Credit Access, Selection, and Incentives in a Market for Asset Collateralized Loans: Evidence from Kenya*

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Abstract

We study the potential for asset collateralization to expand access to credit in rural Kenya. Increasing the share of a loan for a durable agricultural asset that is collateralized by the physical asset itself (from zero to 96%) while reducing the share backed by financial assets increases loan take-up considerably, with only a very limited impact on repayment behavior and the lender's profitability. A Karlan-Zinman test finds evidence of small and marginally significant selection effects in some specifications but no evidence of moral hazard. We find no evidence that joint versus individual liability affects take-up or repayment. Loans had real impacts on investment, milk sales and girls' school enrollment. The lender, a savings and credit cooperative, responded to the study results by offering 80% asset-collateralized loans.

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1 Introduction

Formal-sector lenders in developing countries often impose very tight conditions on borrowers, including high deposits and requirements that guarantors co-sign loans. These borrowing requirements could potentially reduce moral hazard and adverse selection and thus default rates. But they could also potentially inefficiently restrict credit access, impeding investment and technology adoption, which could be particularly costly in developing country settings where many studies have estimated high rates of return (see De Mel, McKenzie and Woodruff (2008a, 2008b, 2009, 2012) and Kremer, Lee, Robinson and Rostapshova (2013)).

By leveraging existing client relationships to exploit social capital and local information, microfinance provides one approach to addressing the underlying incentive constraints that lead to adverse selection and moral hazard. For example, joint liability within borrowing groups is sometimes seen as an important feature of such contracts. However, the extent to which replacing individual with joint liability expands credit access remains to be seen (Attanasio et al., 2015, Giné and Karlan, 2006). Moreover, recent empirical papers suggest that resources channeled through microfinance institutions are not always used by borrowers to finance investment in productive assets (Banerjee, et al., 2015, Banerjee, et al., 2019, and Crepon, et al., 2015).

An alternative way to reduce default risk is to use assets purchased with the loan as collateral. This approach is common in developed economies for the acquisition of large assets, including houses, vehicles, and business equipment. Such asset collateralization is less common in developing countries, possibly due to weak property rights or limited enforcement capacity, and to financial repression which may limit lenders' willingness to take risks. But a shift to asset-collateralization could alleviate liquidity constraints that otherwise severely limit take-up.

Indeed, a growing number of studies have estimated take-up rates and effects of loan products with various design features, including cash collateralization (in the form of deposits, and minimum account balances), social capital collateralization (e.g., through guarantors and joint liability), product collateralization (mostly using agricultural output, either existing at the time of the loan, or to be harvested in the future), and durable asset collateralization.[1] While comparisons across studies are not necessarily informative, take-up rates appear to be higher when durable assets are used as collateral, as borrowers are unable or unwilling to put at risk cash, social capital, or consumption goods. This paper provides direct experimental evidence of the take-up effects, by making an explicit comparison across cash, social capital, and durable asset collateralization.[2,3]

We examine a credit program in which a dairy cooperative in central Kenya offered smallholder dairy farmers loans to purchase 5,000-liter rainwater harvesting tanks. Nearly two-thousand farmers were randomly assigned to receive one of four primary loan offers. Loan amounts and interest rates were identical across arms, but security features differed. In particular, loans varied in terms of the size of upfront deposit and guarantor requirements, with the balance of the debt not covered by these financial commitments collateralized with the purchased asset (the water tank). We find that asset collateralization dramatically expanded credit access. In contrast, replacing borrower deposit requirements with guarantor requirements – a form of joint liability – had no impact on credit access.

One group of farmers was offered the standard loan traditionally offered by the dairy cooperative, which serves here as a benchmark. This loan required borrowers to secure one-third of the loan with security deposits and find guarantors to co-sign for the remaining two-thirds and

[1] Angelucci, Karlan, and Zinman (2015), Attanasio, Augsburg, De Haas, Fitzsimons, and Harmgart (2015), Augsburg, De Haas, Harmgart, and Meghir (2015), Banerjee, Duflo, Glennerster, and Kinnan (2015), Bari, Malik, Meki and Quinn (2021), Basu, and Wong (2015), Beaman, Karlan, Thuysbaert, and Udry (2014), Burke, Bergquist, and Miguel (2019), Cai, Park, and Wang (2020), Casaburi, Glennerster, Suri, and Kamara (2014), Crépon, Devoto, Duflo, and Parienté (2015), Delavallade, and Godlonton (2020), Deutschmann, and Tjernström (2018), Devoto, Duflo, Dupas, Parienté, and Pons (2012), Field, Pande, Papp, and Rigol (2013), Fink, Jack, and Masiye (2014), Fink, Jack, and Masiye (forthcoming), Gertler, Green and Wolfram (2021), Giné and Karlan (2006), Giné and Yang (2009), Hossain, Malek, Hossain, Reza, and Ahmed (2019), Kaboski, and Townsend (2012), Karlan, and Zinman (2010), Karlan, and Zinman (2011), Karlan, Kutsoati, McMillan, and Udry (2011), Khalily, Baqui, Samad, and Khandker (2010), Maazullah, and Bedi (2017), Nakano, and Magezi (2020), Tarozzi, Desai, and Johnson (2015).

[2] The paper is not a study of the *pure* effects of asset collateralization compared with fully uncollateralized credit. Within a context in which lenders are very risk averse and demand high levels of protection, loans that were collateralized by neither financial, social, or physical capital, were not feasible. We also believe identification of the pure effect of asset collateralization would have been less relevant to actual policy decisions made by potential lenders in this environment.

[3] A subsequent lab-in-the-field experiment conducted with dairy farmers in the same location suggests borrowers are more willing to collateralize loans using the assets they are borrowing to purchase than using existing assets (Carney et al., 2019).

to back this with cash or shares in the cooperative (joint liability). Amongst this first group, only 2.4% took a loan for a tank.

In two other groups, loans were partially asset-collateralized, with the tank covering 75% of the loan and the remainder secured either with a borrower deposit of 25% (individual liability), or with a combination of a 4% borrower deposit and a 21% guarantee by a third party (joint liability). Take-up in these two groups increased to 27.3% in the case of individual liability and 23.5% in the case of joint liability, which are statistically indistinguishable from each other. There was thus no evidence that substituting joint liability for individual liability would expand credit access in the context of this study.

In the fourth group, the loan was essentially fully asset-collateralized, with only a 4% individual security deposit required. In this group, take-up was 44.3%, which implies that nearly 95% (i.e., (44.3 – 2.4)/44.3) of those who wished to borrow at the prevailing interest rate offered on standard loans were credit constrained. Two years later, using proceeds generated from the first sample, a second out-of-sample test was conducted, in which an additional 2,597 farmers received similar loan offers (though at a higher interest rate and tank price) with very similar results in terms of take-up and repayment. We analyze this sample separately.

Naturally, lenders may be concerned that relaxing loan requirements might expand credit access but lead to financially unsustainable levels of default due either to selection and/or incentive (moral hazard) effects. To explore these channels, we develop a simple model in which farmers have heterogeneous tank valuations and face uncertain future incomes. In the absence of full income insurance, a borrower chooses to default and lose access to the asset when realized income is sufficiently low. Low-valuation farmers are less likely to take out a loan, but if they do, they are more likely to default, as they have less to lose in doing so. A higher deposit increases the cost of default and reduces the expected utility derived from a loan, thereby inducing exit of low-valuation farmers, while reducing the incentive to default amongst remaining borrowers.

We find that 75% asset collateralization, coupled with either individual or joint liability for the balance, lead to no repossessions. Amongst loans with 96% asset-collateralization and a 4%

deposit requirement, there was just one repossession out of 224 loans in the initial experiment, and two repossessions out of 205 loans in a later replication. All attempted repossessions were successful, and the proceeds were sufficient to cover forgone principal and interest.

We observe a number of differences in other measures of repayment (such as lateness, etc.) across treatment arms, but little that can be considered economically or financially significant. In fact, repayment was generally early among the small number of farmers who took out the standard loan with full cash/share collateralization. Based on these results, we argue that low-deposit collateralized loans are profitable either with a small administrative fee incorporated or if tanks are priced at their retail value (or both). Consistent with this, the lender continued the program after the end of the study, incorporating a small administrative fee and pricing the tanks at their retail value.

Following Karlan and Zinman (2009), the experimental design also allows us to distinguish between, and separately estimate the quantitative significance of, selection and incentive effects of deposit and guarantor requirements predicted by the model. We do this by introducing *ex post* variation in loan terms in the two partially asset-collateralized groups, returning the bulk of the deposit to a random sub-sample of borrowers, and absolving a random sub-sample of guarantors of their obligations, *ex post*.[4]

With this design, the incentive effects of the deposit and guarantor requirements are captured by comparing repayment across sub-groups within each primary loan group, that is, between those who *ex post* had the requirement waived and those who did not. In contrast, to capture the selection effects of deposits and guarantors, we compare repayment of borrowers in the sub-groups that were initially subject to these requirements but had them waived *ex post* with those who were offered a fully asset-collateralized loan from the outset.

The Karlan-Zinman test provides no evidence of material adverse selection or moral hazard associated with the introduction of partial asset collateralization from the status quo – i.e., a move

[4] One limitation of the Karlan-Zinman method of isolating selection and incentive effects is that the behavior of participants in each sub-group might be affected by the experiment itself, if they anticipate (incorrectly) further improvements in loans terms might be forthcoming as a reward for punctual, or indeed early, repayment.

from complete cash security to a 25% deposit.[5] Considering other measures of loan payment (lateness, etc.), we are able to detect a small selection effect of the deposit and guarantor requirements; however, no consistent picture emerges that would suggest imposing tighter borrowing requirements substantially improves repayment. Our main finding then is that asset collateralization has the potential to sustainably expand access to credit in the setting we studied, as the reduction in deposits and guarantors induces limited, if any, negative selection and moral hazard effects.[6] From the lender's perspective, profitability per-loan is essentially unchanged, and the expansion in demand translates proportionately into higher net revenues.

In light of these findings, it is natural to ask if a relaxation of borrowing requirements would increase lender profits, what other factors might explain the previously prevailing practices, and whether we could expect to see changes in the lender's strategy as a result of our study. We provide evidence below that reducing requirements would indeed be profitable. Indeed, our experimental results appear to have induced the lender to update its beliefs about the profitability of asset collateralization: after the completion of the study the lender reduced the required deposit to 20% of the loan, incorporated a modest administrative fee and priced the tanks at the retail value, as its access to capital deepened.

Finally, our experiment allowed us to estimate the real impact of greater access to credit for water tanks on rural households. Farmers given access to credit on less restrictive terms have more water storage capacity and are more likely to own tanks with more than 2,500-liter capacity. Further, access to asset-collateralized loans reduced the time households spent fetching water by 20 percent, and in some specifications the enrollment of girls in school increased by 4 percentage points. Point estimates based on survey data suggest positive effects on milk production, but standard errors are too large to rule out either a high financial rate of return or zero impact on milk production.

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[5] In contrast to Karlan-Zinman (2009), which examines the selection and incentive effects of alternative interest rates, and the promise of a future low rate loan, our paper focuses on other borrowing requirements that are commonly used and thought to screen and incentivize borrowers. Nonetheless, our results are consistent with theirs: while they find that dynamic incentives induce higher repayment, they do not detect any "static" selection or incentive effects - that is, effects of existing loan terms on current repayment. We do not test for dynamic effects, but similar to Karlan-Zinman, we find no evidence of static effects.

[6] Gertler, Green and Wolfram (2021) compare an asset collateralized loan with unsecured credit, and find significant selection and treatment effects. In contrast, our study compares different kinds of collateralization, some of which impose much higher up-front costs on borrowers than others.

Our results contribute to the literature on the capacity of alternative contractual structures to expand credit access and spur investment. They complement cross-country evidence from emerging and high-income economies that when institutional reforms at the national level expand collateralization options, borrowing increases at both extensive (higher loan take-up) and intensive (more leverage) margins (Aretz, Campello, and Marchica 2017, Calomiris et al. 2016).[7] Our results also relate to the literature on joint liability. While a large literature examines group liability in microfinance, the literature on traditional guarantor requirements is more modest, even though such requirements are widespread. Finally, consistent with Devoto et al. (2013), our results suggest that credit provision can contribute to increased access to clean water in the developing world.

The rest of the paper is structured as follows: Section 2 provides background on the dairy and the loan program. Section 3 presents a simple model of hidden information adverse selection and moral hazard that illustrates the potential selection and incentive effects of deposits, and, by analogy, guarantors. Section 4 discusses the experimental design and implementation. Section 5 describes the data and empirical specifications. Section 6 presents the results on loan take-up rates and repayment outcomes, profitability calculations, as well as the impacts of the tanks themselves. Section 7 concludes, noting that while more research is needed to assess external validity, our results, and the recent adoption of similar models of lending by the dairy with which we worked, and by other similar cooperatives, suggest that addressing institutional barriers to asset collateralized lending has the potential to substantially increase credit access.

2 Background

While much of our analysis in this paper concerns the workings of credit markets in a developing country context, the study is also motivated by the acute under-provision of an essential input in the development process: water. It is estimated that approximately 900 million people lack access

[7] See also Assuncao et al. (2014). Skrastins (2016) also considers asset collateralization, examining how institutional design can facilitate easier collection of debt and collateral.

to water at their homes (WHO and UNICEF, 2010). The collection of water from distant sources limits water use, including for hand washing and cleaning, with potential negative health consequences (Wang and Hunter, 2010; Esrey 1996). It also imposes a substantial time burden, particularly for women and girls, with potentially negative consequences for schooling.[8] Because installation of water supply at the household level requires substantial fixed costs, there has been increasing interest in whether extension of credit can help improve access to water (Devoto et al 2011).

Dairy farmers benefit from reliable access to water because the cattle require a regular water supply (Nicholson (1987), Peden et al. (2007), and Staal et al (2001)), especially if the practice of "zero grazing," in which cows are fed and watered in fixed locations, is adopted. Without easy access to water, the most common means of watering cattle is to take them to a source every two or three days, which is time consuming and can expose cattle to diseases.[9] Rainwater harvesting tanks provide convenient access to water, reducing the need to travel to collect water and enabling zero-grazing. Moreover, if properly managed, rainwater is not subject to contamination by disease-bearing fecal matter, so that livestock are not exposed to potentially harmful pathogens found in local streams and ponds (Kristjanson et al. 1999).

In the area in which we conducted our study, about 30% of farmers are connected to piped water systems, but these systems provide water only intermittently, typically three days per week. Historically, many farmers in the area used stone or metal tanks to harvest rainwater or store piped water. One-quarter of our control group farmers had a tank of this type, with capacity of at least 2,500 liters at baseline. However, stone tanks are susceptible to cracking, and metal tanks are susceptible to rusting, so neither is particularly durable.

Lightweight, durable plastic rainwater harvesting tanks were introduced about 10 years prior to the start of the study. These tanks are displayed prominently at agricultural supply dealers in the area and are the dominant choice for farmers obtaining new tanks. Almost all farmers are thus

[8] In our baseline survey, women report spending 21 minutes per day fetching water, three times as much as men, and our enumerators reported that women were typically more eager than their husbands to purchase tanks.

[9] During the baseline survey, it was reported that farmers spent on average ten hours per week taking their cows to the water sources.

familiar with the product but at a cost of about US $320 or 20% of annual household consumption, very few farmers own them. [10] The tanks are typically placed beside the farmers' houses, most of which have metal roofing that can be fitted with cheap guttering. Average installation costs are about Ksh 3,400 (US $48), or 15 percent of the cost of the asset.[11]

Like most of Kenya's approximately one million smallholder dairy farmers, the farmers in our sample sell milk daily to a dairy cooperative, the Nyala Dairy Cooperative.[12] The dairy was set up in 2002 and was part of a large East Africa dairy development project[13] implemented by the international NGO TechnoServe, with which one of the authors had an existing research collaboration, to expand and modernize Kenya's dairy infrastructure. There are two distinct elements to the cooperative: a so-called SACCO (Savings and Credit Cooperative) that provides financial services to paid-up share-holding members with savings accounts;[14, 15] and a dairy that takes daily milk deliveries, performs basic quality tests, cools the milk, and then sells it to Brookside Dairies Ltd., a large-scale milk processor that then controlled 40 percent of the market, for pasteurization, packaging and distribution nationally. At the time, the Dairy took delivery of 20-30,000 liters of milk per day from some 5,300 farmers, 1,900 of whom were SACCO members, although sales subsequently grew considerably. Some farmers living nearby the dairy deliver milk themselves, but most live too far away, and rely on commercial transporters operating on dedicated routes. Farmers were paid on a monthly basis, either in cash for SACCO non-members,

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[10] The exchange rate at the time of the study which was approximately $1:KSh 75.

[11] Installation costs are those reported by households who took up loans and reflect both the costs of guttering systems and base construction (on which the tank would stand). Some households had guttering in place already, and some chose not to construct a base.

[12] The dairy industry represents about 3.6%of Kenya's GDP, and is dominated by about a million smallholder farmers with between one and three cows, who collectively own over 80% of the country's dairy cattle (Kenya Dairy Board, 2019).

[13] See https://www.technoserve.org/our-work/projects/east-africa-dairy-development/.

[14] The cost of membership is about USD5, comprised of a small membership fee and a minimum required shareholding.

[15] SACCOs are widespread in Kenya, with total membership of almost 5% of the population, and represent a rapidly growing sub-sector within the broader cooperative movement in Kenya. This movement encompasses two categories of cooperatives, each of which constitutes roughly half of the total: financial (SACCOs) and non-financial (such as farm produce and commodity-marketing co-operatives, housing, transport, and investment cooperatives). Although cooperative services correspond to the needs of rural and urban dwellers alike, the sector has expanded most aggressively in rural areas where banking services and infrastructure are scarce. SACCOs can be either deposit-taking or non-deposit-taking, though a substantial majority of those audited by regulatory authorities are non-deposit-taking. As of December 2010, there were 6,007 registered SACOs in Kenya, roughly half of which had been audited. With total membership at 1.8 million or 4.8 percent of the national population, SACCOs play a consequential role in the Kenyan financial sector.

or into member accounts earning 3% per quarter, at prices that were relatively more remunerative than selling on the local market or to another dairy.

Farmers have access to two sources of credit as a result of their relationship with the dairy. First, the SACCO is affiliated with an Agrovet store that provides agricultural inputs and services to members, often purchased on credit, limited to the value of the previous month's milk sales and repaid with proceeds in the following month with a 1% monthly interest rate. Second, the SACCO itself makes cash loans to farmers who sell milk to the dairy, mostly for the payment of school fees and to cover family emergencies, including funerals and health care costs. About 36% of farmers in our sample had used one or both of these sources of credit in the one year prior to the baseline survey, but very few – less than one percent – had taken out a loan for the purchase of capital equipment, such as a tank or water pump for use on the farm.

The loans we evaluated were similarly issued by the SACCO to members. SACCOs are typically limited by Central Bank regulation to charge a 12% annual interest rate on loans, but in some cases they can charge 14% annually (SASRA, 2013). In practice, this is interpreted as 1% or 1.2% monthly interest, respectively, paid on a declining balance.[16] SACCOs are also required by law to maintain minimum core capital reserves equal to 10% of total assets (SASRA 2008). At the start of our experiment the SACCO did not pay members interest on their deposits. By the end of our study, they had begun to pay interest on deposits and they also raised the interest rate on the loans, however, the spread remained quite low.[17] As such, lending by the SACCO is being pursued to generate benefits to members, not necessarily purely as an activity for the SACCO to generate profits. As a result, SACCOs typically lend conservatively, imposing stringent borrowing requirements to avoid defaults. For example, under the standard terms prevailing at the time of our study, in order to borrow from the SACCO, a member had to have savings in her/his SACCO account worth one third of the loan amount and had to find up to three guarantors willing to collateralize the remaining two thirds of the loan with savings and/or shares in the SACCO.

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[16] Charging interest on a declining balance is common in Kenya. Borrowers repaid a fixed proportion (one-24th, or KSh 1,000) of the principal each month for 24 months, plus interest on the remaining principal. The schedule of payments was such that in the first month, when borrowers had not repaid any of the KSh 24,000 principal, they would repay KSh 1240, in the second month, KSh 1230, in the third month, KSh 1220, etc., and in the final month, KSh 1,010.

[17] The Nyala SACCO pay members 3% interest per quarter on deposits. This works out to an annual compound interest rate of 12.55%. The rate at which it lends to members during the study period is 1.2% per month. Compounded, this works out to an annual interest rate of 15.39%.

Several features of the institutional environment in which we worked were especially favorable to lending. First, farmers who borrowed agreed to let the SACCO deduct loan repayments from the dairy's payments for milk sales. This provides an easy mechanism for collecting debt that not only has low administrative cost for the lender but also makes repayment the default option for borrowers, instead of requiring them to actively take steps to repay debt. Second, the dairy paid a higher price for milk than alternative buyers, providing farmers with an incentive to maintain their relationship with it. Finally, the SACCO may have had more legitimacy in collecting debt than would an outside for-profit lender.

The physical characteristics of the water tanks also made them well-suited as collateral. They are bulky and are installed next to a user's house, so a lender seeking to repossess a tank can locate it easily. Moreover, tanks have no moving parts and are durable, so they preserve much of their value through the repossession and resale process. Finally, while tanks are too large to be easily transported by hand, a lender seeking to repossess them can easily load them onto a truck.

3. Modeling Selection and Incentive Effects of Loan Requirements

In this section, we model the trade-off between expanding credit access and loan quality, in the context of asset collateralization. We outline a model in which *ex post* default incentives and *ex ante* loan take-up decisions create a mechanism through which security deposits can have impacts on both incentives to repay (moral hazard) and accept a loan offer (selection). A complete exposition is provided in the Appendix. In the context of loan-financed asset purchases, *ex post* income variability induces potential moral hazard, as those with low realizations find it optimal to default.[18] And heterogeneity in asset valuations leads to *ex ante* selection into the credit market.[19] We compute comparative statics results to identify the likely incentive and selection effects of changing the size of the security deposit. We argue that the selection and incentive

[18] Bryan, Karlan and Zinman (2015) develop a model of guarantors in which individuals differ in repayment type and susceptibility to peer pressure, and find no evidence of selection by important enforcement effects.

[19] A simple model of liquidity constraints correlated with borrower quality could also be used to motivate the selection effects of deposits, but it would need to be augmented to incorporate moral hazard effects. Similarly, deposits could affect the incentives to exert ex ante effort (hidden action moral hazard), but that again introduces the need for more complexity.

effects of security deposits likely correspond qualitatively to those of guarantors.[20]

Individuals have heterogeneous valuations, θ, of an asset, the water tank in our empirical setting, and face uncertain future income, y. The purchase price of the asset is constant across potential buyers. To purchase a tank, an individual must take out a loan, either due to liquidity constraints or simply as part of the contractual agreement with the supplier.[21] We show in the Appendix that ex ante efficiency is characterized by farmers with valuations above a certain cut-off purchasing the asset, but that this would result in large and inefficient variability in *ex post* marginal utility of net incomes. A first-best insurance contract restores full Pareto optimality, but introduces incentives for moral hazard, which can be mitigated with a security deposit.

Borrowers are required to make a deposit, D. One role of a deposit is to screen out potential borrowers who cannot come up with the funds, under the assumption that such individuals are less likely to repay the loan. However, we attribute the screening (and incentive) functions of the deposit not to ex ante liquidity constraints, but to the fact that it increases the cost of default, a source from which the lender can at least partially offset losses associated with non-payment.

In the model, which has just two periods, either a single repayment equal to the full amount owed is made in period 2, or the farmer defaults. Default is strategic, in the sense that the borrower is able to make the payment but finds it in his self-interest not to.[22] In the event of a default, the lender repossesses the asset and retains that portion of the deposit, D, that is needed to cover collection costs and asset depreciation, the combination of which we call repossession costs, denoted C. Any remaining equity the farmer has is refunded. In this stylized context, as long as the deposit is smaller than the repossession costs, increasing it reduces the incentive to default. But when the deposit is large enough to cover the repossession costs, increasing it further imposes

[20] Our formal analysis models the effects of deposits, but guarantors can be expected to induce similar costs and benefits. If a guarantor is called upon to pay off a loan, the borrower may be subject to explicit or implicit costs, either in the form of direct reimbursement, or in terms of general social disapproval. Guarantees by a third party thus play a parallel role to deposits in our model.

[21] That is, farmers order a tank by making a deposit, then pay the balance. This "loan" is short term, but not for credit reasons as much as due to the time lag between ordering and delivery. Such a scenario rationalizes very early repayment by some borrowers who don't otherwise need the full 24-month credit.

[22] In practice in the setting we study, non-payment can be effected by side selling milk to a buyer other than the dairy cooperative. We find little evidence of such behavior however.

no additional cost on the farmer for defaulting, and so does not strengthen the incentive to repay. In the context of our study, the repossession fee charged to borrowers was capped by the SACCO at US $53, and the deposit amounts we tested were about $13 and $80 for the 4% and 25% deposit treatments, respectively.

Working backwards we first characterize how the default decision depends on the security deposit.

Proposition 1 (incentive effect): For a borrower with a given valuation, as long as the deposit is less than the repossession cost, increasing the deposit reduces the probability of default.

Anticipating these incentives to repay, an individual with valuation θ takes out a loan if the gain in expected utility from doing so is positive. Under regularity conditions, there is a cut-off valuation $\hat{\theta}(D)$ such that all individuals with valuations $\theta > \hat{\theta}(D)$ choose to take out a loan, while those with lower valuations do not.

Proposition 2 (selection effect): As long as the deposit is less than the repossession cost, increasing the deposit increases the cut-off valuation above which individuals take out a loan, thereby reducing loan take-up rates.

To summarize, deposits make default more costly, and thus reduce default incentives. And because higher valuation borrowers derive greater utility from retaining the asset and so are more likely to repay, a higher deposit improves the average quality of the applicant pool by reducing the expected surplus of marginal borrowers, but at the expense of inefficiently reducing credit access compared with the first best. Our empirical analysis allows us to assess the trade-off between the positive effects of deposits on repayment on the one hand, and the negative impacts on access to credit on the other.

We have motivated the need to borrow to finance the asset purchase by alluding to liquidity constraints, or the timing of the ordering, payment, and delivery processes. However, in characterizing the take-up decision, we have implicitly assumed that individuals are able to finance the required deposit. Of course, those same liquidity constraints would limit take-up when the required deposit is high, and it is conceivable that borrower valuation, and hence quality, would be correlated with the ability to finance the deposit. Our empirical results suggest however that a very high deposit essentially chokes of demand entirely, without selecting especially high valuation borrowers.

Similar selection and incentive effects can arise when financial guarantees by a third party are required, although there are clear nuances. As well as being a source of collateral funds, the ability of a farmer to find a guarantor could vary across potential borrowers, as might the social costs of calling on a guarantor to cover a debt. The precise patterns of selection and the strength of the incentives that guarantors might generate, would depend on information asymmetries between the borrower and guarantor and the value of the relationship they share.

In the remaining sections, we evaluate the magnitude of the effects of deposit and guarantor requirements on credit access and repayment behavior. We see very little outright default but do observe other indicators of incomplete compliance with repayment terms that allow testing for selection and moral hazard effects, which nonetheless turn out to be small. In contrast, the impact of deposits and guarantor requirements on take-up are very large, suggesting that heavy reliance on these screening and incentive tools is inefficient.

4. Project Design and Implementation

This section first discusses the features of the loan contracts that were common across treatments, and then highlights the differences across treatments that are used to estimate (i) the total impact of borrowing requirements on take-up and repayment, and (ii) the extent of moral hazard and adverse selection.

A. Common loan features

To be eligible to participate in the study, farmers had to have at least one dairy cow and to have sold milk to the Dairy at least once in the previous three months. All farmers in the study sample were offered a loan to purchase a 5,000-liter water tank. The tanks were purchased at a wholesale price that was approximately KSh 4,000 (about $53) below the prevailing retail price and included delivery to the farmer's home. The price offered was KSh 24,000 (about $320), or 20% of annual household consumption. Borrowers incurred installation costs for guttering systems and base construction that averaged about KSh 3,400, or 15% of the cost of the tank. All farmers received a hand-delivered loan offer and were given 45 days to accept it. Loans were for the full purchase price of KSh 24,000, but they all required an up-front security deposit of at least KSh 1,000.[23] Farmers had to have at least one cow, and to have sold milk to the dairy at some point over the previous 3 months. No other individual characteristics were considered in making loan offers.

The repayment and loan enforcement schedule for all loans was the same: a monthly principal payment of KSh 1,000, plus interest of 1% per month on the declining outstanding balance. Since the inflation rate was about 10% per annum, the real interest rate was low.[24] The 1% monthly interest rate was standard for SACCOs at the time but was below the prevailing commercial rate at the time. A 1% monthly penalty was charged on late balances, bringing the full interest rate on arrears within the range of the market rate, albeit at the low end. The amount due each month was automatically deducted from the payment owed to the farmer by the cooperative for milk sales. If milk sales fell short of the required payment, the farmer was required to pay the balance in cash. Debt service was 8.4% of average household expenditures and 11.4% of median expenditures at the beginning of the loan.

If a farmer fell behind on principal payments by two months (i.e. KSh 2,000), the SACCO sent a letter warning of pending default and provided 60 days to pay off the late amount and fees. The letter was hand-delivered to the farmer and followed up with monthly phone reminders. An important feature of the agreement was that the SACCO applied any available borrower or guarantor deposit to the balance if the payment was outstanding after the additional 60 days. As such, the deposit did not drain borrower liquidity compared to a situation where the deposit could not be applied. For loans that were less than 100% secured (described below), it was possible that a balance would remain due after the garnering of deposits. If so, the SACCO gave

[23] The security deposits were held in an escrow account with a Kenyan commercial bank (so the SACCO did not pay interest on these deposits) and earned interest just below the rate charged on the loan.
[24] Over the course of our study, both the macroeconomic environment and the price of water were stable.

the farmer an additional 15 days to clear it and waited to see if the next month's milk deliveries would be enough to cover the balance. If not, the SACCO would repossess the tank, charging a KSh 4,000 fee. This fee did not however cover the full costs of repossession, which were estimated at about KSh 5,880. The lender also balanced two opposing reputational effects of repossession – the negative publicity it might have generated in the context of the local community, and the credibility that would be built with regard to the threat to repossess on future delinquent loans. [25]

The SACCO was the residual claimant on all loan repayments and was responsible for administering the loan. To finance the loans of farmers, a research organization (Innovations for Poverty Action) purchased tanks from the tank manufacturer, which delivered them to farmers. Loan repayments were made to the research organization, with an agreed administrative fee withheld by the SACCO, structured so as to ensure it was the residual claimant.[26] To ensure that the cooperative repaid the research organization, the two parties signed an agreement with the milk processing plant that was the sole buyer of milk delivered to the dairy. The agreement authorized the processor to make loan repayments directly to the research organization out of the milk payments to the cooperative.

B. Experimental arms

As documented in Table 1, and illustrated in Figure 1, farmers were randomly assigned to one of four experimental groups, two of which were randomly divided into subgroups after take-up of the loans. The loans varied in the size of the security deposit and whether guarantors were required, and the extent to which the asset was pledged as collateral.

One group was offered loans with the standard 100% secured joint-liability conditions typically required by the SACCO (and by most other formal lenders in Kenya), under which the borrower had to put down KSh 8,000 (one-third of the loan value) as an up-front security deposit, and to

[25] The decision to repossess the tank, or to take other remedial actions in the face of payment arrears, belonged to the SACCO. The terms and process of repossession of the collateral as described in the text were governed by the loan contract signed between the farmer and the SACCO, and by the agreement the SACCO signed with the research team.
[26] Of the amount of principal and interest paid by the borrower (KSh 1,000/month in principal, plus interest), the SACCO was entitled to 100% of the amount actually paid up to the first KSh 50, 10% of the amount actually paid between KSh 50-950, and 100% of the amount actually paid above KSh 950. This structure provided the SACCO with adequate compensation for its contribution to the project and made it the residual claimant on loan repayments.

have up to three guarantors pledge the remaining two-thirds of the loan value, i.e. KSh 16,000, against default. This group will be denoted Group *C*.[27]

A second group was offered a similar loan but with a requirement to put down a 25% (KSh 6,000) deposit, and to collateralize the remaining 75% of the loan with the tank. This group is denoted Group *D* (for deposit). In a third group, the borrower had to put down 4% of the loan value (KSh 1,000) as a deposit and had to find a guarantor (whose identity was different to that of the borrower) to secure the remaining 21% (KSh 5,000) making the total cash security equal to 25% of the loan value. As in Group *D*, the remaining 75% of the loan was collateralized with the tank. This group is denoted Group *G* (for guarantor). In a final group, denoted Group *A* (for asset collateralization), 96% of the value of the loan was collateralized with the tank and only a 4% deposit was required.[28]

Across these four groups, the SACCO's level of protection, not counting repossession costs, was held constant, with the value of the loan recoverable from either the cash deposit, the guarantors, or the asset itself. What varied was the mix of these sources of protection.[29] Another parameter that did not change across treatment arms was the interest rate since the deposit was held by a third-party in an interest-bearing escrow account.[30]

To distinguish treatment and selection effects of deposit requirements, the set of farmers who took up the 25% deposit loans were randomly divided into two sub-groups, following Karlan and Zinman (2009). In one, all loan terms were maintained, while in the other, KSh 5,000 of the deposit was returned one month after it was made, leaving borrowers with a deposit of KSh 1,000, the same conditions facing borrowers in Group *A*. The subgroup whose deposit was maintained is denoted

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[27] Our study did not include a pure control group, in which farmers would have been precluded from taking a loan for a tank. But take-up was so low in this first group that it effectively serves as a control. Hence the "C."

[28] If guarantors and borrowers could write fully enforceable side contracts, we might not expect to see any difference in outcomes between Groups *D* and *G*, and indeed, take-up rates and repayment behavior are similar. However, differences could have arisen if such side-contracts were not enforceable, say due to limits on the effectiveness of social pressure, or simply due to the fact that guarantors themselves might have been liquidity constrained.

[29] We might have varied just the deposit, say, without making offsetting changes to other sources the lender could draw on to recover an unpaid loan, but that could have materially affected the lender's enforcement effort. In neither case would we be able to isolate the "pure" effect of asset collateralization. We believe our design allows us to measure policy-relevant differences across alternative credit products.

[30] The gross loan amount was held constant across groups, so if the deposit did *not* earn interest comparable to the borrowing rate, the effective interest rate on the net loan would increase.

D^M, and the subgroup whose deposit was waived is denoted D^W.

Similarly, within the guarantor group, in one randomly generated subgroup loan terms were maintained and in the other, guarantors had their pledged cash returned and were released from joint liability. Borrowers were informed of this change. These guarantor-maintained and guarantor-waived sub-groups are denoted G^M and G^W, respectively.[31] The selection effect corresponds to the difference between borrowers in the 4% deposit group and the 25% deposit group (waived) subgroup. The deposit treatment effect is the difference between the deposit (maintained) and deposit (waived) subgroups. Selection and treatment effects of the guarantor are identified analogously.

5. Data and Empirical Specifications

A. Sampling and Data

We use both survey and administrative data in our analysis. We administered detailed questionnaires at baseline and subsequently, both during face-to-face meetings at respondents' residences and in phone surveys. And we had access to comprehensive administrative data on loans and repayments from the SACCO, and on milk deliveries and sales from the dairy.

In mid-2009, we obtained a list of all 2,793 farmers who had sold milk to the dairy in the previous 3 months (most of whom were not members of the SACCO). From this sample frame, we drew an initial random sample of some 1,194 households, to whom we administered an in-person baseline survey between June and November 2009. We subsequently added a further 851 households to our sample who were surveyed between February and June 2010, for a total sample of 2,045.

[31] To avoid any suggestion that we were not fully informing participants, at the time of offers, potential borrowers were told that they would face a 50% chance of having KSh 5,000 of the deposit or guarantor requirement waived. In light of this necessary disclosure, the true selection effects of the 25% deposit and guarantor might be larger than those estimated in this paper, especially if the effects are mediated more through farmer concerns about having financial or social assets "at risk" than through strict liquidity constraints.

Randomization into experimental groups occurred after the baseline surveys were conducted. It took some time to draft and agree on the loan contracts that the SACCO would offer, so we resurveyed all 2,045 farmers and found that only 1,804 were still selling milk to the dairy. Since engagement with the dairy was a necessary condition for being offered a loan, only these 1,804 farmers were retained in the study and were randomized into the six experimental arms as described in Table 1. 419 farmers were assigned to Group *C* and offered 100% cash-secured joint-liability loans, 510 were assigned to Group *A* and offered 4% cash deposit and 96% asset collateralized loans; of the remainder, half each were assigned to Groups *D* and *G*.[32] Table 2 reports F-tests for baseline balance checks across all treatment groups. Of the 26 indicators, one shows significant differences across groups at the 5% level, and two at the 10% level, as expected from randomization.

Between March and September 2010, participating farmers were offered loans according to the randomized assignment, and in all, 460 offers were taken up. Subsequently, we conducted a number of follow-up surveys as described in the Appendix. From January to May 2011, we administered a survey in which we solicited information on agricultural production, including the production and sale of milk, consumption, child health, water sources, and time use by household member. This survey was intended to shed light on the impacts of the water tanks. Faced with a limited budget we included just two of the six treatment groups where the difference in loan take-up rates was highest: Group *C*, to which the full cash collateralized loans were offered, and in which there was very low take-up; and Group *A*, to which the asset collateralized loans were offered, and in which take-up was highest. The total sample size for these surveys was therefore 929 farmers.

In Appendix Table 1, we refer to this as a "full survey," in addition to which we collected by phone four rounds of a "production survey," including information on child and livestock health, production and sales of milk, and tank use, administered to Groups *C* and *A*. From September 2011 to May 2012, we administered three time-use surveys, in which we asked about activities of each household member in the preceding 24 hours, this time to participants in all six experimental

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[32] The groups with the least and most restrictive contracts were the largest as this maximized power to estimate real effects of the loans. Loans were offered in 3 waves since take-up rates were initially unknown, and the capital available was limited.

arms.[33] In late 2014, we administered a second detailed follow up survey with all the treatment groups. This survey was less extensive than the 2011/12 survey: it did not include consumption or crop modules, but we did solicit information on livestock, water sources, assets, credit, savings, and remittances. In each of the full surveys, we collected recall data on monthly milk production, sales and consumption for the 12 months prior to the survey. For the high-frequency follow-up production surveys, we collected monthly data going back to the most recent survey. This yields a large number of household by month observations for all production and sales survey data, and allows us to account for seasonal variations.

We had access to administrative data covering the full period of our study. Daily milk deliveries and monthly sales by farmer, as recorded by the dairy, were made available starting in July 2009 and through till the end of 2014 when the study ended. For the duration of the study, a member of the research team was stationed at the SACCO to ensure comprehensive loan data was collected. This included data on loan execution (i.e., tank delivery), monthly repayments, missed payments, issuance of pending default letters, reclamation of the borrower's security deposit, late balances, and repossession actions. These data were used to construct indicators of loan recovery, repossession, late payment collection actions, and early repayment.

Finally, in 2012 a second replication round of loan offers was made to some 2,616 farmers using proceeds from the loan repayments from the first round. We did not collect survey data from this sample but have administrative data on take-up and repayments that we use in a replication exercise, reported in section 6F.

B. Empirical Approach

Our empirical specifications typically take the form:

$$y_i = \alpha + \beta_A A_i + \beta_D^M D_i^M + \beta_D^W D_i^W + \beta_G^M G_i^M + \beta_G^W G_i^W + \varepsilon_i$$

[33] Specifically, 1,699 households were interviewed in September 2011: 1,710 in February 2012; and 1,660 in May 2012.

where y_i is the outcome of interest, A_i, D_i^M, D_i^W, G_i^M, and G_i^W are indicators for the loan group farmer i was randomized to. The comparison group in this specification is Group C.

The overall average impact of moving from a 4% deposit requirement to a 25% deposit or guarantor requirement on take-up or tank repossession or any other dependent variable are those given by the differences $\beta_{D/G}^M - \beta_A$ respectively. The *ex post* randomized removal of deposit and guarantor requirements in groups D^W and G^W allows estimation of the selection and treatment effects of deposits and guarantors. The selection effects of being assigned to either the 25% deposit or guarantor group, relative to the 4% deposit group, are identified by $\beta_{D/G}^W - \beta_A$, which reflects the extent to which greater deposit or guarantor requirements select borrowers who exhibit different repayment behavior than those who take up loans in the 4% deposit group, even when faced with identical loan requirements ex post. In terms of the model of section 3, such differences in repayment correspond to selection of farmers with different tank valuations.

The treatment effects of borrowing requirements are identified by comparing loan repayment outcomes of borrowers who had their loan requirements maintained with outcomes for those who had them waived *ex post*. Any treatment effect of the deposit or guarantor requirement would show up in a difference between $\beta_{D/G}^M$ and $\beta_{D/G}^W$.

6. Results

In sections 6A through 6E we discuss impacts on take-up, repayment and profitability of the loans and their real effects on farmer productivity using data from our primary experiment. In section 6F we replicate the findings with data from the replication round of loan offers that were made in 2012. We do not combine data from different rounds because there were differences between contracts offered in the primary experiment and the replication, and we have less data on loan outcomes for the replication.

A. Borrowing requirements and loan take-up

Our first finding is that allowing farmers to collateralize loans with the tank greatly increases their ability and/or willingness to take out a loan to purchase the asset (Table 1). In the sample, 2.4% of farmers borrowed under the standard SACCO contract with 100% secured joint-liability (Group *C*); 27.6% - more than ten times as many – borrowed when the deposit was 25% and the rest of the loan could be collateralized with the tank (Group *D*); 44.3% borrowed when 96% of the loan could be collateralized, with only a 4% deposit is required (Group *A*). This implies that more than 40% of all farmers would have liked to borrow at the prevailing interest rate but are not doing so because of borrowing requirements. Furthermore, 95% ((44.3 – 2.4)/44.3) of those who were willing to borrow at the prevailing interest rate were prevented from doing so by standard borrowing requirements.

Our second main finding is that a joint liability contract (in which 21% of the loan is secured by a guarantor and the borrower makes a 4% deposit) did not increase loan take-up relative to an individual liability contract in which a deposit of the same total value (25%) is required. Indeed, the point estimate of the difference is negative: 27.6% of farmers borrowed when they had to make a 25% deposit (Group *D*), while only 23.5% borrowed when they could ask a friend or relative to pledge 21% of the loan while being required to come up with a deposit of just 4% (Group *G*).

The high elasticity of loan take-up with respect to asset collateralization and the lack of response to joint liability points to a potential limitation of traditional joint liability based microfinance and suggests that reducing barriers to asset collateralization may play an important role in addressing barriers to borrowing. This may be because farmers were liquidity constrained, or because lower deposits allowed them to smooth consumption. Liquidity constraints can also help explain why it is difficult for individuals to get guarantors to cover the whole loan in group *C*. Ultimately, take up is the same in groups *D* and *G*, suggesting that a security deposit and a guarantor requirement impose broadly similar demands from a farmer's perspective, perhaps because of the existence of informal markets**.** Our lack of evidence of selection effects of either the deposit or the guarantor suggests that liquidity constraints at the level of either the farmer or his/her network, which clearly limit take-up, are not correlated with loan quality.

B. Borrowing requirements and selection

Under the model presented in Section 3, when the lender does not observe or condition loan offers on heterogeneous individual characteristics, strict borrowing requirements might potentially serve to screen out borrowers with low asset valuations, who are more likely to default. However, they may also screen out credit constrained farmers with high valuations who would repay their loans. In this context, a first test of the model is to verify that within each experimental arm, compared with those who did not accept a loan offer, borrowers exhibited characteristics that are plausibly consistent with higher tank valuations, compared with those who did not accept a loan offer.

In treatment groups *A*, *D*, and *G*, relative to those who did not accept loan offers, borrowers tended to have more assets, higher per capita expenditure, more milk-producing cows, and more years of education, all of which could exhibit complementarities with, and hence be associated with greater valuations of, the tank, as conceived in the model. On the other hand, they may also be correlated with not being credit constrained. There were few statistically significant differences between borrowers and non-borrowers in Group *C*, but we have little power to detect such differences due to the very small number of borrowers.

If take-up rates differ significantly across treatment arms (which they do), then not only should borrowers and non-borrowers within each arm exhibit different characteristics, but the average characteristics of borrowers *across* arms should also differ. In Appendix Table 2, we find some evidence that borrowers in Group A are not as well off, as they had lower mean assets and lower mean monthly milk production than those in both Groups *D* and *G*. Overall, we find only small differences in observable characteristics of borrowers across arms. In fact, of the 84 possible pairwise comparisons, we observe statistically significant differences at the 5% level in just four, essentially what one would expect under the null of no differential selection on observables across arms.[34]

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[34] The challenge of detecting statistically significant differences in average borrower characteristics across groups is in part due to the fact that, in the context of our model, the supports of the distributions of borrowers' valuations in the different groups overlap, that of borrowers in group *C* being a subset of that of borrowers in Groups *D* and *G*, which in turn would each be subsets of the support of the type

C. Borrowing requirements and loan repayment

There were no repossessions associated with lowering loan requirements from 100% cash collateralization to 25%. Across all 460 loans issued in the first round of the study, repossession of the collateral occurred only once, in Group *A*, representing a rate of just 0.7 percent amongst those farmers who borrowed with the 4% deposit.[35] This implies that 1.85% (1 in 54) of the marginal loans made under a 4% deposit requirement would lead to a repossession (based on the marginal loan take-up estimates from section 6A).[36] We found similar results in the replication study (see section 6F), suggesting that it is unlikely that the difference in repossession rates between the 4% deposit group and other groups was purely due to sampling variation.

Delinquency and late payments, both over the loan cycle and at its conclusion, could also have imposed costs on the lender. To investigate the impacts of loan requirements on these outcomes, Table 3 presents late payment results for 456 of those who took out loans in the first round.[37] The top panel presents OLS estimates of differences in repayment behavior of borrowers in Groups *A*, D^M, D^W, G^M and G^W.[38] The remaining coefficients measure impacts of assignment to the waived treatment groups, D^W and G^W. These coefficients in general measure differences in outcomes vis-à-vis borrowers in Group *C* and reflect a combination of a selection effect associated with a 25% deposit or guarantee and the incentive effect of 4% deposit. Comparing the coefficients on D^W and G^W with those on D^M and G^M respectively, or with Group *A*, allows us to isolate the selection and

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distribution of Group *A* borrowers. Differences in average characteristics between disjoint supports, for example in comparing borrowers and non-borrowers in a given experimental arm, would be easier to detect.

[35] The SACCO visited 4 defaulting borrowers to repossess their tanks, but 3 of the 4 cleared their remaining balances when visited by the loan officers. Nonetheless, we account for the administrative costs of visiting all 4 defaulting borrowers in our profit calculations below.

[36] To calculate the marginal repossession rate in the combined sample when moving from 25% loans to 4% loans, note that the average repossession rate is 0.7% for 4% deposit loans and 0 for 25% loans. The aggregate take-up rate for 4% deposit loans is 43.9% and the take-up rate for 25% deposit loans is 27.3%. Thus, the marginal borrowing rate is (43.9-27.3)/43.9 = 37.8% - i.e., 37.8% of those who borrow with a 4% deposit would not borrow with a 25% deposit.

[37] Data on the time of repayment are missing for four borrowers.

[38] The constant term corresponds to average outcomes in Group *C*, reflecting a combination of both the kinds of farmers who took out loans (the selection effect), and their incentives to repay conditional on borrowing (the treatment effect). It is difficult to interpret these selection and treatment effects directly, the comparison presumably being to a randomly selected group from the sample frame, *all* of whom were forced to take out loans with a zero, or perhaps 4%, deposit. Of course we do not have such a group in our study. The reported coefficients on indicators for Groups *A*, D^M, and G^M reflect differences in average outcomes of borrowers in these groups compared with those of the borrowers in Group *C*. Again, these coefficients measure the combined result of both selection and treatment effects.

treatment effects of the 25% security. The bottom panel presents *p*-values on these selection and treatment effects.

Columns 1 to 3 of Table 3 report the impacts of loan requirements on events related to late repayment during the 24 months of the loan cycle, including whether the borrower was ever late in making a payment, whether a pending default letter was received, and whether the security deposit (which differed in size across groups) was reclaimed. In columns 4 to 6, we report impacts on measures of late repayment at the end of the cycle.

First, compared to borrowers in Group *C*, column 1 shows that the borrowers in Groups *A*, D^M, and G^M were between 51 and 57 percentage points more likely to have ever been late in making a repayment than the borrowers in Group *C*. Similarly, while no borrowers in Group *C* received a pending default letter, those in Groups *A*, D^M, and G^M were between 18 and 33 percentage points more likely to have received one, and between 9 and 16 percent of them had their security deposit reclaimed, compared with none in Group *C*.

Comparing the coefficients of Group *A* (row 1) and each of the loans with maintained 25% financial security (groups D^M and G^M, rows 2 and 3) suggests there are some total effects of deposits and guarantors on late payment. During the loan cycle, there were no sizeable effects on ever being late (column 1) or having the security deposit reclaimed (column 3), but recipients of guarantor loans were 11 points less likely to receive a pending default letter than borrowers in Group *A* (column 2).

These combined effects of the different terms during the course of the loans do not translate into economically meaningful end-of-loan under-performance, however. Some farmers did pay off their loans later than contractually required – 12% in Group *A* and 6% in Group G^M, but the share who did so in Group D^M (2%) was statistically indistinguishable from the proportion of group *C* who did, which was zero. More importantly, the amount that was not paid on time – the late balance (column 5) – was economically irrelevant, being statistically insignificantly different from zero in Groups D^M, and G^M, and amounted to just KSh 222 (about US $3, or less than one percent of the loan value) in Group *A*. And while some loans were late, the average additional length of time it took to repay the loans (counting on-time and early repayments as zero) ranged from a few hours to a few days (0.02-0.13 months) in Groups *A*, D^M, and G^M.

Next, comparing loans with a 25% deposit or guarantor requirement (D^M and G^M) to those with a 4% deposit (Group *A*), the coefficients and standard errors in Table 3 indicate that those who took out loans with the larger deposit were more likely to repay on time, had lower late balances, and repaid earlier (columns 4 to 6). The effects were in the same direction, if smaller, for guarantor loans, but we cannot reject the hypotheses that there was no difference with regard to Group *A* loans.

However, near the end of the loan period, many farmers paid off their outstanding debt using their deposits. The payment of an upfront security deposit, which is held in a separate account and refunded once the loan is paid off, provides a potential explanation for this behavior. Borrowers with larger deposit requirements will *mechanically* be less likely to pay late toward the end of the loan cycle. Since the deposit can be used to fully cover remaining payments on the loan and the interest borrowers pay on the loan is slightly more than what they earn on the security deposit, borrowers are incentivized to apply the security deposit to pay down their loan as soon as this is possible.

Our evidence on selection and treatment effects (see below) is consistent with the hypothesis that any early repayment by those with 25% deposit is driven by this mechanical effect. Indeed, Table 4 supports this conclusion, as across all loan types, early repayment was common, and amongst those who repaid early, the time of repayment was highly correlated with the size of the deposit that was still available. For example, under the standard SACCO contract (Group *C*), 90 percent of farmers repaid early by, on average, 15 months. That said, our data do not allow us to definitively distinguish between such a mechanical effect of deposits and a "true" treatment or incentive effect, but it would be independent of any selection effect.

Another possible explanation for early repayment is the structure of our program, which provided not only the credit with which to purchase a water tank, but the ability to order and purchase it at a subsidized price, and have it delivered – all attractive features, even for buyers with sufficient savings and who didn't need or value the loans themselves. Other reasons for early repayment include dynamic incentive effects, if farmers perceive eligibility for future loans to be a function of early repayment, and debt aversion driven by reference dependent preferences (Carney et al., 2019).

Even if there is no combined effect of moving from 100% cash collateralization to a 25% deposit or guarantee, it is possible to disentangle selection and treatment effects of these loans, which could be offsetting, on late repayments.[39] We find some weak evidence of selection effects on whether a borrower was ever late in making a repayment (column 1). For example, 46% of those who had the 25% deposit reduced to 4% were ever late in making a repayment, compared with 57% of those in Group *A*. This 11-percentage point difference is barely statistically significant ($p = 0.10$). Similarly, the point estimate of the selection effect of guarantors on ever being late during the loan period was about 14 percentage points ($p = 0.07$). But among the dependent variables in Table 3, being ever late is the only one that appears to exhibit a selection effect. Deposits and guarantors might help select borrowers who are better at keeping on track with monthly repayments, but the effects are tenuous.

There is even less evidence of treatment effects on repayment behavior during the loan period. Having the guarantor released of the obligation increases the probability of receiving a pending default letter, but this is the only variable that exhibits a statistically significant effect, and it is only marginally so ($p = 0.10$). At the end of the loan period, we find no treatment effects of guarantors, and observe treatment effects of the higher deposit on whether (column 4) and by how long (column 6) repayment is late, but no effect on the late balance.

D. Profitability and sustainability

In the study, the 5,000-liter water tanks for which farmers were offered loans were sold at the wholesale price, with no retail mark-up. The SACCO was willing to take part in the study because the loans were financed by grant funds (not by its own capital so it faced no cost of capital), and

[39] Our model does not accommodate negative selection or treatment effects of deposits (and by analogy guarantors), which could offset positive treatment or selection effects respectively, but we do not impose this condition on the data.

it shared in the repayments. To create realistic collection incentives, repayments were structured so that the SACCO was the residual claimant at the margin, earning about $1.50 on each monthly installment, or about $36 per loan over the two-year period.

The sustainability of collateralized credit turns depends on whether the SACCO would have made a profit had they chosen to provide these loans under "normal" market conditions. To address this question, we estimate that under a range of reasonable assumptions on administrative costs, collateralized loans in which tanks are priced at the retail price or with a modest administrative fee would be profitable for the SACCO. We make the following assumptions, which simulate market conditions at the time our experiment ended: (i) a tank price equivalent to the prevailing retail price (KSh 28,000),[40] (ii) a loan interest rate of 1.2% per month (the standard SACCO rate by the end of our study), and (iii) a cost of capital equal to the interest the SACCO paid on deposits by the end of our study. In addition, we assume that the take up and repayment path of the loans is not affected by these changes in conditions. This last assumption is supported by both the repayment and default rates found in the replication of the original experiment, which we present in Section F below. Finally, we estimate that the administrative and marketing costs amount to $25 per loan and that defaulted loans incur an additional gross repossession costs of $78 (of which $53 are passed on to the borrower).

We find that under these conditions, the average profit per loan ranges from $32 to $37,depending on treatment arm.[41] The large treatment effects on demand that we document suggest that a SACCO that is not capital constrained and that anticipated similar default rates would choose to offer collateralized loans. It is natural then to ask why the SACCO had not offered collateralized loans of its own accord prior to the experiment. One explanation is that the SACCO was concerned that relaxing borrowing conditions might lead to a substantial number of defaults and tank repossessions and hence substantial losses. Instead we found only one repossession when tanks were used to collateralize 96% of the loan, and no repossessions when tanks were used to collateralize 75% of the loan. While the higher level of late payments with asset-collateralized loans might generate some additional administrative costs for the SACCO, these costs were not

[40] Note that the SACCO did sell small tanks (500 liter or less) through their agrovet service on credit to farmers. These tanks were sold to farmers at the retail price.
[41] Detailed calculations are available upon request.

large and could easily be offset by an administrative fee or retail mark-up, as described above. In support of this hypothesis, after the experiment the SACCO began using its own funds to offer asset-collateralized loans for 5,000-liter water tanks with a small administrative charge of KSh 700, a 20% deposit requirement and marking the tanks up to their retail price. The SACCO also began to offer a suite of other products via asset-collateralized loans, and other lenders have begun offering similar credit products.

Another explanation is that before our experiment the SACCO was subject to very tight credit constraints, raising limited resources from its members and client farmers and lacking meaningful access to external sources of finance. Kenyan regulatory requirements imposed caps on the interest rates that could be charged, implying that there was very limited scope to use the gap between borrowing and lending costs to cover even the very modest extra administrative costs of collateralization using water tanks (e.g. – repossession costs, costs of following up with borrowers on late payments). Further, SACCO deposits increased significantly after the experiment due to a large expansion in membership, and a subsequent transition to making milk payments to farmers via direct deposit into their SACCO accounts.

While it is too early to fully assess the external validity and potential adoption of this approach elsewhere, it is worth noting that a pilot program similar to our study was subsequently implemented by the J-PAL Africa policy team in Rwanda. In the first phase of that program, 43 out of about 160 farmers took up the loan, with only one default. Thirteen other SACCOs have chosen to implement similar programs without subsidies. And sources of external finance for cooperatives are growing, potentially relaxing the credit constraints under which they operate.[42]

E. Real effects of improved access to credit

[42] A local Kenyan bank also entered the market, making asset collateralized loans for water tank purchases, although the program was discontinued when the government imposed extremely stringent interest rate caps on bank loans in September 2016 (while exempting SACCOs) to far below market rates (see Bharadwaj and Suri, 2020). Although it has not made capital available for asset-collateralized loans to dairy farmers, since 2009, Root Capital has provided more than $1.5 billion in loans to over 735 cooperatives at levels of between $200,000 and $2 million each, loans they consider far too large for microfinance organizations, but too small and too risky for commercial banks. For context, our loan to the SACCO was about $150,000.

Our results above indicate that collateralizing loans with real assets rather than cash had extremely large impacts on farmers' access to finance. In this section, we report the real effects of the expansion of credit, on investment and productivity, milk sales, and children's time use and schooling, using both our survey data as well as administrative data from the dairy.

In our intent-to-treat estimates, we use Group *C*, in which there was very low take-up of loans, as the control, to which we compare outcomes in Group A, employing a difference-in-differences framework to boost power, although with just over 900 households in the two groups, detection of productivity effects remains a challenge. The first three columns of Table 5 include ITT estimates of the first stage impacts of assignment to Group A on tank ownership and water storage capacity.[43] All specifications include survey round fixed effects. Assignment to Group *A* increased the likelihood of owning any kind of water storage tank by almost 24 percentage points (column 1), an increase of about 46% (note that about 45% of all households had a tank at baseline). Ownership of large 5,000-liter tanks increased by 30 percentage points (column 2), more than doubling the prevailing rate, and household water storage capacity increased by 59 percentage points (column 3). All effects are significant at the 1 percent level.

These effects reflect capital expansion on both the extensive and intensive margins. For example, since the difference in loan take-up between Group *C* and Group *A* is roughly 42 percentage points, we estimate that approximately 56 percent (0.235/0.42) of borrowers in Group A who would not have had access to credit otherwise were able to buy their first water storage tank, while the other farmers who were induced to borrow by the treatment likely added to an existing stock of water storage capacity, although we cannot rule out that some of the farmers would have bought a tank without the loan. This implies that about two-thirds (0.297/0.42) of the additional loans were used by recipients to acquire their first large tank, while one-third of them were taken out by farmers who either already had at least one large tank or would have bought one even if they had not received a loan.

In the remaining columns of Table 5, we report significant effects on cow health (column 4), perhaps mediated through a reduction in the need to travel to far-away ponds or streams.

[43] Note that the number of observations varies across specifications due largely to differences in information collected in different survey rounds, as explained in the data section above, the table notes and as illustrated in Appendix Table 1.

We find no significant effects on self-reported milk production (columns 5 through 7, which employ levels, log, and inverse hyperbolic sine, specifications), although we cannot rule out increases in milk production that would have made a tank a good investment, particularly in light of the consumption value to households of a convenient source of clean water much less subject to microbial contamination, as discussed further below. Self-reported impacts on milk sales, which make up just over 70% of production, show larger effects (columns 8 through 10).

The self-reported impacts on milk sales are confirmed by monthly administrative data routinely collected by the dairy. In Table 6, using data on over 1,800 households, we compare outcomes for those in Group *C* to those in an aggregated treatment group comprised of groups *A*, *D* and *G*, using an ITT difference-in-differences approach. First, there is evidence that farmers offered favorable credit terms were more likely to sell milk to the dairy by almost 5 percentage points (Column 1). While the volume of milk sales does not appear to be affected when we use the full sample (Column 2), trimming 1%, 5% and 10% of outliers yields robust positive impacts (Columns 3, 4 and 5) corresponding to between a 6% and 10% increase in milk sales to the dairy cooperative. Applying a non-linear transformation to sales volumes (a log transform in Column 6 and the inverse hyperbolic sine in Column 7) yields even larger estimated effects on milk sales of about 25-29%. Note that the effects on sales in the administrative data are larger (and more precise) than those in the survey data. For the inverse hyperbolic sine transform specification, the effect on sales in the survey data is not statistically different from that in the administrative data. We do have more power in the administrative data, which includes all treatment groups and covers approximately an additional year of sales. In addition, the survey data is likely to be noisier than the administrative data.

Just to give a sense of magnitudes, the sales effects in Table 6 range from 15% to 67%, implying increases in revenues of between KSh 670 and 2,970 a month[44] (the latter is about 30% of average monthly household consumption in our sample). We would expect these gains in revenue to last over the fifteen-year lifespan of the asset (the tanks are extremely durable and come with at least a 10-year warranty).

[44] We use median milk price in our data to value the production and sales, which was KSh 25 per liter.

In addition to the returns generated by increases in production and sales, the tanks provide real additional benefits, such as clean water for domestic consumption and even impacts on girls' education as discussed below. There is also considerable revealed-preference evidence that farmers found this a good investment since they took up the loans not once, but over two rounds of the experiment (discussed below), and the SACCO has subsequently continued to offer these loans and farmers have continued to buy tanks after the study period.

The apparent inconsistency between effects on (administrative) milk sales and (self-reported) production could potentially derive either from differences in power, from greater measurement error in the survey data, or from farmers increasing the proportion of milk production sold to the dairy (as opposed to being consumed or sold locally) as a convenient way to pay off their loans. However, the difference in milk sales to the dairy continues to be significant at approximately the 10% level in multiple specifications post-loan maturation, suggesting the observed sales increases are not driven by loan repayment.[45]

Table 7 reports difference-in-differences impacts on school-aged children, including school enrollment (columns 1 and 2) and certain time use measures (columns 3-10). The data includes information collected at baseline and during two follow-up surveys, and while we include dummies for each follow-up separately (not reported in the table), the interaction term reflects the average effect across both follow-up rounds (that is, the variable *Post* is equal to one for observations made in either the first or second follow-up). For girls, household access to an asset collateralized loan appears to solve a last mile problem: while enrollment of girls in the treatment group at baseline was close to universal, by endline it had essentially reached 100%.[46] The same cannot be said for boys in treatment group households however, whose enrollment appears not to have been materially affected.

These changes could have been brought about simply by the income effects if households expected a

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[45] Adding an interaction term between treatment and post loan maturation to the specification reported in Table 6, we find that the treatment effects on milk sales after repayment ended (Treat*Post + Treat*Post Maturation) are 20.8 liters (p = 0.104) and 10.4 liters (p = 0.097) in untrimmed and 5%-trimmed specifications, respectively. Results are available upon request.

[46] The impact on girls' schooling is only significant in the difference in differences specification, but not in the levels specification. We acknowledge that, as we test for effects on a variety of outcomes, the girls' enrollment effect should be interpreted with caution. That said, any adjustment for multiple hypothesis testing would be conducted for a family of outcomes, which in this case would naturally include just two - boys' and girls' education levels separately.

positive long-run increase in wealth due to the consumption and production value of the tanks. Alternatively, they could have been driven by changes in intra-household time allocation, for example if girls had been relieved of the burden of collecting water as a result of the acquisition of the tank. Having stratified our randomization by access to piped water, due in part to the hypothesis that the effects might differ accordingly, Columns 3-10 present difference-in-differences estimates of the effects of treatment on the amount of time (measured in minutes per day) that girls and boys, by stratum, spend in two activities: collecting water (primarily for household use) and tending to livestock (including walking them to water sources). We observe no statistically detectable affects, and in any case the point estimates are all small enough that it is highly unlikely that a better powered test would provide evidence that a reallocation of time within households freed up enough time to permit enrollment in school.[47,48]

F. Replication of main results

In accordance with our agreement with the dairy, in 2012 a second round of loans were made to a new group of 2,616 farmers previously not sampled. Three types of loans were offered – the same as were originally offered to members of Groups *A*, *D*, and *G* in the main part of the experiment – and no ex post adjustments were made. No loans corresponding to Group *C* were offered. In this second round, the loans were for a larger amount (KSh 26,000 instead of 24,000) as the manufacturer's tank purchase price had increased, and the interest rate charged was higher, 1.2 instead of 1.0 percent per month.

Using administrative data from the SACCO, Table 8 compares take-up rates (columns 1-3) and repayment behavior (columns 4-8) in the two rounds.[49] Take-up was very similar to the first

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[47] In households without piped water, there appears to be a (small) statistically significant difference in the effect of credit on the time boys and girls spend tending livestock. However, we argue that such a gender *difference* should not be expected to drive girls to enroll in school; the *reduction* in the time girls tend to livestock is more relevant, and that is statistically insignificant.

[48] We conducted an alternative analysis (results available upon request) of intra-household time use reallocation, distinguishing not between boys and girls, but between the individual self-identified at baseline as having primary responsibility for either fetching water or tending livestock, and others. Again, we find little evidence of effects, except for the time spent tending livestock in households without access to piped water – the 31 minute per day estimated reduction is in line with the estimated difference between boys and girls of 22 minutes per day reported in Table 7, for the same task in the same group of households.

[49] Additional repayment analysis is reported in Appendix Table 3.

round. Those to whom the 25% deposit loan was offered were about 5 percentage points less likely to accept it in round 2 than in round 1, significant at the 5% level. A roughly similar reduction (5.1 percentage points) is estimated in Group *A*, but is not significant, while there was a negligible increase in take-up in Group *G*. These patterns in take-up rates reflect a small price/interest rate elasticity, in the context of otherwise consistent demand across both rounds. Repossessions in the replication were similar to those in the initial experiment, with no repossessions for loans with a 25% deposit or guarantor loans, and a repossession rate of 1.0% (2/205) for loans with a 4% deposit, compared with 0.4% (1/224) in the first round, a statistically insignificant difference.[50]

Other differences in repayment behavior between rounds (aggregated across all three loan types) were statistically significant but economically unimportant. For example, while the share of loans that were repaid late rose from 10% to 16.5%, the average late balance was actually smaller, and the average delay in payment was 0.196 months, i.e., less than a week. On the other hand, more loans were paid off early in the second round (61% compared with 37%), and they were paid off earlier - 4.1 months early on average in round 2 compared with 2.9 months early in round 1. Again, the magnitudes of these differences were such as to impose no meaningful costs on the SACCO. These results represent an important inter-temporal replication of our initial findings, especially in light of the removal of the price subsidy and the increased price and interest rate.

7. Conclusion

In high-income countries, individuals can often borrow to purchase assets with a relatively modest deposit, collateralizing the remainder of the loan with the asset itself. In contrast, formal-sector lenders in low-income countries typically impose stringent borrowing requirements. Among a population of Kenyan dairy farmers, we find credit access is greatly constrained by such strict borrowing requirements. Forty-four percent of farmers borrowed to purchase a water tank when they could take out a loan that was virtually fully collateralized with the asset. In contrast, a very small fraction (2%) borrowed under the lender's standard contract, which required loans

[50] Similar to the first round, in round 2 the SACCO attempted 3 repossessions total in this phase, but one borrower cleared their remaining balance when visited by the loan officers.

to be 100% collateralized with pre-existing financial assets of the borrower and guarantors. Repossession rates for asset-collateralized loans were very low. There were no repossessions for loans with a 25% deposit and 75% asset collateralization, so it seems unlikely that instituting these loans would have a meaningful negative impact on financial sustainability of the lender. In addition, we find no evidence that substituting financial collateral of guarantors for the deposits of individual borrowers expands credit access, casting doubt on the extent to which joint liability can serve as a substitute for the type of asset-collateralization common in developed countries.

In the two years following the main experiment, a second round of offers of fully or partially asset-collateralized loans were made (using proceeds from repayments on the first loans) to a new sample of 2,616 farmers who sold milk to the dairy.[51] Take-up and default rates in this replication phase tracked those in the main study closely: for the fully asset-collateralized loan, take-up was 39%, and there were just two defaults; and for the partially asset-collateralized option take-up was 22-25%, and there were no defaults.

Thus, across both the main experiment and the later replication, repossessions only emerged once asset-collateralization reached 96%, with just a 4% deposit, and even then, only around 1% of such loans led to a repossession. Despite potential concerns about contract enforcement, repossession proved possible, and asset sales fully covered principal and interest due on loans.

Since the study the SACCO has begun to issue asset-collateralized loans using its own capital for the purchase of water tanks, reducing the required deposit to 20% of the loan, marking up the tanks to the retail price and adding an administrative fee of KSh 700. It has also expanded the program to finance other durable assets including chaff cutters, biogas systems, cook stoves, gas cookers, and solar panels. These developments, along with the replication results, suggest that our initial results have some temporal, if not necessarily spatial, external validity.[52] To the extent our results generalize, regulatory barriers to collateralized loans for the purchase of durable and

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[51] No offers of the previously standard SACCO loan (Group C loans) were made in this follow-up.

[52] These results work against the contention by Rosenzweig and Udry (2016) that due to weather, market, and other time-varying factors, experimental results at one point might not translate to other time periods. Moreover, the Nyala SACCO's so-far successful introduction of asset-collateralized loans for assets other than rainwater harvesting tanks also suggests external validity of this loan structure beyond the particular asset serving as collateral, despite the previously-noted observation that rainwater harvesting tanks may be particularly well-suited for collateral as they are durable (and thus retain their value) and bulky (and thus are hard to conceal).

traceable assets should be removed.

The loan contracts we studied could likely be improved if coupled with state-contingent insurance, in line with the model we develop. However, demand for insurance, especially amongst poor farmers, is often very low (Cole, et al., 2013). Casaburi and Willis (2018) present evidence that take-up of insurance can be expanded considerably if up-front premiums are replaced with state-contingent transfers. In our context, a potential benefit of asset collateralization is that it can make credible a farmer's commitment to make transfers to the insurer in good states of the world.

An additional area for study may be experimenting with contract structures that allow borrowers to save toward the required security deposit, which may make it more affordable to some borrowers (e.g. those that were willing to take up loans offered at 96% collateralization but too credit constrained to do so for loans that were 75% collateralized). Thirdly, while our results suggest that asset-collateralization can meaningfully increase credit access for the purchase of durable, repossessable assets like water tanks, more research is needed to determine whether loans collateralized with *existing* repossessable assets are an effective tool for financing non-collateralizable assets like human capital and working capital.[53] More generally, our results suggest there is value to exploring whether alternative financial contracts, beyond those normally used by microfinance institutions, may offer the potential to expand credit access in ways that spur investment.

Data Availability Statement

The data and the code underlying this research are available on Zenodo at https://doi.org/10.5281/zenodo.7594227.

[53] Carney et al. (2019) find that in a lab-in-the-field context, demand for loans that require existing assets as collateral is much lower than for loans collateralized by the asset purchased using the loan.

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8. Appendix

This appendix first provides details of the model referred to in section 3, and then presents further information related to our data collection.

A. The Model

Set-up

Individuals have heterogeneous valuations of an asset, the water tank in our empirical setting, and face uncertain future incomes. Individual preferences are defined over money and the asset, and take a simple quasi-linear form. Utility of net *ex post* income m is $u(m)$, increasing and concave, and satisfying the Inada conditions. Total utility when the individual owns the asset is $u(m) + \theta$, where $\theta \in [\underline{\theta}, \bar{\theta}]$ is the idiosyncratic tank valuation, which is private information.

Let the cost of the asset be K, constant across potential buyers. Realized *ex post* incomes y are i.i.d. and are drawn from a distribution $f(y)$ with support $[\underline{Y}, \bar{Y}]$, with $\underline{Y} > K$, and independent of θ. We assume $u(\underline{Y}) - u(\underline{Y} - K) > \bar{\theta}$. This ensures even high valuation farmers would prefer to default for a sufficiently small income realization if default is costless.

To purchase a tank, an individual must take out a loan, either due to liquidity constraints or simply as part of the contractual agreement with the supplier.[54] However, to focus on the incentive effects of deposits, we assume all potential borrowers can finance the deposit if they choose to take out a loan. The loan is characterized by a security deposit, $D < K$, which is used to cover any costs incurred by the lender (see below) in the event of default. The deposit is held by the lender, but the borrower nonetheless takes out a loan for the full cost of the asset, K. For simplicity, the interest rate is zero.

In the event that the borrower defaults, the lender repossesses the tank, which has a resale value of βK, where $\beta < 1$, and incurs a transaction cost P. We assume $P < \beta K$, since otherwise the

[54] That is, farmers order a tank by making a deposit, then pay the balance. This "loan" is short term, but not for credit reasons as much as due to the time lag between ordering and delivery. Such a scenario rationalizes very early repayment by some borrowers who don't otherwise need the full 24-month credit.

lender will have no incentive to repossess the asset. Default thus imposes a cost $C = P + (1 - \beta)K$ on the lender. If the deposit is greater than this cost, the cost is deducted from the deposit and the borrower receives a refund of the balance, $(D - C)$. If the deposit is less than the cost, the full deposit is retained by the lender.

We treat all households as having no initial assets, so, if repayment could be costlessly enforced and default is not an option, net *ex post* income is either (i) $m = y$, in the event that no loan is taken, and the asset is not purchased, (ii) $m = y - K$, when a loan is taken and fully repaid, or (iii) $m = y - D$, if a loan is taken but not repaid and $D < C$, or $m = y - C$, if a loan is taken but not repaid and $D > C$.

Total *ex post* utility in each of these three scenarios is, respectively,

(i) $u(y)$;

(ii) $v^1(y,\theta) \equiv u(y - K) + \theta$; and

(iii) $v^0(y,D) \equiv \begin{cases} u(y - D) & \text{if } D < C \\ u(y - C) & \text{if } D > C \end{cases}$

Working backwards, we first characterize the default decision and how it depends on the security deposit. Then, in light of this anticipated default behavior, we characterize the take-up decision, and its dependence on the deposit.

Default decision

An individual who has taken out a loan with deposit D to purchase the asset defaults if and only if *ex post* utility is greater by doing so, that is, if and only if $v^1(y,\theta) < v^0(y,D)$, or

$$\theta < \tilde{\theta}(y,D) = \begin{cases} u(y - D) - u(y - K) & \text{if } D < C \\ u(y - C) - u(y - K) & \text{if } D > C \end{cases}$$

where we have suppressed the dependence of $\tilde{\theta}(.)$ on the repossession cost. As long as the deposit is less than the cost of the asset, and because of our assumption that it is always optimal to repossess in the event of a default, $\tilde{\theta}(y, D)$ is guaranteed to be positive.

Default does not occur because repayment is not feasible, or because an individual "cannot afford to pay," but simply because realized utility is higher. Indeed, under our assumptions on the concavity of preferences and the support of the income and preference parameter distributions, repayment is *always* possible, but in certain states of nature it is not utility maximizing. This is the sense in which there is *ex post* moral hazard, which arises from the fact that repayment cannot be directly enforced.

Note that $\tilde{\theta}(y, D)$ is decreasing in y as: $\tilde{\theta}_y(y, D) = u'(y - D) - u'(y - K) < 0$ for deposits less than the repossession cost C, and $\tilde{\theta}_y(y, D) = u'(y - C) - u'(y - K) < 0$ for $D > C$. Similarly, $\tilde{\theta}(y, D)$ is decreasing or constant in D as $\tilde{\theta}_D(y, D) = -u'(y - D) < 0$ for $D < C$. (For $D > C$, $\tilde{\theta}_D(y, D) = 0$.) Thus, for a given *ex post* realization of income, y, a larger deposit weakly reduces the value of θ below which individuals default.

Similarly, let $\tilde{y}(\theta, D)$ solve

$$\begin{cases} u(y - D) - u(y - K) = \theta & \text{for } D < C \\ u(y - C) - u(y - K) = \theta & \text{for } D > C \end{cases}$$

Then an individual of type θ defaults if and only if income is low enough, $y < \tilde{y}(\theta, D)$.

Individuals with higher asset valuations default less often, since

$$\tilde{y}_\theta(\theta, D) = \begin{cases} \dfrac{1}{[u'(y - D) - u'(y - K)]} < 0 & \text{for } D < C \\ \dfrac{1}{[u'(y - C) - u'(y - K)]} < 0 & \text{for } D > C \end{cases}$$

Proposition 1: For a borrower with a given valuation, as long as the deposit is less than the repossession cost, increasing the deposit reduces the probability of default.

Proof: Totally differentiating the condition for $\tilde{y}(\theta, D)$,

$$\tilde{y}_D(\theta, D) = \begin{cases} \dfrac{u'(y-D)}{[u'(y-D) - u'(y-K)]} < 0 & \text{for } D < C \\ 0 & \text{for } D > C \end{cases}$$

so for $D < C$, a higher deposit reduces the value of realized income below which an individual of type θ defaults. As the *ex post* distribution of income is independent of the deposit, the density of income realizations that lead to default falls, thus reducing the *ex ante* probability that the borrower will default on the loan. This is the incentive effect of the security deposit. When the deposit exceeds the repossession cost, increasing it further has no additional incentive effect.

Loan take-up decision

An individual who does not take out a loan cannot purchase the asset, and earns expected utility of $u_0 \equiv \int_{\underline{Y}}^{\bar{Y}} u(y) f(y) dy$.

On the other hand, an individual of type θ who purchases a tank with a loan with deposit D pays off the loan and keeps the asset as long as $y > \tilde{y}(\theta, D)$, and defaults if $y < \tilde{y}(\theta, D)$. *Ex ante* expected utility in the presence of a loan, denoted $v(D, \theta)$, is thus

$$v(D,\theta) = \int_{\underline{Y}}^{\tilde{y}(\theta,D)} v^0(y,D) f(y) dy + \int_{\tilde{y}(\theta,D)}^{\bar{Y}} v^1(y,\theta) f(y) dy$$

$$= \begin{cases} \displaystyle\int_{\underline{Y}}^{\tilde{y}(\theta,D)} u(y-D) f(y) dy + \int_{\tilde{y}(\theta,D)}^{\bar{Y}} [u(y-K)+\theta] f(y) dy & \text{for } D < C \\ \displaystyle\int_{\underline{Y}}^{\tilde{y}(\theta,D)} u(y-C) f(y) dy + \int_{\tilde{y}(\theta,D)}^{\bar{Y}} [u(y-K)+\theta] f(y) dy & \text{for } D > C \end{cases}$$

which is increasing in θ, since for $D < C$

$$v_\theta(D,\theta) = u(\tilde{y}-D) f(\tilde{y}) \tilde{y}_\theta - \left([u(\tilde{y}-K)+\theta] f(\tilde{y}) \tilde{y}_\theta + \int_{\tilde{y}(\theta,D)}^{\bar{Y}} f(y) dy \right)$$

$$= \int_{\tilde{y}(\theta,D)}^{\bar{Y}} f(y) dy + (u(\tilde{y}-D) - [u(\tilde{y}-K)+\theta]) f(\tilde{y}) \tilde{y}_\theta = \int_{\tilde{y}(\theta,D)}^{\bar{Y}} f(y) dy > 0$$

and for $D > C$

$$v_\theta(D,\theta) = u(\tilde{y} - C)f(\tilde{y})\tilde{y}_\theta - \left([u(\tilde{y} - K) + \theta]f(\tilde{y})\tilde{y}_\theta + \int_{\tilde{y}(\theta,D)}^{\bar{Y}} f(y)dy\right)$$

$$= \int_{\tilde{y}(\theta,D)}^{\bar{Y}} f(y)dy + (u(\tilde{y} - C) - [u(\tilde{y} - K) + \theta])f(\tilde{y})\tilde{y}_\theta = \int_{\tilde{y}(\theta,D)}^{\bar{Y}} f(y)dy > 0$$

An individual of type θ takes out a loan if and only if

$$v(D,\theta) > u_0$$

Our assumptions guarantee that for each D there exists a valuation $\hat{\theta}(D)$ that equates expected utility from a loan with u_0:

$$v\big(D,\hat{\theta}(D)\big) = u_0$$

Then all individuals with valuation greater than $\hat{\theta}(D)$ take out a loan and purchase the asset.

Finally, for given valuation θ, when $D < C$, *ex ante* expected utility $v(D,\theta)$ is decreasing in D:

$$v_D(D,\theta) = (u(\tilde{y} - D) - [u(\tilde{y} - K) + \theta])f(\tilde{y})\tilde{y}_\theta - \int_{\underline{Y}}^{\tilde{y}(\theta,D)} u'(y - D)\, f(y)dy$$

$$= -\int_0^{\tilde{y}(\theta,D)} u'(y - D)\, f(y)dy < 0$$

However, for larger deposits, when $D > C$, further increases in D do not affect expected utility:

$$v_D(D,\theta) = 0$$

Thus we have:

Proposition 2: As long as the deposit is less than the repossession cost, increasing the deposit increases the cut-off valuation above which individuals take out a loan, thereby reducing loan take-up rates.

Proof: Totally differentiating the expression for $\hat{\theta}(D)$ yields

$$\hat{\theta}'(D) = \begin{cases} -\dfrac{v_D(D,\theta)}{v_\theta(D,\theta)} > 0 & \text{or } D < C \\ 0 & \text{or } D > C \end{cases}$$

This is the selection effect of the security deposit: at low to moderate levels, a higher deposit pushes marginal valuation farmers out of the credit market, increasing the quality of the borrowing farmers, in terms of their expected repayments. But increasing the deposit above the repossession cost induces no additional selection effect.

The first-best

It is instructive to characterize the first best allocation of resources in this highly simplified economy. If repayment could be costlessly enforced, and default is not an option, expected utility from taking a loan would be

$$\theta + \int_{\underline{Y}}^{\bar{Y}} u(y-K)f(y)dy = \theta + u_1$$

where $u_1 \equiv \int_{\underline{Y}}^{\bar{Y}} u(y-K)f(y)dy$, and an individual with valuation θ would take a loan as long as $\theta > u_1 - u_0$. This is *ex ante* efficient, but could result in large and inefficient variability in *ex post* marginal utility of net incomes.

A first-best insurance contract that fully smoothed *ex post* income realizations equal to $\bar{y}$ would deliver *ex post* efficiency while simultaneously resolving the moral hazard problem, as default would be zero amongst those who take out a loan, and take-up itself would be Pareto optimal. To see this, suppose an individual of type θ has taken out a loan with security deposit D. He repays as long as utility with a fully paid tank is greater than utility without the tank, and without the deposit, that is, as long as $v^1(\bar{y},\theta) > v^0(\bar{y},D)$. If $\theta < \tilde{\theta}(\bar{y},D)$ the borrower defaults for sure, and if $\theta > \tilde{\theta}(\bar{y},D)$ he always repays.

When making the loan take-up decision, an individual of type θ compares his anticipated utility with what he receives with full insurance but no loan or tank, $u(\bar{y})$. For $\theta > \tilde{\theta}(\bar{y},D)$, anticipated utility is $u(\bar{y}-K)+\theta$, so he takes a loan as long as $\theta > u(\bar{y}) - u(\bar{y}-K) = \tilde{\theta}(\bar{y},0)$. But since $\tilde{\theta}_D(y,D) < 0$, any individual for whom $\theta > \tilde{\theta}(\bar{y},D)$ who takes a loan will repay. Alternatively, for an individual with $\theta < \tilde{\theta}(\bar{y},D)$, anticipated utility is $u(\bar{y}-D)$, so he will not take a loan, since $u(\bar{y}-D) < u(\bar{y})$.

Thus, with full income insurance, for any positive deposit, any individual for whom $\theta > u(\bar{y}) - u(\bar{y}-K)$ takes out a tank loan and repays it, while those for whom $\theta < u(\bar{y}) - u(\bar{y}-K)$ do not take a loan and do not acquire a tank. This allocation is Pareto efficient.[55]

B. Data appendix

Appendix Table 1 below presents a detailed catalogue of the surveys we administered over a 5-year period.

The second Appendix Table 2 presents borrower characteristics by experimental arm in the first round of offers.

Appendix Table 3 reports additional results on late and early repayment by loan type in the replication exercise.

[55] Our model assumes individuals' preferences are independent of asset holdings, and exhibit no reference dependence. In recent work however, Carney et al. (2019) suggest that farmers could be more willing to use newly acquired debt-financed assets as collateral than to pledge assets that they already possess against new loans. Such behavior would further rationalize the increases in take-up we observe of loans collateralized by the purchased asset (as in Groups A, D, and G), compared with loans collateralized by existing savings (as in Group C). In this paper however, we focus on the impact of up-front contractual conditions (the deposit and guarantor requirements) on take-up.

Figure 1: Experimental Design

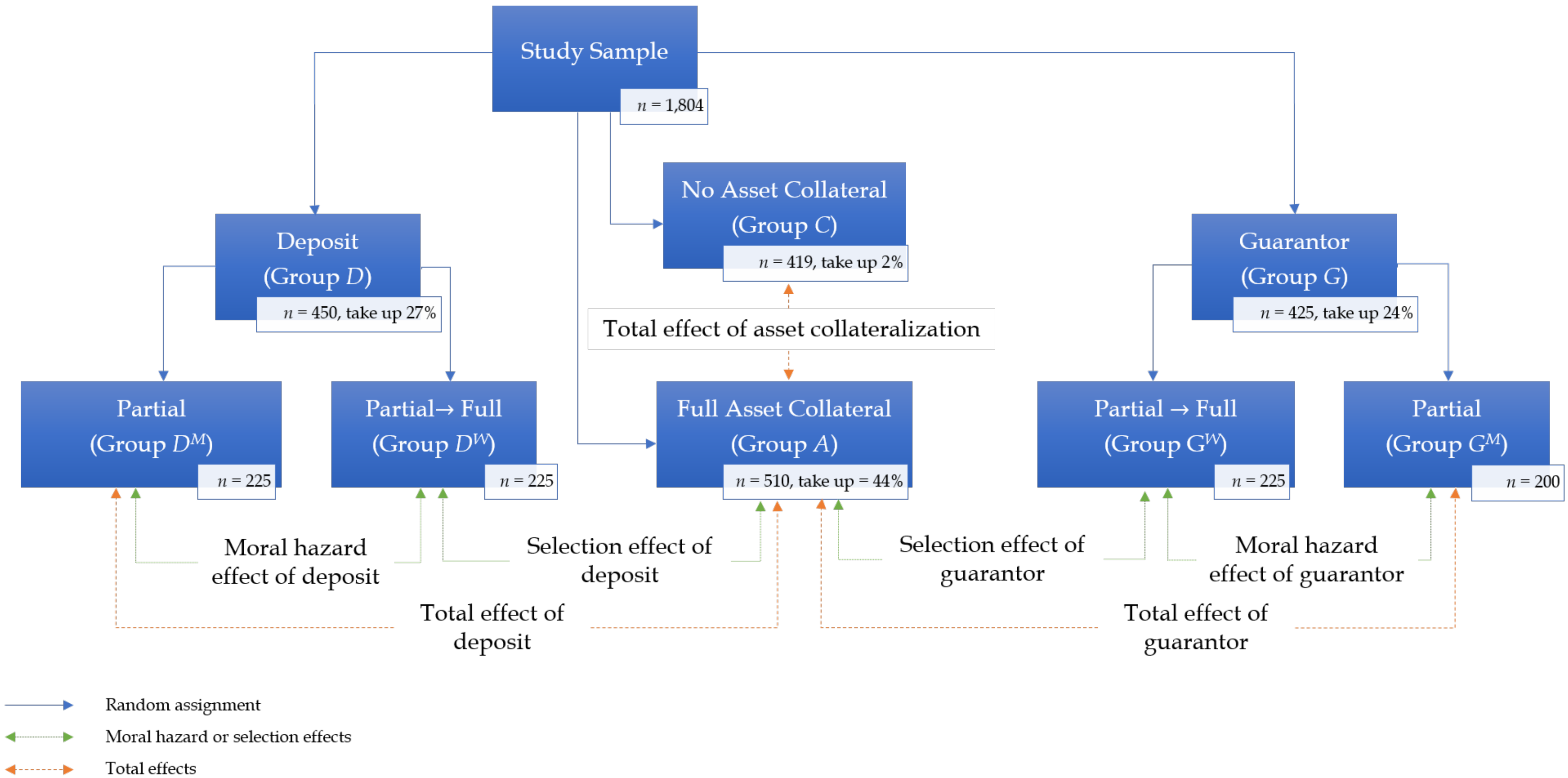

Table 1: Program Design

Treatment (Loan) Description	Group	Deposit	Guarantor	Asset collateralized	Offers	Take Up
4% deposit loan	A	$1,000$	0	23,000	510	0.44 (0.013)
25% deposit loan, maintained	D^M	$6,000$	0	18,000	225	0.28 (0.011)
25% deposit loan, waived	D^W	$6,000 \rightarrow 1,000$	0	$18,000 \rightarrow 23,000$	225	
21% guarantor loan, 4% deposit, maintained	G^M	$1,000$	$5,000$	18,000	225	0.24 (0.011)
21% guarantor loan, 4% deposit, waived	G^W	$1,000$	$5,000 \rightarrow 0$	$18,000 \rightarrow 23,000$	200	
100% secured joint-liability loan	C	$8,000$	$16,000$	0	419	0.02 (0.021)

Note: Loan amount is Kenyan Shillings (KSh) 24,000 for all treatment groups.

In the last column we report the take up rates (as fractions) as well as standard errors from a regression of take up on treatment group.

All amounts above are reported in KSh (KSh 75=$1).

Table 2: Baseline Randomization Checks

	Mean	F-test stat	P-value
Production			
Milk production	222.176	0.756	0.554
Milk production per cow	137.718	1.048	0.381
Cows producing milk	1.673	2.024	0.089
Cows calved down	0.104	2.74	0.027
Sales			
Monthly milk sales	82.356	0.855	0.49
Sold milk	0.478	2.189	0.068
Livestock			
At least one cow died	0.318	0.539	0.707
At least one cow got sick	0.516	2.091	0.08
Zerograzing dummy	0.177	0.265	0.901
Zero or semi-zerograzing dummy	0.749	1.899	0.108
Assets			
Log household assets (ln KSh)	12.273	0.976	0.42
Log value of livestock (ln KSh)	11.291	1.038	0.386
Baseline piped water	0.315	0.726	0.574
Own water tank	0.428	0.256	0.906
Own water tank ¿2500 liters	0.241	0.444	0.777
Schooling			
Kids (5-16) enrolled in school	0.982	.137	0.969
Girls (5-16) enrolled in school	0.983	1.332	0.256
Boys (5-16) enrolled in school	0.981	0.696	0.595
HH Char	.	.	.
Household head education (years)	8.459	1.193	0.312
Female household head	0.201	0.603	0.66
Time Use			
Farming	87	1.298	0.269
Livestock	77.2	0.665	0.616
Fetching water	14.3	1.556	0.184
Working	38.8	0.172	0.953
School (Girls 5-16)	330.5	.647	0.629
School (Boys 5-16)	336.3	1.033	0.39

Note: Milk volumes in liters per month. Reported means are across all six loan groups. The F-stat tests for equality of means across all six loan groups. Certain time use variables are omitted due to space constraints. One excluded time use variable (socializing with neighbors) has a significant F-test statistic. Including the ten omitted time use variables, we conduct baseline checks on 39 variables. Standard errors clustered at the household level when necessary.

* $p<0.1$, ** $p<0.05$, *** $p<0.01$

Table 3: Loan Repayment

	During Loan Cycle			Late at End of Loan		
	(1)	(2)	(3)	(4)	(5)	(6)
	Late Ever	Received Letter	Deposit Reclaimed	Repaid Late	Late Balance	Months Late
4% deposit loan [A]	0.68***	0.29***	0.10***	0.12***	225.61***	0.12***
	[0.03]	[0.03]	[0.02]	[0.02]	[49.89]	[0.02]
25% deposit loan, maintained [D^M]	0.70***	0.33***	0.16***	0.02	44.41	0.02
	[0.06]	[0.06]	[0.05]	[0.02]	[32.53]	[0.02]
21% guarantor loan, 4% deposit, maintained [G^M]	0.62***	0.18***	0.10**	0.06*	101.91	0.06*
	[0.07]	[0.05]	[0.04]	[0.03]	[63.42]	[0.03]
100% secured joint-liability loan [C]	0.20	0.10	0.10	0.00	0.00	0.00
	[0.13]	[0.10]	[0.10]	[.]	[.]	[.]
25% deposit loan, waived [D^W]	0.57***	0.28***	0.08**	0.12***	161.90**	0.12***
	[0.06]	[0.06]	[0.04]	[0.04]	[66.76]	[0.04]
21% guarantor loan, 4% deposit, waived [G^W]	0.54***	0.32***	0.14***	0.14***	297.52***	0.14***
	[0.07]	[0.07]	[0.05]	[0.05]	[111.67]	[0.05]
Deposit Selection Effect P-value: $D^W = A$	0.10	0.88	0.73	0.94	0.45	0.87
Guarantor Selection Effect P-value: $G^W = A$	0.06	0.72	0.43	0.71	0.56	0.78
Deposit Treatment Effect P-value: $D^M = D^W$	0.11	0.59	0.21	0.02	0.11	0.02
Guarantor Treatment Effect P-value: $G^M = G^W$	0.42	0.10	0.54	0.18	0.13	0.18
Mean of dependent variable	0.64	0.28	0.11	0.10	181.46	0.10
Observations	459	459	459	459	459	459

Note: * $p<0.1$, ** $p<0.05$, *** $p<0.01$. Heteroskedasticity-robust standard errors in brackets.

For these regressions, we estimated all six treatment dummies and excluded the constant so the coefficients are the means for each group.

In column (2), the dependent variable is a dummy variable for whether the borrower ever recieved a pending default letter.

In column (3), the dependent variable is a dummy variable for whether the borrower's security deposit was reclaimed.

In column (5), the late balance is measured in KSh (KSh 75=$1).

Table 4: Early Repayment of Loans

	(1) Repaid Early	(2) Months Early	(3) Months of Principal in Deposit	(4) Foregone Months of Low Interest Loan
4% deposit loan [A]	0.24***	1.62***	1	0.62**
	[0.03]	[0.28]	[0.28]	
25% deposit loan, maintained [D^M]	0.61***	4.48***	6	-1.52**
	[0.06]	[0.73]	[0.73]	
21% guarantor loan, 4% deposit, maintained [G^M]	0.60***	3.56***	1	2.56***
	[0.07]	[0.75]	[0.75]	
100% secured joint-liability loan [C]	0.90***	15.00***	8	7.00***
	[0.10]	[2.32]	[2.32]	
25% deposit loan, waived [D^W]	0.40***	3.83***	1	2.83***
	[0.06]	[0.89]	[0.89]	
21% guarantor loan, 4% deposit, waived [G^W]	0.38***	4.62***	1	3.62***
	[0.07]	[1.10]	[1.10]	
Deposit Selection Effect P-value: $D^W = A$	0.03	0.02		0.02
Guarantor Selection Effect P-value: $G^W = A$	0.07	0.01		0.01
Deposit Treatment Effect P-value: $D^M = D^W$	0.02	0.57		0.00
Guarantor Treatment Effect P-value: $G^M = G^W$	0.03	0.43		0.43
Mean of dependent variable	0.38	3.14	1.29	
Observations	459	459		459

Note: * p<0.1, ** p<0.05, *** p<0.01. Heteroskedasticity-robust standard errors in brackets.

For these regressions, we estimated all six treatment dummies and excluded the constant so the coefficients are the means for each group.

In column (3), we report the number of months of principal held as security deposit.

Table 5: Impacts on Water Access, Cow Health, Milk Production and Sales

	First Stage			Cow Health	Milk Production			Milk Sales		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Own Water Tank	Own a Large Tank	Log Total Water Capacity	Cow Sick	Levels	Log	Asinh	Levels	Log	Asinh
Treat*Post	0.235***	0.297***	0.591***	-0.129***	3.448	0.041	0.040	5.589	0.108	0.125
	[0.021]	[0.028]	[0.083]	[0.035]	[12.781]	[0.097]	[0.094]	[11.739]	[0.132]	[0.149]
Treatment	-0.100***	-0.052**	-0.170	0.102***	10.997	-0.034	-0.032	6.886	-0.070	-0.085
	[0.031]	[0.024]	[0.109]	[0.033]	[12.518]	[0.103]	[0.100]	[10.761]	[0.136]	[0.153]
Constant	0.499***	0.179***	6.955***	0.449***	173.728***	4.278***	4.999***	109.758***	2.888***	3.286***
	[0.022]	[0.019]	[0.085]	[0.025]	[8.491]	[0.084]	[0.082]	[7.581]	[0.112]	[0.126]
Control Mean	0.506	0.239	7.074	0.370	327.634	5.171	5.880	241.039	4.476	5.043
Round FE	Yes	Yes	Yes	Yes						
Month*Year FE					Yes	Yes	Yes	Yes	Yes	Yes
HH Clustering	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline	X	X	X	X	X	X	X	X	X	X
2011 Follow-Up	X	X	X	X	X	X	X	X	X	X
No of Phone Follow-Ups	1	0	0	4	4	4	4	4	4	4
2014 Follow Up	X	X	X	X	X	X	X	X	X	X
Observations	3529	2709	2710	5910	41747	41747	41747	41747	41747	41747

Note: Household survey data in cols (1)-(4) is by survey round and was collected only in the 100% cash collateralized and the 4% deposit treatment groups.
Household survey data in cols (5)-(10) is by survey round and month (the surveys asked for monthly data on milk production and sales.
This data is from two detailed in-person follow ups conducted in 2011 and 2014 and four short phone surveys conducted between 2011 and 2012.
Specifications include relevant dummies for the round of data collection (ommited round is the baseline) or month of data collection.
The Post main effect is absorbed by the round or month dummies.
In col (1), cow sick is a dummy. In col (5) and (8), milk production and sales are reported in liters. In columns (6) and (9), logs are computed as ln(1+variable).
Standard errors clustered at household level are reported in brackets. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Table 6: Impacts on Milk Sales, Administrative Data

	(1) Sold Milk	(2) Milk Sales	(3) Milk Sales, 1% trim	(4) Milk Sales, 5% trim	(5) Milk Sales, 10% trim	(6) Log(1+Sales)	(7) Asinh Sales
Treat*Post	0.045**	11.214	12.580*	12.749**	9.790**	0.246**	0.277**
	[0.019]	[10.137]	[6.419]	[5.106]	[4.389]	[0.101]	[0.114]
Treatment	-0.022	-1.882	-3.568	-5.960	-6.161	-0.117	-0.132
	[0.016]	[10.372]	[5.804]	[4.691]	[3.914]	[0.085]	[0.096]
Constant	0.398***	-90.073***	-37.407***	-7.673	7.671*	1.256***	1.515***
	[0.020]	[26.458]	[8.101]	[5.572]	[4.584]	[0.107]	[0.120]
Control Mean	0.676	179.834	156.067	130.744	111.627	3.473	3.932
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
HH Clustering	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Admin Data	X	X	X	X	X	X	X
Observations	109460	109460	108360	103963	98517	109435	109460

Note: All the sales data in this table comes from administrative data on monthly sales for each household from July 2009 to May 2013.
The administrative data is for all treatment groups, with the 100% secured joint liability group treated as the control.
The estimates are intent to treat estimates with all the treatment groups combined.
All specifications include 64 month dummies to cover the 65 months of data (which absorb the Post dummy).
The Post dummy refers to all months from June 2010 (the median loan offer date) onwards.
Milk sales are reported in liters.
A 1% trim means the top percentile of observations have been trimmed; similarly for the 5% and 10% trims.
Standard errors clustered at household level are reported in brackets. * $p<0.1$, ** $p<0.05$, *** $p<0.01$

Table 7: School Enrollment and Time Use Impacts on Children

	Enrollment		Water, No Piped Water		Water, Piped Water		Livestock, No Piped Water		Livestock, Piped Water	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
Treat*Post	0.02**	-0.00	2.76	1.65	0.35	3.61	-10.14	12.07	-3.36	9.82
	[0.01]	[0.02]	[3.31]	[3.58]	[2.98]	[3.82]	[9.16]	[11.68]	[12.88]	[26.34]
Treatment	-0.02*	0.00	-5.38*	-2.70	-1.47	-2.94	11.61	-20.73*	-9.68	-11.51
	[0.01]	[0.01]	[3.03]	[3.51]	[2.65]	[3.56]	[8.35]	[11.07]	[12.23]	[24.78]
Constant	1.03***	1.07***	13.36***	10.50***	4.37**	5.84*	7.40*	38.50***	15.00	34.74*
	[0.02]	[0.02]	[2.57]	[2.99]	[2.20]	[3.16]	[3.96]	[9.50]	[11.92]	[20.50]
Control Mean	0.975	0.971	9.080	5.920	4.925	2.839	15.103	44.781	19.495	43.363
Round FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
HH Clustering	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline	X	X	X	X	X	X	X	X	X	X
2011 Follow-Up	X	X	X	X	X	X	X	X	X	X
No of Phone Follow-Ups	0	0	4	4	4	4	4	4	4	4
2014 Follow Up	X	X	X	X	X	X	X	X	X	X
Observations	1581	1576	2009	2188	729	774	2009	2188	729	774

Note: All household survey data is by survey round and was collected only in the 100% cash collateralized and the 4% deposit treatment groups.
The household survey data comes from two detailed in-person follow ups conducted in 2011 and 2014 and four short phone surveys conducted between 2011 and 2012.
Specifications include and report relevant dummies for the round of data collection (ommited round is the baseline). The Post main effect is absorbed by these dummies.
In cols (1) and (2) enrollment is a dummy for a child aged 6-16 being enrolled in school.
The time use modules collect time spent (minutes per day) by activity in the last 24 hours for children aged 5-16.
Standard errors clustered at household level are reported in brackets. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Table 8: Loan Takeup and Repayments, Main Experiment vs Replication

	(1) Group A	(2) Group D	(3) Group G	(4) Repaid Late	(5) Late Balance	(6) Months Late	(7) Repaid Early	(8) Months Early
Phase Two Loans	-0.051*	-0.053**	0.014	0.064***	-14.359	0.093***	0.240***	1.241***
	[0.031]	[0.025]	[0.025]	[0.020]	[37.446]	[0.025]	[0.029]	[0.350]
Constant	0.443***	0.276***	0.235***	0.100***	185.502***	0.102***	0.372***	2.873***
	[0.022]	[0.021]	[0.021]	[0.014]	[30.548]	[0.015]	[0.023]	[0.263]
Phase 1 Mean	0.443	0.276	0.235	0.100	185.502	0.102	0.372	2.873
Phase 2 Mean	0.392	0.223	0.249	0.165	171.143	0.196	0.612	4.114
Observations	1033	1496	1472	1148	1146	1144	1148	1144

Note: This table uses administrative loan data on the main experiment (Phase 1) and the follow up loans post the main experiment (Phase 2). All columns exclude the Group C loans in Phase 1 as there were no Group C loans in Phase 2. Robust standard errors are reported in brackets. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Appendix Table 1: Surveys Collected

Survey Round	Pre/Post Treatment	Sample Size	Dates Conducted	Full Survey	If Not Full Survey, Modules Collected
Baseline	Pre	2045 over two rounds:		Yes	
		(i) 1194	Jun-Nov 2009		
		(ii) 851	Feb-Jul 2010		
Follow Up 1	Post	901	Jan-May 2011	Yes	
Production 1	Post	843	Oct-Dec 2011	No	Child health, livestock, production and tank use
Time Use 1	Post	1699	Oct-Dec 2011	No	Time use
Production 2	Post	863	Jan-Mar 2012	No	Child health, livestock, production and tank use
Time Use 2	Post	1710	Jan-Mar 2012	No	Time use
Production 3	Post	845	May-Jun 2012	No	Child health, livestock, production and tank use
Time Use 3	Post	1675	May-Jun 2012	No	Time use
Production 4	Post	827	Sep-Oct 2012	No	Child health, livestock, production and tank use
Time Use 4	Post	1636	Sep-Oct 2012	No	Time use
Follow Up 2	Post	1703	Sep-Dec 2014	Yes	

Note: Surveys included are for the first round of loans only.

Appendix Table 2: Borrower Characteristics Across Arms

	Full Sample	Group C Borrowers	Group D Borrowers	Group G Borrowers	Group A Borrowers
Log household assets	12.28	12.30	12.60	12.68	12.44
	[1.01]	[0.78]	[1.11]	[1.02]	[0.94]
Log per capita expenditure	10.37	10.36	10.56	10.64	10.41
	[0.65]	[0.32]	[0.74]	[0.71]	[0.56]
Average cows producing milk	1.67	1.8	1.94	2.04	1.93
	[1.22]	[0.55]	[1.86]	[1.29]	[1.13]
Milk per cow (liters)	142.66	142.67	163.88	143.58	148.43
	[93.63]	[74.54]	[112.85]	[110.12]	[88.5]
Monthly sales to dairy (liters)	78.23	86.33	106.07	89.26	115.14
	[175.89]	[104.22]	[149.66]	[141.34]	[345.57]
Education (years) of HH head	8.46	10.3	9.78	9.08	9.14
	[4.37]	[4.88]	[3.89]	[4.72]	[4.38]
Female HH head	0.2	0.20	0.17	0.24	0.15
	[0.40]	[0.42]	[0.38]	[0.43]	[0.36]
Girls as % of HH	0.13	0.05	0.13	0.11	0.10
	[0.16]	[0.12]	[0.16]	[0.14]	[0.15]
Piped water access	0.32	0.40	0.27	0.30	0.34
	[0.46]	[0.52]	[0.44]	[0.46]	[0.47]
Own water tank	0.43	0.80	0.49	0.46	0.49
	[0.49]	[0.42]	[0.50]	[0.50]	[0.50]
Own water tank 2500 liters	0.24	0.40	0.30	0.33	0.24
	[0.43]	[0.52]	[0.46]	[0.47]	[0.43]
Number of big tanks	0.32	0.40	0.41	0.43	0.30
	[0.65]	[0.52]	[0.81]	[0.70]	[0.61]
Practice zero grazing	0.18	0.20	0.18	0.19	0.23
	[0.38]	[0.42]	[0.38]	[0.40]	[0.42]
Practice zero or semizero grazing	0.75	1.00	0.81	0.77	0.80
	[0.43]	[0.00]	[0.39]	[0.42]	[0.40]

Note: Standard deviations in brackets.
All data is pre-treatment.
There are significant differences between borrowers and non-borrowers at the 5% level in the first three rows, columns (3)-(5); row 5, columns (4) and (5); row 6, column (5); row 10, column (2); row 11, column (4); and row 14, column (3).
Log per capita expenditure is measured in log KSh per year.

Appendix Table 3: Loan Repayment and Early Repayment, Replication Exercise

	During Loan Cycle	Late at End of Loan			Early Repayment		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Late Ever	Repaid Late	Late Balance	Months Late	Repaid Early	Months Early	Forgeone Months of Loan
4% deposit loan [A]	0.93***	0.23***	247.98***	0.31***	0.49***	2.99***	1.99***
	[0.02]	[0.03]	[45.48]	[0.05]	[0.04]	[0.37]	[0.37]
25% deposit loan, maintained [D^M]	0.89***	0.07***	88.90**	0.09**	0.74***	4.89***	-1.11*
	[0.03]	[0.02]	[38.30]	[0.03]	[0.04]	[0.57]	[0.57]
21% guarantor loan, 4% deposit, maintained [G^M]	0.86***	0.09***	89.40**	0.09***	0.72***	4.72***	3.72***
	[0.03]	[0.02]	[38.31]	[0.02]	[0.04]	[0.52]	[0.52]
25% deposit loan, waived [D^W]	0.84***	0.20***	146.12***	0.20***	0.66***	4.88***	3.88***
	[0.03]	[0.04]	[48.54]	[0.04]	[0.04]	[0.64]	[0.64]
21% guarantor loan, 4% deposit, waived [G^W]	0.89***	0.18***	237.60***	0.22***	0.53***	3.81***	2.81***
	[0.03]	[0.03]	[63.32]	[0.05]	[0.05]	[0.56]	[0.56]
Deposit Selection Effect P-value: $D^W = A$	0.02	0.49	0.13	0.08	0.00	0.01	0.01
Guarantor Selection Effect P-value: $G^W = A$	0.32	0.24	0.89	0.24	0.48	0.22	0.22
Deposit Treatment Effect P-value: $D^M = D^W$	0.31	0.00	0.36	0.03	0.18	0.99	0.00
Guarantor Treatment Effect P-value: $G^M = G^W$	0.46	0.04	0.05	0.03	0.00	0.24	0.24
Mean of dependent variable	0.89	0.16	171.14	0.20	0.61	4.11	2.30
Observations	699	699	697	695	699	695	695

Note: * $p<0.1$, ** $p<0.05$, *** $p<0.01$. Heteroskedasticity-robust standard errors in brackets.

In Phase 2, A, D^M, D^W, G^M, G^W had sample sizes of 523, 523, 523, 523 and 524, respectively. Take up was 205, 114, 119, 139 and 122 respectively.