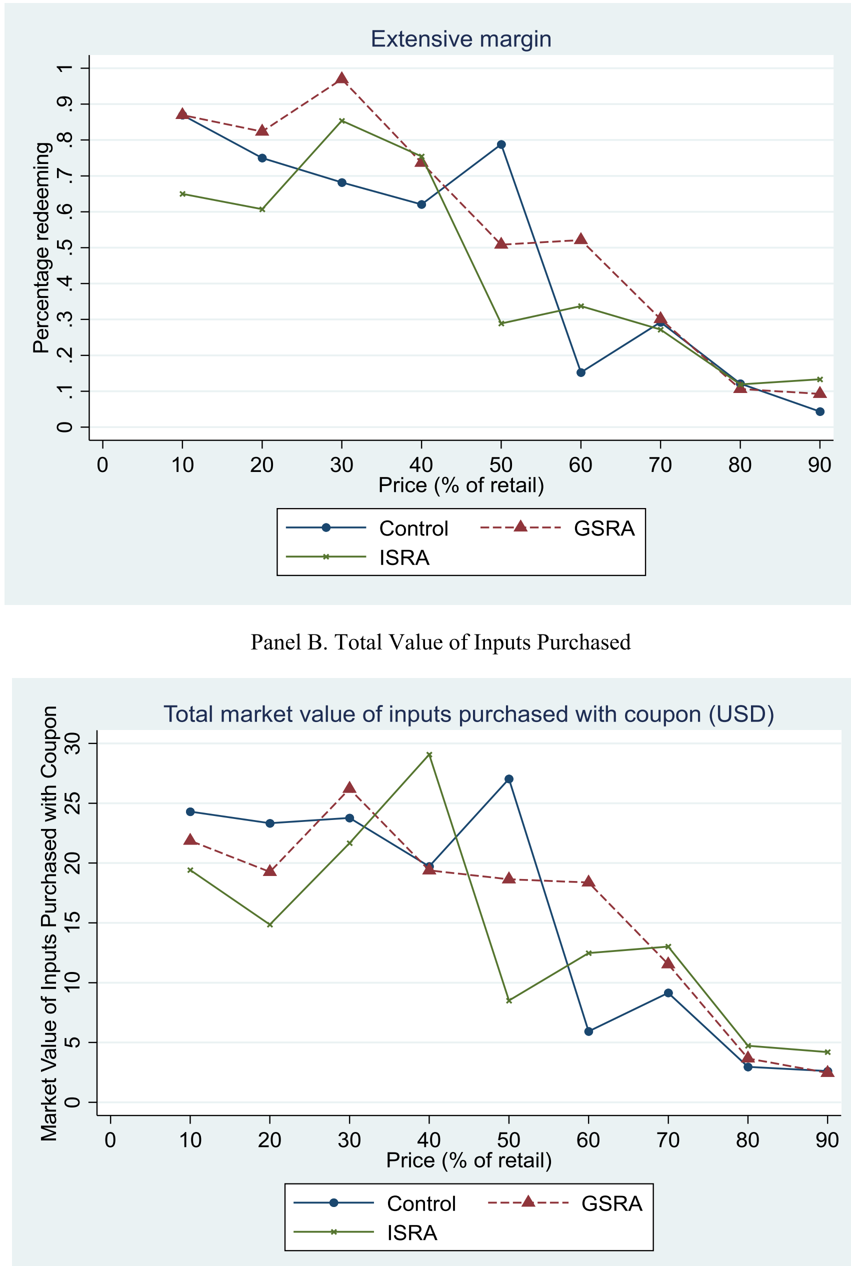
Fig. 3 shows the timing effect for the GSRA graphically, but conditional on making a sale. We calculate average maize sales per month by treatment group, and find that GSRA sales are shifted back in time – conditional on selling, GSRA respondents are less likely to sell maize immediately, and more likely to hold onto maize until prices rise before the following year's harvest.

3.4. Effects on input adoption and other outcomes

Ex ante, one of our main outcomes was intended to be redemption of the experimental coupons. However, in retrospect, the intervention was not particularly appropriate to the context. First, input usage is quite high in this part of Kenya by this time – 90% of control group farmers were using fertilizer and 88% were using seeds, much higher than the 30–40% found in earlier work (i.e. Duflo et al., 2011). Second, as can be seen in Fig. 1, prices reach a peak during the hungry season just before the long rains harvest, around June, about 10 months after the long rains harvest. However, planting is in March, by which point prices have not yet risen (due in part to the short rains harvest which occurs near the end of the year). Thus, the GSRA intervention was not well suited for the coupons.

Panel A. Extensive Margin

Panel B. Total Value of Inputs Purchased



Notes: Figures show experimental demand curves from coupon experiment. See text for more details.

Fig. 4. Experimental demand curves.

Nevertheless, we show the experimental demand curve in Fig. 4 for each treatment group. The GSRA lies above the control for most price points, but differences in redemption are small and jump around. We find near-universal redemption at heavily subsidized prices but virtually no redemption at prices near retail – which is consistent with high baseline input usage, in which many of these purchases are crowding out purchases that would have been made anyway. We show the effect of the treatments on redemption using a regression in Table 6, Columns 1–2, but coefficients are not significant. We examine total input usage in Columns 3–5, finding no effect of either the GSRA or ISRA. Finally, we examine food security in Columns 6–7. We find high baseline levels of insecurity: 45% of control respondents ran out of maize and could not afford more, and 45% reduced food intake to buy inputs, but the treatments had no effect on these outcomes.

3.5. Pathways

In designing the project, we anticipated at least three main reasons why the GSRA might be effective: (1) a reduction in losses due to pests or spoilage; (2) reducing demands on income from others; and (3) discouraging consumption of maize kept at home. In the endline, we included a number of questions to explore these possibilities, which we tabulate in Table 7. Starting with Panel A, we see descriptive evidence in favor of intra- and inter-household demands on income: 66

Table 6
Other outcomes.

	(1) Input coupon experiment[a]	(2)	(3) Agricultural Inputs	(4)	(5)	(6) Food security	(7)
	Redeemed Coupon	Market value of inputs purchased (USD)	Used chemical fertilizer	Quantity of fertilizer used (kg)	Used hybrid seeds	Ran out of maize during season and could not afford more	Reduced food intake around planting to afford inputs
GSRA	0.06	1.56	0.00	−0.27	0.02	0.02	0.02
	(0.05)	(1.92)	(0.04)	(4.13)	(0.03)	(0.07)	(0.07)
ISRA	0.01	1.10	0.02	2.38	0.01	−0.07	−0.07
	(0.05)	(2.28)	(0.03)	(4.83)	(0.03)	(0.08)	(0.08)
Log (price after coupon rebate)	−0.39***	−10.23***	−0.05**	−2.33	−0.03**	−0.07	−0.07
	(0.04)	(1.32)	(0.02)	(2.63)	(0.02)	(0.05)	(0.05)
2015 Long Rains Harvest[b]	0.04	5.17*	0.14***	70.90***	0.11***	−0.20***	−0.20***
	(0.06)	(2.69)	(0.04)	(6.67)	(0.03)	(0.06)	(0.06)
Control mean	0.31	9.98	0.88	50.90	0.90	0.45	0.45
Control sd	–	17.81	–	45.94	–	–	–
Number of respondents	2966	2966	577	576	577	583	583
Number of ROSCAs	141	141	132	132	132	132	132

Notes: All data is from endline survey. Farming questions are in relation to the 2016 long rains season. All regressions in columns 3–7 control for variables that are imbalanced in Table 2. Quantity of hybrid seeds wsa not asked in the survey (only expenditures). Quantity of fertlizer winsorized at 5%. Standard errors clustered by ROSCA in parentheses. ∗, ∗∗, and ∗∗∗ indicate significance at 10%, 5%, and 1%, respectively.

[a] Regressions in Columns 1–2 are from experimental coupon intervention, and include all members of ROSCAs (2966 respondents). See text for details.

[b] Harvest quantity is in 1000 kg.

percent of respondents agree with the statement "If I have maize at home, my household is tempted to eat more than we need", while 50 percent agree with the statement "If a friend or relative comes to me to ask for maize, and if I have maize at home, I am obligated to give him/her some." [30]We find limited evidence in favor of spoilage: in the season of the program, only 6 percent of maize stored at home was spoiled (conditional on spoilage, farmers lost 21 percent of their total maize). This is somewhat smaller than spoilage reported in Table 1, perhaps due to lower spoilage in the year of study than in previous years.

Panel B tabulates responses to a number of open-ended questions about the GSRA. Ninety-four percent of respondents reported that the GSRA was helpful (this number actually exceeds the number that took it up in the first place, perhaps because people expected to use it in future years).[31] Those reporting yes were asked for reasons why they liked the GSRA: 53 percent reported lower spoilage, 39 percent reported that they used the GSRA to allocate money towards inputs, 37 percent reported the benefit of defraying costs of storage across members, 37 percent reported that they reduced consumption, and 24 percent reported giving away less maize to others. Thirty-six percent agreed with the statement "The GSRA program prevented my household from eating more maize than needed" while 62 percent reported that they gave away less maize as a result of the GSRA. Of those who reported giving away less, 39 percent reported that they got fewer requests because less maize was in the house while 55 percent reported that it was easier to say no.

Finally, Panel C shows perceptions of the ISRA. The vast majority of respondents thought the ISRA were helpful and said that they would use it in the future. Even though the ISRA had no effect on outcomes, this result is suggestive that the accounts might have had a small positive effect on people's ability to save (for example, it might have been a place to save up a small percentage of the money needed for inputs). In Table 6 for example, we found a negative point estimate for the ISRA on needing to reduce food intake to fund inputs – perhaps with a larger sample, this effect might have been significant.

3.6. Cost-benefit calculation

Our results strongly suggest that the GSRA is cost-effective, since the intervention targeted a number of respondents at once and the costs on a per-person basis were fairly modest. In this subsection, we perform a back of the envelope calculation to show this somewhat more formally. However, we should note that the data collection was not set up to measure all the possible benefits of the GSRA. In particular, the GSRA may have had effects on the seasonality of consumption, as well as on purchases of maize during the season, and we are not able to pick this up with the surveys we have (indeed, the GSRA could be cost-effective even if no sales were made).[32] In addition, the small sample in this study does not give much precision on key outcomes such as the revenue gain.

[30] We also find some differences between GSRA and control respondents in some of these questions. GSRA respondents are more likely to say that they are tempted to eat more maize when it's around the house. We do not have a good explanation for this, other than that perhaps having the GSRA made these respondents more cognizant of the problem of holding maize at home. We also find that GSRA respondents are less likely to report that others are less likely to help them if they refuse requests. This response could be due to the treatment – since the maize is out of the home, people are less obligated to give. Finally, GSRA respondents are more likely to say that they consumed maize stocks before they had planned. Again, we do not have a great explanation for this, but we conjecture that they may have been overly optimistic about having less maize around the house.

[31] It is also possible that at least some of the ROSCAs ran into a capacity constraint. Ledger records kept by ROSCAs suggest that about half the ROSCAs stored more then 360 kg of maize, which was the capacity of the bags we provided (Appendix Fig. A3). It is possible therefore, that some people were rationed out of the GSRA. In the individual endline, 55 people (i.e., 25% of the endline GSRA sample) said that they saved less than what they desired, of which, 6 people said that they did so because the ROSCA decided that everyone would save the same amount.

[32] We did ask about month-by-month consumption in the surveys, but people had difficulty recalling consumption months in the past and for this reason consumption showed no seasonality.

Table 7
Pathways.

	(1) Control Group	(2) Difference between GSRA and control
Panel A. Barriers to home storage (all respondents)		
Agrees with statement: "If I have maize at home, my household is tempted to eat more than we need"	0.39	0.11*
		(0.06)
Agrees with statement "If a friend or relative comes to me to ask for maize, and if I have maize at home, I am obligated to give him/her some."	0.60	0.06
		(0.06)
Agrees with statement: "If I refuse requests when people ask me for maize, they are going to be less likely to help me out in the future."	0.75	−0.14**
		(0.06)
Some maize stored at home after 2015 harvest was spoiled	0.04	0.03
		(0.03)
If yes: percentage spoiled	0.20	0.02
		(0.07)
Consumed maize stocks earlier than had planned and/or consumed maize intended for sale	0.04	0.10***
		(0.03)
If yes: percentage consumed	0.39	0.11*
		(0.06)
Panel B. GSRA respondents only		
Do you think the GSRA was helpful?	0.94	
If yes, why?		
Less spoilage	0.53	
Helped save for inputs	0.39	
Shared costs	0.37	
Consumed less	0.37	
Gave away less	0.24	
Agrees with statement: "The GSRA program prevented my household from eating more maize than needed."	0.36	
Do you think you gave away less maize because of GSRA?	0.62	
If yes: why do you think you gave away less?		
Fewer people asked for maize because I had less in house	0.39	
It was easier to say no because I had less maize in the house	0.55	
Some maize stored in the GSRA in 2015 was spoiled	0.05	
If yes: percentage spoiled	0.02	
Will you adopt the GSRA next year?	0.98	
Will the ROSCA continue with the GSRA program next year?[a]	0.92	
Panel C. ISRA respondents only		
Do you think the ISRA was helpful?	0.91	
Will you adopt the ISRA next year?	0.93	

Notes: Data from midline and endline surveys. N = 583 for endline survey, 529 for midline.
[a] Based on an endline survey with ROSCA treasureres only (N = 49).

These (major) caveats in mind, we estimate that revenues in the GSRA group increased by about $5 on a base of $34, i.e. 15% (see Table 5), but this is not statistically significant. For a ROSCA of 21 members, the revenue gain is therefore about $105.

The costs of the intervention are fairly straightforward. Each ROSCA received 4 PICS bags (costing $2.50 each) and one stand (costing about $25).[33] There are some additional costs to storing extra maize. Farmers may have to transport the maize from the treasurer's home to the nearest market center to sell the maize. While we do not have good data on this cost in Kenya, companion work in Tanzania (Aggarwal et al., 2018) finds that the cost of transporting a bag of maize one-way to the nearest market is about $2 (for a distance of about 5.7 km) in Northern Tanzania, whereas a bag is worth about $27.00, so that the ad valorem cost is roughly 7.5%.[34] This would reduce the value of the revenue gain to about $98. In addition, maize would have to be transported from the farmer's home to the treasurer's home. However, this is unlikely to be a major cost since the ROSCAs operate within villages. Other costs of storing maize, like the labor time for periodically re-drying the maize, or the money and time costs of buying and applying pesticides, are close to zero since the PICS bags cut off oxygen entirely such that fungus and insects cannot survive.[35]

Ultimately, then, we estimate roughly $98 per ROSCA in gains against $35 in costs, for a ratio of approximately 2.8/1. We believe this is a lower bound, however, for several reasons. First, it was a new technology and farmers might have held off in the first year. Second, we only provided 4 bags but people may have chosen to store more in future years.[36] Third, it is likely possible to lower the cost of the stand and the bags if purchased in bulk, at scale. Moreover, once procured, a stand and the bags can be reused several times (according to scientists at Purdue University, a PICS bag lasts for 3 seasons),

[33] Note that ROSCAs paid $1 in cost-sharing.

[34] Please note that this is likely an upper bound on the transportation cost as the markets are located closer-by and the roads are likely better in the Kenyan context relative to Tanzania. For instance, using data from 2004, Suri (2011) reports a mean distance of 3.5 km to the fertilizer seller, which is a reasonable proxy for the distance to market. According to the CIA World Factbook, the density of roads in Kenya is 0.28 km per square kilometer of land area, while it is 0.9 km per square kilometer of land area in Tanzania.

[35] While outside the scope of this cost-benefit analysis, please note that storage without chemicals can enable farmers to access higher market prices due to the premium on pesticide-free food.

[36] Indeed, more than half the GSRA ROSCAs added more bags to the GSRA in the first year itself (Web Appendix Fig. A3).

making the intervention nearly costless during the subsequent seasons.

Having said all this, please note that our calculations above do not take into account non-pecuniary costs that may deter GSRA storage. For instance, there may be some discomfort involved in storing grain at someone else's house, especially if it impacts the power dynamic between the parties involved. GSRA may also disrupt the informal insurance networks in rural communities by concentrating the risk of spoilage or theft during storage faced by the members of the ROSCA. Finally, there may be physical or psychological costs involved for the person responsible for storing everyone's grain.

4. Discussion and conclusion

This paper shows that a group-based savings scheme can increase storage among smallholder farmers – providing savings clubs with a simple way to set aside maize increased the likelihood that a farmer stored maize by 23 percentage points and approximately doubled the probability of selling maize. This increase in storage could potentially have a substantial effect on cash income from the farm: we find an increase in revenue of about 15% (though not statistically significant).[37] We find encouraging evidence that ROSCAs continued the GSRA even after the evaluation: in ongoing follow-up work conducted in early 2018, we find that approximately 90% of ROSCAs that could be traced are still implementing the GSRA, 2.5 years after the original intervention.

This paper is differentiated from much of the literature because it focuses on storage of grain rather than cash. The seasonality inherent in agricultural prices almost mechanically makes grain storage not just an act of saving, but also one of investment, with nearly guaranteed nominal returns (and real returns as well, so long as spoilage is limited). On the other hand, the real return to savings in the types of banks available in rural Africa often have negative real rates of return due to high fees and high inflation. This suggests that interventions to help farmers store maize could potentially have larger welfare effects on outcomes like real income than would encouraging savings in the banking options that are currently available.

An important caveat is that our experiment was not designed to test for pathways. The GSRA could have worked through the safe-keeping afforded by the bags, the impact of labeling that comes from segregating the grain for storage with the ROSCA, or the peer-effects generated by the communal storage. However, we do not think this diminishes the importance of our findings, as there may be benefits from combining the treatments. Specifically, no amount of mental accounting or social commitment will spur storage if farmers view it as fundamentally risky due to the potential for spoilage. Similarly, merely providing insulated bags that continue to locate grain in plain sight is unlikely to arrest intra and interpersonal issues.[38] Indeed, Basu and Wong (2015) who studied a similar question in Indonesia by providing storage supplies and lean season in-kind loans as two *separate* interventions, found that while storage in the absence of credit had a small positive effect on lean season consumption, credit in the absence of reliable storage had no effect. This point is of great importance even outside of the immediate context: the poor often operates under multiple binding constraints (for instance, a farmer's storage choices are guided by financial limitations as well as the lack of physical storage technology). Good policy will need to remove these constraints simultaneously in order to be effective.[39]

Multilateral agencies and NGOs like Feed the Future, One Acre Fund, and USAID are currently working to commercialize PICS bags by building local capacity.[40] There is ample entomological evidence to suggest that these bags could be helpful, for poor smallholder farmers whose current storage technology is inefficient. The basic social structure of the ROSCA, on which we layered the storage intervention, is prevalent in this part of the world, and comes about organically without outside intervention – suggesting that the GSRA could be easily scaleable. Even now, PICS bags are commercially available in moderate-sized Kenyan towns (like Busia), and usage of PICS bags has been expanding in recent years: the distribution and sale of PICS bags under the USAID's KAVES program went from 69,209 in 2014 to 215,248 in 2015 to over 300,000 by January 2016 (equivalent to more than 27,000 metric tonnes of maize in storage capacity).[41] Our results suggest that the effect of programs like KAVES might be larger if policy makers also encourage farmers to use their bags for setting aside a portion of their maize for communal storage in order to take advantage of seasonal fluctuations in maize prices.

An open question for future research concerns the general equilibrium effects of such an intervention. Bergquist et al. (2017) find a general equilibrium effect on prices from their credit intervention – inducing people to hold maize will affect prices even for those who sell earlier. Analogously, returns will also be impacted for those who currently do benefit from seasonal arbitrage, notably large farmers and traders. Such general equilibrium effects will lessen incentives to hold maize in the first place. As the return to storage declines, people may find it less profitable to store maize then to invest elsewhere at potentially high returns (i.e. de Mel et al., 2008). Our paper suggests that at current prices, many farmers evidently find storage more profitable than the next-best alternative, but such storage would become less attractive as more people do it and seasonal price fluctuations diminish.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jdeveco.2018.04.001.

References

Aggarwal, Shilpa, 2018. Do rural roads create pathways out of Poverty? Evidence from India. Forthcoming J. Dev. Econ. 133, 375–395.
Aggarwal, Shilpa, Giera, Brian, Jeong, Dahyeon, Robinson, Jonathan, Spearot, Alan, 2018. Market Access, Trade Costs, and Technology Adoption: Evidence from Northern Tanzania. Working Paper.
Baland, Jean-Marie, Guirkinger, Catherine, Mali, Charlotte, 2011. Pretending to Be poor: borrowing to escape forced solidarity in Cameroon. Econ. Dev. Cult. Change 60 (1), 1–16.
Barrett, Christopher, Dorosh, Paul, 1996. Farmers' welfare and changing food prices: nonparametric evidence from rice in Madagascar. Am. J. Agric. Econ. 78 (3), 656–669.
Basu, Karna, Wong, Maisy, 2015. Evaluating seasonal food storage and credit programs in East Indonesia. J. Dev. Econ. 115, 200–216.

[37] It is possible that increases in storage were also accompanied by a decrease in purchases, and therefore, had an even larger effect on welfare than shown here, but our data are not equipped to measure this.

[38] Our results on pathways show that the treatment effects are not explained by safe-keeping alone as people also report consuming and giving away less.

[39] We should caveat all of this however, by saying that there is likely an upper bound on the benefits from such an intervention relative to an individual storage one if for instance, farmers feel uncomfortable about storing their grain in somebody else's house or if there are space constraints at the treasurer's house. There may also be power dynamics at play. It is also worth considering that storing collectively in this manner concentrates the risk faced by the ROSCA members.

[40] Efforts are already underway in Burundi, DRC, and Kenya by USAID, in Tanzania and Sierra Leone by CRS, and in Ethiopia and Rwanda by the One Acre Fund.

[41] See https://picsnetwork.org/wp-content/uploads/2016/04/Newsletter_2016_4-22-16.pdf.

Beaman, Lori, Karlan, Dean, Thuysbaert, Bram, 2014. Saving for a (not so) Rainy Day: A Randomized Evaluation of Savings Groups in Mali. Unpublished.
Bergquist, Lauren, Burke, Marshall, Miguel, Edward, 2017. Selling Low and Buying High: an Arbitrage Puzzle in Kenyan Villages. Unpublished.
Bernard, Tanguy, Collion, Marie-Héléne, Janvry, Alain de, Rondot, Pierre, Sadoulet, Elisabeth, 2008. Do village organizations make a difference in African rural Development? A study for Senegal and Burkina Faso. World Dev. 36 (11), 2188–2204.
Bold, Tessa, Kaizzi, Kayuki C., Svensson, Jakob, Yanagizawa-Drott, David, 2017. Lemon technologies and adoption: measurement, theory and evidence from agricultural markets in Uganda. Q. J. Econ. 132 (3), 1055–1100.
Brune, Lasse, Giné, Xavier, Goldberg, Jessica, Dean, Yang, 2014. Facilitating savings for agriculture: field experimental evidence from Malawi. Econ. Dev. Cult. Change 64 (2), 187–220.
Carter, Michael, Laajaj, Rachid, Yang, Dean, 2013. The impact of voucher coupons on the uptake of fertilizer and improved seeds: evidence from a randomized trial in Mozambique. Am. J. Agric. Econ. 95 (5), 1345–1351.
Chibwana, Christopher, Fisher, Monica, 2011. The Impacts of Agricultural Input Subsidies in Malawi. MASSP Policy Note No. 5. IFPRI, Washington, D.C.
Collier, Paul, Garg, Ashish, 1999. On Kin groups and wages in the Ghanaian labour market. Oxf. Bull. Econ. Stat. 61 (2), 133–151.
Conley, Timothy, Udry, Christopher, 2010. Learning about a new technology: pineapple in Ghana. Am. Econ. Rev. 100 (1), 35–69.
de Mel, Suresh, McKenzie, David, Woodruff, Christopher, 2008. Returns to capital in microenterprises: evidence from a field experiment. Q. J. Econ. 123 (4), 1329–1372.
Demirgüç-Kunt, Asli, Klapper, Leora, Singer, Dorothe, Oudheusden, Peter Van, 2015. The Global Findex Database 2014: Measuring Financial Inclusion Around the World. World Bank Policy Research Working Paper 7255.
Desai, Raj, Joshi, Shareen, 2014. Can producer Associations improve rural Livelihoods? Evidence from farmer centres in India. J. Dev. Stud. 50 (1), 64–80.
Dillon, Brian, 2016. Selling Crops Early to Pay for School: a Large-scale Natural Experiment in Malawi. Unpublished.
McCloskey, Donald, John, Nash, 1984. Corn at interest: the extent and cost of grain storage in Medieval england. Am. Econ. Rev. 74 (1), 174–187.
Duflo, Esther, Kremer, Michael, Robinson, Jonathan, 2011. Nudging farmers to use fertilizer: theory and experimental evidence from Kenya. Am. Econ. Rev. 101 (6), 2350–2390.
Dupas, Pascaline, Robinson, Jonathan, 2013a. Why Don't the poor save More? Evidence from health savings experiments. Am. Econ. Rev. 103 (4), 1138–1171.
Dupas, Pascaline, Robinson, Jonathan, 2013b. Savings constraints and microenterprise development: evidence from a field experiment in Kenya. Am. Econ. J. Appl. Econ. 5 (1), 163–192.
Dupas, Pascaline, Keats, Anthony, Robinson, Jonathan, 2017. The effect of savings accounts on interpersonal financial relationships: evidence from a field experiment in rural Kenya. Forthcoming Econ. J.
Dupas, Pascaline, Karlan, Dean, Robinson, Jonathan, Ubfal, Diego, 2018. Banking the Unbanked? Evidence from three countries. Am. Econ. J. Appl. Econ. 10 (2), 257–297.
Emerick, Kyle, 2017. Trading frictions in Indian village-economies. Forthcoming J. Dev. Econ.
Fischer, Elisabeth, Qaim, Matin, 2012. Linking smallholders to markets: determinants and impacts of farmer collective action in Kenya. World Dev. 40 (6), 1255–1268.
Foster, Andrew, Rosenzweig, Mark, 1995. Learning by doing and learning from others: human capital and technical change in agriculture. J. Polit. Econ. 103 (6), 1176–1209.
Foster, Andrew, Rosenzweig, Mark, 2010. Microeconomics of technology adoption. Ann. Rev. Econ. 2, 395–424.
Gilbert, Christopher L., Luc, Christiaensen, Jonathan, Kaminski, 2017. Food price seasonality in Africa: measurement and extent. Food Pol. 67, 119–132.
Greaney, Brian, Kaboski, Joseph P., Leemput, Eva Van, 2016. Can self-help groups really Be Self-Help? Rev. Econ. Stud. 83 (4), 1614–1644.
Hanna, Rema, Mullainathan, Sendhil, Schwartzstein, Joshua, 2014. Learning through noticing: theory and evidence from a field experiment. Q. J. Econ. 129, 1311–1353.
Jack, B. Kelsey, 2013. Market Inefficiencies and the Adoption of Agricultural Technologies in Developing Countries. White Paper. Agricultural Technology Adoption Initiative, JPAL (MIT) and CEGA (UC Berkeley).
Karlan, Dean, Osei, Robert, Osei-Akoto, Isaac, Udry, Christopher, 2015. Agricultural decisions after relaxing credit and risk constraints. Q. J. Econ. 129 (2), 597–652.
Karlan, Dean, Savonitto, Beniamino, Thuysbaert, Bram, Udry, Christopher, 2017. Impact of savings groups on the lives of the poor. Proc. Natl. Acad. Sci. Unit. States Am. 114 (12), 3079–3084.
Kimenju, Simon, De Groote, Hugo, 2010. Economic Analysis of Alternative Maize Storage Technologies in Kenya. Unpublished.
Ksoll, Christopher, Bie Lilleor, Helene, Helth Lonborg, Jonas, Rasmussen, Ole Dahl, 2016. Impact of village savings and loans Associations: evidence from a cluster randomized trial. J. Dev. Econ. 120, 70–85.
Lee, Jeong-Joon, Sawada, Yasuyuki, 2010. Precautionary saving under liquidity constraints: evidence from rural Pakistan. J. Dev. Econ. 91, 77–86.
Maitra, Pushkar, Mitra, Sandip, Mookherjee, Dilip, Motta, Alberto, Visaria, Sujata, 2017. Financing smallholder agriculture: an experiment with agent-intermediated microloans in India. J. Dev. Econ. 127, 306–337.
Moser, Christine, Barrett, Christopher, Minten, Bart, 2009. Spatial integration at multiple scales: rice markets in Madagascar. Agric. Econ. 40, 281–294.
Mullainathan, Sendhil, Shafir, Eldar, 2014. Freeing up intelligence. Sci. Am. Mind 25, 58–63.
Prina, Silvia, 2015. Banking the poor via savings accounts: evidence from a field experiment. J. Dev. Econ. 115, 16–31.
Ricker-Gilbert, Jacob, Mason, Nicole, Jayne, Thomas, Darko, Francis, Tembo, Solomon, 2013. What Are the Effects of Input Subsidy Programs on Equilibrium Maize Prices? Evidence from Malawi and Zambia. Unpublished.
Saha, Atanu, Stroud, Janice, 1994. A household model of on-farm storage under price risk. Am. J. Agric. Econ. 76 (3), 522–534.
Shamdasani, Yogita, 2016. Rural Road Infrastructure and Agricultural Production: Evidence from India. Unpublished.
Stephens, Emma, Barrett, Christopher, 2011. Incomplete credit markets and commodity marketing behaviour. J. Agric. Econ. 62 (1), 1–24.
Sun, Dingqiang, Qiu, Huanguang, Bai, Junfei, Liu, Haiyan, Lin, Guanghua, Rozelle, Scott, 2013. Liquidity constraints and postharvest selling behavior: evidence from China's maize farmers. Develop. Econ. 51, 260–277.
Suri, Tavneet, 2011. Selection and Comparative Advantage in Technology Adoption. Econometrica 79 (1), 159–209.
Thaler, Richard, 1999. Mental accounting matters. J. Behav. Decis. Making 12, 183–206.
van Campenhout, Bjorn, Lecoutere, Els, D'Exelle, Ben, 2015. Inter-temporal and spatial price dispersion patterns and the well-being of maize producers in southern Tanzania. J. Afr. Econ. 24 (2), 230–253.
Williams, Scott B., Murdock, Larry L., Baributsa, Dieudonne, 2017. Storage of maize in purdue improved crop storage (pics) bags. PLoS One 12 (1), e0168624.
World Development Report, 2008. Agriculture for Development. World Bank, Washington, D.C.
World Bank, 2011. Missing Food: the Case of Postharvest Grain Losses in Sub-saharan Africa Report Number 60371-AFR. World Bank, Washington D.C.
Wollini, Meike, Zeller, Manfred, 2007. Do farmers benefit from participating in specialty markets and cooperatives? The case of coffee marketing in Costa Rica. Agric. Econ. 37, 243–248.