Paying to Repay? Experimental Evidence on Repayment Commitment

Eilin L. Francis *

July 31, 2018

Abstract

This paper studies the demand for, and welfare impacts of, costly self-control. I offer Malawian micro-entrepreneurs solar lamps for purchase, for which payment can be completed either in weekly installments or as a single deferred lump sum payment. An incentive-compatible willingness-to-pay experiment reveals that individuals are willing to pay a premium of nearly 22 percent of the price of the solar device to pay for it in weekly installments. Lack of access to secure savings technologies, and demand for self control rules can both drive demand for the installments plan. To identify the relative importance of each of these factors, I induce experimental variation in access to a secure savings technology. Despite a 15 percent reduction in the premium among those given the savings technology, it remains large and significant indicating that there are barriers to saving beyond access to basic savings products. Paying in installments increases the probability of timely completion of payment by 13 percentage points, but defaulters are hurt more by the installments plan than the lump sum plan.

Keywords: self control, commitment contract, solar lamps, field experiment.

JEL Classification: D01, D12, D14, D91, O15, Q21.

*Department of Economics, University of California, Santa Cruz, Santa Cruz. Email: elfranci@ucsc.edu. I am exceedingly grateful to my advisor, Jonathan Robinson. His guidance, and extraordinary support were crucial to this work. I am very thankful to Ajay Shenoy and Jesse Cunha for their guidance and the many conversations that led to this paper. I thank Nirvikar Singh, Shilpa Aggarwal, Valentina Brailovskaya, George Bulman, Brian Giera, Jithin Joseph, Dahyeon Jeong, Bryan Pratt, and Kristian Lopez Vargas and seminar participants at UC Santa Cruz, the University of San Francisco, and JPAL for comments and suggestions. SunnyMoney Malawi was a fantastic implementation partner, and I am esQpecially grateful to Natalia Walton for patiently working on multiple tests of the repayment plans. This work would not have been possible without field assistance of Catherine Mwafulirwa, Kennedy Banda, Milward Chanthomba, Kennedy Chavula, Fredrick Chipokasa, Dennis Kachenje, Kettie Mgala, Justina Mwambira, Gerald Ndalma, and Freddie Ngulwe. This research protocol was approved by the UC Santa Cruz IRB and the National Committee on Research in Social Science and Humanities, Malawi. Financial support for this project was provided by the Department of Economics, UC Santa Cruz, UC Santa Cruz Blum Center, and UC Santa Cruz Disseration Year Fellowship. This trial is registered with the American Economic Association's registry for randomized control trials (AEARCTR-0002309). All errors are my own.

1 Introduction

Self control can be elusive – rarely persistent, and always difficult. Consequently, many choose to restrict choice sets of future behavior. This strategy is at least weakly dominated from a neo-classical perspective, but it can often be an effective way to reduce the effort cost of resisting temptation. For example, many choose contracts that commit to future provision of effort (Augenblick, Niederle and Sprenger, 2015; Kaur, Kremer and Mullainathan, 2015) even when such contracts are costly (Vigna and Malmendier, 2006), and may not always be optimal (Ariely and Wertenbroch, 2002).[1] Failure at self control can have negative consequences, and these consequences can be particularly severe for the poor[2] by preventing them from making useful and necessary investments.[3] In this paper, I study the demand for, and welfare impacts of, costly self control among Malawian micro-entrepreneurs. The study population is offered a solar lamp for purchase – a very useful investment for this population who are overwhelmingly disconnected from the electric grid. Then, among those who receive the offer to purchase the solar lamp, I elicit willingness to pay for the lamp with one of two types of deferred payment plan.

With the deferred payment plan, the solar lamp has to be completely paid either in eight equal, weekly installments or as a single lump sum paid at the *end* of eight weeks. The installments plan is designed to be a costly repayment strategy in this experiment. First, the solar light supports a technology that causes the light to become "inactive" every time a scheduled payment is not fulfilled. An inactive device does not provide energy and remains unusable until outstanding payment is covered completely. So, those who choose to pay in installments face the risk of the lamp switching to inactive status each time they are unable to adhere by the weekly payment

[1] The classical perspective of decision utility assumes that preferences that are consistent with each other, and with the axioms of rational choice are utility-maximizing. A behavioral framework of decision-making, on the other hand, does not assume that utility is always maximized. As Kahneman and Thaler (2006) discuss, individuals do not always make accurate predictions of future outcomes when making choices, and hence choices may not always maximize utility. For example, Ariely and Wertenbroch (2002) find that students set deadlines to force self control rules. While the deadlines improve performance, students do not select optimal deadlines.

[2] Moreover, exercising self control can be more effortful for the poor. The cognitive load of pressing, and persistent budgetary concerns may make the poor more likely to fail at exercising self-control (Mani et al., 2013).

[3] The literature provides several examples of useful and cost-effective investments that require large lump sums. A behavioral model can explain why individuals may find it difficult to save to fulfil some of these investments needs, for example in agriculture (Duflo, Kremer and Robinson, 2011; Beaman et al., 2015) or health (Dupas and Robinson, 2013*b*; Tarozzi et al., 2014)

schedule. Next, for those with investment opportunities with a positive return, the most obvious cost of the installment plan is foregone returns on investment, which is usually quite high among micro-enterprises in the developing world.[4] Paying in installments also leads to less liquidity. This can be a considerable cost with serious impacts for the poor or those with limited access to liquidity or credit.[5] Finally, the experimental installment price is often higher than the lump price, resulting in the installment plan being straightforwardly more expensive.

An incentive-compatible willingness-to-pay (WTP) experiment is used to measure revealed preference to pay in installments. In this exercise, individuals choose whether to pay the lump sum price, P_L =MWK 20,000,[6] as one deferred lump sum amount, or an installment price $P_{ins} = P_L(1 + r)$ in equal, weekly installments. Every respondent makes this choice for each $r \in$ (-0.10, 0, 0.10, 0.20, 0.25, 0.30). Next, to compare demand with installment and lump sum plan, every respondent is asked whether she would purchase the lamp at P_{ins} paid as a deferred lump sum at the end of eight weeks. Thus, the WTP exercise records twelve responses for each individual in the deferred payment group. Before they make these choices, all respondents are informed that the solar lamp will be shut off when a payment is not completed. The results indicate that individuals are willing to pay a premium for the rigid installments plan. At installment prices that are equal to or greater than the lump sum price, 92 percent of the population choose to pay in installments. When the installment price is strictly greater than the lump sum price, 75 percent of the population still choose to pay in installments. And, at every price, demand is far greater if payment is completed in installments, rather than as a deferred lump sum.[7]

Demand for installments may be driven by at least two challenges to save – lack of a secure place to hold savings, and intra-personal conflicts that undermine savings plans. In the absence of a secure place to hold savings, individuals may worry about theft of their savings, especially liquid

[4]For example, De Mel, McKenzie and Woodruff (2008) and Karlan and Zinman (2009).

[5]Jacoby and Skoufias (1997) and Duryea, Lam and Levison (2007) provide evidence that poor households respond to shocks by reducing schooling and increasing child labor.

[6]At the time of the experiment, the exchange rate was roughly MWK 720/USD 1.

[7]Time-payments are popular in other contexts because they allow for relatively low-cost experimentation of unfamiliar technology (Mobarak et al., 2012). However, in this study setting choosing the lump sum plan is the cheaper contract to experiment with solar technology, because with this plan the lamp can be used without any payment for eight weeks.

savings. In fact, 12 percent of respondents cite this as the reason for choosing the installments plan (Table A1). The installments plan can also help impose self control rules. Abandoning self control rules, and succumbing to temptation is usually associated with positive utility in the contemporaneous period, and negative or zero utility in the future. The installments plan distorts this outcome by generating immediate negative utility (of the lamp turning off) when breaking self control rules. This, in turn, reduces the benefit of giving in to temptation, and consequently, the effort cost associated with resisting temptation is lowered. Second, individuals may be tempted to spend savings that are at their disposal, especially when these savings are accumulated in small denominations. The installments plan is an effective way to prevent future selves from diverting savings to other uses. In this sample, 70 percent of respondents report choosing the installments plan as a mechanism to impose self control.

In order to distinguish between these drivers of the demand for installments, I provide access to a secure savings technology – a lockbox (with padlock and key)– to one half of the population, and encourage them to use this lockbox to save for the solar lamp. Importantly, the lockbox is provided before the WTP experiment is implemented. Because respondents retain access to the key, the lockbox is unlikely to have a meaningful impact on exercising self control.[8] I compare the premium that individuals with and without the box are willing to pay for the installments plan and find that respondents who are not offered the lockbox are willing to pay about 22 percent of the lamp's price as a premium for the installments plan. In the group that is offered the box, this premium reduces by a significant 15 percentage points – a reduction that is attributable to gaining access to a secure place to hold savings. Despite this reduction, the demand for installments continues to be significant. Thus, lack of access to a secure place is an important, but not the only, reason to demand the installments plan. The costly task of imposing self control rules continues to be an important determinant of the demand for installments.

Paying in installments can be helpful for some people. The probability of completely paying for

[8] Dupas and Robinson (2013*b*) show that a lockbox can be helpful in increasing savings by offering a secure storage technology. In the present experiment, users retain access to the key. Hence, they can access money in the lockbox quite easily. And while withdrawing money from the lockbox may induce some transactional cost (relative to accessing money on the person, for example) or some psychic cost (associated with mental accounting), these costs may not provide strong self control rules.

the lamp within the scheduled time increases by 10-13 percent in the installments group. But, commitment can be utility-reducing. This experiment is designed to measure one way through which the repayment plan affects individual-utility – the probability of having a solar lamp that is fully paid for at the end of the study period. This strategy allows precise, albeit narrow, measure of the welfare impacts of the installment plan. The installment plan increases probability of having an active lamp by about 10-13 percentage points. But, those who failed to complete payment were hurt more by the installments plan than the lump sum plan. On average, 65 percent of those who failed to complete payment in the installment group made at least one installment payment towards the lamp. And, defaulters on the installment plan had the light shut-off for nearly three weeks due to incomplete payment. Everyone who failed to complete paying for the lamp in the lump sum group was able to use it for eight weeks, without making any payment.[9]

After completing the WTP exercise, the solar lamp is offered for purchase at MWK 20,000 and on a randomly determined repayment plan (either installments or deferred lump sum) or, for a random 10 percent of the population, at one of the choices of the WTP exercise. Purchase decisions indicate that, in addition to the challenges to save, credit constraints are important in driving the decision to invest in solar technology.[10] Purchase of the solar lights is 4 percent in the group assigned to payment-at-purchase, whereas 49 percent of those assigned to deferred payment group decide to take a solar lamp. This measure is roughly comparable with documented purchase rates of goods with lumpy upfront costs and relatively long stream of benefits (Ashraf, Berry and Shapiro, 2010; Cohen and Dupas, 2010; Tarozzi et al., 2014).

The reminder of the paper is organized as follows. I describe how this research builds on, and

[9] Qualitative evidence suggests that people feel optimistic about being able to complete payment for the solar lamp at a later date. At the end of the eighth week, defaulting respondents received a surprise offer to return the lamp back to receive some repayment against the payment they made. Individuals who made at least one payment but were unable to complete full payment against the lamp should use this offer to get their money back (or some fraction of it if the solar lamp is not returned in good condition). No one who made at least some payment against the solar lamp took up this offer. The most commonly cited reason for this was that people planned to complete payment for the lamp at our partner's office at a later date. As of the first week of November (roughly 7 weeks after the end of the study), 17.5 percent of respondents paid the outstanding balance on their solar lamps.

[10] Devoto et al. (2012) provide evidence that access to credit increases willingness-to-pay for private water connection in Morocco. Relieving credit constrains has also had significant demand for several other health-improving products, like ceramic water filters (Guiteras et al., 2014) and fuel-efficient cookstoves (Levine et al., 2016).

contributes to the existing literature in section 2. After describing the background for this study in section 3, I lay out a basic framework to motivate demand for the installments plan in section 4. The experimental design is explained in section 5. I present results that show demand for installments, and outcomes related to purchase in section 6, and then conclude in section 7.

2 Relationship to the Literature

This paper contributes to the literature on the demand for self control rules to achieve savings goal. In the present paper, demand for self control rules is manifest as preference to pay for the solar lamp in several, smaller payments. This interpretation of the demand for installments as demand for commitment adds to the literature which shows how behavioral devices and arrangements help overcome challenges posed by difficult self control to saving (Gugerty, 2007; Collins et al., 2009). Frequency of repayment is a salient mechanism in behavioral approaches to saving. For example, Bauer, Chytilová and Morduch (2012) provide evidence that some part of the popularity for microcredit loans stems from how these loans impose discipline to savings behavior.[11]

Further, this paper adds to the nascent evidence base that shows willingness to pay for commitment contracts (Casaburi and Macchiavello, 2015; Schilbach, 2015). Demand for commitment that is as rigid as in this experiment is striking. The installments plan is a rigid repayment contract because individuals are effectively pledging their access to a functioning solar light for the study period of eight weeks. In addition to the disutility of the lamp turning off during the experimental period, and the associated monetary costs of paying for other forms of lighting makes the installment plan quite punitive. The installments plan also leads to less liquidity. What makes the installment plan rigid relative to other commitment devices in the literature is that respondents cannot choose to revise how much they are willing to pay for self control on the intensive margin after they select into a commitment plan. Commonly studied commitment contracts offer some flexibility to soften the blow of failing at self control by allowing individuals to refine their commitment contract on the intensive margin, for example by depositing less money into a designated account when users

[11] Bauer, Chytilová and Morduch (2012) show that present-biased preferences increase the probability of selecting microcredit, instead of credit with less frequent repayment cycles, as the vehicle for borrowing.

feel that they may fail at the commitment rule.[12]

Temptation to save less can undermine long-term plans, and commitment can help against this.[13] Welfare in the current experiment is defined to be ownership of a solar device that is paid for in full. This focused definition of welfare allows me to measure how individuals fare when they choose to self-impose commitment. My results show that commitment can help achieve savings goals, but that those who fail at commitment can be hurt more than those who do not when they fail at their commitment goals. A related work is John (2016) who offers savings accounts with the option to commit to make weekly or bi-weekly deposits. The instalment commitment increased savings, but 55 percent of the clients who committed to make frequent payments defaulted on their contract and incurred penalties.

This paper also adds to the literature on the impact of financial access by demonstrating the access to savings technology can have an immediate, perceptible impact on beliefs about future behaviors and outcomes. Access to a financial account or savings technology has been shown to lead to a host of beneficial downstream outcomes, like reduction in poverty (Burgess and Pande, 2005), better education and consumption outcomes (Prina, 2015), improved firm-level outcomes (Dupas and Robinson, 2013*a*), and reduced debt (Kast and Pomeranz, 2014). In this paper, access to the savings technology leads to a significant increase in the probability of purchasing the lamp, in the range of 13-20 percent. The downward revision in demand for the costly self control mechanism of paying in installments with access to the lockbox adds to the evidence base on how financial accounts can also have less tangible, but nevertheless important, impacts. Another example of the behavioral impacts of financial accounts is reported by Carvalho, Prina and Sydnor (2016) who demonstrate that savings accounts increased increased willingness to take risks and to delay gratification among households in Nepal.

[12]For example, Giné, Karlan and Zinman (2010) offer smokers a savings account which restricts access to deposits for six months. Deposits in this account will be returned to study participants who pass a test that verifies smoking cessation, and is otherwise donated to charity. Despite the possibility of not regaining money deposited into the account, 11 percent take up the product, but the amount they deposit into the account is self-selected.

[13]. Duflo, Kremer and Robinson (2011) find that farmers who are able to purchase fertilizer at the time of harvest, and well in advance of the next planting season, are much more likely to use fertilizer when planting next.

Finally, I estimate the effects of solar lamp usage. This is one of a handful of studies that look at the impact of entry-level solar lights. I use daily records to evaluate the impact of treatment on outcome variables of interest. Treated individuals experience significant reduction in off-grid lighting expenditures at home and business. They also report a significant reduction in the number of hours that their phone is without charge, and a 96 percent reduction in phone recharging costs. I do not find a significant impact on business outcomes.[14] In a field experiment in Kenya, Rom, Günther and Harrison (2017) offered households the option to purchase solar lights and find that adults' working hours and children's study hours are not significant affected by usage. They too find a significant reduction in off-grid lighting expenditure.[15]

3 Background

Policymakers working to bring power to the 1 billion people who live without electricity today are shifting their focus towards clean, renewable energy to bring sustainable access to power. Malawi is one of the least electrified countries in the world (World Bank Global Electrification Database). In the study sample, about 80 percent of homes, and 90 percent of business are not connected to the electric grid. And, those connected to the grid spend 2 percent of monthly household income on electricity expenditure. Non-grid lighting is more commonly used – 69 (59) percent use battery-operated lights, and 38 (14) percent use candles to light their homes (shops), and the average household spends 4 percent of its monthly income on lighting needs for the home and shop. Solar technology is a compelling alternative to expensive, and often dangerous and unreliable, fuel-based lighting. For example, in the study setting users of the product are able to recoup the lamp's price in about three months.

Solar devices come in a broad range of sizes and functionalities. The smaller devices, for example, consist of a single bulb, whereas larger solar modules can power appliances like fans and televisions. Solar lights offer a stream of monetary benefit, among other possible benefits, accrued as savings

[14] Aevarsdottir, Barton and Bold (2017) offer Tanzanian households varying subsidy-levels for solar lights, and find impacts on expenditure on lighting and mobile phone charging as well as labor outcomes.

[15] Aklin et al. (2017) also find no socioeconomic impacts of solar technology despite strong electrification and expenditure effects.

on energy expenditure. But, these savings are not available at the time of purchasing solar devices, making even a basic solar light prohibitively expensive for those in most need of them. Pay-as-you-go services have made many useful products more affordable for large numbers of people in developing countries by allowing inter-temporal reallocation of debt. This inter-temporal reallocation of debt can be especially useful when making investments that offer a stream of income or savings in the future, like a solar lamp.[16]

Another reason for the popularity of these plans, as the present study shows, could be that they allow consumers to commit to self control rules. As reported in Table A1, nearly 71 percent of the respondents who preferred the installments plan reported that this is to control their spending habits. The next most-frequently cited reason is the threat of theft (12 percent). Other evidence show that social pressure to share income can have strong impacts on women (Jakiela and Ozier, 2015; Anderson and Baland, 2002). Inter-personnel demands to share income does not seem to be an important reason to demand installments in this largely-male study population.

The solar light used in this project is the ovPilot X, manufactured by Omnivoltaic and distributed by SunnyMoney in Malawi (Figure A2). This product has both lighting and mobile charging capabilities. At full charge, the light is functional for 8 hours at 100 lumens, 16 hours at 50 lumens, and and 38 hours at 29 lumens.[17] This product is particularly well-suited for payment-by-installments. The solar light can be sold in "locked" status. A locked lamp can be set to remain turned on and functional until the next installment is due. Every installment payment tops-up the solar device with enough energy credit for the device to remain functional until the following payment date. Making each scheduled payment, then, tops up the device with energy credits to keep the device active. When the solar device is completely paid for, the device achieves "unlocked" status and can be used without further toping up.

While solar lights have been available in Malawi for several years now, pay-as-you-go (PAYG)

[16]Global PAYG revenue was USD 41.5 million in the second half of 2016, and half of the products were sold in Sub-Saharan Africa. Currently, more than 85 million people are using off-grid solar technology devices (Global Off-Grid Lighting association, 2016).

[17]By way of context, a 40-watt incandescent bulb gives about 450 lumens of light.

financing became viable just recently after introduction of the technology which allows for incremental payments for time-limited access to solar energy.[18] At the time of this study, the PAYG product was quite new to Malawi, and approximately 1,000 lights had been sold country-wide. A large fraction of the study participants knew of solar technology (64.4 percent), but very few owned a solar device (4.5 percent).

4 A Framework to Motivate Preference for Installments

Consider a credit-constrained individual with hyperbolic preferences. There are two time periods, $t = 1, 2$. During each of these time periods, the individual receives non-stochastic income 1, which she can choose to spend on a single consumption good. The behavioral agent is modelled as having time-specific selves, each with different preferences. Time-0 self is the planner with no contemporaneous consumption. In all other periods, future consumption is discounted at $\beta < 1$. So, time-1 utility, for example, is given by:

$$U(c_1) + \beta U(c_2), \tag{1}$$

and time-0 utility is given by:

$$\mathbb{E}[U(c_1) + U(c_2)]. \tag{2}$$

Here U is increasing, concave and continuously differentiable.

The individual may experience a taste shock, which increases the marginal utility of present-period consumption, with probability $\Theta = \{\theta_B, \theta_S, \theta_{NS}\}$. These shocks are private information to the time-specific selves. With probability θ_B, the individual faces a big shock and she consumes all that she has on hand. And, with probability θ_S, she experiences a small shock and consumes half of what is available to her. Finally, with probability $\theta_{NS} = (1 - \theta_B - \theta_S)$, the individual faces no taste shock. All possible states of the world are equally likely.

[18] Prior to the described PAYG technology, a similar light from the same manufacturer was available for purchase at MWK 20,000 paid upfront and in full. The non-PAYG version of the light has only two light settings-8.5 hours at 74 lumens or 35 hours at 12 lumens. The older model, too, has mobile charging capability.

4.1 Frequency of Repayment

At time 0, the individual decides whether to purchase a durable on one of two types of deferred payment plans. The durable is available for use immediately at no payment. The durable's price is $p = 2/3$, has to be paid within time 2. If she buys the durable, she has to save some part of her income to pay for the durable.

With the first repayment plan, the installments plan (subscripted I in all expressions below), the individual enjoys benefit b in time 1. She continues to receive b in time 2 if and only if she makes a payment of at least $p/2$ within time 2 (so, either in $t = 1$ or $t = 2$). I assume that $b = p/4$. With the second repayment plan, the lump sum plan (subscripted L in all expressions below), the individual enjoys benefit b in both times 1 and 2 without having to make any payment, and is instead required to pay p as one lump sum at time 2. If the durable is completely paid for within time 2, the individual enjoys lifetime utility $U(D)$, such that $\beta U(D) = 1$.

A. No Shock in time 1

Consider the ex-ante first-best allocation in the state with no shock, $c_1 = c_2 = 1 - p/2$ as the benchmark allocation. If self 1 experiences no shock, she saves $p/2$ and makes this payment for the durable at the end of time 1 with the installment plan. The individual holds on to this saving, $p/2$, if she buys the durable on the lump sum plan. Thus, self 2 receives b in time 2 with both the installments plan and the lump sum plan. Self 2 can choose to save $p/2$ for the durable, or, alternatively, she can choose to quit saving for the durable. In time 2, the individual may experience a big shock, a small shock or have another period of no shock.

First, consider that self 2 experiences big shock. She consumes everything and utility under each of the repayment plans are,

$$\begin{aligned} \mathbb{E}[U^2_{I,\theta_B}(\Theta)] &= U(1+b), \\ \mathbb{E}[U^2_{L,\theta_B}(\Theta)] &= U(1+b+p/2). \end{aligned} \tag{3}$$

Expected lifetime utility at time-0 is maximized from choosing to buy the durable on the lump sum plan. This is because savings from time 1 can be consumed in time 2 with the lump sum plan, but not with the installments plan.

With probability θ_S, self 2 experiences a small shock. In time 2, the individual spends half of her income in response to the taste shock. The outstanding payment against the durable is $p/2 = 1/3$, and self 2 consumes the rest. And, if she quits saving for the durable, she receives b since she paid $p/2$ in time 2. With the lump sum plan, self-2 has $1 + p/2 = 4/3$ on hand. She spends half of this to respond to the taste shock, and is left with $2/3$ which is used in entirety to pay for the durable. Alternatively, self 2 can quit saving for the durable and spend her income and previous period savings on the consumption good.

$$\begin{aligned}
&U^2_{I,\theta_S,save}(\Theta) = U(1 - 1/2 - p/2 + b) + \beta U(D),\\
&U^2_{I,\theta_S,quit}(\Theta) = U(1 - 1/2 + b),\\
&U^2_{L,\theta_S,save}(\Theta) = U(1 + p/2 - 1/2 - p/4 + b) + \beta U(D),\\
&U^2_{L,\theta_S,quit}(\Theta) = U(1 + p/2 + b).
\end{aligned} \tag{4}$$

Under both plans, continuing to save for the durable is the dominated choice. But, lifetime utility is maximized with the installments plan, and thus self 2 chooses to purchase the durable on the installments plan.

Finally, if both selves 1 and 2 experience periods of no shock, utility in time 2 from saving for the durable and quitting to save are,

$$\begin{aligned}
&U^2_{I,\theta_{NS},save}(\Theta) = U(1 - p/2 + b) + \beta U(D),\\
&U^2_{I,\theta_{NS},quit}(\Theta) = U(1 + b).\\
&U^2_{L,\theta_{NS},save}(\Theta) = U(1 - p/2 + b) + \beta U(D),\\
&U^2_{L,\theta_{NS},quit}(\Theta) = U(1 + p/2 + b).
\end{aligned} \tag{5}$$

Again, self 0 would prefer to buy the durable on the installments plan because the probability of continuing to save is at greater with this plan.

B. Small shock in time 1

Consider that self 1 experiences small-shock. She saves $p/2$ out of her income 1, but then claims half of this saving to respond to the taste shock. Thus, she makes a payment of $p/4$ in time 1 with the installments plan. She holds on to this saving if she bought the durable on the lump sum plan. If self 2 chooses to save for the durable, she has to put away $3p/4$ from her time-2 income to compensate for the shortcoming in savings in time 1.

If self 2 experiences a big shock, she consumes everything on hand. Time-2 utility with the installments and lump sum plan are, respectively,

$$\begin{aligned} U^2_{I,\theta_B}(\Theta) &= U(1), \\ U^2_{L,\theta_B}(\Theta) &= U(1 + p/4 + b). \end{aligned} \tag{6}$$

If the individual faces small shock in time 1 and then a big shock in time 2, self-0 would maximize utility by choosing to buy the durable on the lump sum plan.

Instead, consider that self-2 experiences a small shock. She responds to the small shock by consuming half of her available savings. In the case of the installments plan, available savings is what was set aside in time 2 whereas with the lump sum plan, available savings is the sum of savings from time 1 and time 2. With the installments plan, self 2 is left with $1/2$ after responding to the preference shock and uses this in entirety to pay for the durable. With the lump sum plan, self 2 has $1 + p/4 = 7/6$ on hand. After responding to the prefrnece shock, she is left with less than p and is thus unable to complete payment for the durable.

$$
\begin{aligned}
U^2_{I,\theta_S,save}(\Theta) &= U(1 - 1/2 + 3p/4 + b) + \beta U(D), \\
U^2_{I,\theta_S,quit}(\Theta) &= U(1), \\
U^2_{L,\theta_S,save}(\Theta) &= U(1 + p/2 - 1/2 - p/4 + b), \\
U^2_{L,\theta_S,quit}(\Theta) &= U(1 + p/4 + b).
\end{aligned} \tag{7}
$$

Self 2 continues to save for the durable with the installments plan, but not with the lump sum plan. Thus, self 0 would choose to buy the durable on the installments plan in this case.

If self 2 does not experience a taste shock, her utility from saving for the durable and quitting to save for the durable are,

$$
\begin{aligned}
U^2_{I,\theta_{NS},save}(\Theta) &= U(1 - 3p/4 + b) + \beta U(D), \\
U^2_{I,\theta_{NS},quit}(\Theta) &= U(1), \\
U^2_{L,\theta_{NS},save}(\Theta) &= U(1 - 3p/4 + b) + \beta U(D), \\
U^2_{L,\theta_{NS},quit}(\Theta) &= U(1 + p/4 + b).
\end{aligned} \tag{8}
$$

Self 0 would choose to buy the durable on the installments plan because the probability of completing payment against it is greater with the installments plan.

C. Big shock in time 1

Consider that self 1 experiences big shock. She consumes everything on hand and does not save for the durable. If self 2 chooses to save for the durable, she has to put away p from her time-2 income to compensate for the shortcoming in savings in time 1.

If self 2 also experiences big shock, she too consumes everything. Time-2 utility with the installments

and lump sum plan are, respectively.

$$\begin{aligned} U^2_{I,\theta_B}(\Theta) &= U(1), \\ U^2_{L,\theta_B}(\Theta) &= U(1+b). \end{aligned} \tag{9}$$

Self 0 would choose to buy the durable on the lump sum plan in order to enjoy b in times 1 and 2.

Instead, consider that self-2 experiences small shock after a period of big shock in time 1. In both repayment plans, she claims half of her time-2 income to respond to the taste shock. She can pay just one installment and receive b, but this choice is dominated by the choice to stop saving for the durable. The utility of continuing to save and quitting are:

$$\begin{aligned} U^2_{I,\theta_S,save}(\Theta) &= U(1-1/2-p/2+b), \\ U^2_{I,\theta_S,quit}(\Theta) &= U(1), \\ U^2_{L,\theta_S,save}(\Theta) &= U(1-1/2-p/2+b), \\ U^2_{L,\theta_S,quit}(\Theta) &= U(1+b). \end{aligned} \tag{10}$$

With both plans, the individual receives b in time 2 if she continues to save for the durable. And, with the lump sum plan, she receives b even when she quits saving for the lamp. Continuing to save is the dominated choice here because it does not lead to complete repayment of the durable. Thus, self 0 chooses to buy the durable on the lump sum plan.

If self 2 does not experience a taste shock, her utility from saving for the durable and quitting to save for the durable with the installments and lump sum plan are, respectively.

$$
\begin{aligned}
U^2_{I,\theta_{NS},save}(\Theta) &= U(1-p+b) + \beta U(D), \\
U^2_{I,\theta_{NS},quit}(\Theta) &= U(1), \\
U^2_{L,\theta_{NS},save}(\Theta) &= U(1-p+b) + \beta U(D), \\
U^2_{L,\theta_{NS},quit}(\Theta) &= U(1+b).
\end{aligned} \tag{11}
$$

In this case, saving for the lamp in time 2 leads to an increase in lifetime utility by $\beta U(D)$. Self 0 would now choose to purchase the durable on the installments plan because the probability of completing payment against the lamp is at least greater with the installments plan.

Summing across choices in each of these outcomes, the installments plan is the dominating choice for a larger set of states of the world. Given that each state is equally probable, self 0 maximizes lifetime utility by choosing to buy the durable on the installments plan. Extending the insights to the experiment, we should expect to see greater demand for the installments plan relative to the lump sum plan.

5 Experimental Setup and Data

5.1 Experimental Design

I conducted a census of 93 urban and semi-urban market centers in Lilongwe and Dowa districts of Malawi (Figure A1). For the purpose of sample selection, a micro-entrepreneur is defined to be engaged in business as primary occupation, to have no more than 2 separate businesses and to be present at the business at least 3 days in a week. Because randomization occurs at the individual-level, no more than roughly 20 percent of micro-entrepreneurs in each of these markets was enrolled in the study. The sample was restricted to micro-entrepreneurs who were literate because participants are required to maintain daily logbooks. Solar light agents and mobile money agents were not enrolled at census.[19]

[19]The initial design was to provide mobile money accounts to save for the solar lights. But this involved larger monetary costs and posed some logistical challenges with registering participants on the mobile-money network

There are four treatments in this experiment (see Figure 1). The first treatment distinguishes between groups offered the lamp for purchase and a group that serves as the *Control* group. Second, I randomize financing offers for the lamp. Of those who were offered the lamp, one-third had to pay the full price of the lamp upfront at the time of purchase (*Upfront lump sum* group). The *Upfront lump sum* group had up to one week after the baseline survey to take-up the offer for purchase. The other two-third of the sample could begin using the solar lamp immediately with no requirement for immediate payment. So, effectively, anyone who took up the offer in this group was able to try out the lamp for free. This treatment is to test whether credit constraints when the population wants to make a lumpy investment.

Third, I randomize access to a lockbox to individuals who qualified for the financing treatment and could try out the solar lamp for free (Figure A3). The lockbox is a secure savings technology, and individuals are encouraged to use it to save for the solar lamp. Everyone in the *Box* group knows that the box is theirs to keep even if they decide not to try out the solar lamp. Fourth, cross-cut with the Box-treatment, the group that receives the financing offer is ranodmized into one of two repayment frequencies. The experimental price was held fixed at MWK 20,000, and respondents were randomly assigned to pay this amount in eight weekly installments or as one deferred lump sum payment at the end of eight weeks. The box-treatment and the installments-treatment are applicable only to those who were randomized into the financing group.

All respondents (other than *Control* and *Upfront lump sum* groups) are asked to complete an incentive-compatible willingness-to-pay exercise (see Figure A4 for an example). Importantly, the *Box* group was asked these questions *after* they had received the savings technology, and were encouraged to use it to save for the solar lamp. And, of course, the randomly assigned payment plan and experimental offer was revealed only after the exercise was completed. Every respondent is asked whether she prefers to buy the lamp and pay one lump sum price of P_L at the end of eight weeks, an installment price $P_{ins} = P_L(1 + r)$ completed in eight equal, weekly payments or to not

within the study period. Consequently, lockboxes were used instead of mobile money savings account as the savings technology. A relatively small fraction of micro-entrepreneurs (2.5 percent) were from the sample during censusing because they were mobile money agents. No business that we identified at census was a solar light agent.

purchase the lamp. The lump sum price was always $P_L =$ MWK 20,000. The interest rate on the installments plan ranged from negative, through 0 to positive rates, such that the six installment prices were $P_{ins} \in$ (18000, 20000, 22000, 24000, 25000, 26000). Next, demand is elicited for each P_{ins} paid as one lump sum amount at the end of eight weeks.

Thus, every respondent answered 12 questions about WTP for the solar lamp. All respondents were informed that the solar lamp would be shut off when a payment was not completed. So, if they bought the lamp on the installments plan, it would be shut off anytime an installment payment was incomplete. If, instead, the lamp was bought on the lump sum, the lamp would shut off if they did not complete payment for the lamp in full at the end of eight weeks. The elicitation exercise was designed to be incentive compatible. All respondents knew that the price at which the lamp would be available for purchase would be decided at random, and that the price which is assigned to them could, with some positive probability, be their choice to one of the twelve questions.[20] At the end of the elicitation exercise, *Box* and *No Box* respondents are informed of the experimental price and repayment frequency at which the lamp was available to them for purchase.

The experiment was implemented from from May-September, 2017. Out of the targeted 500 micro-entrepreneurs, 444 (88 percent) were enrolled in the baseline survey. The solar light was introduced to all groups that qualified to purchase the light during the baseline survey. The field team explained how the product could be used for lighting and to charge phones. They demonstrated how the device was to be recharged using the solar panel, and informed all respondents about the manufacturer's two year warranty on the product. *Upfront lump sum* respondents were then told that they could buy the lamp from the project at MWK 20,000 due at the time of purchase, and that the offer would be available to them for one week. Deferred payment plan groups decided whether they wanted to try out the solar lamp at the randomly assigned repayment plan. After completion of the baseline survey, all respondents were given logbooks and instructed how to fill them in. We met study participants twice during the study period to record logbook entries.[21]

[20] Those who purchase the light at one of their selected prices from the price elicitation exercise are excluded from all outcome variables analysis.

[21] Specifically, we met respondents after week 1 and after week 5. Responses from the first week are not used in the analysis because they were intended to ensure that respondents understood our instructions and were filling out the logbooks accurately. At the second meeting, we collected records maintained for all days until then. At each of these

5.2 Data

There are five main sources of data for this study. First, at census, individuals are asked to make a series of choices between receiving some amount of money at a sooner date and a smaller, equal or larger amount of money at a later date. The sooner date is either the day of the census or a week later, and the later date is always one week away from the sooner date. The responses are used to construct a measure of time discounting. The second source of data is the baseline survey. In addition to basic household demographics, and business practices and outcomes, the baseline survey also contains the incentive-compatible willingness-to-pay exercise. Third, my main outcomes of take-up and repayment are measured using administrative data. Fourth, the impact of using solar lights on business outcomes, and expenditure on lighting is measured using daily logbooks records. Fifth, an endline survey was administered to a random sub-sample of respondents who chose to purchase the solar light from us. The survey measures user perception of the solar lights.

6 Results

Table 1 presents summary statistics by treatment group, and results from tests to confirm that intervention groups are comparable at baseline. Columns 1-4 present sample means and standard deviations for each group. P-values of F-tests of equality of means between *Box* and *No Box* groups is presented in column 5, between *Upfront lump sum* and deferred payment groups is presented in column 6, and between the *Control* group and those offered the lamp for purchase in column 7. The intervention groups appear fairly well-balanced. The number of instances of significant difference across treatment groups is what can be expected by chance.

The population of micro-entrepreneurs in this study setting is largely male (68 percent) and married (78 percent). The average micro-entrepreneur is nearly 35 years old, with close to 2 children, and has completed 8.8 years of education. Most respondents are financially excluded – 27 percent have a bank account, and 36 percent participate in at least one informal financial group, like

meetings, respondents who maintained logbook records were compensated with a gift (soap or sugar) of monetary value of about USD 0.75.

rotating savings and credit associations, or village savings and loan associations. Many people use mobile money accounts; 55 percent report having an active mobile money account, of which 41 percent share the mobile money account with their spouse. Credit is expensive; the average micro-entrepreneur pays 23 percent as interest for a one-month loan. On average respondents pay MWK 1744 (USD 2.4) for grid lighting at home, MWK 835 (USD 1.1) for grid lighting at business, and MWK 3959 (USD 5.5) for non-grid lighting in a regular month. This is a significant cost, average monthly expenditure on non-grid lighting is 26 percent of business profit in a good week, and 45 percent of business profit in a bad week. Finally, while many know of solar lights (64 percent), very few own one (4.5 percent).

6.1 WTP Exercise

Responses to the elicitation exercise described above is used to construct measures of willingness to pay for the lamp at each experimental price. The results of the WTP exercise are presented in Figure 3. As motivated in the framework in Section 3, there is a strong demand to pay in installments. At all prices, demand decreases monotonically with price. The familiar, downward sloping demand curve indicates that respondents understand repayment options and prices. Strikingly, preference for installments is so strong that respondents are willing to pay a higher price to pay for the lamp in installments – 85 percent of respondents chose to pay in installments at one of the prices in the elicitation exercise, and 78 percent of respondents chose to pay in installments even when the installment price is at least weakly greater than the lump sum price.[22] The demand for installments when the installment price is greater than the lump sum price indicates some large, negative discount rates (Figure 4). The negative discount rates would be consistent with some part of savings being lost to temptation spending, demands from others, or theft.

Figure 3b distinguishes demand of *Box* and *No Box* groups with lump sum and installment payments. Demand for installments is always measured as preference to pay P_{ins} in installments relative to paying MWK 20,000 as a deferred lump sum. Access to the lockbox lowers demand for the installments plan. As P_{ins} increases, the *Box* group is less likely to buy the lamp on installments,

[22]The choices reported in this WTP exercise largely matches actual purchase decision (see Table A5) indicating that most respondents are not engaging in cheap talk.

and instead switch to the deferred lump sum plan. Further, when the price of the solar lamp is paid as a deferred lump sum, demand for the solar lamp is always higher in the *Box* group. The following regression is estimated to formalize how preference for installments is affected by access to the savings technology.

$$Y_i = \alpha_1 + \delta_1 Box_i + X_i'\theta_1 + \epsilon_{1i}. \tag{12}$$

Here Y_i measures outcome variable of interest for respondent i, Box_i is a dummy equal to 1 if individual i is offered the lockbox, and X_i is a vector of individual and business characteristics. The outcomes of interest here are (i) preference to pay in installments, and (ii) preference to pay in installments when installments price is higher than lump sum price, and (iii) willingness to pay premium over lump sum price of MWK 20,000 to pay in installments. Table 2 presents results of the regression. All outcomes are measured from responses to the WTP exercise.

Echoing the result in Figure 3, 85 percent of choices indicate preference for installments over paying in lump sum. As prefaced in Figure 3, the *Box* group is more likely to want to buy the solar lamp. Consistent with this result, the *Box* group is somewhat more likely to prefer installments when the installment price is lower than the lump sum price. But, demand across *Box* is somewhat lower than, though not statistically distinguishable from, the *No Box* group when installment price is strictly greater than the lump sum price.

I construct a measure of the premium that someone is willing to pay for the lamp in installments as the difference between maximum installment price that an individual is willing to pay and the fixed lump sum price of MWK 20,000 . So, the minimum value of premium is -2000 and maximum value is 6000. Mean value of premium in the *No Box* group is MWK 4385, which is 22 percent of the lump sum price of the lamp. While this premium reduces by a statistically significant 15 percent in the *Box* group, the premium continues to be large at about MWK 3740. The results indicate that access to a a secure savings technology is an important barrier to saving, but it at least not perceived to be the largest barrier to saving in this population.

6.2 Take-up of Solar Lamp

The following regression is estimated to study take-up across three treatments: offer to purchase the lamp on deferred payment, offer to purchase the lamp on installments, and access to the savings technology. The framework outlined in Section 3 predicts that both the lockbox treatment and the installments treatment should at least wekaly increase the probability of trying out the solar lamp. The take-up decision for the *Upfront lump sum* group is really a purchase decision. For the groups that receive the deferred payment plan, the results of the regression indicate the decision to try out the solar lamp.

$$Y_i = \alpha_2 + \beta_2 Def_i + \gamma_2 I_i + \delta_2 Box_i + \zeta_2 I_i \times Box_i + X_i'\theta_2 + \epsilon_{2i}. \tag{13}$$

For respondent i, Def_i is 1 if she was offered the lamp for purchase on a deferred payment plan. The variables I_i and Box_i indicate whether respondent i was offered the lamp for purchase on installments plan, and whether she received the savings technology, respectively. The combined effect of the cross-cutting Box and $Installments$ treatments is given by ζ_2. Baseline measures of individual and business characteristics are controlled for in vector X_i. The results are presented in Table 3.

Credit constraints severely dampens demand for solar light. Those offered the solar light on deferred repayment plans are 48 percent more likely to take-up the offer. Importantly, the *Upfront lump sum* group is not significantly different from the deferred payment in their willingness to buy the solar lamp at a positive price (see Table A4). This increases confidence in the result that it is in fact credit constraints, and not differences in subjective valuation of the product (on the extensive margin), that is driving the difference in purchase rates between groups offered the light for purchase with upfront payment and deferred payment.

Next, restricting attention to those offered the lamp on deferred payment plan, access to the very simple savings technology of a box increases probability of take-up by 13-19 percent. After controlling for the offer to pay in installments, those offered the savings technology are 17-20 percent more likely to want to try out the solar lamp. The strong increase in probability of take-up

with the lock box is quite remarkable because the outcome of interest is change in belief about future behavior, and not future change in behavior. The effects reported here imply that access to the savings technology has an important contemporaneous impact by changing belies about future outcomes. Further, the box was actively used to save for the solar lamp (Table A6). In the *Box* group, everyone took up the product and nearly 97 percent of respondents made at least one deposit into the box. The box was used almost exclusively to save for the solar lamp, which is perhaps unsurprising given the short duration of the repayment period On average, individuals saved nearly 77 percent of the experimental price of the lamp in the lockbox, and median savings in the lockbox is equal to the price of the solar lamp.

The treatment of repayment frequency, on the other hand, does not lead to significantly different behaviors across the two groups. While the coefficient on the indicator for the option to repay in weekly installments, instead of one deferred lump sum payment, is positive, it is not statistically significant. Finally, the combined treatment of having the box and the offer to repay in installments has no significant impact on take-up decision. Perhaps, it is unsurprising that the installments treatment does not have a strong impact on the decision to try out the solar lamp because everyone who chooses to take up the purchase offer is given the lamp immediately, and payment is not due for one week (when paying in installments) or eight weeks (when paying as a lump sum). Someone who does not plan to make any payments for the solar lamp is assured a working light for at least one week. Thus, conditional on the solar lamp bringing positive utility, the optimal choice is always to purchase the light for either repayment frequency.[23]

6.2.1 Correlates of Purchase Decision

Correlates presented in Table A4 indicate several noteworthy trends. First, it does not appear that wealthier or more educated households are more likely to adopt this technology. Individuals who may be wealthier based on baseline indicators like education, business revenue, or material used to construct home are not significantly more likely to purchase a solar light. Baseline lighting expenditure is statistically significant in explaining purchase decision. After controlling for baseline

[23] At the lowest price, 23 respondents did not want to purchase the light with deferred payment. Of this, 87 percent reported that they would not be able to afford the lamp even with deferred payment.

wealth, a doubling of non-grid lighting costs increases the probability of solar light purchase by 2 percent. While not significant, individuals with prior knowledge about solar lights are more likely to buy a solar light and those who already own solar lights are less likely to buy another one. Finally, the strong, significant correlation between number of children and probability of purchase of solar light suggest that the people are likely to use the light for children's study. Having one more child is associated with a 5 percent increase in the probability of purchase. At the same time, increase in household size after controlling for number of children, is not significantly correlated with purchase decision.

Echoing results presented in Table 3, access to a transactional or savings account is correlated with a significant and positive impact on purchase probability. While not causal evidence, ownership of mobile money accounts, bank accounts, and participation in informal financial groups is associated with higher probabilities of taking up the offer for the solar lamp. For example, those with a mobile money account and those who participate in an informal financial group are respectively 8 percent and 10 percent more likely to want to try out the solar lamp on a deferred payment plan.

The solar lights are easily mobile, and a little more than 50 percent of the individuals report using it both at home and in the business. Respondents are asked what is the largest quality-of-life impact that the solar lamp has had on their lives, besides energy savings. Nearly 44 percent of individuals report that they work longer, even though the number of hours worked are not statistically different across the treatment groups as reported in the logbooks (Table A6).

6.3 Completing Repayment

When a lamp is completely paid for, the device achieves "unlocked" status. A "locked" device, on the other hand, turns off when payment is due. Any lamp that is not completely paid for at the end of the study period remains turned off until a payment is made against the outstanding balance. The impact of the cross-cutting treatments on the probability of having an unlocked device at the end of eight weeks is measured using the following regression:

$$Y_i = \alpha_3 + \beta_3 Def_i + \gamma_3 I_i + \delta_3 Box_i + \zeta_3 I_i \times Box_i + X_i'\theta_3 + \epsilon_{3i}. \quad (14)$$

As reported in Table 4, both access to savings technology and frequent repayment leads to higher probability of having an unlocked and functional solar lamp at the end of the study period. The *Box* treatment increases probability of completing payment by 12-14 percent. Paying back in installments increases probability of repayment by 10-13 percent. The impact of the combined treatment of box and installments on repayment is not statistically distinguishable from zero. On average, the installments group paid MWK 17,000 against completing the payment of MWK 20,000 within eight weeks. Average payment for the lamp in the deferred lump sum group is MWK 11,724.

But, this masks heterogeneity in how the installments plan had negative impacts for those who were unable to complete paying for the lamp. As reported in Table A2, restricting attention to those who were unable to finish paying for the lamp, the installment group paid MWK 9,218.75 whereas the lump sum group paid 0. And, the solar light was shut-off every time someone in the installment group missed a weekly payment. Consequently, on average, the installment group had access to the light for nearly three weeks lesser than the lump sum group, despite paying more to use the light during the study period (Table A3). At the same time, individuals who choose the installments plan are significantly about 30 percent more likely to finish paying for the solar lamp and have a functioning light at the end of the study period. And, those who are randomly offered the installment plan when they expressed preference the lump sum plan are less likely to have an active light at the end of the study period Table 5.

6.4 Impact of Solar lamps

I estimate the effect of owing the solar lamp on the following outcomes: expenditure on grid and non-grid lighting for the home and business, mobile phone outcomes, and working hours. Understanding the savings accrued by users of solar light is important to understand the profitability of the investment. I use the following specification to understand the impact of using the solar lamp:

$$Y_i = \alpha_3 + \mu Use_i + X_i'\theta_3 + \epsilon_{3i}. \tag{15}$$

Here Use_i is an indicator variable for using the solar lamp, and is instrumented with experimental treatment as follows:

$$Use_i = \omega + Treat_i'\psi + \nu_i. \tag{16}$$

Experimental treatment have a strong effect on the decision to try out the solar lamp and yields a strong first stage (Table A7).

The solar lamps are easily portable, and are used both at businesses and homes. On average, 31 percent of the respondents used the light at the home, 17 percent at their business, and 52 percent at both home and business (Table A6). The light have an immediate effect on the most obvious outcomes that are expected to change – lighting expenditure and mobile phone usage outcomes. The results for lighting expenditure are presented in Table 6. Treated individuals spend considerably less on off-grid lighting at the home and business. Daily expenditure on off-grid lighting for the home reduces by nearly 95 percent from the control mean. This translates to a daily reduction of MWK 136 on a base of MWK 158.80. Daily expenditure on off-grid lighting for business reduces from MWK 133.60 to MWK 132.44. Expenditure on grid lighting does not appear to be affected significantly by the treatment for the small fraction who are connected to the grid.

The average respondent's mobile phone battery is out of charge for about one and a half hours every day. For the treatment group, this time reduces by 60 percent. Commonly, respondents rely on recharging centres to get their mobile phones recharged at a cost. On average, individuals spend MWK 45.05 for this service everyday. The treatment group stops relying on this paid service almost entirely. Mobile recharge expenditure in this group reduces by about MWK 43, a reduction of nearly 96 percent. Summing across savings on lighting and recharging mobile phone, the treatment group saves about MWK 242 (Table 7). At this rate of saving, the solar lamp's experimental price of MWK 20,000 can be regained with about twelve weeks of use.

Finally, having access to the solar light does not have a significant impact on business hours, revenue, or children's study hours in this sample (Table 8). While qualitative evidence suggests that some types of businesses operated longer (tailors, restaurants) the study was not designed to detect differences across business types. The null effect on children's study hours is not informative in this setting because, unfortunately, the study period coincided with annual school holidays in Malawi.

7 Conclusion

This paper presents prima facie puzzling evidence that individuals prefer to pay for a lumpy investment in several installments, rather than one deferred lump sum, even when the installment price is as much as 30 percent higher than the lump sum price. These choices imply some large and negative returns to saving. Negative returns to saving can be motivated as, for instance, some fraction of savings being lost to temptation spending or theft. This interpretation resonates with the large evidence base that shows that the poor are often unable to save to make investments that can be very useful to them. In this paper, I address two impediments to save – lack of a secure place to hold savings, and intra-personal conflict that undercut savings plans.

The installments plan can help along two fronts – it makes it easier to impose self control by physically relinquishing access to savings, and it can provide a secure means to hold savings to pay for the solar lamp. I am interested in understanding how much of the demand for installments is driven by the desire for self control rules. I measure this by inducing experimental variation in access to a secure savings technology leads. While access to the savings technology leads to a meaningful reduction in the premium that individuals are willing to pay for the installments plan, it continues to remain large and significant. The installments plan offers a commitment mechanism to complete payment against the solar lamp by both moving savings out of the home and by increasing the disutility of reneging on savings plan by having the lamp shut off when periodic payment is not fulfilled. It is, therefore, individuals' desire for commitment savings that is driving the demand for installments after they gain access to the savings technology.

Access to commitment repayment through installments increases the probability of paying for the lamp. This suggests that policymakers can impact the poor's ability to make useful, lumpy investments by restructuring how these investments are made. The scope of impact of nuanced policy, like structuring payment plans to mimic commitment accounts, can be quite broad and significant. And, it can compliment the impact of more traditional solutions to bring financial empowerment, like increasing access to a secure savings technology.

At the same time, we need to remain mindful of heterogeneity in impacts of such policies. For example, at least in the short run and in the context of this experiment, many are hurt by choosing the installments plan – they end up paying more for fewer days of access to solar lights. And, within 6 weeks of the end of the study, about 18 percent of individuals completed arrears on the solar lamp. This is an intersting result in its own right because respondents often have to make a a long and costly journey of about 40 miles in round-trip to making this payment in-town. Longer-term outcomes of interest are how the experimental groups vary in repayment. For example, preliminary evidence indicates that individuals with the box and those who paid in installments are more likely to come back later to fulfil outstanding payment. Another line of further study is whether we can predict ex ante who will benefit from the installments plan.

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8 Figures

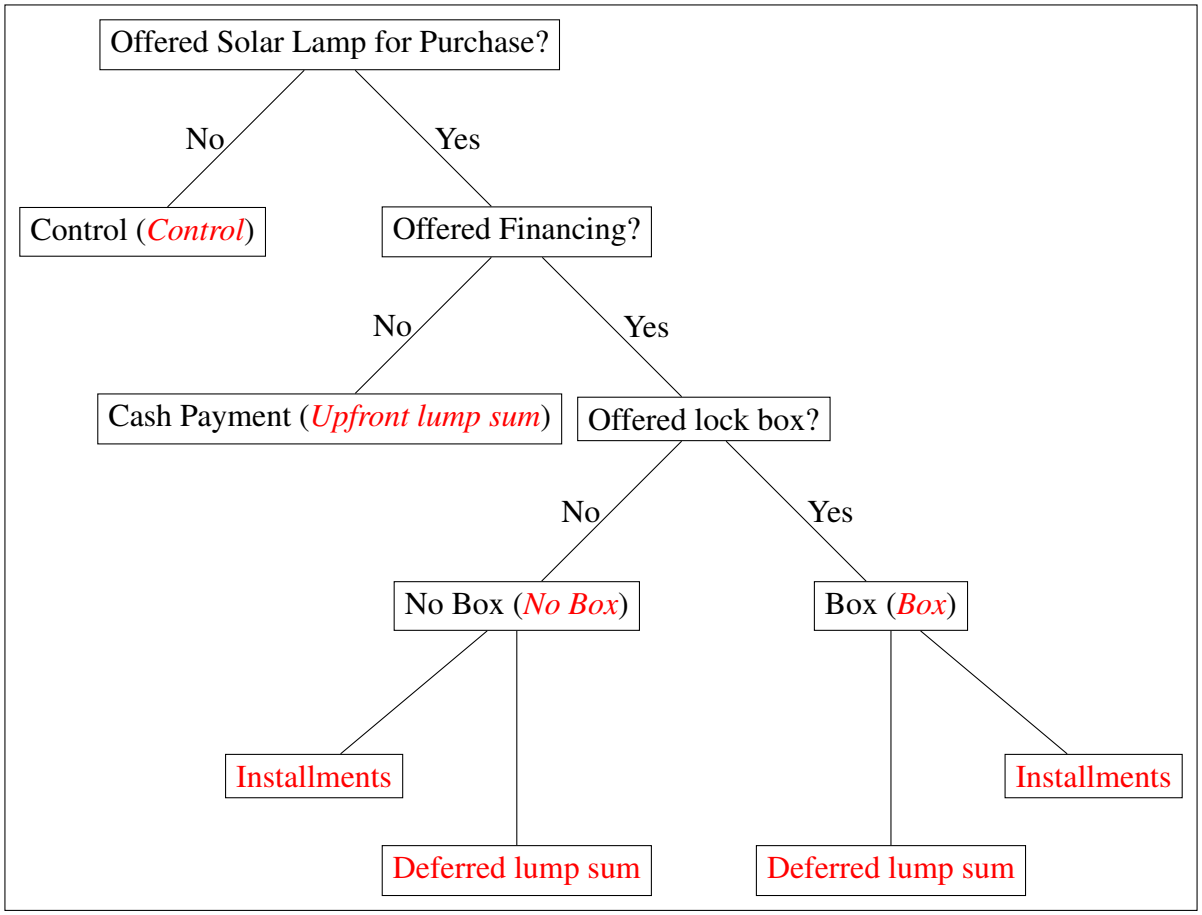


Figure 1: Treatment arms

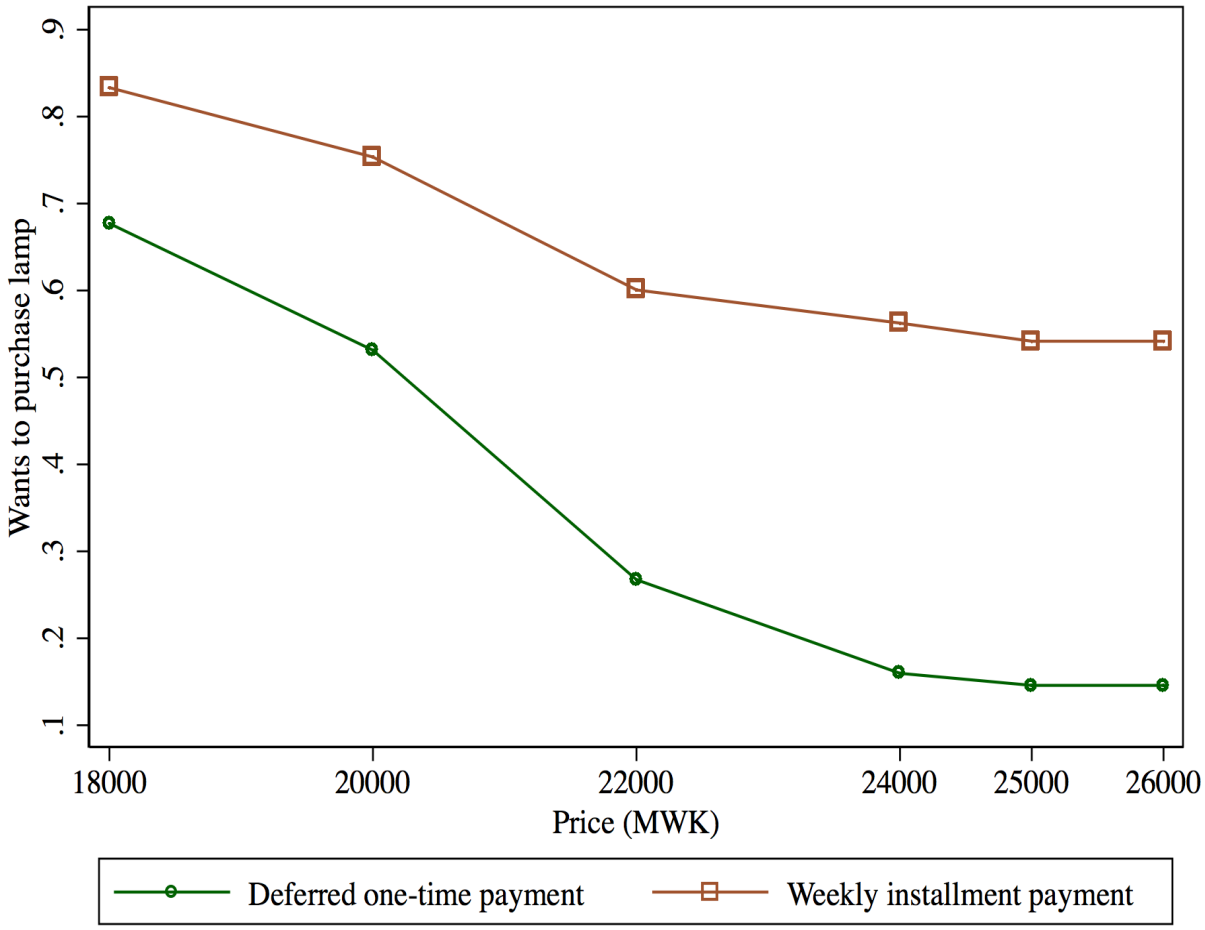
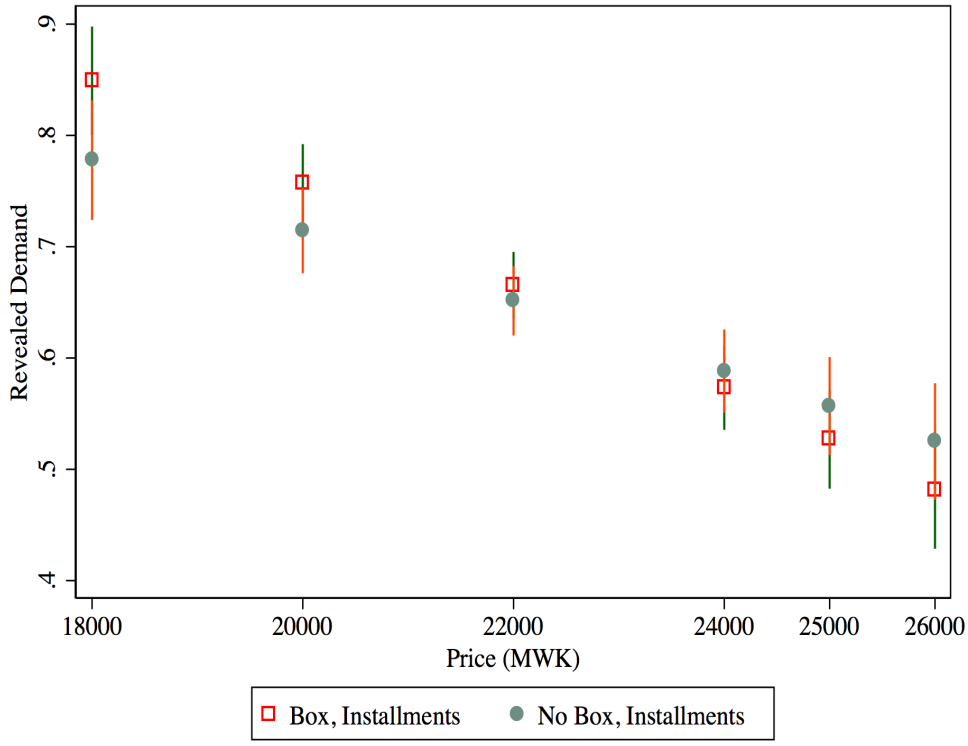
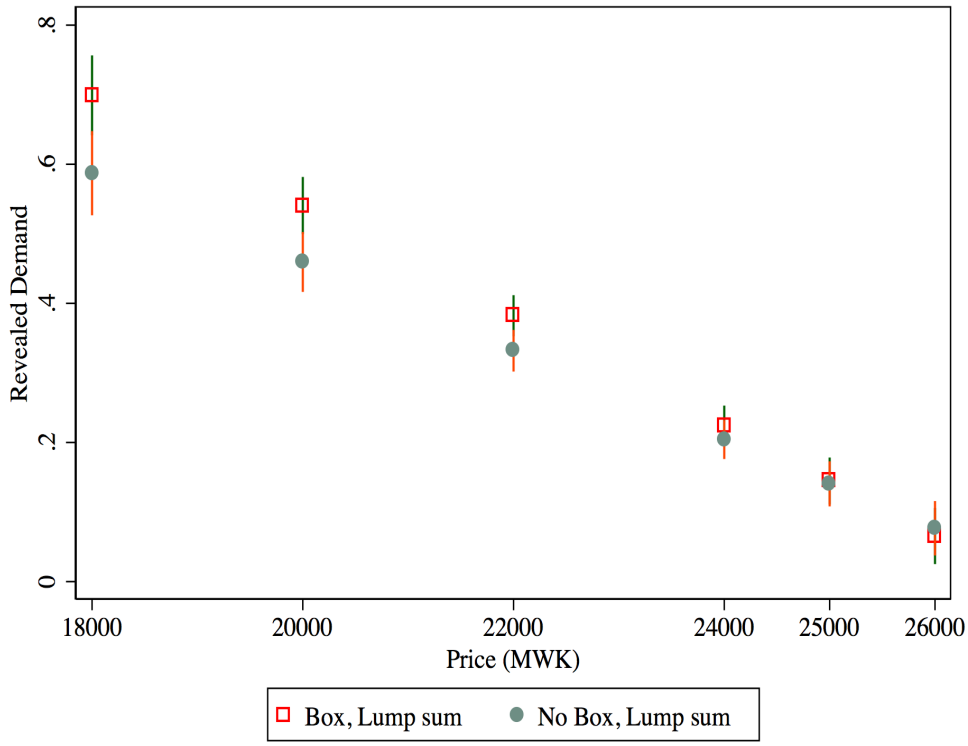


Figure 2: Repayment Frequency & Willingness to Pay

The figure plots demand curves using responses to willingness-to-pay exercises using linear probability model. Demand for the installment plan at $P_{ins} = 1$ if individual chooses to pay P_{ins} for the lamp in installments, instead of paying a lump sum price of MWK 20,000. At every price, demand is aggregated across all individuals in *Box* and *No Box* groups. All monetary values are reported in Malawian Kwacha (MWK). At the time of the study, the exchange rate was roughly MWK 720/ 1 USD. Observations = 1,728.



(a) Willingness to Pay with Installments Plan



(b) Willingness to Pay with Lump Sum Plan

Figure 3: The figures plot demand curves using responses to willingness-to-pay exercises using linear probability models. At every price, demand is aggregated across all individuals in *Box* and *No Box* groups. Robust standard errors reported. All monetary values are reported in Malawian Kwacha (MWK). At the time of the study, the exchange rate was roughly MWK 720/ 1 USD. Observations = 1,728.

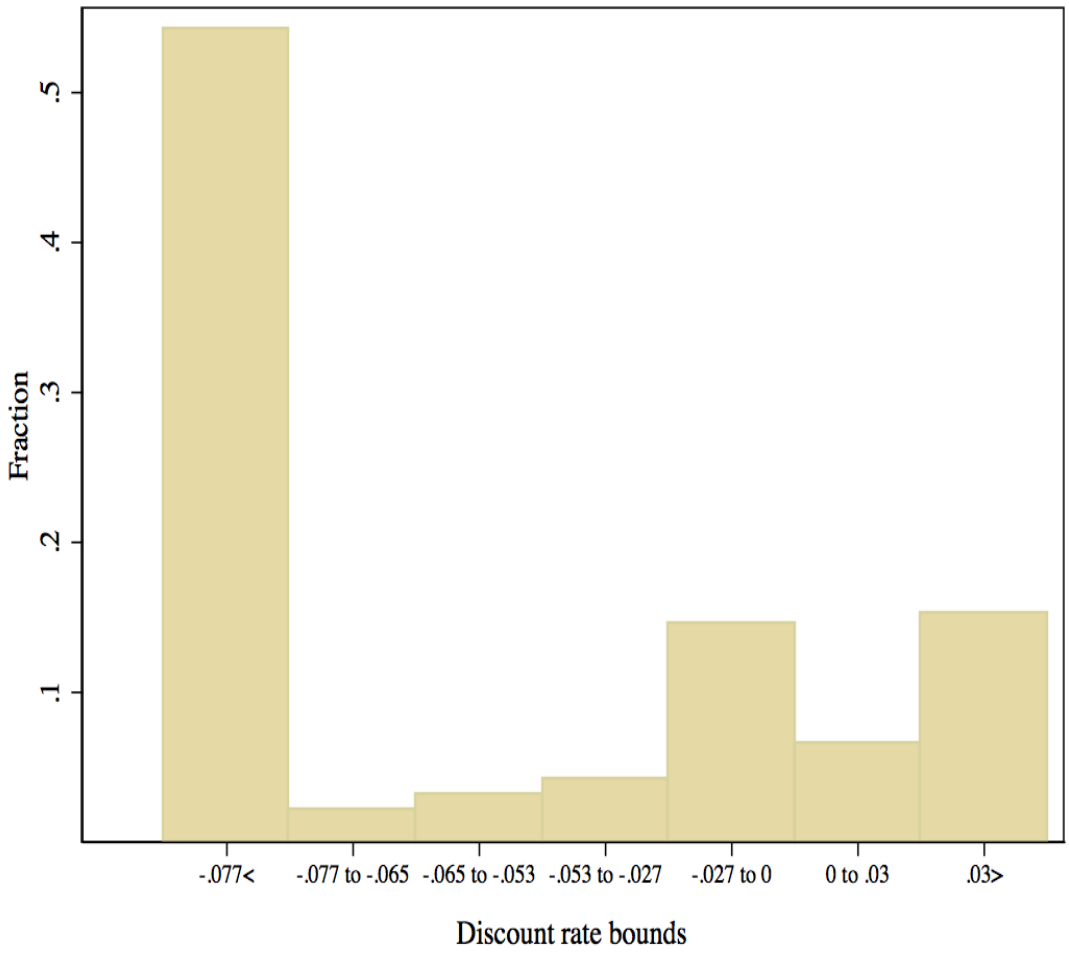


Figure 4: The price at which respondents choose to switch from paying in installments to paying a deferred lump sum is used to construct bounds on respondents' "implied discount rates." The most and least negative discount rate windows pertain to respondents who never choose to pay in lump sum and installments, respectively.

9 Tables

Table 1: Baseline Statistics and Randomization Check

	Box	Deferred lump sum	Upfront lump sum	Control	Joint test 1[a]	Joint test 2[b]	Joint test 3[c]
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Demographic & Household characteristics							
Female	.29	.35	.3	.33	.29	.65	.52
	(.46)	(.48)	(.46)	(.47)			
Age	35.94	33.64	34.85	35.23	.08	.96	.22
	(11.16)	(11.17)	(11.09)	(11.64)			
Education (years)	9.0	9.19	8.68	8.28	.59	.25	.43
	(3.04)	(2.79)	(2.85)	(3.02)			
Married	.78	.71	.9	.81	.2	0	0
	(.42)	(.46)	(.30)	(.39)			
Head of household	.78	.74	.77	.77	.53	.93	.82
	(.42)	(.44)	(.43)	(.42)			
Household size	4.53	4.32	4.67	4.48	.38	.34	.45
	(1.92)	(2.1)	(1.98)	(1.66)			
Children (count)	2.28	2.03	2.27	2.19	.17	.54	.33
	(1.53)	(1.58)	(1.52)	(1.35)			
Burnt brick walls	.65	.66	.63	.69	.93	.7	.93
	(.48)	(.48)	(.49)	(.46)			
Iron sheets roof	.94	.87	.85	.87	.03	.21	.03
	(.23)	(.34)	(.36)	(.34)			
Cement floor	.77	.66	.8	.69	.03	.08	.03
	(.42)	(.48)	(.40)	(.46)			
Financial characteristics							
Interest rate on	.23	.23	.23	.26	.95	.92	.99
one-month loan[e]	(.20)	(.22)	(.18)	(.20)			
Has a bank account	.30	.23	.38	.2	.16	.05	.05
	(.46)	(.42)	(.49)	(.40)			
Participates in ROSCA	.23	.2	.32	.17	.53	.07	.15
	(.42)	(.40)	(.47)	(.38)			
Participates in VSLA	.15	.23	.25	.19	.11	.3	.15
	(.36)	(.42)	(.43)	(.39)			
Has own mobile money	.66	.51	.53	.45	.01	.4	.03
account	(.48)	(.50)	(.50)	(.50)			
Mobile money account	.38	.17	.27	.21	0	.92	0
with spouse	(.49)	(.38)	(.45)	(.41)			

Business characteristics							
Owned this shop (years)	5.96	5.37	6.54	5.89	.41	.31	.41
	(6.18)	(5.67)	(7.1)	(6.4)			
Open air shop	.11	.08	.15	.12	.41	.24	.34
	(.32)	(.28)	(.36)	.33			
Daily hours worked	10.81	10.95	11.1	10.77	.61	.46	.67
	(2.36)	(2.31)	(2.34)	(2.45)			
Business profit (good week)	25.5	16.9	21.8	21.4	.16	.88	.18
	(68.13)	(19.18)	(20.05)	(28.80)			
Business profit (bad week)	13.35	12.33	11.48	10.67	.84	.67	.83
	(28.80)	(51.80)	(16.21)	(19.46)			
Lighting expenditure & solar technology awareness							
Monthly grid exp (home)	2.31	3.07	1.47	2.38	.49	.08	.22
	(5.28)	(11.99)	(4.04)	(8.33)			
Monthly grid exp (shop)	1.10	0.88	0.45	2.57	.61	.08	.22
	(4.46)	(2.93)	(1.94)	(10.92)			
Monthly off-grid exp[f]	5.38	5.08	5.42	59.63	.68	.8	.89
	5.73	6.61	6.23	7.53			
Know of solar lights	.65	.64	.65	.63	.87	.89	.98
	(.48)	(.48)	(.48)	(.49)			
Has solar light(s)	.03	.06	.07	.03	.25	.3	.26
	(.17)	(.23)	(.26)	(.16)			

Notes: [a]Test of equality of means across *Box* and *No Box* groups. [b]Test of equality of means across Upfront lump sum, Installments, and Deferred lump sum groups. [c]Test of equality of means across groups offered lamp for purchase and group not offered the lamp for purchase. [d]Columns 1-4 report means and standard deviations in parentheses. Column 4 reports p-value of test of difference in means across groups 1 and 2. Column 5 reports p-values from a test of equality of means across all four groups.

[e]This is the interest rate paid on loan from most commonly used lender (formal or informal).

[f] Sources of non-electric lighting are candles, kerosene lamps, battery-operated lights and generator (runs on diesel).

All monetary values are reported in USD. At the time of the study, the exchange rate was roughly 1 USD/ MWK 720

Table 2: Preference for Installments & Purchase Decision

	Prefer Installments		Prefer Installments at Higher Effective Price		Premium (Installments)	
	(1)	(2)	(3)	(4)	(5)	(6)
Box	0.08*	0.06	-0.04	-0.06	-644.46*	-617.23*
	(0.042)	(0.044)	(0.057)	(0.058)	(367.727)	(372.147)
Mean dep. variable	0.81	0.81	0.66	0.66	4384.62	4384.62
Observations	288	288	288	288	244	244
Adjusted R-squared	0.009	0.015	-0.002	0.020	0.008	0.035
Individual Controls	No	Yes	No	Yes	No	Yes

This table shows the impact of the *Box* treatment on revealed preference for the installments plan. Each respondent reveals whether she prefers to pay P_L as a deferred lump sum or $P_{ins} = P_L(1+r)$ in weekly installments for the solar lamp for six different values of r. The dependent variable in columns 1 and 2 is 1 if the respondent ever chose to pay in installments over paying the lamp's price as a deferred lump sum. The dependent variable in columns 3 and 4 is equal to 1 for those respondents who chose to pay in installments when $r > 1$. The dependent variable in columns 5 and 6 is the difference between the highest price that an individual is willing to pay for the installments plan and the deferred lump sum price of MWK 20,000. Even columns control for baseline measures of age, gender, marital status, mobile money account ownership, control over own income, interest paid on an informal loan, household wealth indicator and ownership of other solar technology. All monetary values are reported in Malawian Kwacha (MWK). At the time of the study, the exchange rate was roughly MWK 720/ 1 USD.
Robust standard errors are in parentheses. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.
Source: WTP exercise administered at baseline survey.

Table 3: Solar Light Take-Up Across Treatment Groups

	Decides to try out solar lamp							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Deferred payment	0.47***	0.48***						
	(0.038)	(0.041)						
Box			0.19***	0.13**			0.20**	0.17**
			(0.061)	(0.063)			(0.087)	(0.086)
Installments					0.08	0.04	0.10	0.07
					(0.062)	(0.063)	(0.087)	(0.088)
Installments & Box							-0.03	-0.07
							(0.123)	(0.123)
Individual Controls	No	Yes	No	Yes	No	Yes	No	Yes
Mean dep. variable	0.04	0.04	0.28	0.28	0.47	0.47	0.37	0.37
Sample	All groups offered lamp				Installments & Deferred lump sum only			
Observations	339	339	258	258	258	258	258	258

Notes: This table reports linear probability model estimates of the decision to purchase the solar lamp. The dependent variable indicates whether the individual bought the solar lamp (for the upfront lump sum payment group)/ decided to try out the solar lamp (in the installments, and deferred lump sum groups). The independent variable in the first two columns indicates whether the respondent was offered the lamp on a deferred payment plan (either Installments or Deferred lump sum). The dependent variable in columns 3 through 8 indicates whether an individual decides to try out the lamp on the deferred payment plan. The regressions in these columns are estimated for the sub-sample that received the deferred payment plan. Even columns control for baseline measures of age, gender, education, household size, martial status, whether respondent is household head, measure of control over own income, experimentally measured marginal rate of substitution, hours and days worked, ownership of financial accounts and solar devices, and expenditure on lighting. Robust standard errors are in parentheses. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.
Source: Purchase decision measured at baseline survey.

Table 4: Completing Solar Lamp Payment

	Has active lamp					
	(1)	(2)	(3)	(4)	(5)	(6)
Box	0.14**	0.12**			0.13*	0.14*
	(0.057)	(0.056)			(0.075)	(0.077)
Installments			0.13**	0.10*	0.12*	0.12
			(0.057)	(0.057)	(0.074)	(0.075)
Installments & Box					0.01	-0.04
					(0.113)	(0.113)
Mean dep. variable	0.16		0.24		0.17	
Observations	258	258	258	258	258	258
Individual Controls	No	Yes	No	Yes	No	Yes

Notes: All columns report linear probability model estimates. The dependent variable indicate whether respondent has a solar lamp that is completed paid for at the end of 8 weeks. Even columns control for baseline measures of age, gender, education, household size, martial status, whether respondent is household head, measure of control over own income, hours and days worked, ownership of financial accounts, and implied discount rate from willingness-to-pay exercise administered at baseline.
Robust standard errors are in parentheses. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table 5: Repayment Choices and Lamp Ownership

	Has a working lamp		Bought lamp	
	(1)	(2)	(3)	(4)
Random offer matches elicitation exercise	0.02	0.02	0.04	0.04
	(0.152)	(0.159)	(0.183)	(0.191)
Installment	-0.14*	-0.15	-0.28**	-0.29**
	(0.085)	(0.096)	(0.110)	(0.117)
Random offer matches elicitation exercise	0.30*	0.31*	0.46**	0.45**
& Installments	(0.177)	(0.187)	(0.212)	(0.222)
Box	0.12	0.11	0.17*	0.16
	(0.087)	(0.088)	(0.098)	(0.098)
Box & Random offer matches	-0.10	-0.10	-0.03	-0.01
elicitation exercise	(0.208)	(0.211)	(0.243)	(0.251)
Box & Installments	-0.19*	-0.16	-0.08	-0.08
	(0.106)	(0.121)	(0.191)	(0.196)
Box & Random offer matches	0.29	0.26	0.03	-0.01
elicitation exercise & Installments	(0.237)	(0.249)	(0.306)	(0.316)
Observations	263	263	263	263
Individual Controls	No	Yes	No	Yes

This table reports effect of the random repayment plan matching what the respondent's choice in the elicitation exercise. The variable "Random offer matches elicitation exercise" is 1 of individuals who, by chance, were offered the installment (lump sum) plan as the experimental repayment plan and also chose installment (lump sum) plan in the WTP exercise. The variable "Installment" is 1 for individuals who were offered the installments repayment plan, and "Box" is 1 for individual randomized into the *Box* group.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.
Source: Baseline survey.

Table 6: Impact of Solar Lamps : Lighting Expenditure

	Off-grid expenditure (home)		Grid expenditure (home)		Off-grid expenditure (shop)		Grid expenditure (shop)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bought lamp	-137.97***	-135.92***	37.22	23.33	-127.75***	-132.44***	30.34	34.65
	(28.717)	(29.323)	(44.177)	(44.293)	(32.249)	(34.748)	(55.311)	(54.299)
Control mean	158.8	158.8	47.05	47.05	133.6	133.6	50.43	50.43
Observations	8,763	8,763	8,762	8,762	8,763	8,763	8,762	8,762
Individual Controls	No	Yes	No	Yes	No	Yes	No	Yes

This table reports average daily effects of using the lamp on lighting expenditure. The results are from instrumental variable regressions where"Bought lamp" is instrumented with each of the treatment groups. Regressions are at the respondent-day level. Standard errors are in parentheses, clustered at both the individual and day level. Even columns control for baseline measures of gender, education, number of children, self reported control over own income, and measured time preference indicator.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.
Source: Daily logbook records.

Table 7: Impact of Solar Lamps : Mobile Phone outcomes & Savings

	Phone out of power		Phone recharge expenditure		Savings (lighting & mobile)	
	(1)	(2)	(3)	(4)	(5)	(6)
Bought lamp	-0.93***	-0.91***	-43.45***	-43.21***	-241.67**	-262.55***
	(0.292)	(0.293)	(8.039)	(7.819)	(99.087)	(98.787)
Control mean	1.54	1.54	45.05	45.05	434.85	434.85
Observations	8,763	8,763	8,763	8,763	8,763	8,763
Individual Controls	No	Yes	No	Yes	No	Yes

This table reports average daily effects of using the lamp on mobile phone outcomes (columns 1-4) and total savings in energy expenditure (columns 5 and 6). The results are from instrumental variable regressions where"Bought lamp" is instrumented with each of the treatment groups. Regressions are at the respondent-day level. Standard errors are in parentheses, clustered at both the individual and day level. Even columns control for baseline measures of gender, education, number of children, self reported control over own income, and measured time preference indicator.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.
Source: Daily logbook records.

Table 8: Impact of Solar Lamps : Business & Home Outcomes

	Hours worked		Sales revenue		Children study hours	
	(1)	(2)	(3)	(4)	(5)	(6)
Bought lamp	-0.28	-0.25	-390.78	-727.52	-0.08	-0.09
	(0.409)	(0.411)	(2,110.652)	(2,134.594)	(0.103)	(0.110)
Control mean	12.07		9894	9894	0.270	0.270
Observations	8,762	8,762	8,763	8,763	8,762	8,762
Individual Controls	No	Yes	No	Yes	Yes	Yes

This table reports average daily effects of using the lamp on business outcomes and hours spent on study by children. The results are from instrumental variable regressions where"Bought lamp" is instrumented with each of the treatment groups. Regressions are at the respondent-day level. Standard errors are in parentheses, clustered at both the individual and day level. Even columns control for baseline measures of gender, education, number of children, self reported control over own income, and measured time preference indicator.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.
Source: Daily logbook records.

10 Appendix

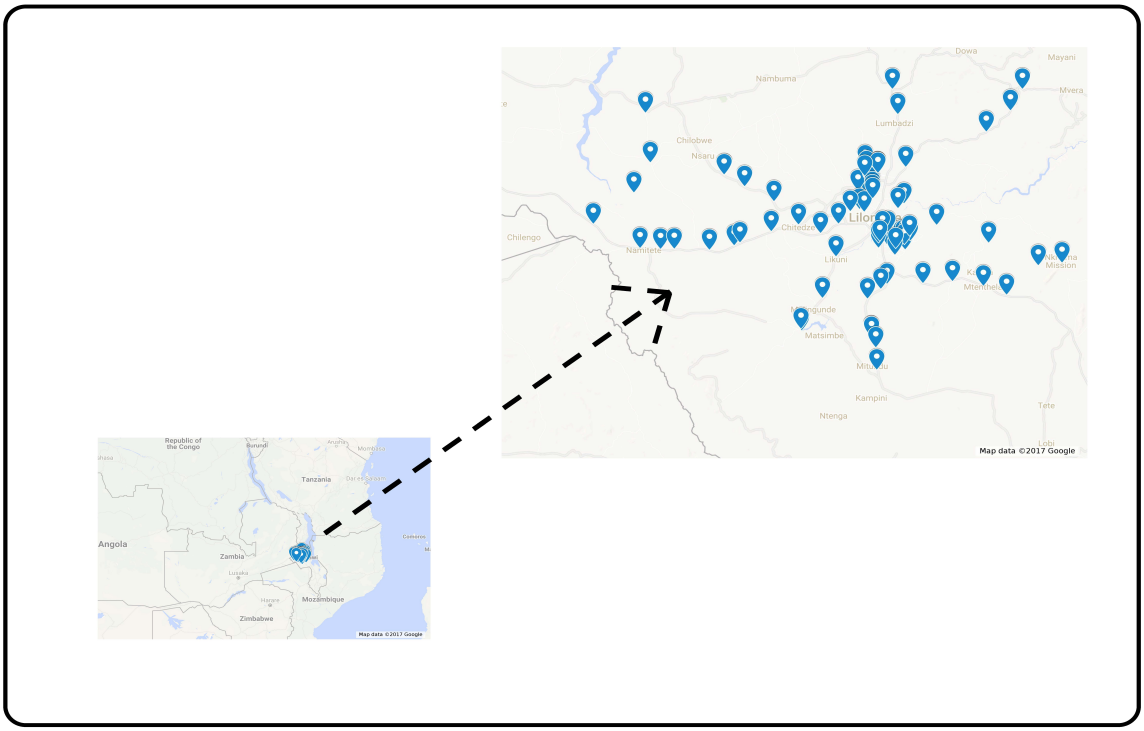


Figure A1: Markets where the experiment was implemented.

Thanks to Google Maps.

Figure A2: Omnivoltaic Pilot X PAYG light.

Source: Omnivoltaic website.

Figure A3: Lockboxes used in the study
Source: Author's collection.

This is round 3 of prices. In round 3 there are two ways to pay for the solar lamp.

Option 1: pay MWK 20,000 after 8 weeks.
So, if you pick option 1 you would pay MWK 20,000 for the solar lamp + charger.

Option 2: pay MWK 3,250 every week for 8 weeks.
So, if you pick option 2 you would pay MWK 26,000 in total for the solar lamp + charger.

Option 3: Don't want to buy the solar lamp.

Figure A4: Example of question in WTP exercise

Table A1: Self-reported Reason for Preference for Installments or Deferred Lump Sum

	Mean	Observations
	(1)	(2)
Panel A: Why do you prefer to pay in installments		
I may be tempted to spend the money before 8 weeks	0.705	156
The money may get stolen before 8 weeks	0.122	156
Family/ friends will ask for money	0.039	156
Other[a]	0.135	156
Panel B: Why do you prefer to pay as a deferred lump sum		
I want to use money for my business	0.64	25
I want to use my money for home needs	0.12	25
I want to keep my money with me in case of an emergency	0.20	25
Other	0.16	25

Notes: The data is collected at baseline survey. The summary statistics in Panel A are from the sub-sample who demonstrated the strongest desire for the installments plan by reporting that they would rather pay the highest installment price (MWK 26,000) over the deferred lump sum price (MWK 20,000) for the solar lamp. The summary statistics in Panel B are from the sub-sample who demonstrated the strongest desire for the lump sum plan by reporting that they would rather pay the lump sum price of MWK 20,000 over the lowest installment price of MWK 18,000 (MWK 18,000) for the solar lamp. [a] Commonly cited other reason include "the payment frequency matches income frequency," and "it is easy [to remember]." A small fraction (0.045) thought the installment plan was cheaper

Table A2: Amount paid for the solar lamp

	Mean	Std. dev	Obs.
	(1)	(2)	(3)
Completed payment on time			
Installment	0.68	0.47	72
Deferred lump sum	0.52	0.50	60
Amount paid for the solar lamp			
Installment	15660	7494	72
if did not finish repayment at 8 weeks	5795	6564	22
Deferred lump sum	11333	9994	60
if did not finish repayment at 8 weeks	–		
Box	13974	8804	78
No box	13287	9225	54

Notes: This table presents summary statistics on amount paid for the solar lamp. The installment group was scheduled to complete payment in eight weekly installments of MWK 2500 each. The deferred lump sum group pays MWK 20,000 at the end of eight weeks. The box-treatment was crosscut with the repayment frequency treatment.
Source: Angaza Energy Hub, through SunnyMoney Malawi.

Table A3: Days Device Shut Off for Incomplete Payment

	Mean	Std. dev	Obs.
	(1)	(2)	(3)
Installment	12.33	17.25	72
if did not finish repayment at 8 weeks	20.23	19.61	22
Deferred lump sum	–		
Box	8.09	15.49	78
No box	6.65	14.36	54

Notes: The solar lamp is set up to provide energy until a payment is due. It shuts off when a payment has to be made and does not provide energy until the payment is completed. During the experimental period, the solar lamp could have turned off eight times for the installment group, at each of the scheduled installment dates. The deferred lump sum group, on the other hand, does not experience any shut of days during this period.This table presents summary statistics on the number of days that the solar lamp was shut off for the installments group, and also variation from the box-treatment. Arrears are usually, but not always, settled when project staff visit respondents a week later to collect the next installment after a week.
Source: Angaza Energy Hub, through SunnyMoney Malawi.

Table A4: Correlates of Willingness to Pay, Purchase Decision

	WTP > 0	Bought light
	(1)	(2)
Group 1 (Box + deferred)	0.06***	0.13***
	(0.033)	(0.063)
Group 3 (Payment at purchase)	-0.08	-0.42***
	(0.050)	(0.056)
Age	0.00	0.01***
	(0.002)	(0.002)
Married	0.03	-0.02
	(0.043)	(0.063)
Female	0.06	-0.01
	(0.043)	(0.066)
Education (years)	0.01	-0.01
	(0.007)	(0.009)
Household size	0.02	-0.03
	(0.018)	(0.022)
Children (count)	-0.01	0.05***
	(0.024)	(0.029)
Head of household, proportion	0.01	0.08
	(0.047)	(0.075)
Has a bank account	-0.06	0.03
	(0.040)	(0.057)
Has own mobile money account	0.08***	0.11***
	(0.032)	(0.050)
Participates in informal financial group	0.01	0.11***
	(0.037)	(0.054)
Food insecure in the past month	0.01	-0.03
	(0.046)	(0.071)
Monthly non-grid lighting cost (log)	0.01	0.02***
	(0.009)	(0.012)
Daily hours worked	0.01	0.01
	(0.009)	(0.011)
Business revenue in a good week (log)	0.01	0.05
	(0.024)	(0.038)
Business revenue in a bad week (log)	-0.02	-0.05***
	(0.018)	(0.033)

Home has cement floor	-0.02	-0.02
	(0.045)	(0.071)
Home has iron sheets roof	-0.03	-0.04
	(0.062)	(0.092)
Know of solar lights	0.04	0.02
	(0.040)	(0.055)
Has solar light(s)	-0.00	-0.13
	(0.097)	(0.095)
Mean dep variable	0.89	0.41
Std. dev. dep variable	0.21	0.49
Observations	369	339
Adjusted R-squared	0.031	0.239
P-value of F model	0.111	0.000

Notes: Data collected during baseline survey. The dependent variables are indicators for whether respondent wanted to purchase the solar lamp at some positive price (column 1), and whether respondent prefers to pay for the solar light in installments for at least one of the experimental prices (columns 2). Preference for installments plans is measured only for groups 1 and 2. Groups 1 and 2 were unaware of their randomly assigned price when reporting WTP for solar lamp, but knew whether they received a box as part of the study and that they qualified for deferred payment plan. Robust standard errors in parentheses. *** $p<0.1$, ** $p<0.05$, * $p<0.01$

Table A5: Reported Preferences & Purchase Behavior

	Actual Purchase Decision	
	Did not buy lamp	Bought lamp
	(1)	(2)
Reported preference with installments		
Will not buy lamp	0.897	0.103
Will buy lamp	0.291	0.709
Reported preference with lump sum		
Will not buy lamp	0.906	0.094
Will buy lamp	0.293	0.707

Data collected at endline survey administered to a random sub-sample of lamp users. All monetary values are reported in Malawian Kwacha (MWK). At the time of the study, the exchange rate was roughly MWK 720/ 1 USD.

Table A6: Descriptive Statistics: Lamp Usage

Uses the lamp at:	
Home	0.308
Business	0.168
Home & Business	0.523
Largest Impact of lamp:	
Children study more	0.178
Less smoke inside house	0.037
Work longer at business	0.439
Feel safe in the dark	0.047
Mobile phone always charged	0.299
Box respondents only	
Used box	0.967
Saved more money than needed for the lamp in the box	0.067
If used box, money saved:	
Mean	15396.67
Median	20000
Standard Deviation	7360.49

Data collected at endline survey administered to a random sub-sample of lamp users. All monetary values are reported in Malawian Kwacha (MWK). At the time of the study, the exchange rate was roughly MWK 720/ 1 USD.

Table A7: First Stage: Effect of Lamp Usage

Treatment	
Box & Installment	0.230***
	(0.0153)
No Box & Installment	0.166***
	(0.0154)
Box & Deferred lump sum	0.059***
	(0.015)
Upfront lump sum	-0.387***
	(0.0145)
Control	-0.432***
	(0.015)
Constant	0.432***
	(0.011)
F-Stat	754.28
Observations	8762

Here I report coefficients on the first-stage regression of trying out the lamp on treatment indicators. The omitted group is "No Box & Deferred lump sum." All errors are clustered at the day-individual level.
Source: Logbook records.