Credit and Demand for Green Energy: Evidence from Small Firms in Kenya *

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Abstract

Firms in sub-Saharan Africa face simultaneous credit and energy constraints. Off-grid solar bundled with credit financing has the potential to relax both constraints, yet adoption among firms remains low. Understanding how firms value different components of payment structures is crucial for designing green subsidies in credit contracts. This paper evaluates firm demand for solar sold on credit by eliciting discrete choices over contracts, and experimentally compares the impact of down payment subsidies versus flexible subsidies for down payment or repayment. We find that demand is primarily driven by sensitivity to upfront costs rather than future repayments. When offered the flexibility to allocate the subsidy to the down payment or the repayment, nearly all adopters choose to reduce the upfront cost. Despite the same de facto subsidy structure, this tailored subsidy scheme positively selects less liquidity-constrained adopters and leads to greater solar usage and more operational days.

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1 Introduction

Many firms in low- and middle-income countries (LMICs) are credit-constrained and energy-poor.[1] With technology innovations enabling financing for traditionally uncollateralizable assets, off-grid solar bundled with credit has emerged as a promising solution in sub-Saharan Africa (SSA).[2] However, firm adoption of solar remains limited in SSA.[3] This is particularly puzzling given the usefulness of solar-credit bundles in addressing firms' need for both credit and energy.

Understanding firm demand for asset-credit bundles is crucial but non-trivial. In data-scarce environments such as in LMICs, the conventional approach to demand estimation is to collect hypothetical adoption decisions at varying prices and to incentivize truth-telling by randomly implementing one of the decisions, as specified in Becker et al. (1964). But with multiple payments in the credit contract, it is either cumbersome to go over more than one dimension of prices or reliant on certain assumptions to collapse future payments into present values.

This paper studies firm demand for off-grid solar assets purchased with credit (i.e. "credit purchases") using a discrete choice experiment that combines Bayesian-updated choices and incentive compatibility measures. By proposing a novel framework of analyzing demand over multiple price dimensions for credit purchases, we argue that household constraints can bleed into business decisions on investment of productive assets. We then experimentally change the credit purchase contracts faced by small firm owners to understand the impact of contract design on solar adoption, as well as the impact of solar adoption on firm performances.

We evaluate the business demand for a small-scale solar product by collecting firm owners' discrete choices over a series of price menus. We collect data from a firm census

[1]See "Bottlenecks to Private Sector Development in Sub-Saharan Africa: A Firm-Level Analysis" by IMF at https://www.elibrary.imf.org/view/journals/001/2025/188/article-A001-en.xml.

[2]"Off-grid solar is the most cost-effective way to power 41% of people globally by 2030 who are still living without energy access", according to the World Bank in a press release in October 2024.

[3]For example, only 6.7% of firms in Senegal have installed solar in a national survey in 2025, according to UNDP.

in a low-income neighborhood in Kenya in June 2024. The solar product we offer is a small portable solar light with a back-of-the-envelope annual carbon benefit of around 10-60% of the down payment. We elicit demand over the down payment-repayment space using the Bayesian Adaptive Choice Experiment (BACE), a method to efficiently estimate individual utility function parameters structurally with an adaptive sequence of menus (Drake et al., 2022). This method records a series of discrete choices over an efficient set of price menus. We adjust the BACE approach to achieve incentive compatibility by randomly implementing the respondent's selected contract in one of the menus. With efficient variation in down payment and repayment, we construct a conventional demand curve by evaluating demand over the total price, and a demand surface by evaluating demand over the two dimensions of down payment and repayment.

On top of the incentivized discrete choice elicitation, we conduct a randomized controlled experiment with subsidies embedded in one of the choice menus. Each sampled owner is randomly assigned into three treatment groups with equal chance, namely the down payment subsidy group with the subsidy reducing the down payment directly, the tailored subsidy group with the subsidy applied to either the down payment or the repayment, and the control group with no subsidy. In the two subsidized groups, a subsidy amount is randomly drawn from 5 levels (12–60% of the down payment of the market contract). In the down payment subsidy group, the implemented menu shows the down payment-subsidized contract and the prevailing market contract. In the tailored subsidy group, the implemented menu shows the repayment-subsidized contract and the down payment-subsidized contract. In the control group, the implemented menu shows the market contract and a clearly dominated contract. Six months later, we conducted a round of follow-up with the experiment sample.

Firm demand for solar is low at the prevailing market contract and increases when the down payment is reduced to closer to the repayment level. First, using the conventional demand curve, demand is low at the prevailing market price and relatively inelastic. Next, extending the demand analysis to a two-dimensional price space, we find rich variation in demand over contracts with the same total payment allocated differently over time. We measure demand over different down payment-repayment pairs and plot the demand surface as iso-demand contour curves. If the sampled firms are risk-neutral profit-maximizing agents, we should expect the contour curves to be straight lines. However, we find that around the market contract, the iso-demand curves are concave, indicating that owners prefer financial contracts that have down payments and repayments that are closer to each other. This type of contracts is less lumpy, and enables intertemporal smoothing. This concavity diminishes as the prices are lower.

The preference for smoothing is mainly driven by firm owners who are the primary earners in their households, i.e., the household heads. While household heads benefit from managing the household liquidity and on average operate larger businesses, they also bear the responsibility of household liquidity shocks. Therefore, their demand for credit purchases of productive assets is consistent with a preference for intertemporal smoothing. In contrast, non-head owners' decisions around productive asset investment with credit are consistent with the conventional business decision makers who can trade off current and future payments effectively. They appear to be less affected by household liquidity conditions, as they can smooth their income with at least another household member (their household head). The observed heterogeneity in demand curvature, and its link to household responsibilities, underscores the necessity of demand analysis for credit-purchased products in a two-dimensional price space, as collapsing future payments into a single price measure masks important nuances.

Consistent with the low demand around the market price, we find low adoption of solar products among owners in the control group, while subsidies meaningfully increase adoption. In the control group, only 4% of the respondents purchase the solar lights. The down payment subsidy increases solar purchases by about 12 percentage points, while the tailored subsidy raises them by 9 percentage points. Over 80 percent of adopters in the tailored subsidy group apply their subsidy to the down payment, despite the option to apply it towards the first four weeks of repayments. The two treatment effects are not statistically different, and both more than double the control group adoption rate. On average, treated adopters receive a subsidy of 315 Kenya Shillings (KES), which is equivalent to 45 percent of the down payment or 3 percent of the total payment under the market contract.

Leveraging experimental variation in prices, we find that the price elasticity is mainly driven by elasticity to the down payment for owners who are head of households. We evaluate price elasticity by instrumenting for prices (total payment, down payment, and repayment) with the random assignment into treatments and subsidy amount. With a 100 KES increase in the total payment, demand measured by the purchase rate decreases by 1.17 percentage points. When decomposing price into current and future payments, we find that demand is more elastic with respect to down payment than to repayments, consistent with liquidity constraints at the time of contract signing. This asymmetric sensitivity of demand with regard to down payment versus repayment is mainly driven by business owners who are household heads, while non-head owners reveal similar elasticity to both payment terms. The finding corroborates the hypothesis that household-head owners are more likely to be influenced by household-level constraints when making firm decisions due to their pivotal family role in managing family finance and smoothing consumption.

Less constrained owners are more likely to select into adoption under the tailored subsidy. These constraints include being a household head (i.e., with more exposure to household liquidity shocks), being risk averse, and having less household liquidity. In contrast, in the subgroup without such constraints, we find that tailored subsidy and down payment subsidy yield very similar treatment effects on adoption. Business constraints, on the other hand, do not seem to affect firm owners' investment decisions, as shown by the null results for a heterogeneity cut by firm profits.

Both subsidy schemes positively update owners' beliefs about the usefulness and popularity of solar in the neighborhood, while only those in the tailored subsidy group change their business operations. On one hand, treated owners in both arms believe that solar lamps are more useful than traditional lamps powered by on-the-grid electricity, and this usefulness increases from the baseline. They also shift upwards their beliefs on the popularity of solar among fellow owners in Nakuru, on the back of an expansion of solar in the city. On the other hand, consistent with positive selection under the tailored subsidy, we find that treated firms in this group operate more days in a month and spend more on solar, potentially substituting away from on-the-grid electricity. No such substitution is found in the down payment subsidy group. Firms under the tailored subsidy also demonstrate greater operational flexibility, evidenced by their higher likelihood of operation and increased operational days.

This paper contributes to three strands of literature. First, this paper contributes to the literature on evaluating demand for green products in a low-income setting (Berkouwer and Dean, 2022; Berry et al., 2020; Greenstone and Jack, 2015; Grimm et al., 2020; Kremer et al., 2011; Yishay et al., 2017). Complementing existing studies that use the Becker-Degroot-Marschak method to elicit demand over one dimension of price, we extend demand elicitation into multiple dimensions of prices without imposing onerous burdens on the respondents. We also contribute to the growing literature on revealed preference elicitation using discrete choice experiments (Andrew and Adams, 2025; Drake et al., 2022; Feld et al., 2022; Pitts et al., 2023). Our proposed method combines the efficiently updated choice experiments with an incentive compatibility design.

Second, this paper adds important firm-level evidence to the literature on the adoption of affordable clean energy and the green transition in low-income countries. Previous studies explore the impacts of off-grid electricity in rural areas of developing countries with a focus on household outcomes, such as Rwanda (Grimm et al., 2020, 2017), Tanzania (Aevarsdottir et al., 2017), Kenya (Lee et al., 2020; Rom et al., 2023), Togo (Lang, 2025a,b) and India (Burgess et al., 2025). Different from their focus on household energy expenditures and education and/or health outcomes, we provide firm-level insights into the barriers to low adoption and impacts of adoption on firm outcomes. We challenge the firm-household dichotomy in the literature by showing interesting evidence of household constraints affecting business investments for owners who are household heads.

Lastly, this paper speaks to recent studies on the use of credit contracts with lockout technology as an alternative supply of financing in resource-constrained contexts (Bonan et al., 2023; Choudhary and Limodio, 2022; Gertler et al., 2024; Lang, 2025b). These studies show that lockout functions as a form of partial and digital repossession, helping enforce repayment while maintaining flexibility for borrowers. This enables financing for assets/products that were previously harder to repossess and thus uncollateralizable. Compared to cash subsidies that only reduce upfront costs, credit contracts with repayment-linked enforcement mechanisms better address their intertemporal liquidity constraints. We contribute to this strand of literature by experimentally examining small firms' demand for productive assets and their value of flexible contract terms in the context of solar product purchases on credit. We further explore how digital collateral can help relax credit frictions and potentially improve firm performance.

The remainder of the paper proceeds as follows. Section 2 introduces the background on credit purchases and digital collateral in Sub-Saharan Africa, along with the context of solar products in Kenya. Section 3 outlines the experimental design, randomization, data, and empirical specification. Section 4 presents the empirical results on solar adoption and business performance. Section 5 concludes.

2 Background

We study credit purchases of productive assets in Sub-Saharan Africa due to its prevalence and large potential of reaching previously unbanked population. Products with this feature can serve as digital collateral for future loans (Bonan et al., 2023; Gertler et al., 2024). Credit purchases have been widely used in off-grid small-scale solar products in SSA.

2.1 Credit purchase and digital collateral in SSA

Credit purchases have gained popularity across SSA, especially as a contract type for distributing off-grid solar products. Credit purchases provide an opportunity for individuals and businesses to acquire products with much lower upfront costs. With the recent technology, pay-as-you-go (PAYG), lenders can lock out the product in case of missing repayments. Therefore, repayments are credibly incentivized by digital repossession, ensuring financial stability for suppliers/lenders and accessibility for consumers/borrowers (Gertler et al., 2024; Lang, 2022, 2025b). The PAYG feature has been widely used by distributors of solar products in sub-Saharan African countries.

Liquidity-constrained consumers can purchase productive assets with PAYG technology, where loan repayment enables daily usage of the assets. This feature of shutting down flow utility in cases of no-pay serves as digital collateral for the lender, thus reducing the default rate and increasing the lender's return (Bonan et al., 2023; Gertler et al., 2024). Offering credit for purchasing expensive assets also increases consumers' willingness-to-pay (WTP) as they are often liquidity-constrained (Berkouwer and Dean, 2022). PAYG technology is widely used in various solar products and has also been increasingly applied to other electronic appliances like mobile phones and televisions.

2.2 Solar in Kenya

Distributed solar products are typically available for credit purchase by individual customers in sub-Saharan Africa. With PAYG, the appliance and battery attached to solar panels are automatically shut down when repayment is past due. After paying off the loan for a solar product with a satisfactory track record, the borrower can buy some other products while pledging their solar product as digital collateral. Yet we have no evidence on whether the collateralizability increases demand for solar.

The solar product that we subsidize for in this study is a small portable light with a battery and a radio attached to it, as presented in Appendix Figure A.1. Users can charge their non-smart phones with the battery and use the Bluetooth function to play music through the radio. The LED light is energy efficient and can last for 8 hours when fully charged. With a back-of-the-envelope calculation using the social cost of carbon of 24 USD, this solar light has the potential of contributing to around 100 KES annual carbon benefits if substituting away from the same LED light powered by on-the-grid electricity, or 500 KES if substituting away from a kerosene light. The solar panel is roughly the size of an A4 paper. Due to the portability of the light-battery-radio combo, existing customers do carry the lights with them for different use cases. Firm owners, especially those engaged in any form of retailing, can benefit from this portable light by operating more flexibly to capture better customer flows and better cater to personal needs.

In Nakuru, multiple solar distributors offer broadly similar products with similar pricing structures. Individuals are familiar with this portable solar light, as many have already purchased one and use it for various activities after sunset. In our study area, Ronda, adoption of this solar light has been low, primarily attributable to generally lower income levels compared to downtown Nakuru. Before our intervention, sales representatives from multiple solar distributors had attempted to expand their customer base in Ronda. In 2023, the solar distributor with whom we collaborate sold a total of 133 units in Ronda, mostly to households. In our study sample, baseline data shows that 45% owners have purchased at least one solar product, but only 13% used solar at their businesses.

3 Experimental Design

3.1 Sample

We conducted a representative firm listing and a baseline survey with owners during July 2024 in the Ronda district of Nakuru. Our representative firm listing efforts spanned 1.58 square kilometers, with enumerators canvasing the entire area of Ronda. Figure A.2 shows the map of Rhonda divided into 6 enumeration areas based on major roads. The enumerators were paired and assigned to one of the enumeration areas. Each pair of enumerators started at a randomly determined place within their respective map, proceeding to canvas the entire map area by walking down all roads. Each pair of enumerators was accompanied by a village elder who introduced them to the community to ensure the safety of the enumerators. We approached all visible businesses in the enumeration areas, including businesses in permanent structures, household businesses with signage for operation visible from the outside, and mobile businesses.[4]

Our sample consists of 746 firm owners in Ronda. The firm census first listed 873 firms in Ronda as of end-June 2024. After the listing survey, 819 eligible business owners are identified if they (1) anticipate operating in the next six months, (2) have an independent mobile money account, (3) own only one business in Rhonda, and (4) do not deal with electronic appliances.[5] We went back to eligible owners to conduct a baseline survey, where

[4]A detailed de-duplicating exercise was conducted based on owner names, firm locations, and contact phone numbers in order to remove potential double counting of businesses due to co-ownership.

[5]We exclude those that sell electronic appliances to avoid potential conflict of interests with the inter-

746 owners consented to participate in the study. This forms our experiment sample.

Among the 746 firm owners in the experiment sample, 384 (51.5%) are the heads of their households. Household heads are typically the primary earners in this context, with around 80% of the sampled head-owners being the bread-winners of their households by contributing to more than half of their total household income.[6] In contrast, only 40% of non-head-owners are bread-winners. Owners who are heads and non-heads differ in many dimensions in terms of household structure. Heads are on average older and more likely to be male; they have larger family sizes with higher per capita income and liquidity; their businesses operate on a larger scale, with higher sales and profits. However, they are comparable on many personal and operational measures. They are equally likely to be risk averse and liquidity constrained; they operate on very similar capital and labor inputs, including fixed assets, hours of work, and spending on electricity.

3.2 Randomization

We randomize the participants into three treatment groups: 249 in control, 247 in down payment subsidy, and 250 in tailored subsidy, as shown in Figure A.3. The randomization is stratified by whether the business has access to on-the-grid electricity and whether the owner has purchased any solar products before. This yields four strata, each with 18-36% of the sample.

Owners in both subsidy treatment groups are further randomized (within each group) to five different subsidy levels (95, 189, 284, 378, or 473 KES), each of which corresponds to 11.9%, 23.6%, 35.5%, 44.8% or 59.1% of the market down payment. This is equivalent to 1-5% of the total payment in the market contract. The subsidy amounts also fall in between the range of the annual carbon benefits of this product.

vention of providing solar lights.

[6] Appendix Table B.3 compares the characteristics of household heads and non-heads in our experiment sample.

3.3 Intervention

The intervention is embedded in one out of 16 discrete-choice menus, where the respondent chooses one or none of the two credit purchase contracts shown in a menu. The market contract is down payment of 800 KES and a weekly repayment of 168 KES for 56 weeks (or equivalently, a daily repayment of 24 KES for 390 days). All contracts in the 16 menus share the same number of repayments (56 weeks) and the same repayment amount of 168 KES from week 9 onward. The two contracts in each menu have different repayment amounts for the first 4 weeks as well as different down payment amounts. Figure A.4 shows an example of the interface that a respondent faces. Among the 16 menus, 15 of them are optimally updated through a Bayesian rule based on previous responses, whereas one of them is the implemented menu randomly placed in the sequence. Respondents are informed before the game that their choice in one of the 16 menus will be randomly picked and implemented. This incentivizes them to report truthfully.

The implemented menus reflect different subsidy designs in different treatment arms. Each firm owner in the control group faces the choice between a market contract and a clearly dominated contract with a more expensive down payment and repayment. Each firm owner in the down payment treatment group faces the choice between a market contract and a subsidized contract, with the subsidy applied to the down payment. Each firm owner in the tailored treatment group faces the choice between two subsidized contracts, with the subsidy applied to either the down payment or the repayment.

After the 16 choices have been made, we reveal the implemented question and show to respondents their earlier choices. If the choice in the implemented menu is none of the two contracts, we inform the respondent that they are not able to purchase the solar lamp this time. If the choice in the implemented menu is one of the two contracts, a sales representative from the solar company comes to sign the contract with the respondent and set up the solar lamp. The contract being signed is still the same as the market contract of 800 KES down payment and 24 KES daily repayment for 390 days (i.e., 168 KES weekly repayment for 56 weeks), but the research team will pay for the subsidy directly to the respondent's account with the solar company. The down payment subsidy is paid on-site when the contract is signed, so the respondent will only pay for the remaining amount. The repayment subsidy is implemented in the form of “pay x (daily repayments of 24 KES) get 7-x (days) free”, where x ranges from 1 to 5. If respondents do not have the cash on hand to pay for the down payment, they can schedule a later date when the enumerator and sales representative will come back to complete the transaction.

3.4 Data

Listing and baseline surveys were conducted in July 2024, with outcome data referencing June 2024. Then we conducted the treatment game from end-July to end-August 2024. Our implementation team worked with the solar company to ensure contracts were signed and subsidies were provided according to the game choices. Implementation lasted until the first week of October 2024. We conducted the first follow-up survey in early December 2024, collecting outcome data referencing November 2024.

The listing and baseline survey collected firm characteristics, including operating hours, location of the firm, measurements of firm input and output, as well as household characteristics such as owner age and marital status, household size, other income sources, etc. We also included a module on firm energy usage, collecting detailed information on access to different electricity sources, cost, activities powered by electricity, and exposure to blackouts. At the end of the baseline survey, enumerators will introduce the basic features of the solar light and show respondents a photo of the product. We ask respondents’ views on how substitutable this solar light is compared with a traditional electricity lamp. Most of the sampled firms operate in the retail sector, followed by services like hairdressing or mechanics, and artisanal manufacturing like garment making and carpentry. Baseline data shows that, in Ronda, half of the businesses are connected to the electricity grid, while around 30% of the businesses do not use electricity from any source. Among the sampled owners, 45% have purchased at least one solar product, but only 13% use solar at their businesses.

During the treatment game intervention, we collected discrete choice data over 16 menus of credit purchase contracts for the solar light. One of the 16 choices is for the implemented menu, which is randomly selected to embed the intervention subsidy. Therefore, we observe both the within-game take-up of the subsidized credit purchase contract as well as the out-of-game take-up measured by actual purchase of the solar light. Overall, 3.6% of the owners in the control group and 8.3% of the owners in the treated groups purchased the solar light. Among those who made the purchase through the tailored subsidy program, more than 80% chose to apply the subsidy to their down payment. The average subsidy amount received by adopters is 315 KES, or 45% of the market down payment. Although the overall take-up rate is low, the number of solar lights purchased through our study represents more than a third of the sales of the same product by the solar company across Nakuru in 2023.

In the follow-up survey, we collected main outcomes related to firm operation and performance, as well as owners' beliefs about the usefulness and popularity of solar products. We also collected detailed data on spending on various electricity sources, including solar.

3.5 Attrition and Baseline

The attrition rate is 2.9% in the treatment game and 28.0% in the follow-up survey. Neither treatment significantly changes the attrition rate in either round of the survey compared to the control group (Appendix Table B.1). The relatively higher attrition rate in follow-up is mainly due to the timing of the survey in December. Although we have anticipated that respondents would travel ahead of the Christmas holidays and have arranged data collection to occur during the first two weeks of December, around 20% of our sampled firm owners have temporarily closed the business and traveled out of Nakuru.

We test for baseline differences in owner and firm characteristics between the two treatment groups and the control group according to the following specifications

$$Baseline_i = \beta_0 + \beta_1 Tailored_i + \beta_2 Down_i + \gamma_s + \epsilon_i \tag{1}$$

where $Tailored_i$ is a dummy indicating tailored subsidy, and $Down_i$ is a dummy indicating down payment subsidy, and γ_s are strata fixed effects.

The baseline statistics and the balance test results are summarized in Appendix Table B.2. We test 21 covariates for balance across the three pairs of treatment groups, i.e. $\beta_1 = 0$, $\beta_2 = 0$, and $\beta_1 = \beta_2$, individually. We also test for joint orthogonality across the three pairs of treatment groups. We fail to reject joint orthogonality across all covariates at conventional levels. At the individual covariate level, we do reject equality between treatment groups in at least one of the three bilateral tests for four covariates: whether the owner is their household head, whether the firm operates after sunset, the number of hours that the owner works in the business, and the expenditures in on-the-grid electricity. In the main specification, we control for the baseline levels of these four variables.

3.6 Estimation

We evaluate the intend-to-treat (ITT) estimates of our subsidy treatments on main outcomes including adoption, beliefs, and firm performance using the following specification:

$$Y_i = \beta_0 + \beta_1 Tailored_i + \beta_2 Down_i + \gamma_s + \delta' \mathbf{X}_i + \epsilon_i \tag{2}$$

where Y_i is the outcome variable, $Tailored_i$ is a dummy indicating tailored subsidy, and $Down_i$ is a dummy indicating down payment subsidy, γ_s are strata fixed effects, and X_i is a vector of baseline controls including any imbalanced covariates discussed above, indicator variables for when those covariates are missing, subsidy fixed effects, and baseline level of the dependent variable (if any).

Besides the ITT estimates, we also estimate the demand for solar using instrumental variables (IV). We instrument for the price level (or the down payment and repayments) using the experimental treatment assignment and subsidy amount. The IV specification consists of two stages:

$$Y_i = \beta_0 + \beta_1 \mathbf{P}_i + \gamma_s + \delta' \mathbf{X}_i + \epsilon_i \tag{3}$$

$$\mathbf{P}_i = \alpha_0 + \alpha_1 Tailored_i + \alpha_2 Down_i + \alpha_3 Subsidy_i + \gamma_s + \delta' \mathbf{X}_i + \eta_i \tag{4}$$

where $\mathbf{P_i}$ is a vector of price(s) of the solar light contract, which can be the sum of all payments, or the down payment and the repayments measured separately; $Subsidy_i$ is the present value of the subsidy randomly assigned to each individual, which is equal to 0 for those in the control group.

4 Results and Discussion

4.1 Demand over One-Dimensional Total Price

We document the shape of demand for the solar product in a one-dimensional price measure, the total payment including down payment and all future repayments. We estimate demand using respondents' choices over different contracts offered in the BACE game along with their actual purchases post the game. As expected, demand decreases monotonically with price, both within the game and in post-game transactions.

We construct the demand curve using discrete choices recorded in the BACE procedure. We measure price in a one-dimensional space as the total payment, which equals the arithmetic sum of the down payment and all future repayments, essentially assuming a zero discount rate,[7] and then group the total payments into bins of 100 KES. We measure demand as the share of respondents willing to purchase the solar product with a total payment falling in a certain bin. A respondent is only considered in a bin if we have a confirmed measure of whether they are willing to accept a contract in that bin, either by directly observing a response from their BACE questions or by inferring their response according to a monotonicity rule. Under the monotonicity assumption, a respondent is inferred to be willing to accept a contract in a bin if they were never offered a contract in this bin in any BACE question, and they selected to accept a contract in a more expensive bin. Figure 1 shows the demand for the solar product at varying total payments, using responses to all contracts in the 16 BACE questions (blue) and only the responses to the two contracts in the implemented questions (green).

[7]Discount rate only linearly changes the weight of repayments in the decision-making process. We show in Appendix Figure A.5 that our results are not sensitive to reasonable levels of discount rates.

In addition, we compare the within-game and post-game demand at the five subsidy levels in Figure 1. The within-game demand is estimated using the decision to adopt under the preferred contract in the implemented menu, in black dots. The post-game demand is measured by real-life purchasing action, regarding the same preferred contract in the implemented menu.

First, as a sanity check, the estimated demand is low and decreases as price increases. At the market price bin, less than 20% of our respondents are willing to accept the contracts. Both demand curves estimated using all questions in BACE and using only the implemented questions are downward sloping as total payment increases. The estimated within-game and post-game demands at different subsidy levels are noisy but still track the downward trend. The low demand around the market price is also relatively inelastic when the price is reduced by up to 5%. In practice, our subsidy only reduces the total payment by up to 4.6%. Therefore, some non-compliance is expected when our respondent gift (200 KES) cannot fully cover the down payment amount (ranging from 327 KES to 800 KES). Consequently, the post-game adoption rate (red dots) remains lower than the within-game estimated demand (black dots). Across the two subsidy treatment groups and five subsidy levels, the average adoption rate is only 8.5%.

Secondly, we show that the incentive compatibility design is functioning well beyond the implemented questions. The demand curve estimated using contracts from the implemented questions (two contracts per person) closely tracks the demand curve estimated using all observations (16 contracts per person), with understandably less precision due to a smaller sample size. This shows that respondents are not differently reporting their purchasing decisions in the implemented questions than the rest. This reassures that the random ordering of the implemented question indeed ensures incentive compatibility across all questions.

Finally, both the within-game demand estimated using implemented questions and the post-game real-life purchase rate drop to zero when the total payment is above the prevailing market price, lower than the demand estimated using all data. This is consistent with the fact that the market contract is a credible and well-understood outside option, beyond which incentive compatibility no longer constrains respondents' choices.

4.2 Demand over Down Payment-Repayment Space

We extend the demand analysis to the two-dimensional price space defined by the down payment and repayment components of credit purchase contracts. This discussion allows us to move beyond a one-dimensional measure of total cost and uncover how respondents' willingness to purchase varies with the composition of payment schedules.

Similar to a demand curve where demand is evaluated at a single price value, we evaluate demand for credit purchases at a given down payment-repayment pair, i.e., a demand surface. We represent this demand surface using an iso-demand contour plot. Figure 2 presents the share of respondents willing to purchase the solar product with a given down payment (x-axis) and weekly repayment for the first four weeks (y-axis), holding constant the weekly repayment for weeks 5 to 56. The darker (lighter) shade indicates higher (lower) demand, with contour lines drawn through the set of price pairs at which the demand is the same. The data used in this figure are all contracts presented in the BACE questions. Demand is calculated as the fraction of respondents willing to accept a contract in a price grid of 150 KES down payment and 70 KES weekly repayment. Similar to the definition of demand in the previous section, we extend the support of a respondent's demand under a monotonicity assumption: a respondent is considered to implicitly accept (decline) a contract if she accepts (declines) an alternative contract with a higher (lower) down payment and repayment. The straight lines represent iso-cost contracts, i.e., all contracts along the straight line have the same total payment. The red dashed line represents contracts with the same cost as the market contract, and the black dotted line (gray dashed line) represents contracts 5% (10%) cheaper than the market contract.

Demand for the solar product is decreasing as price increases in either and both dimensions. The color gradient in Figure 2 lightens towards the upper-right, indicating that demand declines as the down payment, the repayment, and/or the total payment increases. This is consistent with the negative relationship between demand and total payment documented in the conventional one-dimensional demand curve as shown in Figure 1.

The slope of the contour lines reflects the respondents' implied discount rate, i.e., a steeper slope indicating a higher discount rate. Comparing the iso-cost line passing through the market contract under an assumed zero annual discount rate with those under alternative assumptions of 100% or 500% annual discounting (Appendix Figure A.5), we find that variation in demand along equal-cost lines cannot be fully explained by differences in intertemporal discounting. This comparison also validates that a limited discount rate, i.e., zero, lies within a plausible range. This is potentially due to the short-term nature of our solar loan which is only 13 months. We cannot extrapolate to longer-term credit where discount rate may still play a crucial role in shaping demand.

The curvature of the contour lines represents important features of firm owners' preferences unexplained by the conventional demand curve. If our sampled firm owners were risk-neutral profit-maximizing decision makers when evaluating this investment opportunity, we should expect to find straight contour lines in the two-dimensional demand plot. However, Figure 2 shows concave contour curves at higher price ranges, with curvature diminishing at lower price levels. At higher total payment levels, respondents prefer contracts that more evenly distribute payment burdens between the present and the future, consistent with preferences for intertemporal smoothing. However, at lower total payment levels, the preferences appear to be consistent with the conventional profit-maximizing risk-neutral firm. This suggests that the conventional one-dimensional demand measure masks important features of demand for credit purchases, where different compositions of payment schedules may affect demand differently.

This heterogeneity in curvature across payment levels is primarily driven by business owners who are the primary earners of their households, i.e., the household heads.[8] This highlights the role of household responsibilities in shaping firm investment decisions, especially among those informal small businesses. Household heads, who often take responsibility

[8]Appendix Figure A.5 shows the two-dimensional demand for subsamples of household heads and non-heads. Appendix Table B.4 tests for the curvature of demand across different price ranges when varying down payment and repayment, for the full sample and the subsamples of household heads and non-heads. We fit the demand for solar at a given total payment on a second-degree polynomial of down payment (in 100 KES), and test for difference in the shape of demand at different price ranges.

for managing household liquidity and smoothing income and consumption over time, exhibit preference for financial contracts that help with intertemporal smoothing. In contrast, non-head respondents behave more like risk-neutral profit-maximizing firms: their demand remains nearly constant across alternative down payment-repayment combinations at a given total cost, as they could rely on other household members for income smoothing and face fewer household obligations. Such differences are often obscured in the one-dimensional demand analysis, while become evident when examining the full price composition over a two-dimensional price space.[9]

4.3 Treatment Effects on Adoption

Our main outcome of interest is the adoption of solar lights among the representative sample of small businesses in Ronda. Consistent with the solar distributor's experience that households remain their major customers rather than firms, we find that demand for solar is low among business owners.

First of all, adoption rate is low in the control group. Table 1 shows the treatment effects on within-game adoption measured by take-up of the selected contract in the implemented game in BACE (Column (1)) and post-game adoption measured by actual purchases (Column (2)). In the control group, the within-game adoption is 19%, which dropped to 4% in the actual purchases.[10] It is worth noting that in the tailored subsidy group, over 80% of the adopters choose to apply the subsidy to the down payment.

Secondly, both the tailored and the down payment subsidy treatments increase solar adoption by statistically significant and economically meaningful amounts (Columns (1) and (2)). The tailored and down payment subsidy treatments increase the share of owners purchasing the solar products by 9.1 and 12.3 percentage points, respectively, compared with the 4% adoption in the control group. While the point estimate for the tailored subsidy is slightly lower than that of the down payment subsidy, the difference is not statistically

[9] Appendix Figure A.6 presents one-dimensional demand for solar product, separately for household head and non-head owner respondents, and shows similar patterns.

[10] Comparing Column (1) and Column (2), the discrepancies indicate a relatively high non-compliance rate from the game to actual purchases. However, the treatment effects remain comparable in size.

significant.

Thirdly, demand is relatively inelastic around the market price. Columns (3) - (6) of Table 1 present the estimated demand elasticities. We instrument for the product price using two treatment dummies (tailored and down payment subsidies) and the randomized subsidy amount. We measure price by either the total amount of all payments (Columns (3) and (4)), or the down payment and the future repayments separately (Columns (5) and (6)). We find that a KES 100 increase in the total contract payment leads to a decline in the purchase rate by 1.71 percentage points. When decomposing the total contract payment to down payment and future repayments, we find that demand is more elastic to changes in the down payment compared with those in future repayments. This shows that upfront liquidity constraint is a main barrier to solar adoption.

Moreover, we find that the asymmetric elasticity to down payment versus repayment terms is mainly attributed to firm owners who are the primary earner of their households, i.e. the household heads (Table 2). Aligned with the previous observation of the solar demand in a two-dimensional space, Column (4) shows that non-heads, facing fewer household obligations and hence less bound by household financial commitments, display similar elasticities with respect to down payment and repayment. In contrast, business owners who are household heads, are substantially more responsive to down payment changes (Column (3)). This pattern indicates that the business decisions of household heads are further influenced by their household responsibilities, as they are more exposed to household-level liquidity constraints and have a stronger need to manage intertemporal consumption smoothing, reflecting the interplay between their business and domestic roles.

Tailored subsidy is not more effective in driving demand compared with the down payment subsidy. Since the down payment subsidy is one of the embedded options in the tailored subsidy scheme that can be chosen without additional cost, we should expect that the tailored subsidy is at least as good as the down payment subsidy in increasing solar adoption. While we cannot reject that the two treatment effects are different, the point estimate for tailored subsidy is 3 percentage points smaller than down payment subsidy compared with a 4 percentage point control group mean.

One explanation is that the tailored subsidy draws less attention to the subsidy amount and induces adoption among those less constrained at the personal or household level. The tailored subsidy implemented game shows two comparable contracts (both with the same amount of subsidy) whereas the down payment subsidy implemented game shows a clearly dominated contract (market contract without the subsidy). More constrained respondents may be less likely to be prompted by the subsidy in the tailored group. Table 3 shows heterogeneous treatment effects by different measures of constraints. Columns (1)-(3) show that the tailored treatment effect is negative for those with personal- or household-level constraints, including being a household head (thus having more responsibilities to consider household spending), having less household liquidity, or being risk averse. In the subgroup without such constraints, tailored subsidy and down payment subsidy yield very similar treatment effects on adoption. On the contrary, Column (4) finds no heterogeneous treatment effects by the firm-level constraint measured by low monthly profits. Column (5) combines all four heterogeneity cuts in one regression and the patterns remain consistent with the individual estimates.

4.4 Impacts of Solar Adoption on Beliefs

We show in this section that being offered a subsidized contract to purchase solar products increases the subjective beliefs of usefulness and popularity of solar. Downstream outcomes on owner beliefs related to solar are summarized in Table 4.

Overall, subsidy-induced adoption successfully shifts beliefs for the usefulness of the offered solar light compared with a traditional lamp powered by on-the-grid electricity. Column (1) shows that, an average owner in the control group believes that the solar light is just substitutable with a traditional electricity lamp (with a score of 5 out of the range of 0 and 10). Both subsidy treatments shift the score upwards, such that solar is considered slightly superior to the traditional lamp (Columns (2) and (3)).

Meanwhile, treated owners also adjust upwards their beliefs on the popularity of solar among fellow firm owners in Nakuru (Column (4)). Treated owners are 12-15 percentage points more likely to update their beliefs on the share of firm owners in Nakuru adopting solar compared with the baseline. This is on the back of an overall increase in solar popularity, with 45% of the control group believes that more firm owners in Nakuru are adopting solar.

4.5 Impacts of Solar Adoption on Business Performance

Due to the low adoption rate in the first stage and high attrition, our results on the downstream impacts of solar adoption on firm performances are very noisy. We summarize the ITT treatment effects on firm performance and input in Tables 5 and 6, respectively. Column (1) of Table 5 shows that non-attrited firm survival is 98% in the control group and that there is no treatment effect on firm survival by either treatment. Therefore, the rest of the analysis is based on estimations conditional on firm survival.

Despite the slightly smaller impact on adoption, tailored subsidy significantly changes firm operation. Conditional on firm survival, firms in the tailored subsidy group operate for almost one more business day in November 2024 compared with the control firms, which is also significantly higher than the down payment subsidy group (Column (2), Table 5). Meanwhile, firms in the tailored subsidy group almost doubles the spending on solar usage compared with the control group, which is also marginally significantly different from the down payment subsidy group (Column (2), Table 6). This is consistent with the fact that less liquidity-constrained owners are selecting into adopting solar, who are more likely to complete the repayments earlier. The increase in solar usage in the tailored group, however, appears to be potentially substitution away from on-the-grid electricity although very imprecisely estimated (Column (3), Table 6). This might explain the muted response on firm sales and profits (Column (5)-(6), Table 5).

Among firms that remain operational in November 2024, treated firms experience around 20% higher monthly sales compared with the control group. Point estimate of the treatment effect on profits is around 13%, but is less precise. The positive treatment effects on sales and profits are mainly driven by the down payment subsidy group, possibly due to the fact that liquidity-constrained owners are more likely to select into adoption under down payment subsidy, and that they are more likely to benefit from a credit-based product.

As treated firms adjust the composition of electricity sources, we find evidence that labor input is also adjusted accordingly. Consistent with existing literature that firms increase worker labor input (if possible) when experiencing electricity outages (Hardy and McCasland, 2021), we find suggestive evidence that when offered a subsidy to adopt solar, firms downward adjust worker labor input, around half of the total wage bill and 40% number of workers (Column (5)-(6), Table 6). While these point estimates are imprecise, the sizes are economically meaningful. Meanwhile, owners increase their own labor input to the firm by working longer hours (Column (7), Table 6).

5 Conclusion

This paper provides new evidence on how small firms in low-income contexts respond to the payment structure of credit contracts when evaluating renewable energy investment opportunities. Using a randomized subsidy design, we show that adoption of solar products is primarily constrained by liquidity at the point of purchase: firms are substantially more responsive to reductions in down payments than to reductions in repayments, which is driven by the owners who are head of their households. The majority of adopters under the tailored subsidy scheme chose to apply their subsidy to the upfront cost, underscoring the salience of immediate liquidity constraints.

We demonstrate the importance of analyzing demand in a two-dimensional price space, showing that collapsing payment schedules into a single price measure obscures critical demand responses. When examining demand over the two dimensions of current and future payments, we find household responsibilities interact with firm investment decisions, which may become barriers to small firm growth.

Despite a modest adoption rate, we find that adoption improves firms' perceptions of solar technology and that more-usage owners are more likely to select into adoption under a more flexible subsidy scheme. These downstream effects suggest that even small shifts in subsidy design and credit structure can meaningfully influence how small firms integrate renewable energy into their operations. Importantly, the differential selection patterns across subsidy arms demonstrate that contract design not only affects the likelihood of adoption but also shapes which types of firms adopt and how they subsequently use the technology.

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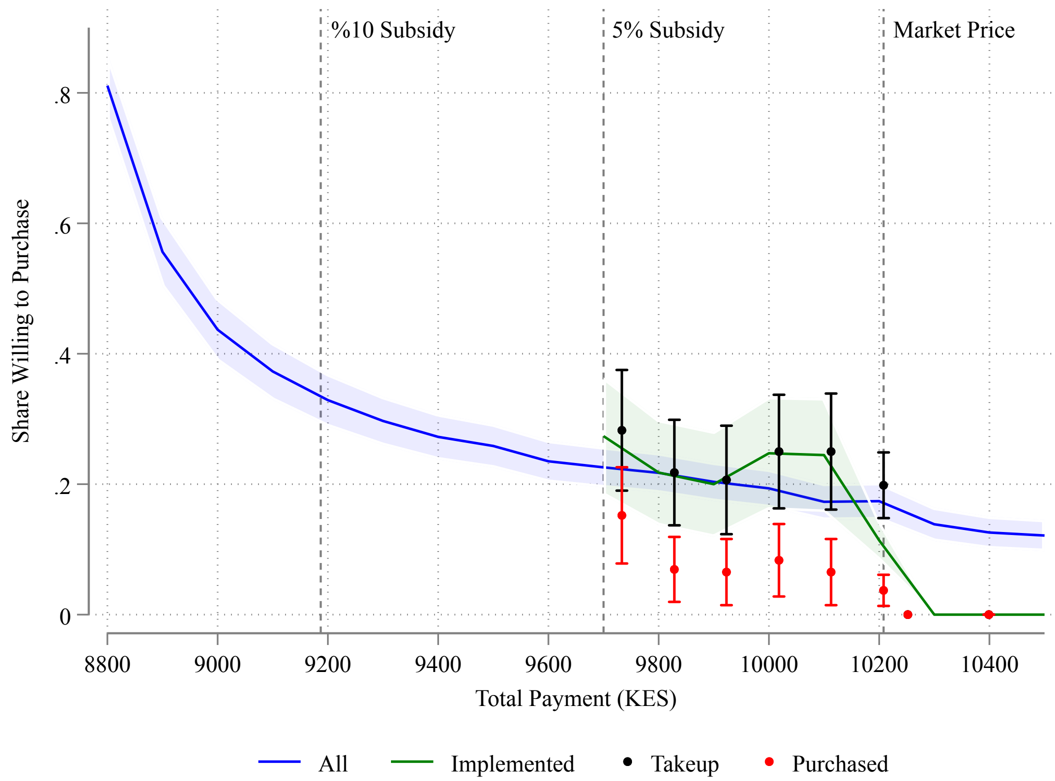
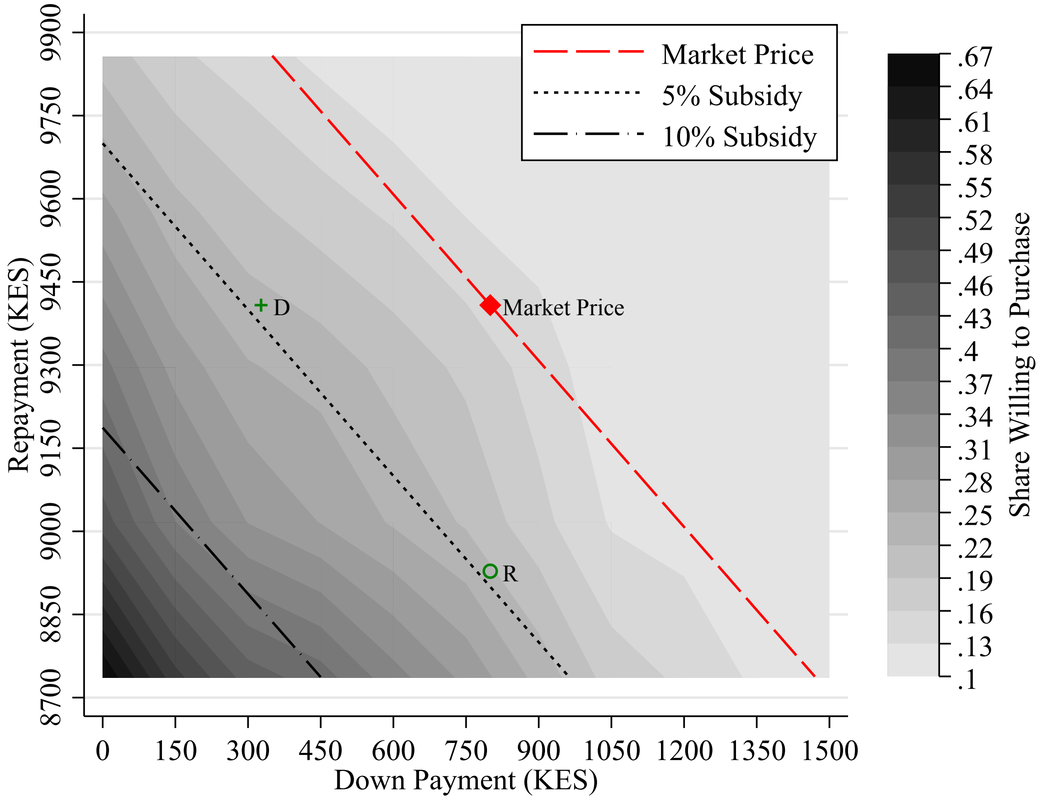
Figures

Figure 1: Demand for Solar Product by Total Payment



Notes: This figure shows the share of respondents willing to purchase the solar product at different price levels with a 95% confidence band, measured using contracts in all the BACE questions (blue) and contracts only in the implemented questions (green). The figure also shows the take-up (black) and purchase (red) rates with 95% confidence intervals at different price levels, corresponding to the treatment assignment and 5 random subsidy levels. Total Payment equals the arithmetic sum of the down payment and all repayments at their face value, essentially assuming a zero discount rate. “Share willing to purchase" equals the share of respondents willing to purchase the solar product with a total payment falling in different 100 KES bins. A respondent is “willing to purchase” the product at a total payment in a certain bin, either if they select to accept a contract in this bin in any of the BACE questions, or if they are never offered a contract in this bin while selecting to accept a contract in a more expensive bin. A respondent is “not willing to purchase” the product at a total payment in a certain bin, either if they select not to accept a contract in this bin in any of the BACE questions, or if they are never offered a contract in this bin while selecting not to accept a contract in a cheaper bin. The blue curve is based on responses to all BACE questions. The green curve is based on responses to the two contracts shown in the implemented question. The black dots are based on the responses to the preferred contract in the implemented question. The red dots are the share of respondents actually purchasing the solar product at their preferred contract in the implemented question. Each dot corresponds to a subsidy level. The dashed line shows the total payment of the prevailing market contract.

Figure 2: Demand for solar product by down payment and repayment



Notes: This figure shows the share of respondents willing to purchase the solar product at different down payment and repayment levels, measured using all contracts shown in the BACE questions. The x-axis is the value of down payment in KES. The y-axis is the weekly repayment (KES) for the first 4 weeks; weekly repayment for week 5 to week 56 is fixed at 168 KES. The grayscale scheme reflects the share of respondents willing to purchase the solar product at a contract with down payment in the corresponding down payment bins of 150 KES and weekly repayment of the first 4 weeks in the corresponding repayment bins of 70 KES, with a darker color corresponding to a higher demand. A respondent is "willing to purchase" the product at a contract in a certain bin either if they select to accept a contract in this bin in any of the BACE questions, or if they are never offered a contract in this bin while selecting to accept a contract in a bin with either higher down payment and/or higher repayment. A respondent is "not willing to purchase" the product at a contract in a certain bin, either if they select to not prefer or accept a contract in this bin in any of the BACE questions, or if they are never offered a contract in this bin in any of the BACE questions while selecting to not prefer or accept a contract in a bin with either cheaper down payment and/or cheaper repayment. The red diamond corresponds to the prevailing market contract (i.e., down payment of 800 KES and weekly repayment of 168 KES). The green dots correspond to the down payment (D) or repayment (R) subsidized contracts in the intervention with the largest subsidy level. The straight lines are equal-cost curves, each reflecting contracts with the same total payment calculated as the arithmetic sum of the down payment and all repayments. The red line shows all contracts with the same total payment as the market contract. The dotted (dashed) black line shows all contracts with a total payment 5% (10%) cheaper than the market contract.

Tables

Table 1: Treatment Effects on Demands

	ITT		IV			
	(1) Take-up	(2) Purchased	(3) Take-up	(4) Purchased	(5) Take-up	(6) Purchased
Tailored	0.0694	0.0934**				
	(0.0559)	(0.0399)				
Down	0.110*	0.125***				
	(0.0569)	(0.0411)				
Total Payment '00s			-0.0123	-0.0171***		
			(0.00919)	(0.00592)		
Down Payment '00s					-0.0195*	-0.0236***
					(0.0117)	(0.00763)
Repayment '00s					0.0135	0.00600
					(0.0268)	(0.0171)
Observations	724	724	724	724	724	724
Mean (Control)	0.19	0.04	0.19	0.04	0.19	0.04
Prob > F (T=D)	0.30	0.22				
Prob > F (D=R)					0.31	0.16
First stage F-stat			2800.69	2800.69	62.05	62.05
Sample	All	All	All	All	All	All

Notes: This table shows the treatment effects on demand, measured by within-game take-up and out-of-game purchase rates. The outcome "Take-up" indicates take-up of the solar product within-game, and "Purchased" equals one if the respondent purchased the solar product post-game. Columns (1)-(2) report the intent-to-treat (ITT) effects of the two treatment arms on demand; each regression includes strata fixed effects, subsidy fixed effects, and imbalanced baseline control variables. Columns (3)-(6) report instrumental variables estimates of the demand measured by purchase rate. In Columns (3) and (4), we instrument for total payment using the two treatment arm dummies and the random subsidy amount; in Columns (5)-(6), we instrument for down payment and total repayment using the two treatment arm dummies and the random subsidy amount. Total Payment is calculated as the simple arithmetic sum of the down payment and all future repayments (in 100 KES). Repayment is the simple arithmetic sum of all future repayments (in 100 KES). "Prob > F (T=D)" reports the p-value of the F-test on the equality of the two treatment effects. "Prob > F (D=R)" reports the p-value of the F-test on the equality of the down payment and the repayment. All regressions are estimated using the full sample. *, **, and *** represent statistical significance at 10, 5, and 1 percent levels, respectively.

Table 2: Heterogeneous Demand Elasticities

	(1) Purchased	(2) Purchased	(3) Purchased	(4) Purchased
Total Payment '00s	-0.0129	-0.0197**		
	(0.00882)	(0.00843)		
Down Payment '00s			-0.0271**	-0.0205**
			(0.0127)	(0.00939)
Repayment '00s			0.0361	-0.0202
			(0.0279)	(0.0237)
Observations	376	348	376	348
Mean (Control)	0.04	0.04	0.05	0.02
Prob > F (D=R)			0.08	0.99
First stage F-stat	1170.39	1670.45	20.93	41.15
Sample	Head	Non-Head	Head	Non-Head

Notes: This table shows the treatment effects on demand, measured by out-of-game purchase rates which equals one if the respondent purchased the solar product post-game. In Columns (1)-(2), we instrument for total payment using the two treatment arm dummies and the random subsidy amount; in Columns (3)-(4), we instrument for down payment and total repayment using the two treatment arm dummies and the random subsidy amount. Total Payment is calculated as the simple arithmetic sum of the down payment and all future repayments (in 100 KES). Repayment is the simple arithmetic sum of all future repayments (in 100 KES). "Prob > F (T=D)" reports the p-value of the F-test on the equality of the two treatment effects. "Prob > F (D=R)" reports the p-value of the F-test on the equality of the down payment and the repayment. Columns (1) and (3) are estimated using the sub-sample of owners who are their head of households, while Columns (2) and (4)are based on the subsample of non-household-heads. *, **, and *** represent statistical significance at 10, 5, and 1 percent levels, respectively.

Table 3: Heterogeneous Treatment Effects on Adoption

	(1) Purchased	(2) Purchased	(3) Purchased	(4) Purchased	(5) Purchased
Tailored Subsidy	0.134***	0.146***	0.146***	0.119***	0.259***
	(0.0467)	(0.0480)	(0.0566)	(0.0454)	(0.0712)
Down Payment Subsidy	0.134***	0.130***	0.135**	0.148***	0.183***
	(0.0444)	(0.0445)	(0.0562)	(0.0526)	(0.0696)
HH Head	0.0279				0.0295
	(0.0244)				(0.0255)
T X Head	-0.0769*				-0.0857**
	(0.0406)				(0.0411)
D X Head	-0.0130				-0.0194
	(0.0457)				(0.0452)
T X Liq Const		-0.0907**			-0.0892**
		(0.0408)			(0.0431)
D X Liq Const		0.000771			0.0156
		(0.0462)			(0.0465)
T X Risk Averse			-0.0775		-0.0803
			(0.0503)		(0.0516)
D X Risk Averse			-0.0169		-0.0230
			(0.0497)		(0.0501)
T X Low Profit				-0.0475	-0.0128
				(0.0437)	(0.0476)
D X Low Profit				-0.0399	-0.0466
				(0.0494)	(0.0504)
Observations	724	724	724	724	724
Mean (Control)	0.04	0.04	0.04	0.04	0.04
Prob > F	0.99	0.67	0.82	0.54	0.28
Prob > F (Het)	0.07	0.02	0.09	0.21	

Notes: This table shows the treatment effects on solar product adoption by various heterogeneity cuts. Head indicates whether the owner is the head of their household. Liq. Cons. equals one if the owner-reported household liquidity, measured by the amount of money that can be collected in a week in case of emergency, is no more than 6500 KES in the baseline round. Risk Averse equals one if the lowest amount of sure payment that a respondent prefers over a lottery of 50-50 chance of winning KES 200 or nothing is less than KES 100. Low Profit equals one if the baseline monthly profits from the business is less than KES 10,000, which is the 75th percentile in the data. Regressions include the heterogeneity cut variable(s), strata fixed effects, imbalanced baseline control variables and subsidy fixed effects. "Prob > F (T=D)" reports the p-value of the F-test on the equality of the treatment effects in the group without the heterogeneity characteristic(s). "Prob > F (T=D, Het)" reports the p-value of the F-test on the equality of the treatment effects in the group with the heterogeneity characteristic(s). *, **, and *** represent statistical significance at 10, 5, and 1 percent levels, respectively.

Table 4: Treatment Effects on Owner Beliefs

	(1) Score	(2) Superior	(3) Score Increase	(4) Nakuru Solar Increase
Panel A: Unconditional				
Tailored	0.821*	0.0982	0.0877	0.151**
	(0.444)	(0.0744)	(0.0768)	(0.0754)
Down	0.859*	0.149**	0.0591	0.124*
	(0.455)	(0.0742)	(0.0762)	(0.0749)
Observations	537	537	537	537
Mean (Control)	5.00	0.48	0.47	0.45
Prob > F (T=D)	0.91	0.33	0.59	0.60
Panel B: Conditional on survival				
Tailored	0.854*	0.102	0.0916	0.159**
	(0.441)	(0.0753)	(0.0775)	(0.0754)
Down	0.814*	0.146*	0.0548	0.121
	(0.454)	(0.0748)	(0.0767)	(0.0749)
Observations	530	530	530	530
Mean (Control)	5.09	0.49	0.48	0.45
Prob > F (T=D)	0.91	0.41	0.49	0.47

Notes: This table shows the treatment effects on owner beliefs about solar usefulness and usage. Panel A is unconditional on firm survival; every non-attrited owner response is included. Panel B is conditional on firm survival. Score (scaled between 0 and 10) measures the respondent's view on the usefulness of the solar light compared with a traditional electricity lamp, with 5 being comparable/substitutable and 10 being very superior. Superior equals one if the usefulness score is greater than 5. Score increase equals one if the usefulness score in November 2024 is equal to or greater than their responses in June 2024 (baseline). Nakuru solar increase indicates whether the respondent thinks the share of owners in Nakuru that have adopted solar products in November 2024 is equal to or greater than that in June 2024. Regressions include strata fixed effects, imbalanced baseline control variables, and subsidy fixed effects. "Prob > F (T=D)" reports the p-value of the F-test on the equality of the treatment effects. *, **, and *** represent statistical significance at 10, 5, and 1 percent levels, respectively.

Table 5: Treatment Effects on Firm Performance

	(1) Operate	(2) Days Open	(3) Operate after Sunset	(4) Assets	(5) Sales	(6) Profits
Panel A: Unconditional						
Tailored	-0.00665	0.707	0.0123	-2101.7	588.3	-600.6
	(0.0216)	(0.686)	(0.0436)	(8139.4)	(5224.2)	(1299.9)
Down	0.00817	0.502	-0.00104	-2749.7	1676.7	642.8
	(0.0161)	(0.600)	(0.0455)	(9206.2)	(5026.1)	(1415.8)
Observations	537	537	537	535	534	533
Mean (Control)	0.98	26.52	0.83	41858.65	24944.13	8153.09
Prob > F (T=D)	0.22	0.66	0.68	0.91	0.78	0.24
Panel B: Conditional on survival						
Tailored		0.869**	0.00980	-1325.8	896.7	-546.0
		(0.404)	(0.0422)	(8291.4)	(5347.0)	(1319.4)
Down		0.266	-0.0140	-2657.8	1675.7	609.7
		(0.421)	(0.0442)	(9296.7)	(5095.5)	(1424.1)
Observations		530	530	528	527	526
Mean (Control)		26.97	0.84	42576.23	25369.32	8292.86
Prob > F (T=D)		0.09	0.45	0.82	0.85	0.28

Notes: This table shows the treatment effects on firm performance in November 2024 (reference month). Panel A is unconditional on firm survival; every non-attrited owner response is included. Panel B is conditional on firm survival. Top 1 percent of sales, profits and assets are winsorized. Operate is a dummy indicating the the reference business is operating in the reference month. Days Open measures the number of days that the reference business is operating during the reference month. Operate after Sunset equals one if the owner reports to be operating the reference business after sunset. Regressions include strata fixed effects, imbalanced baseline control variables and subsidy fixed effects. "Prob > F (T=D)" reports the p-value of the F-test on the equality of the treatment effects. *, **, and *** represent statistical significance at 10, 5, and 1 percent levels, respectively.

Table 6: Treatment Effects on Firm Input

	(1) No Power	(2) Solar Cost	(3) Grid Cost	(4) Tot. Elc. Cost	(5) Wagebill	(6) Num. Workers	(7) Hours
Panel A: Unconditional							
Tailored	-0.0549	51.67	-62.85	9.607	-573.4	-0.112	5.895
	(0.0497)	(42.33)	(83.48)	(98.19)	(417.6)	(0.0747)	(3.928)
Down	-0.0273	-4.707	-45.42	-60.22	-504.2	-0.0976	2.923
	(0.0490)	(35.35)	(71.47)	(83.78)	(420.8)	(0.0749)	(3.827)
Observations	537	536	534	537	536	537	537
Mean (Control)	0.29	59.89	464.36	544.51	1145.81	0.26	61.96
Prob > F (T=D)	0.47	0.10	0.86	0.53	0.80	0.80	0.31
Panel B: Conditional on survival							
Tailored	-0.0520	53.31	-57.61	16.88	-570.4	-0.113	6.408*
	(0.0501)	(43.15)	(85.19)	(100.0)	(425.3)	(0.0759)	(3.755)
Down	-0.0280	-4.115	-48.13	-62.15	-512.2	-0.100	2.493
	(0.0491)	(35.60)	(71.08)	(83.34)	(427.1)	(0.0759)	(3.737)
Observations	530	529	527	530	529	530	530
Mean (Control)	0.30	60.91	472.27	553.80	1165.34	0.27	63.01
Prob > F (T=D)	0.53	0.10	0.92	0.48	0.83	0.83	0.18

Notes: This table shows the treatment effects on firm operational inputs in November 2024 (the reference month). Panel A is unconditional on firm survival; every non-attrited owner response is included. Panel B is conditional on firm survival. No power equals one if the reference business does not use any of the electricity sources in the reference month. Solar Cost is the total spending on using solar panels at the reference business in the reference month. Grid Cost is the total spending on on-the-grid electricity in the reference month. Tot. Elc. Cost is the total amount of spending on electricity across different sources, including grid, solar, batteries, and generators, in the reference month. Wagebill is the total amount of wages paid to all workers in the reference month. Num. Workers is the number of individuals providing positive number of hours of work to the reference business in the reference month. Hours it the number of hours that the owner worked at the reference business in a typical week in the reference month. Regressions include strata fixed effects, imbalanced baseline control variables and subsidy fixed effects. "Prob > F (T=D)" reports the p-value of the F-test on the equality of the treatment effects. *, **, and *** represent statistical significance at 10, 5, and 1 percent levels, respectively.

Appendices

Appendix A Appendix Figures

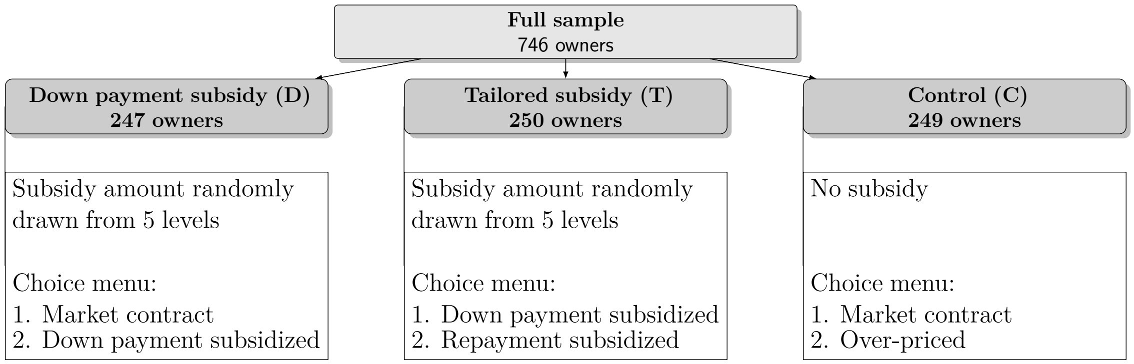
Figure A.1: Sample of Portable Solar Light

Notes: This figure presents the sample of the solar product we subsidized in the experiment. The product includes a 5W solar panel which is light-weight and portable, and a Flexx12 device. The Flexx12 integrates a keypad to input passcode for unlocking the device (front), a light with adjustable brightness (back), a radio/music player with bluetooth function, and a battery that supports USB input and output. The product is marketed with two pricing schemes: cash purchase at KES 6500, or credit purchase with down payment of KES 800 and 390 (56) daily (weekly) repayment of KES 24 (KES 168). If purchased with credit, the product has pay-as-you-go function where passcodes will be provided after payments are made, and can be keyed in to unlock the product for the period of time paid for.

Figure A.2: Enumeration Areas in Ronda, Nakuru of Kenya

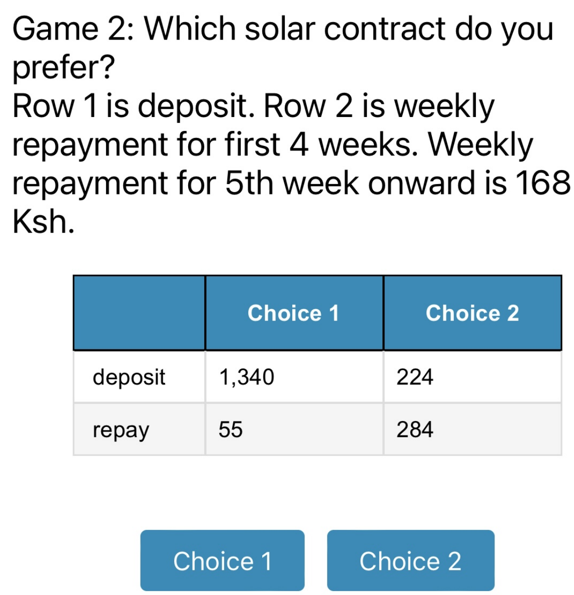
Notes: This figure shows the enumeration areas in Ronda, a low-income neighborhood of Nakuru City of Kenya. We divide Ronda into 6 enumeration areas by major roads in town. Each enumeration area is canvased by a pair of enumerators, onboarding every business operating from a permanent structure, from a household with signage observable from outside, or from a mobile structure.

Figure A.3: Randomization Design across Treatment Arms



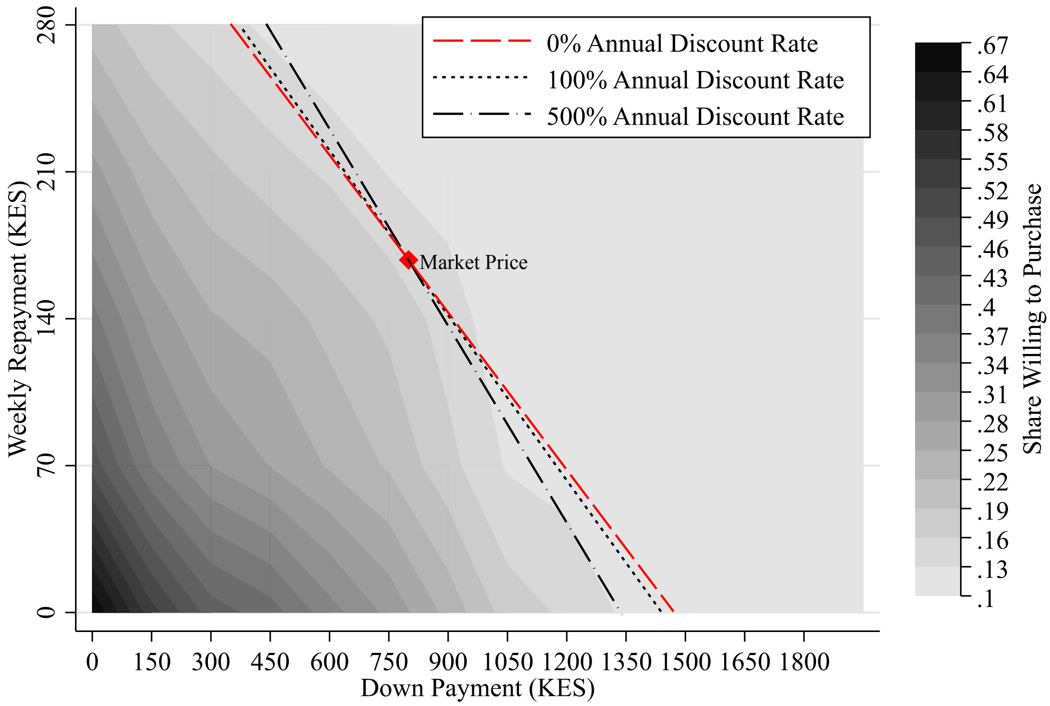
Notes: This flowchart shows the random assignment of eligible business owners across three treatment arms. Randomization is conducted at the owner level and stratified by whether the business has access to on-the-grid electricity, and whether the owner has purchased any solar products. Owners are first randomly assigned into the down payment subsidy group, the tailored subsidy group, or the control group. Within the two subsidy groups, owners are randomly assigned a subsidy amount from five different subsidy levels. The subsidy levels are KES 95, KES 189, KES 284, KES 378 and KES 473. In the down payment-subsidized contract, the corresponding subsidy amount is directly subtracted from the market down payment of KES 800. In the repayment-subsidized contract, a subsidy amount of KES 24, KES 48, KES 72, KES 96 or KES 120 is subtracted from the market weekly repayment of KES 168 for the first 4 weeks. The total present values of the repayment subsidies are equivalent to the corresponding down payment subsidies.

Figure A.4: Game Interface of One of the 16 Questions



Notes: This figure is a screenshot of the interface that respondents see when completing the BACE procedure, which shows one of the 16 questions. The interface shows the second of the 16 questions, where the respondent needs to make a discrete choice over which one of the two contracts is preferred. Once the decision is made, the respondent will be prompted to indicate whether they are willing to purchase the solar product with this preferred contract. "Deposit" refers to the down payment, which is a locally accepted term in this context. "Repay" refers to the weekly repayment amount for the first 4 weeks.

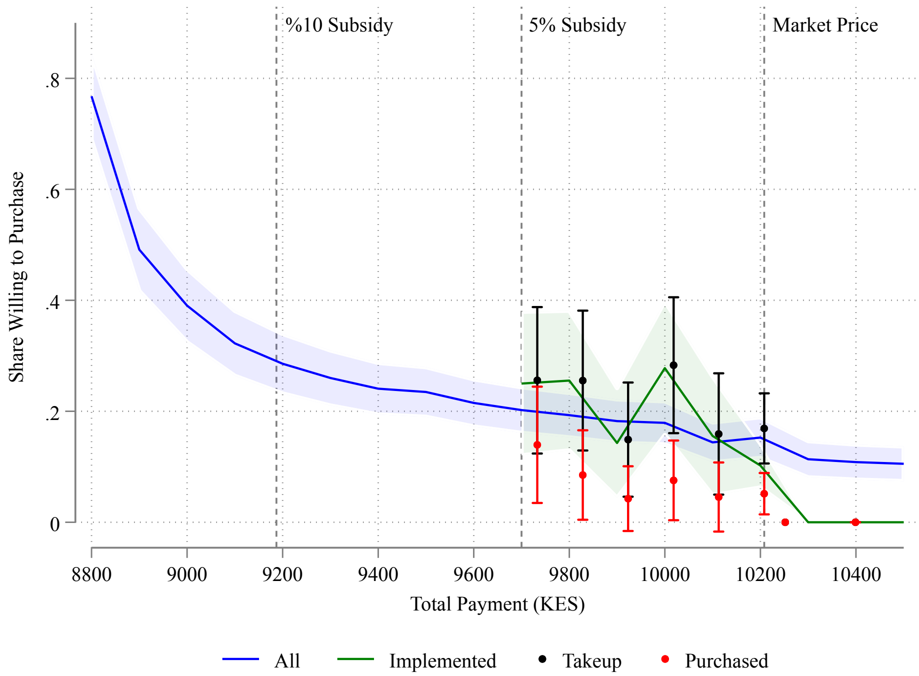
Figure A.5: Demand for solar product by down payment and repayment with different discount rates



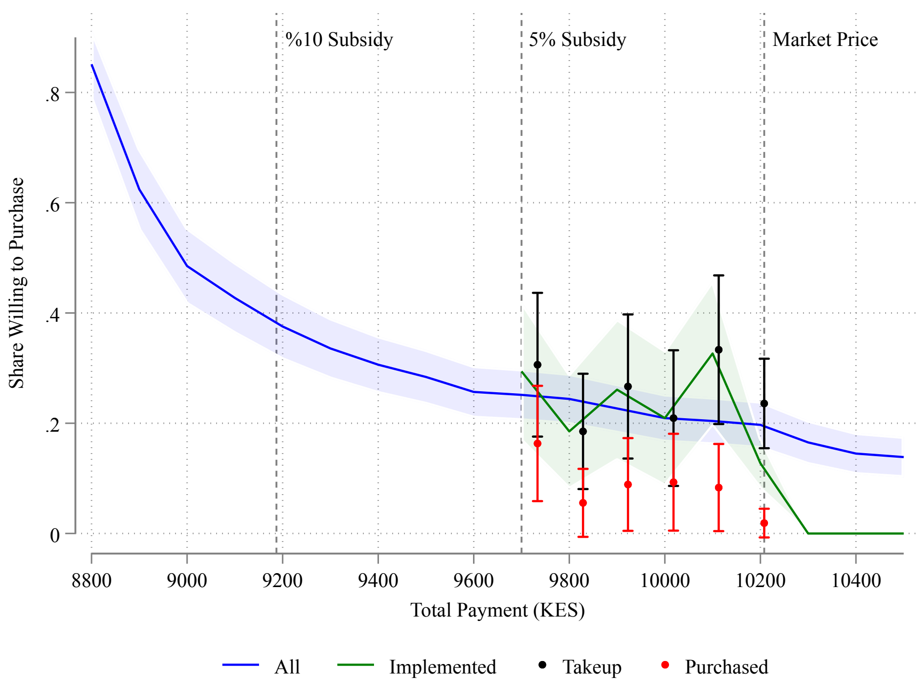
Notes: This figure shows the share of respondents willing to purchase the solar product at different down payment and repayment levels, measured using all contracts shown in the BACE questions. The x-axis is the value of down payment in KES. The y-axis is the weekly repayment (KES) for the first 4 weeks; weekly repayment for week 5 to week 56 is fixed at 168 KES. The color scheme reflects the share of respondents willing to purchase the solar product at a contract with down payment in the corresponding down payment bins of 150 KES and weekly repayment of the first 4 weeks in the corresponding repayment bins of 70 KES. A respondent is "willing to purchase" the product at a contract in a certain bin either if they select to accept a contract in this bin in any of the BACE questions, or if they are never offered a contract in this bin in any of the BACE questions while selecting to accept a contract in a strictly more expensive bin. A respondent is "not willing to purchase" the product at a contract in a certain bin, either if they select to not prefer or accept a contract in this bin in any of the BACE questions, or if they are never offered a contract in this bin in any of the BACE questions while selecting to not prefer or accept a contract in a strictly cheaper bin. The red diamond corresponds to the prevailing market contract. The straight lines are equal-cost curves with different discount rates, each reflecting contracts with the same total payment calculated as the total present value of the down payment and all repayments. The red line shows all contracts with the same total payment as the market contract, assuming a zero discount rate (i.e., arithmetic sum of all payments). The dotted (dash-dotted) black line shows all contracts with the same total payment as the market contract, assuming a 100% (500%) annual discount rate.

Figure A.6: Demand for Solar Product by Total Payment in Subsamples

Panel (a) Household Head



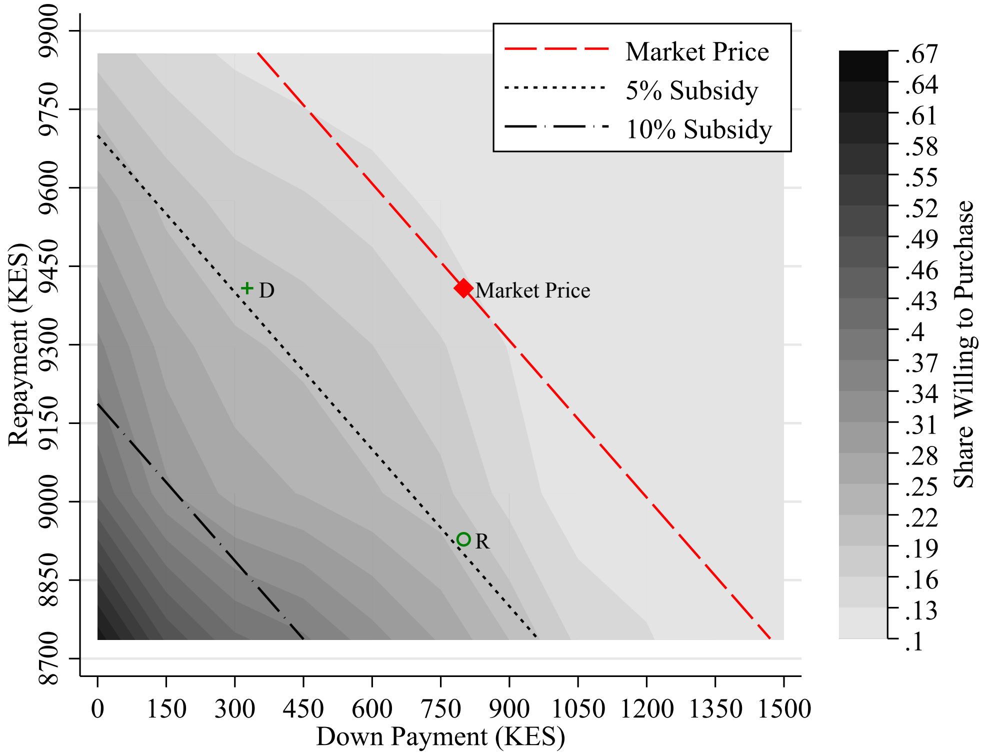
Panel (b) Non-head



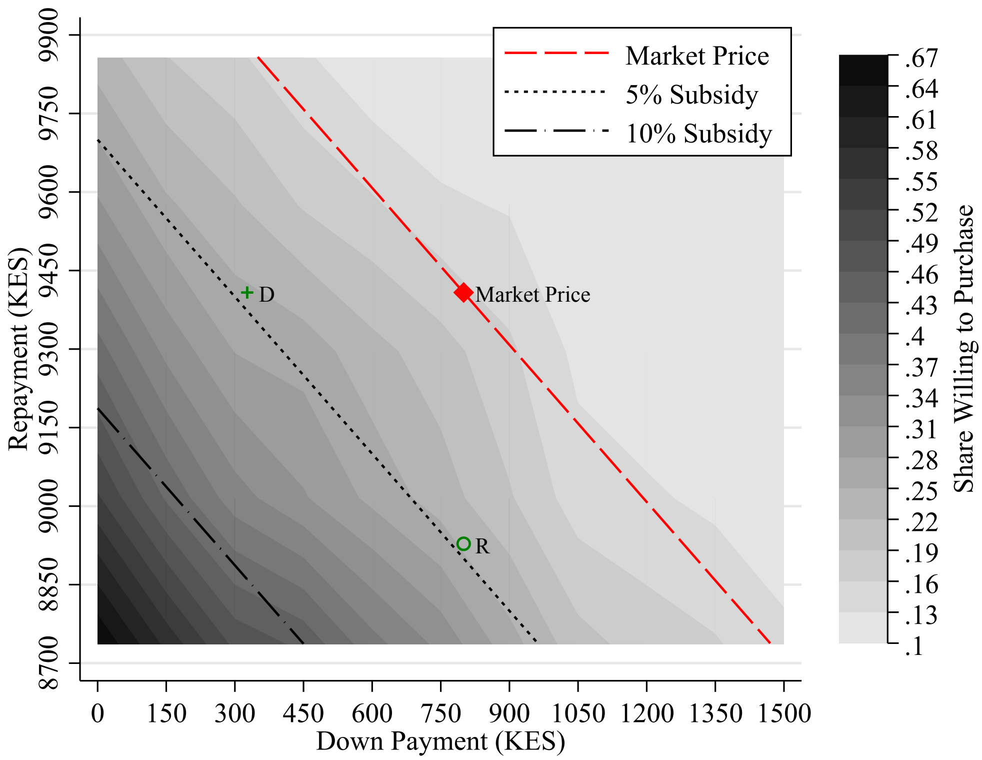
Notes: Here we construct Figure 1 using different subsamples. Panel (a) is based on all respondents who are the head of their household. Panel (b) is based on non-household heads.

Figure A.7: Demand for Solar Product by Down Payment and Repayment in Subsamples

Panel (a) Household Head



Panel (b) Non-head



Notes: Here we construct Figure 2 using different subsamples. Panel (a) is based on all respondents who are the head of their household. Panel (b) is based on non-household heads.

Appendix B Appendix Tables

Table B.1: Attrition in Treatment and Follow-up Survey

	(1) Treatment	(2) Follow-up	(3) Both
Tailored	-0.0121	-0.00140	-0.00811
	(0.0163)	(0.0402)	(0.0126)
Down	-0.0200	-0.00235	-0.0161
	(0.0153)	(0.0400)	(0.0113)
Observations	746	746	746
Mean (Control)	0.04	0.28	0.02
Prob > F (T=D)	0.57	0.98	0.42

Notes: This table compares the attrition rate by treatment arms in the intervention round and in the follow-up round. Regressions are based on a balanced panel of 746 firms. Attrition equals one if the respondent is not reachable or refused to participate in the survey. Regressions include strata fixed effects. "Prob > F (T=D)" reports the p-value of the F-test on the equality of the treatment effects. *, **, and *** represent statistical significance at 10, 5, and 1 percent levels, respectively.

Table B.2: Baseline Summary Statistics and Balance

	All	Control	Down Payment Subsidy		Tailored Subsidy		D - T		N
	mean	mean	diff	(diff=0) p-val	diff	(diff=0) p-val	diff	(diff=0) p-val	
Female	0.72	0.69	0.04	(0.33)	0.04	(0.29)	0.00	(0.94)	746
Age	37.62	37.04	0.97	(0.31)	0.78	(0.43)	-0.19	(0.84)	746
Household head	0.51	0.56	-0.08*	(0.09)	-0.05	(0.22)	0.02	(0.62)	746
Num. boys	0.98	0.96	0.02	(0.81)	0.04	(0.68)	0.02	(0.85)	746
Num. girls	1.03	1.01	0.03	(0.80)	0.03	(0.78)	0.00	(0.97)	746
Num. men	0.76	0.68	0.13	(0.12)	0.12	(0.13)	-0.00	(0.96)	746
Num. women	0.46	0.43	0.04	(0.56)	0.05	(0.48)	0.01	(0.89)	746
Secondary school	0.12	0.14	-0.01	(0.82)	-0.03	(0.26)	-0.03	(0.37)	746
Emergency fund	13332.39	14135.74	-2274.31	(0.22)	-222.59	(0.91)	2051.72	(0.23)	744
Operate after sunset	0.84	0.88	-0.07**	(0.03)	-0.05*	(0.09)	0.02	(0.64)	746
Owner hours	65.75	65.16	-1.03	(0.62)	2.72	(0.19)	3.75*	(0.09)	746
Sales	32623.70	33486.87	-1689.97	(0.63)	-975.50	(0.76)	714.47	(0.82)	744
Profits	11096.55	11100.05	-277.95	(0.81)	228.85	(0.84)	506.80	(0.66)	744
Has worker	0.08	0.09	-0.01	(0.76)	-0.03	(0.16)	-0.02	(0.28)	746
Cost for solar	86.45	105.77	-20.75	(0.61)	-36.90	(0.12)	-16.15	(0.67)	746
Cost for KPLC	436.06	453.83	-91.78	(0.13)	39.90	(0.58)	131.68**	(0.04)	738
Machinery and Equipment	5987.25	5010.04	2795.16	(0.30)	99.72	(0.97)	-2695.44	(0.26)	745
Any asset on-credit	0.07	0.08	-0.01	(0.64)	-0.03	(0.14)	-0.02	(0.31)	745
Customer distance	41.53	38.16	8.73	(0.45)	1.38	(0.90)	-7.35	(0.55)	746
Risk averse	0.70	0.70	-0.01	(0.88)	-0.01	(0.79)	-0.00	(0.91)	746
Risk aversion	20.91	21.18	-0.27	(0.96)	-0.53	(0.93)	-0.26	(0.96)	746
F-test of joint sig. (p-value)				(0.33)		(0.21)		(0.50)	

Notes: This table provides summary statistics and balance tests. Each coefficient is from a separate regression of baseline covariates on treatment assignments and strata fixed effects. Randomization is stratified by access to on-the-grid electricity and past experience in purchasing solar products. *, **, and *** represent statistical significance at 10, 5, and 1 percent levels, respectively.

Table B.3: Comparison of Baseline Characteristics between Household Heads and Non-heads

	All	Head	NonHead	Head - NonHead		
	mean	mean	mean	diff	(diff=0) p-val	N
Female	0.72	0.49	0.96	-0.46***	(0.00)	746
Age	37.62	38.86	36.31	2.56***	(0.00)	746
Num. boys	0.98	0.79	1.19	-0.39***	(0.00)	746
Num. girls	1.03	0.81	1.26	-0.45***	(0.00)	746
Num. men incl. owner	1.04	0.84	1.26	-0.41***	(0.00)	746
Num. women incl. owner	1.18	1.08	1.28	-0.20***	(0.00)	746
Bread winner	0.60	0.79	0.40	0.39***	(0.00)	739
HH Income per capita	5937.22	6731.15	5096.84	1634.31***	(0.00)	739
Emergency fund per capita	4325.83	5875.66	2690.37	3185.28***	(0.00)	744
Sales	32623.70	37631.67	27310.53	10321.14***	(0.00)	744
Profits	11096.55	12685.85	9410.39	3275.46***	(0.00)	744
Assets	57262.85	68535.80	45335.95	23199.85***	(0.00)	745
Machinery and Equipment	5987.25	6535.25	5407.46	1127.79	(0.58)	745
Operate after sunset	0.84	0.83	0.85	-0.03	(0.34)	746
Owner hours	65.75	66.91	64.51	2.40	(0.18)	746
Has worker	0.08	0.09	0.06	0.02	(0.24)	746
Cost for electricity	521.74	560.96	480.14	80.82	(0.23)	746
Customer distance	41.53	37.24	46.08	-8.84	(0.35)	746
Risk averse	0.70	0.71	0.69	0.02	(0.60)	746
Liq. constrained	0.55	0.53	0.57	-0.04	(0.33)	746
N	746	384	362			
F-test of joint sig. (p-value)				(0.00)		

Notes: This table provides summary statistics between owners who are the head of their households and those who are not. Each coefficient is from a separate regression of baseline covariates on the household head status. Standard errors are clustered at individual level. *, **, and *** represent statistical significance at 10, 5, and 1 percent levels, respectively.

Table B.4: Curvature in BACE-elicited Demand at Different Price Ranges

	High Price			Low Price		
	(1)	(2)	(3)	(4)	(5)	(6)
	% Take-up	% Take-up	% Take-up	% Take-up	% Take-up	% Take-up
Down Payment '00s	0.161	0.457	-0.193	-1.063***	-1.144***	-0.947*
	(0.213)	(0.301)	(0.303)	(0.339)	(0.418)	(0.533)
Down Payment '00s Squared	-0.0340**	-0.0557***	-0.00824	0.0971***	0.113**	0.0776
	(0.0132)	(0.0189)	(0.0185)	(0.0370)	(0.0459)	(0.0584)
Observations	13060	6843	6217	7791	4020	3771
Mean (Zero Down)	20.62	17.89	23.62	33.20	30.42	36.05
Sample	All	Head	NonHead	All	Head	NonHead

Notes: This table tests the curvature of demand (in percentage points) given the same total payment, varying the down payment (thus repayment) as shown in Figures 2 and A.7. The outcome variable equals 100 if a respondent is willing to purchase the solar product at the given contract, and equals 0 otherwise. Each regression controls for total payment fixed effects. "Down Payment '00s" refers to the amount of down payment in 100 KES. "Down Payment '00s Squared" is the squared term of the down payment in 100 KES. "High Price" sample includesprice grids with total payment between 95-100% of the market contract total payment; "Low Price" sample includes price grids with total payment between 90-94% of the market contract total payment. "Mean (Zero Down)" is the average take-up rate in contracts in the corresponding price range with zero down payment. *, **, and *** represent statistical significance at 10, 5, and 1 percent levels, respectively.