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Short communication

Unlocking the benefits of credit through saving

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ABSTRACT

Access to microcredit has been shown to generate only modest average benefits for recipient households. We study whether other financial market frictions – in particular, lack of access to a safe place to save – might limit credit's benefits. Working with Kenyan farmers, we cross-randomize access to a simple savings product with a harvest-time loan. Among loan offer recipients, the additional offer of a savings lockbox increased farm investment by 11% and household consumption by 7%. Results suggest that financial market frictions can interact in important ways and that multifaceted financial access programs might unlock dynamic household gains.

1. Introduction

A vast literature on microcredit has found mixed evidence on whether credit access allows households to finance profitable investments and improve key livelihood indicators (Karlan and Zinman, 2011; Angelucci et al., 2015; Attanasio et al., 2015; Augsburg et al., 2015; Banerjee et al., 2015; Crépon et al., 2015; Tarozzi et al., 2015; Fiala, 2018; Meager, 2018). Even in settings where microcredit has had positive immediate effects on revenues, it often fails to translate into sustained consumption gains or business growth for the majority of households (Banerjee et al., 2015; Meager, 2016).

One possible explanation for this lack of sustained impact is difficulty in channeling increased revenues into future investments due to limited ability to save. If the timing of when the returns from microcredit-enabled investments are realized does not align with the timing of when those additional revenues are needed for consumption or reinvestment, households lacking a safe way to save may struggle to translate increased revenues into desired investments. This channeling also requires mental accounting, which may be more difficult in the absence of savings technologies. Finally, households without access to protected saving vehicles may face pressure to share any increase in revenue with kin, rather than re-invest.

In this study's Kenyan setting, as in many other low- and middle-income countries (LMICs), households that lack access to credit typically also face barriers to accessing other financial services, including savings products that could help channel the returns from loans more effectively. Therefore, it may be that – rather than being substitute financial services – credit and savings products can serve as complements.

We present novel experimental evidence on the complementarities between credit and savings. In the context of African agricultural markets, large seasonal fluctuations in the price of staple commodities provide substantial opportunities for arbitrage through storage. Despite this, smallholder farmers typically sell their crops immediately after harvest, when prices are low; many buy back grain for personal consumption in the lean season when prices are higher. We build on work by Burke et al. (2019), which finds that credit constraints contribute to farmers' inability to take advantage of this arbitrage opportunity. They find that a harvest-time loan allows farmers in Kenya to more effectively time their maize sales and earn higher revenues. However, it did not on average translate to a significant increase in consumption or other productive investments.

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In this paper, we present the results from a contemporaneous field experiment in Kenya in which we randomly overlay access to the harvest-time loan with access to a simple savings technology, namely, a durable, concealable metal box with a key (or "lockbox").[2] We find that among those who are offered a loan, being offered a savings lockbox enables farmers to channel loan returns (and possibly part of the loan itself) to increase farm investment by 11% and household consumption by 7%, relative to farmers only offered the loan but not the lockbox.

The evidence on mechanisms is merely suggestive, but three forces are possibly at play. First, the lockbox may have provided households with a technology to move money intertemporally to times when it is most needed. We see especially large consumption gains from lockbox usage during the lean season, when the marginal utility of consumption is presumably highest. Consumption gains in the lean season can have meaningful positive welfare effects for households, as food and non-food consumption typically sees a large drop in the lean season (Barrett and Dorosh, 1996; Kaminski et al., 2014; Basu and Wong, 2015). Second, the lockboxes may have enabled households to shield loan returns against a "kin tax" (Jakiela and Ozier, 2016; Squires, 2016). Consistent with this, we find that in addition to enabling the inter-temporal movement of consumption, lockboxes also increase total consumption.[3] Finally, the lockbox may have facilitated mental accounting, allowing households to align expenditure with their spending goals (Thaler, 1999; Dupas and Robinson, 2013b).

We present two further pieces of evidence that bolster the central conclusion that access to savings products helps translate credit-enabled returns into long-run reinvestment and consumption gains. First, we exploit a second source of variation in the Burke et al. (2019) study, which found that returns to loans offered immediately after harvest (in October) yield much higher returns than loans offered three months later (in January). In this paper, we find that the consumption and investment benefits of being offered a lockbox are concentrated among the early loan (October) group, suggesting that access to savings is most useful when combined with access to a profitable investment (facilitated here by timely credit). A second exercise estimates the effects of a lockbox alone (among households without access to the harvest-time loan), and finds null effects on consumption and farm reinvestment, implying that the results are not the impact of having a lockbox alone. These results point to important complementarities between various financial market frictions, and suggest that multi-faceted financial access programs that include access to both credit and savings technologies may be well-positioned to unlock opportunities for virtuous cycles of reinvestment and dynamic household gains.

This paper is closely related to a large literature on the role of microcredit in enabling productive investments by households. Summarizing six randomized studies, Banerjee et al. (2015) find that microcredit access increases borrowing, business creation, and investment, but does not lead to a sustained increase in profits, labor supply, and consumption for the average borrower. We also speak to a separate literature on savings in LMICs that highlights the positive impacts that access to savings products – even simple ones like the lockbox studied here – can have on household economic outcomes including income, expenditure, investments and wealth (Brune et al., 2016; Chandrasekhar et al., 2018; Dupas and Robinson, 2013a,b; Karlan et al., 2014b; Prina, 2015; Schaner, 2018). For example, Dupas and Robinson (2013b) show that a safe place to store cash helps individuals accumulate health savings, and other studies find that commitment savings products enable higher savings (Ashraf et al., 2006).

In contrast to most of this work, we focus on the interplay between access to a savings product and to credit. To our knowledge, this paper is among the first to explicitly cross-randomize credit and savings products. A handful of recent studies have explored interactions between different types of financial products. For example, Atkinson et al. (2013) find that a commitment savings product allows time-inconsistent individuals to transition from a debt-financed to a savings-financed investment path. Kast et al. (2018) test the impact of a precautionary savings program among a sample of microcredit borrowers. Burgess and Pande (2005) study the impact of access to credit and savings services via large-scale rural bank branch expansion in India and document a significant reduction in poverty. In a framed field experiment, Afzal et al. (2018, 2022) show that when expenditures are lumpy, individuals demand both credit and savings products.[4] We contribute to this literature by explicitly testing the importance of simultaneous provision of two distinct financial instruments – credit and savings – to enable households to undertake productive investments, in an experimental setting.

2. Setting and experimental design

2.1. Arbitrage investment opportunities, reinvestment, and savings access

Agricultural markets in LMICs commonly experience large seasonal price fluctuations. In East African maize markets, prices can rise by over 25% in the months between the harvest and lean seasons. In our study area in rural western Kenya, price fluctuations during the study period of 2013–2014 and 2014–15 were 42% and 45%, respectively (Burke et al., 2019).

These price fluctuations appear to offer farmers a productive opportunity for investment in arbitrage. Rather than sell maize immediately after harvest, when prices are low, farmers can wait to sell until later in the year, when prices are substantially higher. On the other side of the market, farmers who buy maize during the lean season can buy earlier, reducing outlays. However, we find that most of the smallholders in our sample tend to "sell low and buy high," selling right after harvest when prices are low and buying maize back at high prices later in the year. In particular, in our baseline data we see that over 50% of maize sales occurred when maize prices were low (prior to January).

Why do farmers forgo the seemingly profitable investment of storage? Evidence from Burke et al. (2019) suggests the credit constraints are at least partially to blame. Farmers have large expenses, such as school fees, that come due shortly after harvest. Lacking alternative sources of funds, many feel compelled to sell their crop for low prices at that time to pay these bills. Burke et al. (2019) find that offering farmers a loan at harvest-time enables investment in maize market arbitrage, holding off selling – for some, even buying – immediately after harvest, and selling later in the season at a far higher price. This investment yields increase in revenues of 1,573 Ksh (US$18) on an average loan size of 5,476 Ksh (US$63) and has a rate of return of 29%. However, Burke et al. (2019) show that this profitable investment fails to translate into significant household consumption gains, nor is there

[2] An appendix in Burke et al. (2019) briefly discusses the lockbox, and explores using preliminary and incomplete data the narrow question of whether the lockbox mediated the loan's direct effect on storage behavior. Here, we present the complete analysis of the lockbox experiment, following our pre-analysis plan (registered here: https://www.socialscienceregistry.org/trials/67), to (i) bring in new data from the full trial period and (ii) study the dynamic impacts of access to savings on productive reinvestment, testing whether the "lockbox could help farmers channel the loan to their planned investment, as well as make better use of any profits emanating from the loan" (PAP, pg. 1) by testing whether "access to the savings lockbox increased investment in farm inputs and increased consumption expenditure" (PAP, pg. 11). The analysis in this paper therefore utilizes the complete dataset and explores new (but pre-specified) questions.

[3] We also fine that households that are most interconnected with friends and family at baseline become less likely to provide money gifts or loans to them when they have access to a lockbox. See Section 4 for further discussion.

[4] Related studies are Kaboski and Townsend (2005), Duflo et al. (2011), Karlan et al. (2014a).

evidence that these one-time gains are reinvested in future productive capacities, such as farming inputs (see Section 4).

In this paper, we test one explanation for why farmers are unable to convert one-time benefits into sustained gains, namely that they lack the savings vehicles necessary to protect and channel profits. This is particularly critical when there is a mismatch in the timing of when an investment yields returns and when those returns are needed for consumption or reinvestment. To see this more clearly, we divide the year into four periods: (i) Harvest (September to December), (ii) Post-Harvest (January to March), (iii) Planting (March to June) and (iv) Lean (July to August) seasons. The Harvest season is marked by the production of maize, the primary source of annual income for most farm households in our setting. They can choose to set aside maize for consumption, sell it immediately for cash, or store it for selling later. In the Post-Harvest season, households have need for large and often lumpy expenditures, including repayment of debt that has accumulated through the year, discretionary expenses such as holiday expenditures, and school fees, which are due in January.[5] All together, approximately 43% of total households expenditures are incurred during the Post-Harvest phase. The next period is Planting, when farmers invest in farm inputs, which directly affect the following year's harvest. Lastly, the Lean period prior to the next harvest is characterized by a substantial dip in consumption for both food and non-food items.

As shown in Burke et al. (2019), a harvest-time loan reduces farmer sales during Harvest (September–December); instead, farmers hold more inventories through January, then sell off maize from February-July, when prices are higher (see Figure V in Burke et al., 2019). A portion of these sales are completed prior to when investment is needed for Planting (March-June) and the majority are completed prior to the height of the Lean season (July-August). Given this lag, farming households may find it challenging to channel loan returns into planting investment and lean season consumption. Moreover, even short gaps between the timing of sales and intended expenditure can expose returns to theft, kin tax, or limited self-control.[6]

Access to effective, protected, and discrete savings technologies could reduce these pressures. However, in our setting, access to formal savings remains limited: two-thirds of the sample has no money saved in a formal savings account.[7] The two most prevalent forms of savings remain the most traditional, namely, cash and bags of maize. However, saving in cash runs the risk of theft and stored maize is less liquid and more prominent to kin. Many farmers therefore lack access to safe and protected vehicles in which to save returns and channel profits.

Given these constraints on household savings, this study examines whether access to an improved savings technology can help convert short-run credit-enabled revenue increases into longer-run investment and consumption growth.

2.2. Experimental design

The sample is comprised of 1589 smallholder farmers in the Webuye and Matete counties of western Kenya (see Burke et al., 2019 for a more detailed description of the sample). The design overlaid two treatments: (1) an investment opportunity, in the form of a harvest-time storage loan, and (2) access to a savings product, in the form of a simple lockbox. The storage loan was offered in partnership with the organization One Acre Fund (OAF), a non-profit social enterprise that supplies financing and training to smallholder farmers. The product was a cash loan provided at harvest.[8] To ensure that farmers took on a loan they were able to repay, the loan size was capped at an amount proportional to the number of maize bags the farmer had in storage at the time of loan disbursal. OAF did not take possession of these bags as collateral and there was no formal obligation to store the maize beyond the date of loan disbursal. The cash loans were structured similar to the in-kind loans that OAF usually offers, with a flat interest rate of 10% and a flexible repayment structure. As noted above, this loan can enable a productive investment, as it allows farmers to potentially earn high rates of return by storing and selling their maize in a timely manner.

The savings product offered to farmers was a lockbox, a simple metal box to which the farmer held the key. Lockboxes can encourage savings through several channels (Dupas and Robinson, 2013b). First, the lockbox is a safe place to store money, with cash less prone to theft compared to other at-home alternatives. Second, since participants are free to keep the box hidden, it can also help shield money from family and friends and thus reduce the magnitude of the kin tax. Third, the product can also facilitate savings through a mental accounting effect, as it provides a soft form of commitment by allocating the savings to a specific use. Unlike some commitment accounts, a lockbox allows full flexibility in withdrawal timing and usage (for the holder of the key) and unlike formal savings accounts, can lower transaction or other costs (e.g. time to travel to the bank or minimum account balances).

Farmers were first randomized into the loan product. Then, in an additional layer of randomization, farmers in each treatment group were randomized into receiving a lockbox or not. See Fig. 1(a) for details on the experimental design. Because OAF operates in a farmer group model, the loan was introduced to randomly selected groups, consisting of 8–12 farmers, all of whom were assigned the same treatment. Randomization was stratified based on geographic sublocation and on whether the group average OAF loan size in the previous year was above or below the median. In Year 1, two-thirds of groups were offered a loan and one-third were not. In addition, to test the importance of loan timing, a random half of offers in Year 1 were made in October, immediately post-harvest, and the remainder were made in January, when school fees are typically due (in both cases, farmers were made aware of the timing of the forthcoming loan beforehand, in September).

While all farmers in a group were assigned the same loan treatment, for budget reasons only a random set of 6–8 farmers per group were followed for survey data collection. Then, within these 6–8 farmers in the study sample, the savings lockboxes were randomized across farmers at the individual level, stratified by the group treatment assignment and gender. On average, 30% of farmers were offered the lockbox. Lockboxes were disbursed in November of Year 1.

In Year 2 of the study, the loan groups were re-randomized, with loan offers stratified based on sublocation and treatment status from Year 1. All loans for Year 2 were offered in November, as immediate-post harvest-time loans were seen to be more effective in Year 1 (Burke et al., 2019). Note that additional lockboxes were not provided in Year 2.

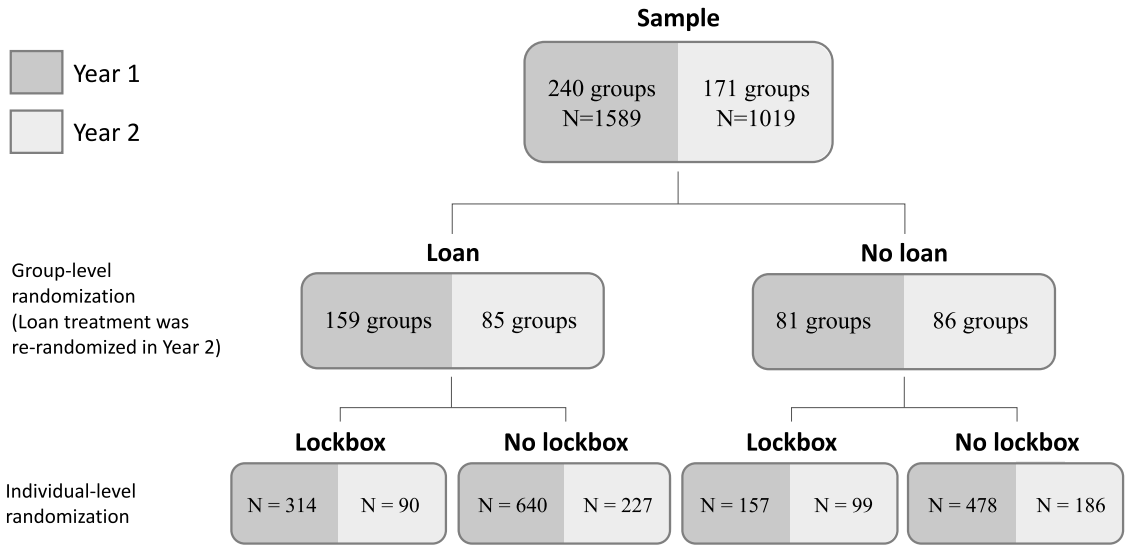
Taken together, in Year 1, the study included 240 farmer groups, for a total sample size of 1589 farmers. In Year 2, there was an attempt to follow all of the same groups, but several groups dissolved or merged, leaving 171 intact groups, and some farmers also re-shuffled among groups. As a result, the Year 2 sample contains 1019 farmers, with 602 farmers remaining from the Year 1 sample and 417 new randomly chosen farmers added from within these groups. Because the lockbox was only distributed at the start of Year 1, these 417 farmers new to the sample in Year 2 are not part of the lockbox experiment and are excluded from the analysis in this paper.

[5] In our sample, 90% of farmers have school aged children and they report spending 37% of their harvest income on school fees.

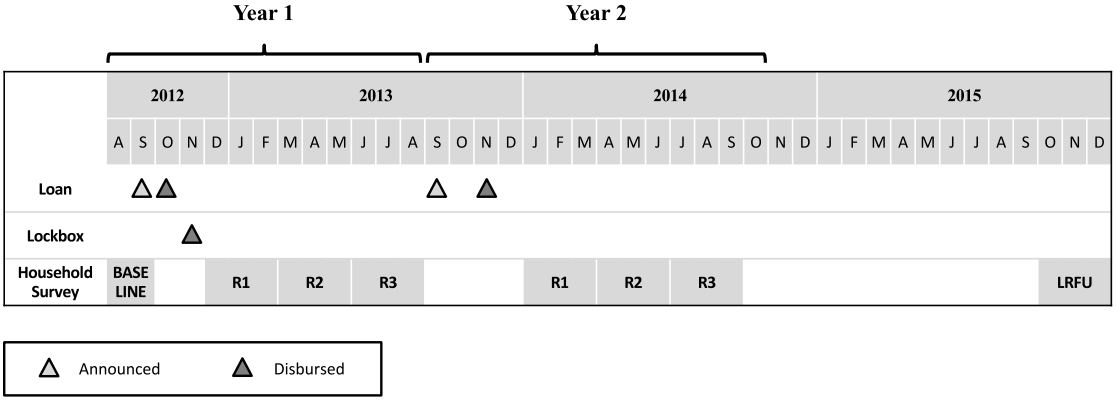
[6] Kin tax, or pressure to share household resources with family and friends, has been shown in other settings in Kenya to limit savings and reinvestment of profits (Anderson and Baland, 2002; Jakiela and Ozier, 2016; Squires, 2016). In our data, sharing with one's social network is very common, with 20% of the sample having taken a loan from kin and over 50% reporting giving a money or maize "gift" to kin.

[7] See Dupas and Robinson (2013a), Prina (2015), Suri and Jack (2016), Dupas et al. (2018), Karlan et al. (2014b).

[8] Outside of OAF, access to credit was limited in our sample, with only 8% ever having taken out a formal bank loan. See Burke et al. (2019) for details.



(a) **Study design**: There were two levels of randomization in year one- a loan and lockbox treatment. The loan treatment was randomized at the group level. The lockbox treatment was randomized at the individual level. In Year 2, the loan treatment was re-randomized. The lockbox treatment was not re-randomized in year two, but we follow a sub sample of year one individuals who participated in year two. Numbers of randomized units are given in the boxes.



(b) **Study timeline**: This figure depicts the harvest periods, timing of interventions and the survey waves.[a]

Fig. 1. Experimental design. [a]R1, R2 and R3 and LRFU indicate the three survey rounds and the long run follow-up.

3. Data and estimation

The study collected a baseline household survey before Year 1, three follow up rounds each year (Years 1 and 2), and a long-run follow-up (LRFU) survey one year after the completion of the last Year 2 survey round (see Fig. 1(b) for the timeline).[9] Three follow-up rounds were conducted in each year spanning the nine months after harvest, and were spread out across the post-harvest, planting and pre-harvest (lean) period. Surveys collected data on household information, farming practices, maize harvest and inventory, expenditures, consumption, household finances and transfers, non-farm income, time and risk preferences. The multiple follow-up rounds provide the high-frequency data necessary to document the role of credit and savings products in allowing inter-temporal movement of cash and investment, as well as measuring living standards via consumption expenditures.[10]

[9] The LRFU survey tracks both the Year 1 and Year 2 study samples. Note we cannot use Year 2 data to look at long-run effects of Year 1 treatment status, because these samples differ sightly. Though there is substantial overlap, loan recipients from Year 1 were more likely to re-enroll in OAF the next year — and therefore to enter into the Year 2 study sample among which the Year 2 loan was re-randomized (the lockbox did not have any effect on re-enrollment). We therefore restrict our main analysis to effects within the year after receiving the loan, for which these differences across years in re-enrollment are irrelevant.

[10] Collecting multiple follow up rounds of survey data also improved statistical power (see McKenzie, 2012).

Table 1
Treatment effects.

	(1) Net Revenues	(2) Total HH consumption (logs)	(3) School Fees	(4) Farm Investments
Panel A: Treatment effect of Loan				
Loan	533.44***	0.04	3.85	−69.84
	(195.49)	(0.02)	(244.86)	(155.90)
Observations	6730	6736	6787	2276
Mean DV	−1616.12	9.55	3911.31	5332.46
SD DV	6359.06	0.64	8281.46	3596.71
R squared	0.12	0.06	0.06	0.15
Panel B: Treatment effect of Lockbox, conditional on Loan				
Lockbox	175.60	0.07**	418.45	496.03**
	(237.98)	(0.03)	(310.71)	(223.13)
Observations	3436	3443	3473	1172
Mean DV	−358.80	9.52	3400.94	4549.72
SD DV	6503.00	0.64	7455.92	3587.37
R squared	0.10	0.07	0.10	0.18

Notes: The dependent variables are Net Revenues, Total HH consumption, Farm Investment and School Fees. Net revenues are measured by the value (in Ksh) of maize sales minus the value of maize purchases that round. The exchange rate during the study period ranged from 80 to 90 Kenyan shillings per USD. Total HH consumption is the log of HH consumption (measured in logged Ksh), aggregated from a detailed 30 day recall consumption module. School Fees are the expenditures on school fees over the past month (in Ksh). Farm Investment is the value (in Ksh) of hybrid seeds, DAP (fertilizer), and CAN (fertilizer) used on maize plots in the season following the loan disbursal (because the Year 2 survey only measured the quantities used, average prices from Year 1 are used to get values in Year 2). This variable was only measured in round three for each year, as that is when farmers undertake this investment. School Fees are a part of Total HH Consumption, but Farm Investment is not. "Lockbox" is an indicator for being in the lockbox treatment group. Panel A shows the treatment effect of the loan treatment. Panel B shows the treatment effect of the lockbox, conditional on being offered the loan treatment. The results are pooled for year one and two of the study. Regressions include round-year fixed effects, strata dummies, and controls for survey date, with errors clustered at the group level. "Mean DV" and "SD DV" are the mean and standard deviation of the dependent variable among the control group. Significant at 90%(*), 95%(**), 99%(***) confidence. Standard errors in parentheses.

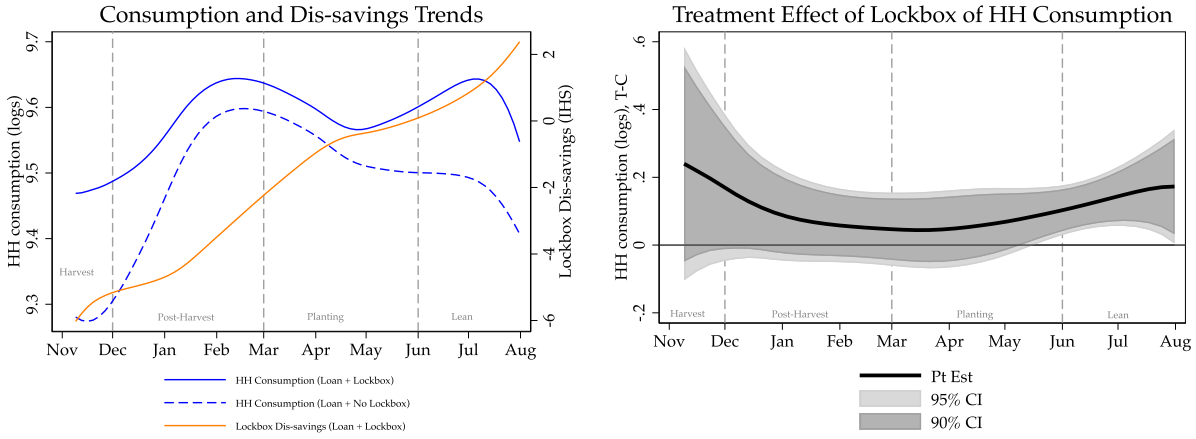


Fig. 2. Time trends for HH consumption and Lockbox Dis-savings.
Notes: The left panel shows how average log household consumption and lockbox savings evolve from November to August in Y1 and Y2 (pooled), as estimated with fan regressions. HH consumption (measured in logged Ksh) is aggregated from a detailed 30 day recall consumption module. Lockbox dis-savings is measured in IHS as the change in the amount saved in the box at the time of the survey. A positive dis-savings implies a decrease in the amount of savings. The exchange rate during the study period ranged from 80 to 90 Kenyan shillings per USD. The right panels show the difference in treatment minus control over time for the lockbox treatment, with a 90% and 95% confidence interval. This is estimated by bootstrapping a fan regression 1000 times (clustering at the group level), without replacement.

The LRFU survey followed all 1019 farmers from the Year 2 sample and a representative subset of 481 farmers from the Year 1 sample.

Sample attrition was low, with over 90% follow-up for both years and no differential attrition across the treatment arms (see Appendix Table C.1). Appendix C presents balance in the characteristics of farmers in the Year 1 sample and the subset who continue into the Year 2 sample, for both the loan and the lockbox treatment groups. We see balance across both treatments for most variables, and present robustness checks in Appendix C in which we control for any covariates that are imbalanced at baseline.

3.1. Estimation of treatment effects

The study has four main outcome variables: net revenues from maize, total household consumption, school fees paid (a subset of total consumption), and farm investments.[11] Net revenues from maize are calculated by subtracting the amount spent purchasing maize from the revenues earned by selling maize. For farmers who received a loan, we also subtract the loan payments made each month. We refrain from calling this measure "profits from maize" as we do not measure

[11] These main outcome variables were all pre-specified in our pre-analysis plan (registered here: https://www.socialscienceregistry.org/trials/67), with the exception of school fee expenditure. School fees represent one of the largest investments that many households in low-income countries make (in this case, investment in human capital). They also comprise an important part of consumption: at baseline, households report spending 37% of their harvest income on school fees. However, since school fees were not pre-specified, results for this outcome may be viewed as exploratory.

Table 2
Treatment effects.

	Net Revenues		Total HH consumption (logs)		School Fees		Farm Investment	
	(1) Oct	(2) Jan	(3) Oct	(4) Jan	(5) Oct	(6) Jan	(7) Oct	(8) Jan
Panel A: Treatment effect of Loan (Oct and Jan)								
Loan	587.81**	−41.21	0.03	0.00	−310.36	−234.95	−219.55	−273.09
	(286.31)	(297.98)	(0.04)	(0.03)	(299.00)	(296.60)	(245.20)	(214.61)
Observations	2534	2536	2535	2534	2572	2571	867	869
Mean DV	−1616.12	−1616.12	9.55	9.55	3911.31	3911.31	5332.46	5332.46
SD DV	6359.06	6359.06	0.64	0.64	8281.46	8281.46	3596.71	3596.71
R squared	0.04	0.04	0.04	0.04	0.06	0.06	0.08	0.07
Panel B: Treatment effect of Lockbox, conditional on Loan (Oct and Jan)								
Lockbox	258.66	33.26	0.10**	0.04	1132.37***	−462.69	584.08	576.38
	(341.56)	(415.86)	(0.05)	(0.05)	(417.79)	(421.42)	(389.94)	(366.27)
Observations	1259	1261	1258	1257	1272	1271	430	432
Mean DV	708.05	284.57	9.45	9.47	2614.39	3207.12	3715.63	3823.85
SD DV	6227.68	6197.31	0.62	0.63	5947.33	7063.82	3225.57	3194.25
R squared	0.05	0.06	0.05	0.05	0.10	0.08	0.12	0.13

Notes: The dependent variables are Net Revenues, Total HH consumption, Farm Investment and School Fees. Net revenues are measured by the value (in Ksh) of maize sales minus the value of maize purchases that round. The exchange rate during the study period ranged from 80 to 90 Kenyan shillings per USD. Total HH consumption is the log of HH consumption (measured in logged Ksh), aggregated from a detailed 30 day recall consumption module. School Fees are the expenditures on school fees over the past month (in Ksh). Farm Investment is the value (in Ksh) of hybrid seeds, DAP (fertilizer), and CAN (fertilizer) used on maize plots in the season following the loan disbursal (because the Year 2 survey only measured the quantities used, average prices from Year 1 are used to get values in Year 2). This variable was only measured in round three for each year, as that is when farmers undertake this investment. School Fees are a part of Total HH Consumption, but Farm Investment is not."Lockbox" is an indicator for being in the lockbox treatment group. Panel A shows the treatment effect of the loan treatment. Panel B shows the treatment effect of the lockbox, conditional on being offered the loan treatment. Columns 1,3,5 and 7 shows the treatment effects for October and January loans of the Y1 treatment. Columns 2,4,6, and 8 show the treatment effects for the October loan. The results are pooled for year one and two of the study. Regressions include round-year fixed effects, strata dummies, and controls for survey date, with errors clustered at the group level. "Mean DV" and "SD DV" are the mean and standard deviation of the dependent variable among the control group. Significant at 90%(*), 95%(**), 99%(***) confidence. Standard errors in parentheses.

all the costs associated with maize farming. Total (log) household consumption is aggregated from a detailed seven-day recall for food expenditure outside the home and 30-day recall for non-food expenditure.[12] To understand what the consumption is spent on, we break out school expenditures (which are otherwise part of total consumption, measured in the 30-day recall). We look at this consumption category in particular as it forms an important part of households' investment in the future. For farm investment, we calculate the amount spent on farm inputs in the planting season, including detailed data on the amount spent on hybrid seeds and chemical inputs such as fertilizers.[13]

We begin by replicating the results in Burke et al. (2019), documenting the effect of the loan on net revenues, consumption, farm investments, and school fees. Eq. (1) presents the primary econometric specification, which pools data across survey rounds where such data is available.[14] Y_{ijrm} is the outcome variable of interest for farmer i in group j in round $r \in \{1,2,3\}$ in year $m \in \{1,2\}$. $Loan_{im}$ is an indicator for whether farmer i was offered a loan in year m. The β coefficients capture the intention to treat (ITT) effects. We include round year fixed effects η_{rm} and control for the survey date d_t. We also control for stratification indicators γ_s as per (Bruhn and McKenzie, 2009). Standard errors are clustered at the OAF farmer group level, the level of randomization for the loans. For all outcome variables, we present robustness to inclusion of baseline covariates as well as to winsorizing the dependent variable at 5% (see Appendix D).

$$Y_{ijrm} = \alpha + \beta_1 Loan_{im} + \eta_{rm} + d_t + \gamma_s + \varepsilon_{ijrm} \quad (1)$$

We then proceed to estimate the added effect of offering a lockbox. The main lockbox specification restricts the sample to those who received a loan, and estimates the additional effect of being offered a lockbox as follows:

$$Y_{ijrm} = \alpha + \phi_1 Lockbox_{im} + \eta_{rm} + d_t + \gamma_s + \varepsilon_{ijrm} \quad (2)$$

The definition of terms is as in Eq. (1), where $Lockbox_{im}$ is the indicator for individual lockbox treatment assignment. To assess whether the gains from the lockbox were more pronounced when combined with more profitable loans, we estimate Eq. (2) by restricting the sample based on the timing of the loan.

Finally, we present the pooled specification as in Eq. (3) showing the interaction between loan and lockbox treatments (termed the "long" model for factorial designs, in the language of Muralidharan et al., 2023):

$$Y_{ijrm} = \alpha + \phi_1 Lockbox_{im} + \phi_2 Loan_{im} + \phi_3 Lockbox_{im} * Loan_{im} + \eta_{rm} + d_t + \gamma_s + \varepsilon_{ijrm} \quad (3)$$

Here the key coefficient of interest capturing the interaction effect is ϕ_3.

4. Results

4.1. Take-up for loan and lockbox

Take-up of both the loan and lockbox treatments was quite high: loan take-up rates were 64% and 62% for Year 1 and 2, respectively, higher than is typical of many other credit interventions in LMICs (Karlan et al., 2010; Banerjee et al., 2015; Jack et al., 2016). Take-up for the lockbox was 97% and, conditional on take-up, 78%, 63% and 50% of farmers report using the lockbox in Year 1, 2 and the LRFU, respectively (see Appendix B and Table B.1 for further descriptive statistics). This high usage rate is a first piece of evidence of the value households attached to this savings technology.

[12] We present consumption results in logs as the distribution of this outcome variable is skewed, as well as to remain consistent with the presentation in Burke et al. (2019). However, results are significant in levels as well (where significant in logs), and we present level magnitudes in the text to facilitate comparison of effect sizes.

[13] Farm investment is not included in total consumption.

[14] For farm investments, there is only data for the planting season, when such investments are made.

Table 3
Interaction of the Loan and Lockbox treatment.

	(1) Net Revenues	(2) Total HH consumption (logs)	(3) School Fees	(4) Farm Investment
Lockbox	−169.95	−0.06	−776.20*	36.69
	(321.48)	(0.04)	(439.50)	(294.89)
Loan	342.25	−0.02	−493.04	−175.35
	(245.88)	(0.03)	(304.95)	(205.62)
Lockbox*Loan	428.87	0.14***	1251.03**	445.00
	(402.80)	(0.05)	(537.57)	(367.49)
Observations	5534	5546	5595	1885
Mean DV	−1616.12	9.55	3911.31	5332.46
R squared	0.11	0.06	0.07	0.15

Notes: The dependent variables are Net Revenues, Total HH consumption, Farm Investment and School Fees. Net revenues are measured by the value (in Ksh) of maize sales minus the value of maize purchases that round. The exchange rate during the study period ranged from 80 to 90Kenyan shillings per USD. Total HH consumption is the log of HH consumption (measured in logged Ksh), aggregated from a detailed 30 day recall consumption module. School Fees are the expenditures on school fees over the past month (in Ksh). Farm Investment is the value (in Ksh) of hybrid seeds, DAP (fertilizer), and CAN (fertilizer) used on maize plots in the season following the loan disbursal (because the Year 2 survey only measured the quantities used, average prices from Year 1 are used to get values in Year 2). This variable was only measured in round three for each year, as that is when farmers undertake this investment. School Fees are a part of Total HH Consumption, but Farm Investment is not. "Lockbox" is an indicator for being in the lockbox treatment group. The results are pooled for year one and two of the study. Regressions include round-year fixed effects, strata dummies, and controls for survey date, with errors clustered at the group level. "Mean DV" and "SD DV" are the mean and standard deviation of the dependent variable among the control group. Significant at 90%(*), 95%(**), 99%(***) confidence. Standard errors in parentheses.

4.2. Treatment effects

As shown in Burke et al. (2019), the loan had significant positive effects on the net revenues earned from maize (Table 1, Panel A, Col. 1).[15] Compared to those who did not receive a loan, farmers who were offered a harvest-time loan earned Ksh 533 higher net revenues per survey round. As discussed in Burke et al. (2019), this was driven by farmers increasing maize purchases when prices were low (in the harvest season), holding more inventories of maize, and selling maize when prices were higher (in the post-harvest, planting, and lean seasons). However, while the loan intervention increased revenues, it did not translate to a statistically significant increase in household consumption (although point estimates are positive) or investment (Cols. 2–4).[16]

We next examine whether combining credit access with a savings technology enables farmers to gain more, either in terms of consumption or long-run productive investment. While the addition of access to a lockbox does not significantly affect farm revenues (Table 1, Panel B, Col. 1), we find that it does enable higher consumption: access to a lockbox, conditional on receiving a loan, significantly increases average consumption by 7% (or Ksh 1,134) across follow-up survey rounds (Col. 2). In particular, it appears to have increased spending on school fees by 12% (or Ksh 418), though results are not significant (Col. 3). We also see that on-farm investment goes up by 11% (or Ksh 496) during the planting season (Col. 4). Taken together, these effects indicate that consumption and investment increased by 1,396 Ksh per round,[17] suggesting that the lockbox enabled farmers to channel the one-time benefits from the loan into future gains and productive investments.[18]

4.3. Unpacking the timing of savings and consumption

We next study impacts by round to offer some understanding of how savings access facilitates gains, though we note that the evidence on mechanisms are merely suggestive. Fig. 2 presents non-parametric estimates for the effects of the lockbox on household savings and consumption over time, conditional on being offered a loan. The left panel presents the mean household consumption for those with and without a lockbox, as well as average lockbox dis-savings for those with a lockbox. We see that farmers with access to a lockbox consume more through the entire year (a point to which we return below), and that this gap is particularly pronounced during the lean season, from June to August. The right-hand panel, which shows the difference between treatment and control consumption over time for the lockbox treatment, along with the bootstrap-estimated 90% and 95% confidence interval, confirms that this gap in lean season consumption is significant at 95% confidence.[19] The timing of these consumption gains is important for welfare, as the lean season is a period of particular farmer need in which the marginal utility of consumption is high.

To understand what drives this increase in lean-season consumption, we return to the left-hand panel, on which we have overlaid the dis-savings for those with access to a lockbox.[20] We define dis-savings as negative savings, such that a negative value implies that money was added to the lockbox, whereas a positive value represents money being withdrawn from the lockbox. Note that the positive treatment effect on consumption coincides with the timing of dis-savings from the lockbox. While not dispositive, this suggests that farmers use the savings accumulated in the lockbox to fund lean-season consumption.

That said, the lockbox appears to work not solely through allowing farmers to move consumption across time. In contrast to a typical "consumption smoothing" mechanism, in which we would expect any increase in lean season consumption to be matched by dips in consumption in other seasons, instead we see that consumption is higher throughout the year. A reduction in kin tax could explain the greater

[15] Appendix D provides robustness checks, estimating Eq. (1) and (2) with baseline covariates and by winsorizing the dependent variable at 5%.

[16] Due to a minor coding error, results in Panel A Column 3 differ slightly from what is presented in Appendix Table E.4 in Burke et al. (2019). This coding error only affected this outcome.

[17] Note that school fees expenditure is part of total consumption and farm investment is only relevant in the planting season, thus this figure is not equal to the sum of coefficients in Table 1, Panel B, Col. 2–3.

[18] Although the point estimate on net revenues generated by the loan is smaller (533 Ksh vs. 1,396 Ksh), their 95% confidence intervals overlap substantially: for net revenues, this is (150, 917), and for consumption + investment, this is (174, 2619). A test of coefficient equality in a Seemly Unrelated Regression (SUR) framework suggest we cannot reject that the treatment effect of the loan on net revenues is equal to the treatment effect of the lockbox on consumption + investment (p-value of 0.92).

[19] Appendix Table E.1 presents treatment effects for consumption by round in regression form. Again, we see the consumption gains are largest in the lean season (round 3), during which time treated households see a 9% increase in consumption (significant at 5%) That said, the difference across rounds is not statistically significant and gains are positive in all periods.

[20] Lockbox saving is measured as the amount saved in the lockbox at the time of each survey round. Lockbox dis-savings is measured as the change in the amount saved in the box between survey rounds.

availability of funds for consumption through the full period; however, we only have weak direct evidence to support this channel.[21] We therefore remain agnostic about the exact mechanisms at play.

4.4. Are the gains from the lockbox most pronounced among the most profitable loans?

In this section, we present additional evidence suggesting that findings we observe are the result of the interplay between access to a profitable investment and a savings technology, by documenting that the gains from the lockbox are most pronounced when combined with the most profitable loans.

In a setting marked by seasonality, the timing of the loan matters. Recall that in Year 1, the timing of the loan was randomized, with half of groups receiving the loan in October, immediately after harvest, and the other half receiving the loan in January. Burke et al. (2019) find that the October loan lead to significantly higher maize inventories, net revenues and household consumption — perhaps because farmers who received the loan in January had already liquidated their maize to meet post-harvest expenditure needs. The October loan thus appeared to open up more productive investments (in this case, greater storage) than the January loan.

Here we analyze whether the lockbox is particularly useful for the October loan group, as one would expect if what the lockbox is doing is enabling better use of the returns from productive investments. We start by replicating the Burke et al. (2019) results in Table 2, Panel A, in which Columns 2, 4, 6 and 8 compare farmers who were offered the October loan to the control group, while Columns 1, 3, 5 and 7 present treatment effects for the January loan groups. Being offered the October loan led to a significant increase in net revenue of 588 Ksh, while the average effect of the January loan in Year 1 led to a smaller (and not significant) increase in net revenues. We next examine (Panel B) whether the gains from access to the lockbox are similarly concentrated among those who received the October loan. We find evidence that this is the case for consumption, school fees, and farm investment (though effects for farm investments are not significant, perhaps because this outcome is only observed in one survey round and therefore estimated effects are less precise). Taken together, this suggests that the savings technology is most impactful when households have greater returns from a productive investment in hand.

4.5. Complementarities between credit and savings

Table 1 suggests that the lockbox enables both consumption and investment. To identify whether these gains are simply the straightforward benefits of accessing savings technologies – which have been documented in the existing literature – or whether there are truly complementary between savings and credit, we run the interaction specification as described by Eq. (3). This also corresponds to the preferred "long" model for factorial designs described in Muralidharan et al. (2023).

Table 3 presents results. First, we see no significant positive effect from the lockbox alone on any outcomes, suggesting that the previous results are not simply the effect of accessing savings technologies on its own.[22,23] Rather, we see strong evidence of complementarities, as suggested by the significant interaction term when consumption or school fees are outcomes and the positive, albeit not significant, effect on farm investment. Point estimates suggest a 14% increase in household consumption (including a 1,251 Ksh increase in school fee expenditures) and a 445 Ksh increase in farm investment when farmers receive both the loan and the lockbox. Taken together, these patterns suggest that there are meaningful complementarities between the credit and savings products.

5. Conclusion

This study examines whether access to an improved savings technology can help convert short-run, credit-enabled revenue increases into longer-run investment and consumption growth. We find that providing a savings lockbox, conditional on being offered a loan, helps farmers undertake expenditures that are incurred with a lag after harvest: farmers increase household consumption by 7%, an increase which is largest in the lean season. Farmers are also able to increase productive investments on the farm by 11%. These gains are not observed when farmers are offered a lockbox or loan alone.

The results highlight the inter-linkages between financial products, and suggest that a more integrated microfinance approach that provides households with complementary credit and savings products could be more effective at meaningfully raising household living standards in low- and middle-income countries.

CRediT authorship contribution statement

Sanghamitra Warrier Mukherjee: Conceptualization, Formal analysis, Writing – original draft, Visualization. **Lauren Falcao Bergquist:** Conceptualization, Formal analysis, Writing – original draft, Visualization. **Marshall Burke:** Conceptualization, Writing – review & editing. **Edward Miguel:** Conceptualization, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Replication data will be posted on Harvard Dataverse.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.jdeveco.2024.103346.

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[21] Over 50% of the sample reports sharing maize or money with kin at baseline. We also find that farmers who at baseline give money to kin are significantly less likely to do so when they have access to a lockbox. Appendix F presents these results in greater detail.

[22] For reasons that are unclear, the impact of the lockbox alone (without the loan) on school fees are negative, but are only marginally significant (Col. 4).

[23] This is in contrast to Dupas and Robinson (2013b), which finds large positive effects from a lockbox alone.

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