Credit, attention, and externalities in the adoption of energy efficient technologies by low-income households

On-line Appendix

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August 3, 2022

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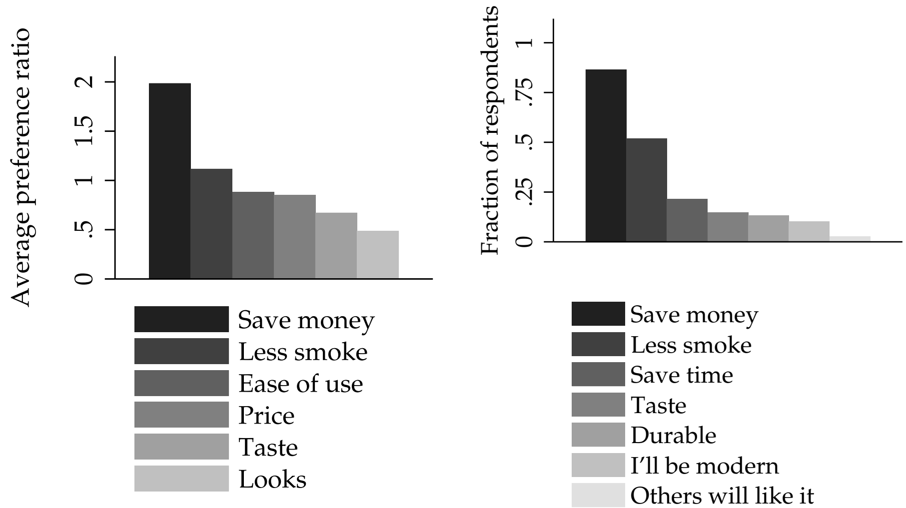
Additional figures



Panel A: Important stove qualities

Panel B: Best attributes of Jikokoa

Figure C1. Most salient benefits of Jikokoa stove

Note: The most salient positive attribute about the Jikokoa stove is that it saves money. This attribute is almost twice as preferred as health benefits from reductions in smoke emissions, which itself is more than twice as large as any other attribute.

If the price of the cookstove is 2500 Ksh would you want to buy it?

You would need to pay 212 Ksh per week for the next 12 weeks.

Panel A: Attention control (A0)

If the price of the cookstove is 2500 Ksh would you want to buy it?

You would need to pay 212 Ksh per week for the next 12 weeks.

JUNE:
Week 1: You would save 200 Ksh
Week 2: You would save 300 Ksh
Week 3: You would save 200 Ksh
Week 4: You would save 300 Ksh

JULY
Week 5: You would save 300 Ksh
Week 6: You would save 300 Ksh
Week 7: You would save 400 Ksh
Week 8: You would save 400 Ksh
Week 9: You would save 300 Ksh

AUGUST
Week 10: You would save 200 Ksh
Week 11: You would save 300 Ksh
Week 12: You would save 300 Ksh

Panel B: Attention to energy savings (A1)

If the price of the cookstove is 2500 Ksh would you want to buy it?

You would need to pay 212 Ksh per week for the next 12 weeks.

Week 1: You would pay -12 Ksh. This is your weekly savings of 200 minus your weekly payment of 212.
Week 2: You would save 88 Ksh (300 Ksh - 212 Ksh)
Week 3: You would pay -12 Ksh (200 Ksh - 212 Ksh)
Week 4: You would save 88 Ksh (300 Ksh - 212 Ksh)

Week 5: You would pay -12 Ksh (200 Ksh - 212 Ksh)
Week 6: You would save 88 Ksh (300 Ksh - 212 Ksh)
Week 7: You would pay -12 Ksh (200 Ksh - 212 Ksh)
Week 8: You would save 88 Ksh (300 Ksh - 212 Ksh)

Week 9: You would pay -12 Ksh (200 Ksh - 212 Ksh)
Week 10: You would pay -12 Ksh (200 Ksh - 212 Ksh)
Week 11: You would save 88 Ksh (300 Ksh - 212 Ksh)
Week 12: You would pay -12 Ksh (200 Ksh - 212 Ksh)

After 12 weeks, you have paid off your stove, and you can keep all of your weekly savings:

Week 13: You would save 300 Ksh

Panel C: Attention to energy savings minus costs (A2)

Figure C2. Attention Treatments

Note: The on-screen information during the BDM decision process for a hypothetical respondent in the weekly credit treatment group (C1). The payment amounts vary over 12 cycles of *Yes/No* questions depending on the respondent's answers. The benefits stay constant. The conversion from total cost to weekly payment amounts incorporates interest. Ksh (KES) 100 $\approx$ USD 1 at the time of surveying. While 'pay -10' might appear to cancel out, this was well understood in context when the field officer talked through the funding stream.

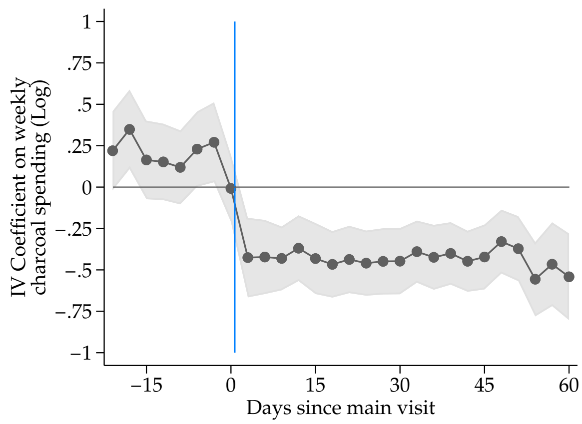


FIGURE C3. CAUSAL IV ESTIMATE OF ADOPTION ON SPENDING OVER TIME

Note: Instrumental Variables (IV) estimates for the causal effect of stove adoption on average weekly charcoal spending over time. Estimates prior to adoption have larger standard errors because only respondents in the attention treatment groups participated in the SMS survey about charcoal expenditures prior to visit 2, which reduces the sample size.

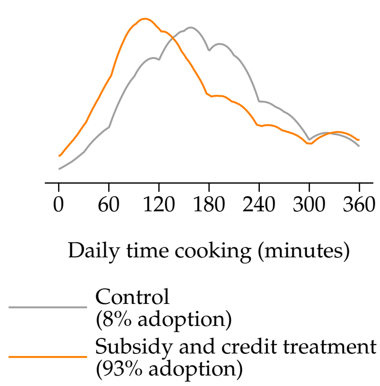


FIGURE C4. TIME SAVINGS FROM STOVE ADOPTION

Note: Time spent cooking per day, self-reported during the endline survey. We plot usage by randomly assigned treatment since stove adoption is correlated with WTP, but compliance is high. The instrumental variables regression suggests that adoption of the stove causes households to reduce their daily time spent cooking by 54 minutes. This is the opposite of the rebound theory in energy efficiency, which states that household usage of an appliance goes up after adoption of a more energy efficient version, since the marginal cost of usage goes down. The reduction is likely due to the ease of lighting the stove, rather than a change in cooking time itself.

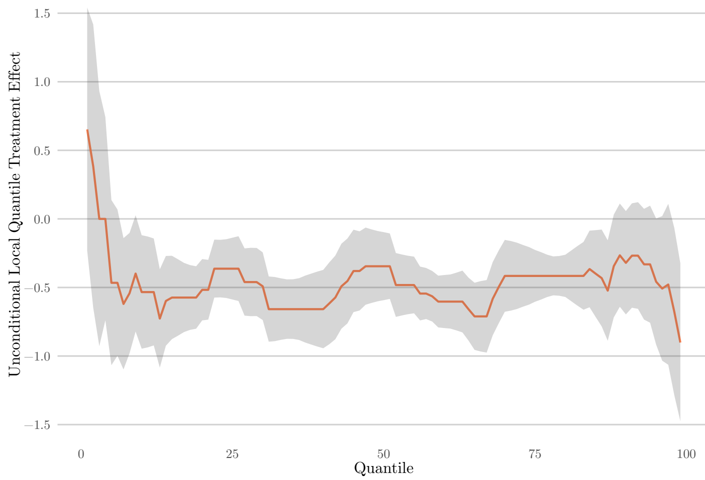


Figure C5. Unconditional Local Quantile Treatment Effects on Charcoal Spending

Note: Unconditional local quantile treatment effect estimates on inverse hyperbolic sin charcoal spending reported via SMS and point-wise 95% confidence intervals using the method proposed by Frölich and Melly (2013). Confidence intervals were computed using a block bootstrap clustered at the respondent level. The results show that the effect is relatively homogeneous across the distribution of charcoal spending.

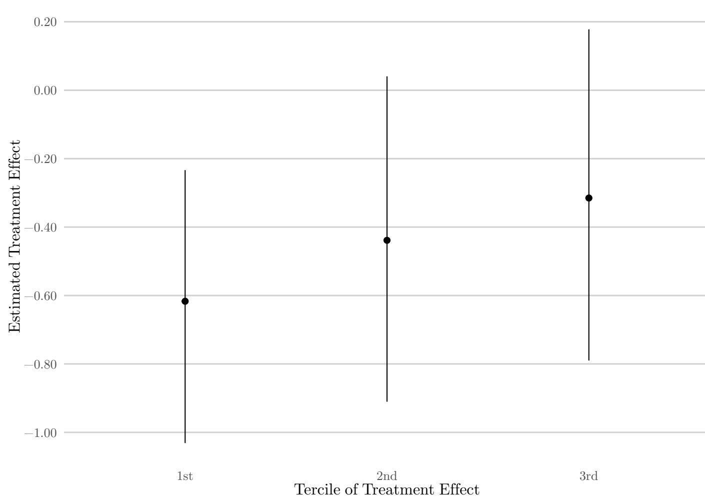


Figure C6. Sorted Group Average Treatment Effects (GATES) on Charcoal Spending

Note: Sorted group average treatment effects on charcoal spending estimated using the method proposed by Chernozhukov et al. (2018). The sample was randomly split into auxiliary and main samples stratifying by quintile of WTP. Using the auxiliary sample, we use LASSO to form predictions of endline charcoal spending based on observed baseline measures of energy consumption, household socioeconomic status, demographics, health and energy prices separately for stove adopters and non-adopters. Using these models, we form predictions for the main sample and difference the predictions to create a predicted treatment effect. We then group the observations into terciles of predicted treatment effect and estimate the treatment effect of adopting a stove for each group using inverse propensity weighting based on quintile of WTP. We then repeat this procedure 1000 times and take medians to form final estimates. The results suggest relative homogeneity in the treatment effect.

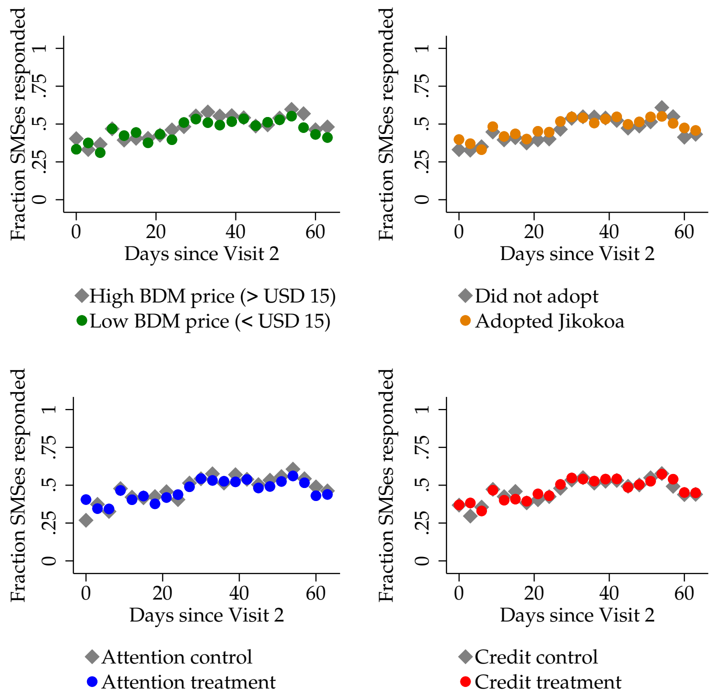


Figure C7. Attrition of SMSes by adoption and treatment status

Note: We test for attrition in SMS responses by Jikokoa adoption and treatment status for all three treatments (credit, attention, and subsidy). Table D3 provides results from statistical tests that confirm balanced attrition across all three treatment groups, adoption status, and most socioeconomic characteristics. We test for attrition in more detail in the recurring SMS survey. Of 955 respondents who completed visit 2, 835 (87 percent) responded correctly to at least one SMS after that visit. Among these respondents, we received correct responses to 44 percent of post-adoption charcoal SMSes. The composition of respondents varies across SMS cycles: some responded to many SMSes while others responded to only a few. Figure C12 presents a histogram of SMSes each respondent correctly responded to during the first 48 days after visit 2. 443 (46 percent) responded to at least half of all SMSes. During the SMS survey conducted one year after the main experiment, more than 75 percent of respondents who completed visit 2 responded to at least one SMS, and the median respondent responded to six.

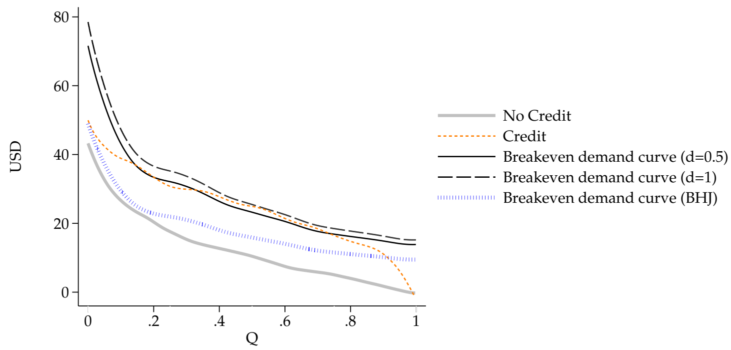
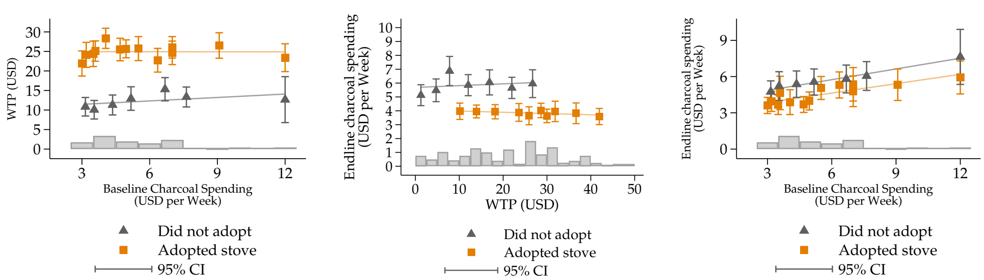


FIGURE C8. ROBUSTNESS OF UNDER-ADOPTION GAP FOR VARYING ANNUAL δ

Note: Demand curves assuming annual discount factors of $\delta = 0.5$ and $\delta = 1$ and summing over 12 weeks—the term of the loan. The BHJ curve uses the discount parameters estimated by Balakrishnan, Haushofer, and Jakiela (2020) in a similar context with a money now or money later design ($\delta = 0.942$ per week and $\beta = 0.924$). Even using BHJ's relatively more conservative estimates, present bias and exponential discounting alone cannot explain the low WTP among the control group.



PANEL A PANEL B PANEL C

FIGURE C9. TREATMENT EFFECT BY WTP

Note: In Panel A, expected returns do not predict WTP. In Panel B, WTP does not predict realized returns. Panel C confirms that adoption affects the relationship between baseline and endline charcoal spending.

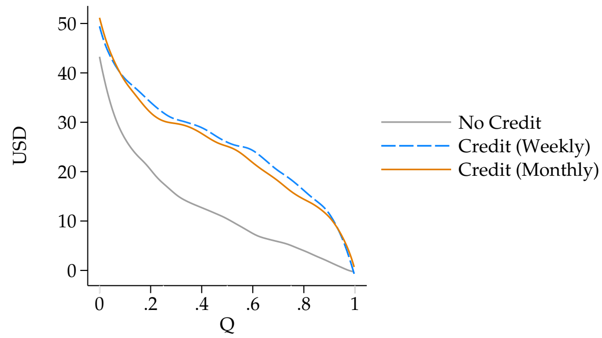
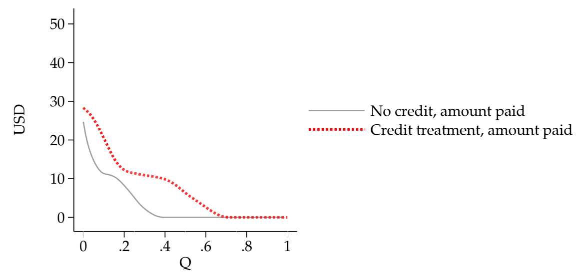
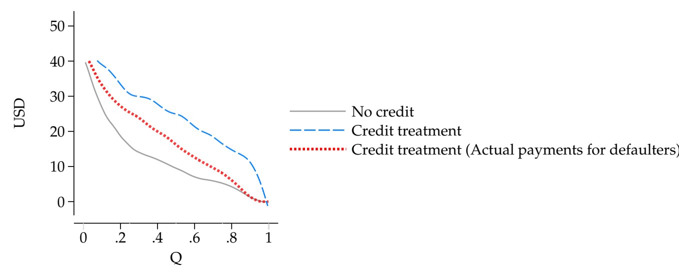


Figure C10. WTP for stove under monthly and weekly deadlines

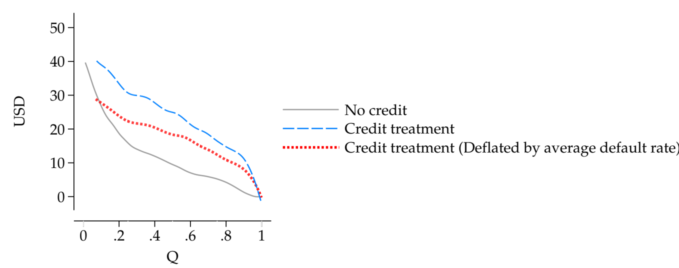
Note: The monthly payment stream might have been preferred as transaction costs are lower, and respondents have significantly more flexibility (including the option to commit to weekly payments if they believe this will facilitate repayment). On the other hand, an agent exhibiting concentration bias would prefer payment plans where costs are dispersed across a larger number of smaller payments rather than concentrated in a smaller number of larger payments. We test for this by randomly assigning respondents to pay by either weekly or monthly deadlines. WTP is presented for the two credit treatments separately. The framing of deadlines does not affect WTP.



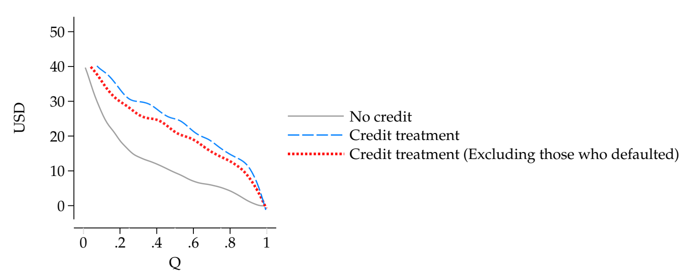
Panel A: Actual amounts received by treatment (counting non-adopters as zero)



Panel B: Replacing WTP with amount paid for defaulters



Panel C: Deflate WTP across the distribution by breakeven interest rate



Panel D: Dropping those who defaulted from the sample

Figure C11. Willingness to Pay Robustness to Default

Note: These figures display the demand curves in Panel A of Figure VIII as well as a several curves dealing with credit default in different ways, including looking at amounts paid by treatment counting non-adopters as zeros (Panel A), replacing WTP with amount paid for defaulters (Panel B), deflating by the average default rate (Panel C), and dropping defaulters from the sample (Panel D).

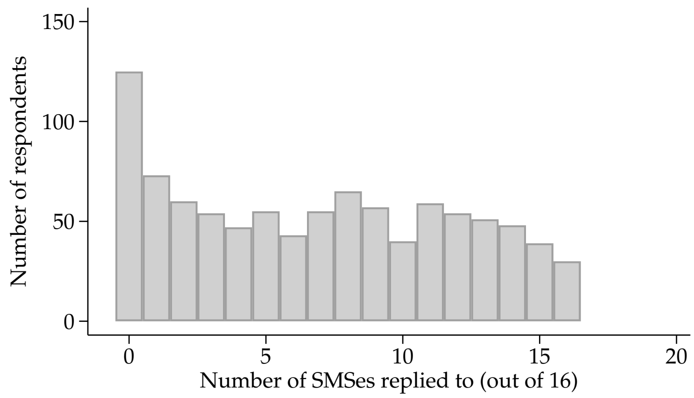


Figure C12. Number of SMSes replied to, by respondent

Note: The number of SMSes each respondent correctly responded to during the first 48 days (16 3-day SMS cycles) after visit 2. Out of 955 respondents who completed visit 2, 123 (13 percent) did not respond to any SMSes in this period. 443 respondents (46 percent) responded to at least half of all SMSes. Table D3 confirms that socio-economic characteristics (with the exception of age) do not predict SMS non-response.

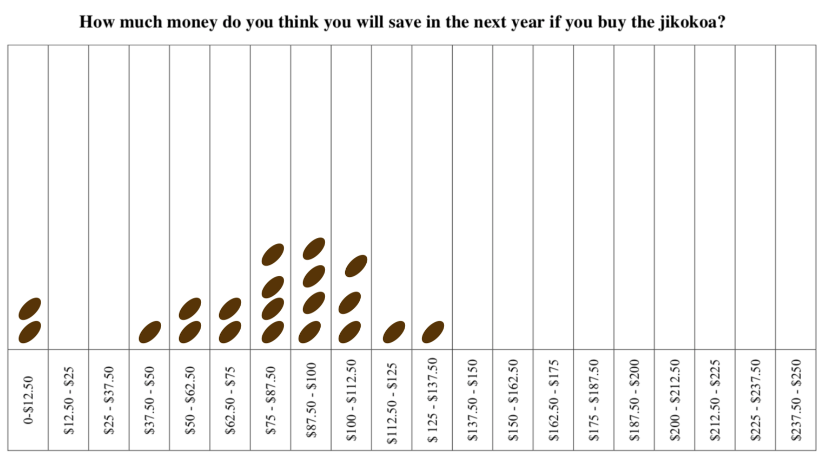


Figure C13. Eliciting beliefs about future savings

Note: Respondents are first asked to estimate the maximum amount they may save in the best possible scenario. They are then asked to allocate 20 beans on the interval $[0, max]$ according to how likely the believe each outcome is. Above is a hypothetical response that a respondent might give. We discuss this in more detail in Table D4.

Panel A: Blank   Panel B: Complete

Figure C14. Effort Task

Note: Example of one blank and one completed *effort task*. Respondents mark the number of times each symbol appears. Respondents are asked to use tick marks in order to prevent more educated or literate participants from gaining an advantage. Most respondents took between one to two minutes to complete one task. The answers had to be within 10 percent of the correct number of ticks to be marked as ‘complete’. Each respondent is required to complete at least three tasks during each visit.

Additional tables

Table D1—Balance test for attention, credit, and subsidy treatments

	Sample Mean	Attention Treatment	Credit Treatment	Subsidy Treatment	N
	(1)	(2)	(3)	(4)	
Sex (female=1)	0.95	0.02	-0.01	-0.01	1011
	[0.21]	(0.01)	(0.01)	(0.01)	
Respondent age	37.22	-0.25	0.20	0.07	1011
	[11.82]	(0.82)	(0.79)	(0.74)	
Number of household residents	4.74	-0.04	0.13	0.07	1011
	[2.09]	(0.15)	(0.14)	(0.13)	
Number of child residents	2.58	-0.03	0.11	0.09	1011
	[1.72]	(0.12)	(0.11)	(0.11)	
Savings in bank, mobile, ROSCA (USD)	74.85	2.46	6.08	-12.13	1011
	[129.51]	(9.00)	(8.64)	(8.14)	
Household income (USD/week)	47.24	-2.32	-3.88	-1.69	1005
	[34.65]	(2.41)	(2.32)	(2.19)	
Total energy consumption (USD/week)	8.55	0.07	0.12	-0.16	1011
	[3.59]	(0.25)	(0.24)	(0.23)	
Charcoal consumption (USD/week)	5.59	0.04	0.04	-0.09	1011
	[2.60]	(0.18)	(0.17)	(0.16)	
Price of old jiko (USD)	3.39	0.07	-0.02	0.07	1006
	[1.33]	(0.09)	(0.09)	(0.08)	
Risky investment amount (0-4 USD)	1.20	0.04	-0.10	-0.11	1011
	[1.00]	(0.07)	(0.07)	(0.06)	
Joint F-Test		0.78	0.48	0.14	

Note: Each row and each treatment column represents an individual regression of the row variable on an indicator for receiving the treatment in the column. For legibility, in this table the sub-treatments for attention and credit are pooled. For the subsidy treatment balance check, we define treatment as BDM price $P_i \leq$ USD 15 (50 percent of respondents). Treatment assignment was stratified on baseline charcoal spending. The three treatments appear to be balanced on observable demographic and socioeconomic characteristics. SD in brackets. SE in parentheses.

Table D2—Causal impact of stove adoption on weekly charcoal spending

	OLS	IV Estimate (1-month endline)			IV Estimate (1-year endline)	
	(1) USD	(2) USD	(3) IHS(USD)	(4) IHS(KG)	(5) USD	(6) IHS(USD)
Control	-2.84	-2.91	-0.64	-0.59	-3.10	-0.79
	(0.53)	(0.70)	(0.18)	(0.20)	(0.94)	(0.22)
Credit Only (pooled)	-1.89	-2.60	-0.60	-0.45	-2.35	-0.50
	(0.51)	(0.69)	(0.17)	(0.18)	(1.00)	(0.23)
Attention Only (pooled)	-1.55	-1.81	-0.40	-0.54	-2.37	-0.60
	(0.38)	(0.52)	(0.11)	(0.15)	(0.80)	(0.14)
Credit and Attention (pooled)	-2.08	-2.30	-0.49	-0.41	-2.54	-0.50
	(0.37)	(0.52)	(0.12)	(0.16)	(0.74)	(0.17)
Observations	7853	7853	7853	796	6979	6979
Control Mean	5.72	4.97	2.16	1.55	5.30	2.21
Socioeconomic controls	Yes	Yes	Yes	Yes	Yes	Yes
Data Source	SMSes	SMSes	SMSes	Buckets	SMSes	SMSes

Note: Results from an instrumental variables regression that uses the (randomly assigned) BDM price as an instrument for stove adoption to estimate the causal impact of adoption on weekly charcoal expenditures. Column (1) presents the OLS results. Column (2) uses weekly charcoal expenditures in USD as the outcome variable. Column (3) uses the inverse hyperbolic sine (IHS) conversion of the USD amount. Column (4) uses the IHS of the weight of the charcoal bucket one month after stove adoption as the outcome variable. Columns (5) and (6) conduct the same analyses as columns (4) and (5) respectively, but using data from the SMS survey conducted one year after the main visit. Socioeconomic controls include baseline savings, income, risk aversion, credit constrainedness, number of adults and children. In regressions using SMS data, errors are clustered by respondent. SE in parentheses.

Table D3—Socio-economic characteristics do not predict attrition

	Attrited (Visit 2)	Attrited (Visit 3)	Attrited (SMSes-1)	Attrited (SMSes-2)
BDM Treatment (Price ¡= 15 USD)	0.015	-0.003	0.007	0.025
	(0.014)	(0.018)	(0.031)	(0.031)
Credit Treatment	0.012	0.004	-0.042	0.001
	(0.015)	(0.019)	(0.033)	(0.033)
Attention Treatment	0.030	0.034	0.001	0.017
	(0.016)	(0.019)	(0.035)	(0.035)
Sex (female=1)	-0.010	-0.001	-0.014	0.043
	(0.035)	(0.042)	(0.075)	(0.075)
Respondent age	-0.002	-0.002	-0.003	-0.004
	(0.001)	(0.001)	(0.001)	(0.001)
Number of household residents	-0.004	-0.007	-0.009	-0.008
	(0.003)	(0.004)	(0.008)	(0.008)
Number of child residents	-0.006	-0.009	-0.001	-0.007
	(0.004)	(0.005)	(0.009)	(0.009)
Savings in bank, mobile, ROSCA (USD)	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Household income (USD/week)	-0.000	-0.000	-0.000	0.001
	(0.000)	(0.000)	(0.000)	(0.000)
Total energy consumption (USD/week)	-0.000	-0.003	0.003	-0.002
	(0.002)	(0.002)	(0.004)	(0.004)
Charcoal consumption (USD/week)	-0.002	-0.004	0.001	-0.002
	(0.003)	(0.003)	(0.006)	(0.006)
Price of old jiko (USD)	0.002	-0.004	-0.007	0.017
	(0.005)	(0.007)	(0.012)	(0.012)
Risky investment amount (0-4 USD)	0.002	0.002	-0.001	-0.020
	(0.007)	(0.009)	(0.016)	(0.016)
Jikokoa (=1)		-0.033	-0.061	-0.042
		(0.012)	(0.033)	(0.033)
Joint F-Test p-Value	0.77	0.98	0.85	0.57
Sample Mean	0.06	0.09	0.46	0.48

Note: Each coefficient in each of the Attrited columns represents a separate regression testing whether the outcome variable predicts attrition. Attrited (SMS) equals one for respondents who responded than fewer of the median number of SMSes. SE in parentheses.

To elicit respondents' beliefs about the savings generated by the stove over a one-year period of ownership we use methods developed in Delavande (2014), Delavande, Giné, and McKenzie (2011b), Delavande, Giné, and McKenzie (2011a), and Mel, McKenzie, and Woodruff (2008). Figure C13 displays the beliefs sheet we employed. So as not to anchor respondents to a specific point on the sheet, prior to commencing the beliefs exercise respondents were first asked what they believed would be the maximum they could possibly save in a year. Respondents then receive the beliefs sheet and are given the following instructions:

> *"There are 20 beans. I would like you to take these beans and place them on this sheet according to how much you think you will save over the next year, if you receive a Jikokoa. If you put some beans in one of the groups, it means you think you might save that amount of money. For example:*
>
> - *If you put all your beans in one group, it means you are sure that you will save exactly that amount of money this year if you had the Jikokoa.*
> - *If you do not put any beans in one of the groups, it means you are confident that you will not save this amount of money.*
> - *As you add beans to a group, it means that you think the likelihood that you will save that amount increases.*
> - *If you put 1 bean in every group, it means you think all of the outcomes are equally likely."*

Table D4—Attention Treatment on Beliefs

	Endline Beliefs	
	(1)	(2)
Baseline beliefs	0.09	0.09
	(0.03)	(0.03)
Attention (pooled)	0.12	
	(0.07)	
Attention (A1 only)		0.21
		(0.08)
Attention (A2 only)		0.05
		(0.07)
Observations	943	943
Control Mean	0.00	0.00

Note: Beliefs in each period are standardized for the control group to have mean 0 and standard deviation 1. Controls include randomized credit treatment and price assignments and socioeconomic controls, which include baseline savings, income, risk aversion, credit constrainedness, number of adults and children.

Additional Background

E1. Energy Consumption

Total spending on firewood and charcoal in Sub-Saharan Africa in 2012 was USD 12 billion (Bailis et al. 2015), and Kenyan households consumed USD 680 million worth of charcoal in 2019 (MoE 2019). Charcoal usage is expected to continue growing in coming decades due to rising incomes and rapid urbanization, as households that currently gather firewood for cooking climb up the energy ladder and switch to charcoal (Hanna and Oliva 2015).

While middle-income Kenyans are increasingly adopting modern cooking technologies, adoption among lower-income households remains low. We focus on low-income households living in informal settlement areas around Nairobi, where *jikos* are common and charcoal is widely available. For these households, the most salient feature of modern cookstoves are their financial savings—and these depend on energy prices. In Kenya, the price of charcoal has fluctuated in recent years due to the off-and-on implementation of government bans on deforestation for environmental reasons (Iiyama et al. 2014). Charcoal is usually sold in small metal or plastic tins ('mkebe' or 'kasuku'), which contain between 1–4 kilograms of charcoal and retail for between USD 0.50–USD 1.50, although respondents report that the price of charcoal can fluctuate by up to 20–30 percent of the average price on a monthly basis.

E2. Credit

According to the Kenya National Bureau of Statistics (2018), 33 percent of households in Nairobi County had accessed credit in the preceding year, primarily from a merchant directly (28 percent) or informally, for example through a Chama[48] or from family or friends. In our sample, 86 percent of respondents had borrowed at least once in that period, primarily through a Chama or from family or friends. For all households, in Nairobi broadly and within our sample, loans primarily served to cover health spending, child's school fees, or business needs. 70 percent of respondents participate regularly in a Chama or *merry-go-round*, with payouts generally ranging between USD 10–300. Around half of respondents participate in a Chama that had a payout of at least USD 40, the cost of the stove at the time of the study, and around one-third had ever taken out a loan via a mobile banking platform such as M-Shwari.

There appears to be heterogeneity in access to credit by gender, although only 46 respondents (5 percent) were male, so these statistics may be noisy. Around 96 percent of both men and women in our sample use mobile money services such as M-Pesa. 24 percent of women would not be able to access a mobile money

[48]A Chama is a common Kenyan savings group. All group members contribute a fixed amount to the group in every period, and the sum of all contributions is given to a different group member in each period.

loan if they wanted to today, while this is the case for only 11 percent of men. The median male respondent would be able to borrow USD 38 while the median female respondent would be able to borrow only USD 10. There may also be unobservable differences—for example, a woman may face social pressure to use credit for household purposes rather than according to her personal preferences. That said, 68 percent of women and 59 percent of men had taken out a loan (formally or informally) in the past 12 months, and 34 percent of women and 46 percent of men had been refused a loan in the past year, suggesting that the overall difference in credit constrainedness by gender is likely small.

Design Details

F1. Sample Representativeness

The primary alternative cooking technology in these neighborhoods is LPG gas, which tends to be used by slightly higher-income families, so there is a modest difference between our sample and the residents of Nairobi slum areas. According to the Nairobi Cross-sectional Slums Survey (2014), whose sampling methodology was designed to be statistically representative, 81.6 percent of residents had completed primary education, while 70 percent of respondents in our sample had. The average household size was 3.1 in the representative sample, while this was 4.7 in our sample.

Respondents in our sample have on average significantly lower incomes than existing cookstove adopters. According to two proprietary studies completed by a third-party consultant on behalf of the cookstove company in 2016 and 2017, consisting of phone surveys with a random sample of existing customers, only 12 percent of recent adopters live below the Kenyan poverty line (Ksh 310 per person per day, or around USD 3), while 88 percent of our respondents do. More than half of adopters had attended college or university, while only 4 percent of our respondents have.

F2. BDM Implementation Details

What follows is a description of our BDM methodology. The full script is available in Section H.

During visit 2, the field officer and the respondent use a binary search over the interval USD 0 to 50 to determine the respondent's maximum WTP. The respondent is asked 12 binary questions asking whether they would purchase the stove for a given price. Question 1 for every respondent asks, *"If the price of the Jikokoa is 2,500 Ksh [USD 25] would you want to buy it?"*[49] The subsequent question then asks about the mid-point of the remaining interval and so on. For

[49]This midpoint was chosen as the starting position in order to take advantage of the efficiencies and concreteness of a binary search. One may be concerned that beginning the elicitation at this number may lead to anchoring effects. To the extent that this is true, because USD 25 is much higher than control willingness to pay, the anchoring effect will lead us to underestimate under-adoption. Second,

instance, if the respondent answers *'yes'* to question 1, the next question will be, *"If the price of the Jikokoa is 3,750 Ksh [USD 37.50] would you want to buy it?"* Conversely, if the respondent answers *'no'* to question 1, the next question will be, *"If the price of the Jikokoa is 1,250 Ksh [USD 12.50] would you want to buy it?"*

The binary questions incorporate each respondent's credit treatment assignment. A participant in the weekly payments credit treatment group might be asked, *"If the price of the Jikokoa is 2,500 Ksh [USD 25] would you want to buy it? You would pay Ksh 212.09 [USD 2.12] per week for the next 3 months."* A participant in the monthly payments credit treatment group might be asked, *"If the price of the Jikokoa is 2,500 Ksh [USD 25] would you want to buy it? You would pay Ksh 852.50 [USD 8.53] per month for the next 3 months."* The conversion from total amount to weekly or monthly payments incorporates interest.

The information presented varies based on which attention treatment the respondent is in. Respondents in A1 will see the savings they wrote down next to the BDM price they are considering at that moment. Respondents in A2 will see the savings they wrote down, the costs, and the net benefits corresponding to the BDM price they are considering at that moment. As the binary questions vary, the costs in each period and net benefits are calculated and updated accordingly. Figure C2 provides examples of the screen for three hypothetical respondents.

After answering 12 binary questions, the respondent has disclosed their maximum WTP to the nearest USD 0.01. After respondent i has stated their maximum WTP_i, the respondent and the field officer then open the envelope containing the hidden price P_i. The decision on WTP is binding: if $WTP_i < P_i$, the respondent is not allowed to purchase the stove, and if $WTP_i \geq P_i$, the respondent must purchase the stove today.[50] To ensure that the respondent understood the consequences of their decision, field officers performed an extensive series of checks and confirmation questions. For example, field officers asked respondents to describe what would happen if $P_i = WTP_i + 5$ and if $P_i = WTP_i - 5$ numerous times throughout the process. In the final question, asked immediately prior to opening the envelope, 97 percent of respondents answered both questions correctly.[51] In addition, each respondent played a practice BDM round with a small item (either a bar of soap or a bottle of hand lotion) prior to the cookstove BDM. We provide more information about this below.

Respondents were told that the price in their envelope had been randomly as-

respondents already were presented with a salient anchor: the market price. Finally, it is not clear why the anchoring would differentially affect the treatments, suggesting the differences in willingness to pay across treatments would still be informative.

[50] 8 respondents for whom $WTP_i \geq P_i$ (1.4 percent) were ultimately not able to pay P_i for the stove. We did not force these respondents to adopt the stove, and we interpret this econometrically as imperfect compliance with treatment assignment.

[51] In the majority of cases where the respondent argued upon losing the BDM elicitation (around 10 percent of all respondents for whom $WTP_i < P_i$), the argument concerned the high price (the respondent wanted a larger discount) rather than miscomprehension about the process itself, again suggesting that comprehension was generally good.

signed to them, but they did not receive any information regarding the probability distribution of prices. We specified the distribution of prices P_i to satisfy several goals. First, to produce a strong first stage and reduce the sensitivity of our savings estimate to the distribution of willingness to pay, we concentrate mass at a high and a low price. Second, to reduce attrition, all participants receive a subsidy of at least USD 10. Third, to ensure incentive compatibility, all prices across the range [0.01, 29.99] have positive probability. Finally, to limit field officers' ability to influence participants' decisions, we draw prices from a narrow uniform distribution around each mass point rather than assigning the center itself.

These specifications result in the following distribution. Six percent of participants are allocated a price drawn from $U[3.50, 4.50]$, 39 percent of participants are allocated a price drawn from $U[10, 12]$, 44 percent of participants are allocated a price drawn from $U[25, 27]$, and 11 percent of participants are allocated a price drawn from $U[0.01, 29.99]$. Figure A4 displays the distribution of BDM prices for all 1,018 participants. Prices were randomly assigned to participants after visit 1 and are stratified on baseline levels of charcoal consumption and on assignment to the attention and credit treatments.

F3. Measuring time-inconsistency

We use effort allocations to reduce concern that the preferences we estimate are the result of fluctuations in credit constraints (O'Donoghue and Rabin 2015; Cubitt and Read 2007; Dean and Sautmann 2021). We adapt the exercise for our context so that it can be completed in a field setting. The effort task we employ consists of counting the triangles, circles, and crosses on a grid. Figure C14 displays an example of an effort task. Respondents on average took one to two minutes to complete one effort task.

Respondents complete three practice effort tasks during visit 1 to understand the procedures and the cost of effort. They are then informed that they will need to complete additional tasks during visits 2 and 3. They are told they will have the opportunity to choose how many of these tasks they would like to do in each visit.

During both visit 1 and visit 2, respondents decide how many of those tasks they would like to do in visit 2 and how many in visit 3 at varying interest rates.[52] During visit 1, decisions about both visit 2 and visit 3 are in the future. In contrast, during visit 2, the decision about visit 2 is in the present while the decision about visit 3 is in the future. Since the time between between visits 2 and 3 does not change, any difference between the decisions made during visit 1 and the decisions made during visit 2 is evidence of time-inconsistent behavior.[53]

[52]To limit the potential relevance of any fixed costs in the exertion of effort, all respondents must complete at least three tasks in each visit.

[53]It is possible that between the two visits that some respondents received a shock to the cost of effort, and that this is why their allocations changed. To the extent that these shocks are uncorrelated with the other variables of interest, this is simply measurement error.

Derivations of the micro-foundations of inattention

We explore the micro-foundations that determine the attention parameter θ_i across individuals. We allow for imperfect attention following Gabaix and Laibson (2017). We define $b_t = u(c_t + \psi_t) - u(c_t)$ to capture the beneficial utility consequences from purchasing the stove, and $\kappa_t = u(c_t + \psi_t - r_t) - u(c_t + \psi_t)$ to capture the costly utility consequences from purchasing the stove. We assume that the agent perfectly perceives the current period, but that both b_t and κ_t are imperfectly observed for $t = 1, ..., T$. By paying attention to each period, the agent is able to generate signals about the utility benefits and costs of purchasing the stove (s_t^b and s_t^κ respectively). The condition then changes to:

$$u(c_0 - p^* + l) - u(c_0) + \sum_{t=1}^{T} D(t) \left[\mathbb{E}[b_t | s_t^b] - \mathbb{E}[\kappa_t | s_t^\kappa]\right] = 0 \tag{G1}$$

We further assume that these signals are correct on average and are imperfectly observed due to independent, normally distributed noise that is linearly increasing in later periods:

$$s_t^b = \mathbb{E}[u(c_t + \psi_t) - u(c_t)] + \epsilon_t \qquad \epsilon_t \sim N(0, \sigma_\epsilon^2 t) \tag{G2}$$

$$s_t^\kappa = \mathbb{E}[u(c_t + \psi_t - r_t) - u(c_t + \psi_t)] + \nu_t \qquad \nu_t \sim N(0, \sigma_\nu^2 t) \tag{G3}$$

The agent then combines these signals with the priors they hold over the benefits and costs of adopting new technologies. This yields the following prediction:

> **Prediction 2:** When attention to benefits is increased (smaller σ_ϵ^2), if the true benefits of the stove are greater than the prior for all technologies this will increase WTP.
>
> $$\frac{\partial p^*}{\partial \sigma_\epsilon^2} < 0$$

The impact of attention to costs on adoption will depend on whether costs are incurred in the present or in the future. Specifically,

> **Prediction 3:** If the agent does not have access to credit and there are no other flow costs, $r_t = 0 \; \forall \; t$. Thus if $0 < \mu$, increasing attention to costs will lower σ_ν^2 and increase WTP.[54]
>
> $$\frac{\partial p^*}{\partial \sigma_\nu^2} < 0$$

[54] Intuitively, the agent expects there to be some flow cost of adoption and after thinking about it realizes there actually isn't.

Prediction 4: If the agent has access to credit and $\mu < r_t$, then increased attention to costs will lower σ_ν^2 and decrease WTP.[55]

$$\frac{\partial p^*}{\partial \sigma_\nu^2} > 0$$

Because the signals are stochastic so is the agent's willingness to pay. Thus, for clarity, we follow Gabaix and Laibson (2017) in studying the behavior of a "representative agent" who happens to receive signals of the costs and benefits with no noise. We begin by considering the case of an agent who has not had their attention augmented. For simplicity we assume that without augmentation the signals have the same noise, ($\sigma_\epsilon^2 = \sigma_\nu^2 = \sigma_s^2$). In this case the agent's condition simplifies to:

$$\text{(G4)}\quad 0 \quad = \quad u(c_0 - p^* + l) - u(c_0) + \sum_{t=1}^{T} D(t) \left[\frac{\mathbb{E}[u(c_t + \psi_t - r_t) - u(c_t)]}{1 + \frac{\sigma_s^2}{\sigma_u^2} t} \right]$$

The agent then combines these signals with the priors they hold over the benefits and costs of adopting new technologies. We assume that agents believe the utility benefits and costs of new technologies are identically and normally distributed $b_t, \kappa_t \sim N(\mu, \sigma_u^2)$. This plausibly holds in equilibrium for an agent who is risk neutral and is not credit constrained.[56] To illustrate, consider an agent who believes the utility benefits of new technologies on average exceed their costs; they should continually be attempting to adopt new technologies. Similarly, agents are unlikely to adopt so many technologies that they begin encountering net negative returns to adoption.

After combining these signals with the prior, the condition becomes:

$$\text{(G5)}\qquad 0 \quad = \quad u(c_0 - p^* + l) - u(c_0) + \sum_{t=1}^{T} D(t) \left[\frac{s_t^b - \mu}{1 + \frac{\sigma_\epsilon^2}{\sigma_u^2} t} - \frac{s_t^\kappa - \mu}{1 + \frac{\sigma_\nu^2}{\sigma_u^2} t} \right]$$

Note that by setting $\sigma_\nu = \sigma_\epsilon = 0$ this model nests the perfect attention case. If the agent perceives perfectly correct and precise signals, the influence of the priors cancel and we're left with the same condition as in the rational case.

Equation (G4) demonstrates that agents with this kind of inattention will systematically undervalue the future utility changes induced by adopting a technology. In the case where the stove generates improvements in utility in future periods, this will reduce willingness to pay.

[55]Intuitively, one benefit of borrowing is that the costs are less acutely perceived by the agent because they are in the future. By forcing the agent to remember they will have to eventually make the loan payments, this counteracts that effect.

[56]Under risk aversion and credit constraints, it is possible that $E[\mu_b] > E[\mu_\kappa]$, with analogous implications for the impact of attention.

BDM Script

Section 1: Practice TIOLI (`take it or leave it') with [item1] and practice BDM with [item2]

Households are randomly assigned into one of the following two groups:

Group 1:	item1 = soap	item2 = lotion
Group 2:	item1 = lotion	item2 = soap

Each household is also randomly assigned a price for the TIOLI item [pracprice1] and a price for the BDM item [pracprice2].

Introduction

We will first give you the opportunity to buy a Lotion and a Soap. After that, we will sell the Jikokoa. As thank you for your time today, you will receive Ksh 300. If you choose to buy a Lotion or a Soap, this will be paid out of the Ksh 300. For example, if you buy the Lotion for 100 and you do not buy the Sabuni, then you will receive the Lotion and your thank you payment at the end of the day will be 200 Ksh (300 - 100). Do you have any questions?

Practice TIOLI

[FO: Show the [item1] to the respondent]

Let's start with the [item1]. Would you like to buy this [item1] for Ksh [pracprice1]?

If you say 'yes', you will pay [pracprice1] and receive the [item1]. If you say 'no', you will not receive it and not pay anything.

Would you like to buy this item?

Practice BDM

[FO: Please take 1 blank piece of paper that says:

PRICE:

__________ KSH

WITHOUT SHOWING THE RESPONDENT, WRITE DOWN THE PRICE ON THE PIECE OF PAPER: [pracprice2]

FOLD THE PAPER CLOSED. WRITE DOWN "[item2]" on the OUTSIDE. Then, put the FOLDED paper on the table. Just to confirm, please write down the price that you just wrote on the piece of paper: _______]

The process for buying the [item2] and the Jikokoa today will be a little bit different. First, you and I will figure out the highest price that you are willing to pay. Then, we will together open a secret piece of paper to look at the price. If the secret price is higher than what you said you are willing to pay, then you will NOT be able to buy the Jikokoa or the [item2] from us today. If you named a price that was the same or higher as the price that is on the paper, then you will be able to purchase the cookstove from us today. You would then pay the price written on the piece of paper. This may be even lower than the price you chose! You will not have to pay anything more than you want to.

Since this is complicated, we will first make a plan for which price you would like to pay. I will ask you whether you would be willing to pay several prices and you will tell me "yes" or "no" for each price. After we are done, you will not be able to change your plan. You will only be able to buy the cookstove or the [item2] if you are willing to pay more than the secret price.

This offer is availabe for today only. If you do not get the stove today, you will not be able to get it tomorrow. This lottery is for today only. Do you understand?

[FO: If the respondent does not understand, please re-explain or answer their questions].

This offer is for your household only. This lottery cannot be used by anyone else.

[FO: Show the [item2] to the respondent]

Let's start by doing a practice exercise for this [item2]. The price of this good is written on this piece of paper.

[FO: SHOW THE FOLDED PIECE OF PAPER BUT KEEP IT CLOSED]

Afterwards, we will do the same for the cookstove. We will use a different secret price for the Jikokoa. Do you have any questions?

Note: For this next section, the quantity in each question depends on the answer immediately prior. If the prior answer is “no”, the subsequent price will be lower. If the prior answer is “yes”, the subsequent price will be higher. This process proceeds with a binary search.

If the price was 75 Ksh, would you want to buy the [item2]?
If the price was [prac_x1] Ksh, would you want to buy it?
If the price was [prac_x2] Ksh, would you want to buy it?

If the price was [prac_x3] Ksh, would you want to buy it?
If the price was [prac_x4] Ksh, would you want to buy it?
If the price was [prac_x5] Ksh, would you want to buy it?
If the price was [prac_x6] Ksh, would you want to buy it?

Confirmation section

So the most you are willing to pay to buy the [item2] is [prac_wtp1]?

So how much is the most you are willing to pay?
Just to make sure you understand, what happens if the price ends up being [prac_wtp1_p5]?

[If not correct:]
This is not correct! If you are willing to pay [prac_wtp1] and the price turns out to be [prac_wtp1_p5] then you would NOT be able to buy the stove from us! You previously said that you were not willing to pay [prac_wtp1_p5]. Do you understand?

And what happens if the price ends up being [prac_wtp1_m5]?

[If not correct:]
This is not correct! If you are willing to pay [prac_wtp1] and the price turns out to be [prac_wtp1_m5] then you SHOULD buy the stove from us! You previously said that you were willing to pay [prac_wtp1_m5]. Do you understand?

Just to double check, if the price ends up being [prac_wtp1_p5], would you want to buy the [item2] for [prac_wtp1_p5]?

[If yes:]
So the most you are willing to pay to buy the [item2] is [prac_wtp2]?

[If no:]
So how much is the most you are willing to pay?

Just to make sure you understand, what happens if the price ends up being [prac_wtp2_p5]?

[note: the Confirmation Section can happen up to 4 times. If the respondent still changes their mind, the field officer will start again from the beginning.]

Great! So the final highest price you will pay is [prac_finwtp].

<u>*Outcome Section*</u>

We have figured out that the maximum amount that you are willing to pay for the [item2] is [prac_finwtp] Ksh. We will now open the piece of paper to see the price.

[FO: Give the respondent the piece of paper and ask them to read the number.]

[If win:]
Congratulations! The price is [pracprice2] Ksh which is less than you said you were willing to spend ([prac_finwtp] Ksh).You may have this [item2] and we will deduct [pracprice2] Ksh from your thank you payment at the end of the survey.
[FO: DO NOT LET THE RESPONDENT CHANGE THEIR MIND AT THIS POINT!!!]
Do you have any questions?

[If lose:]
Unfortunately, the price is [pracprice2] Ksh which is more than you said you were willing to spend ([prac_finwtp] Ksh). You will not be able to buy the [item2] today.
[FO: DO NOT LET THE RESPONDENT CHANGE THEIR MIND AT THIS POINT!!!]

Do you have any questions?

[FO: Did the respondent want to change their mind?
Did the respondent argue?
What was the respondent's argument?]

<u>Section 2: Actual BDM with the Jikokoa</u>

[FO: PLACE THE COOKSTOVE PRICE ENVELOPE IN FRONT OF YOU. KEEP IT CLOSED. The name on the envelope should be [hhname]. Is this the name written on the envelope?

YOU MUST HAVE THE CORRECT ENVELOPE FOR THIS RESPONDENT: [hhname].

If you do not have their envelope, END THE SURVEY, APOLOGIZE, and tell them we will return TOMORROW (or MONDAY).

[if the FO has the wrong envelope] STOP THE SURVEY. Save the survey, and continue later. INFORM THE SFO that this has happened. Then, continue to your next respondent, and tell this respondent that you will return later.]

We are now going to use the same method that we used for the [item2] to see what price you would like to pay for buying the Jikokoa cookstove. The secret price of the Jikokoa for you is inside this envelope. I do not know what the price is. It was randomly chosen using a computer by one of my colleagues. As you can see, the envelope is closed and has your name on it. The price may be lower than the price in the stores!

The price inside this envelope was selected by a random lottery. This means that every participant in our study has a different price inside their envelope, and the prices were selected by random chance. Therefore, the price inside your envelope will be DIFFERENT from the prices that are written inside the envelopes of other people who also participate in the study. Everybody has a different price.

Remember:
- If the price on the envelope is higher than the most you said you were willing to pay, then you will NOT be able to buy the stove today. You cannot change your mind later, and you cannot get another chance tomorrow. This offer is for today only, and it is for you only.
- If you are willing to pay the amount in the envelope, then you SHOULD buy the cookstove from us today.
[Respondents in C0:] - You SHOULD then pay the price that is in the envelope TODAY.

Remember:
- If the price on the envelope is higher than the most you said you were willing to pay, then you will NOT be able to buy the stove today. You cannot change your mind later, and you cannot get another chance tomorrow. This offer is for today only, and it is for you only.
- If you are willing to pay the amount in the envelope, then you SHOULD buy the cookstove from us. You will then pay the price that is in the envelope.
[Respondents in C0:] - To purchase the stove, you will need to have the money to pay us via MPESA TODAY. We understand that if we came back in one week, perhaps you will have more money available. For now, we would like you to just think only about the cash that you have available RIGHT NOW, to spend on MPESA. Only think of the money that you have that you can use to buy the cookstove TODAY.

[FO: give respondent some time to think].

[Respondents in C0:] When we go through the exercise, please only offer to pay what you have available to buy the cookstove today.

We are not affiliated with the Jikokoa company and to us it does not matter whether you would like to buy the stove or not. We are not sales people: we are researchers and we are just trying to learn about people like you. If you do not want to buy the stove today, or if you think the price is too high, that is okay. It does not matter to us whether you buy the stove or not.

We will do our best to keep all our answers completely confidential. We will not share your name or individual information with anyone, and none of your neighbors, family, or friends will ever be able to see your answers. When you are answering the questions, please answer honestly. We are simply trying to learn from the people we are interviewing.

There is no such thing as "too low" or "too high", and there are no right or wrong answers. Throughout this process, you will be able to look at this screen to see the different prices.

[For respondents in A2 and in C1, C2:] The screen will also show how much you will have to pay for each payment. It will also show how much you will probably save in each week. The computer will then take the savings that you expect in every week, and then subtract any payments that you have to make each week. If your savings are larger than your payments for that week, it will show you how much you will save that week. If your payment is larger than how much you will save, it will show you how much you have to pay that week.

Do you understand?

[FO: If the respondent does not understand, please re-explain, and answer any questions].

Do you have any other questions? Let's begin.

Decision Section

[FO: Place the ATTENTION SHEET on the table so the respondent can see it.
REMEMBER: Go through the savings slowly, make sure the respondents understands how it works.

[For respondents in A2:] The screen will show the savings, and then subtract the cost of payment. Explain this carefully -- make sure the respondent understands.]

If the price of the Jikokoa is [x0] Ksh would you want to buy it?

[For respondents in C1:] You would need to pay [x0w] Ksh per week for the next 12 weeks.
[For respondents in C2:] You would need to pay [x0m] Ksh per month for the next 3 months.

[For respondents in A1:] Show all the savings over all weeks.

[For respondents in A2, C0:]

Week 1: [SnetC_x0] [netC_x0] Ksh . This is your savings of [attw1] Ksh minus the cost of the stove [x0] Ksh.
After you pay for your stove today, you can keep all of your weekly savings:
[Show all the savings over all remaining weeks.]

[For respondents in A2 and in C1:]

Week 1: [Snet1_x0] [net1_x0] Ksh. This is your weekly savings of [attw1] minus your weekly payment of [x0w].
Week 2: [Snet2_x0] [net2_x0] Ksh ([attw2] Ksh - [x0w] Ksh)
Week 3: [Snet3_x0] [net3_x0] Ksh ([attw3] Ksh - [x0w] Ksh)
Week 4: [Snet4_x0] [net4_x0] Ksh ([attw4] Ksh - [x0w] Ksh)

Week 5: [Snet5_x0] [net5_x0] Ksh ([attw5] Ksh - [x0w] Ksh)
Week 6: [Snet6_x0] [net6_x0] Ksh ([attw6] Ksh - [x0w] Ksh)
Week 7: [Snet7_x0] [net7_x0] Ksh ([attw7] Ksh - [x0w] Ksh)
Week 8: [Snet8_x0] [net8_x0] Ksh ([attw8] Ksh - [x0w] Ksh)

Week 9: [Snet9_x0] [net9_x0] Ksh ([attw9] Ksh - [x0w] Ksh)
Week 10: [Snet10_x0] [net10_x0] Ksh ([attw10] Ksh - [x0w] Ksh)
Week 11: [Snet11_x0] [net11_x0] Ksh ([attw11] Ksh - [x0w] Ksh)
Week 12: [Snet12_x0] [net12_x0] Ksh ([attw12] Ksh - [x0w] Ksh)

After 12 weeks, you have paid off your stove, and you can keep all of your weekly savings:
[Show all the savings over all remaining weeks.]

[For respondents in A2 and in C2:]

Week 1: You would save [attw1] Ksh. You can keep all of your savings from the stove.
Week 2: You would save [attw2] Ksh
Week 3: You would save [attw3] Ksh
Week 4: [Snet4_x0] [net4_x0] Ksh. This is your weekly savings of [attw4] minus your monthly payment of [x0m] Ksh

Week 5: You would save [attw5] Ksh
Week 6: You would save [attw6] Ksh
Week 7: You would save [attw7] Ksh
Week 8: [Snet8_x0] [net8_x0] Ksh. This is your weekly savings of [attw8] minus your monthly payment of [x0m] Ksh

Week 9: You would save [attw9] Ksh
Week 10: You would save [attw10] Ksh
Week 11: You would save [attw11] Ksh
Week 12: [Snet12_x0] [net12_x0] Ksh. This is your weekly savings of [attw12] minus your monthly payment of [x0m] Ksh

After 12 weeks, you have paid off your stove, and you can keep all of your weekly savings.

[Show all the savings over all remaining weeks.]

If the price of the Jikokoa is [x0] Ksh would you want to buy it? Select yes or no:

[Note: The Decision Section is repeated 12 times, until the respondent has stated their WTP to the nearest 1 Ksh.]

<u>*Confirmation section*</u>

[If yes:] So the most you would be willing to pay for the cookstove is [wtp1]?

[If no:] So how much is the most you are willing to pay?

Just to make sure you understand, what happens if the price ends up being [wtp1_p5]?

[If incorrect:] This is not correct! If you are willing to pay [wtp1] and the price turns out to be [wtp1_p5] then you would NOT be able to buy the stove from us! You previously said that you were not willing to pay [wtp1_p5]. Do you understand?

[If incorrect:] This is not correct! If you are willing to pay [wtp1] and the price turns out to be [wtp1_p5] then you SHOULD buy the stove from us for [wtp1_p5] Ksh! Do you understand?

And what happens if the price ends up being [wtp1_m5]?

This is not correct! If you are willing to pay [wtp1] and the price turns out to be [wtp1_m5] then you SHOULD buy the stove from us for [wtp1_m5].

Do you understand?

Just to double check, if the price ends up being [wtp1_p5], would you like to buy the cookstove and pay [wtp1_p5]?

[note: the Confirmation Section can happen up to 4 times. If the respondent still changes their mind or does not understand, the field officer will start again from the beginning]

We have figured out that the maximum amount that you are willing to pay for the cookstove is [finwtp]. We will now open the envelope to see the price. Remember:
- if the price on the envelope is higher than [finwtp], then you will NOT be able to buy the stove today.
- if the price is less than or the same as [finwtp], you SHOULD buy the cookstove today. You will pay the price in the envelope.

Just to make sure you understand, if the price ends up being [finwtp], do you agree to buy the cookstove and pay [finwtp]?

[FO: [If no:] The respondent does not understand! Please repeat the rules again.]

And what happens if the price ends up being [checkFinal]?

[If incorrect:] The respondent does not understand! Please repeat the rules again. If they change their mind, that is okay. Please go back and re-do the BDM BEFORE they open the envelope.

Outcome Section

[FO: Please give the respondent the envelope and ask them to open it and read the price.

The price written in the envelope should say Ksh [hhbdm]. Is this correct?

[FO: [If no:] What is the price written inside the envelope?]

[If lose:]

[FO: DO NOT LET THE HOUSEHOLD PURCHASE THE STOVE]

Unfortunately the price ([price] Ksh) is higher than you are willing to pay ([finwtp] Ksh). You will not be able to purchase the Jikokoa cookstove today. You may still buy a Jikokoa at the regular price of Ksh 2,990 in major supermarkets.

[FO: Did the respondent argue when they found out they could not buy the stove?]

[If win:]

Congratulations! The price is less than you are willing to pay. You may now purchase the stove for [price].

Pre-Analysis Plan
Behavioral barriers to energy efficiency adoption in Kenya

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Date: April 23, 2019 (latest version available here).
AEA RCT Registry ID: AEARCTR-0002484
IRB (Kenya): Kenya Medical Research Institute Scientific and Ethics Review Unit (SERU) KEMRI/RES/7/3/1. Approved April 4, 2019.
IRB (USA): UC Berkeley CPHS Protocol, 2017-11-10534. Approved March 15, 2019.

We seek to quantify how behavioral biases and market frictions affect poor households' adoption and usage of energy efficient durables. While a substantial literature studies how behavioral anomalies and failures of rationality—self-control problems, incorrect beliefs, and limited attention—contribute to the energy efficiency gap in the US (see Gillingham and Palmer for a review), little work exists in a development setting. This is important because biases might operate differently in poor environments. It could be that biases are exacerbated by stress or cognitive load associated with poverty (see Haushofer and Fehr for a review), or it could be that because poverty makes large, durable purchases high-stakes, poorer individuals are more likely to make decisions more carefully. Market frictions common in developing settings, like liquidity constraints and asymmetric information, might further exacerbate any failures of rationality. This will be the first paper to rigorously quantify the energy efficiency gap, causally identify the mechanisms driving this gap, and estimate its welfare effects, and it will do so in a high-stakes development setting.

This document details the methodology used for the implementation of the experimental randomization, and outlines the intended analysis of the resulting data. We define the outcome variables and main regression specifications that we intend to follow. However, we anticipate that we will carry out additional analyses beyond those included in this document. This document is therefore not meant to be comprehensive or to preclude additional analyses.

1 Introduction

Over the next 35 years, energy demand in the developing world is expected to increase by more than 40%. To respond optimally, policy makers need to understand the drivers of household adoption of energy efficient durables. While the welfare implications of these policies hinge critically on whether households are adopting optimally, almost nothing is known about whether this is true. While a significant literature has studied this in developed settings, little work exists in the developing world.

Cookstoves provide a useful setting for exploring this question because despite theoretically large savings and significant policy attention, demand and usage remain stubbornly low. Several large-

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scale randomized controlled trials have found weak demand and a lack of usage even for households that do adopt.

One potential explanation that reconciles these findings is that households do not fully internalize the potential energy savings in their decisions. Existing evidence largely comes from work on energy efficiency adoption in developed settings. But while a substantial literature shows that behavioral anomalies contribute to the energy efficiency gap in the US, little work exists in a development setting. Behavioral biases might operate differently in poor environments, and credit constraints might exacerbate any failures of rationality. The literature on technology adoption in developing contexts has also found important scope for behavioral biases. It remains unclear whether behavioral biases affect the adoption of energy efficient durables in developing contexts. In this project we seek to quantify how behavioral biases and credit constraints affect poor households' adoption and usage of energy efficient durables.

We partner with a non-traditional cookstove producer and use a Becker-DeGroot-Marschak (BDM) mechanism to elicit participants' willingness to pay (WTP) for an energy saving durable and estimate the causal effect of ownership on energy savings. In a 2018 pilot, we found substantial scope for behavioral biases or market failures: estimated energy savings are large but uncorrelated with household WTP. In particular, to justify the median WTP of \$15 given our estimated savings of \$130 within a year with only exponential discounting, participants would need discount factors of approximately 0.86 per week, or indifference between receiving \$10 today and \$25,500 a year from today. These savings imply an internal rate of return of 27% per month, significantly exceeding the Kenyan cost of credit: M-Shwari, Kenya's largest mobile lending platform, charges 7.5% monthly interest.

On 17 April 2019 we launched a full study in Nairobi with up to 1,000 households to disentangle the likely behavioral and market mechanisms. We quantify under-adoption by comparing household WTP to realized energy savings, and study three potential causes of under-adoption: inattention, credit constraints, and present-bias. We implement a randomized controlled trial that (1) quantifies household under-adoption, and (2) assesses whether inattention, credit constraints, or present bias impede adoption.

2 Experimental Design

This section describes the experimental design and the randomized treatment arms. We plan to enroll up to 1,000 participants to participate in this study. Individuals must:

- reside in one of our primary study areas (all lower-income areas in or around Nairobi, Kenya);
- use a traditional charcoal cookstove as their primary cooking technology;
- spend at least Ksh 300 per week on charcoal; and
- not plan to purchase a Jikokoa in the next 3 months;

to qualify for participation.

2.1 Credit Treatment Arms

To understand the effect of access to credit on WTP, we assign each participant to one of three credit treatment arms:

1. **Loan - Control ("L0")**
   Participants pay 100% of the price at the time of Visit 2. As an example, a participant in the

Loan Control group might be asked during the BDM: "Would you be willing to pay Ksh 2,000 for the stove?"

2. **Loan - Weekly Payments ("L1")**
   Participants may pay for the stove in 12 weekly payments, starting one week from Visit 2. As an example, a participant might be asked during the BDM: "Would you be willing to pay Ksh 2,000 for the stove? You would pay Ksh 169.67 per week for 12 weeks. Your first payment would be due in one week."
3. **Loan - Monthly Payments ("L2")**
   Participants may pay for the stove in three 4-weekly payments, starting four weeks from Visit 2. As an example, a participant might be asked during the BDM: "Would you be willing to pay Ksh 2,000 for the stove? You would pay Ksh 682 per month for the next three months. Your first payment would be due in four weeks."

None of the participants in L1 and L2 will be required to make any payment on the day of Visit 2. However, they may choose to pay any amount on that day, if they wish. The balance will then be paid in equal instalments. They would not pay interest on the amount paid during Visit 2.

Participants in L1 and L2 may pay ahead of their payment schedule if they choose, but they may not fall behind. The only requirement is that they must have cumulatively paid the scheduled amount by their scheduled payment dates. If the participant falls behind on their payments, this will trigger a series of reminder SMS messages, culminating in the retrieval of the cookstove one week after the participant fell behind if they still have not paid at that point.

Weekly payments begin one week from Visit 2 while monthly payments begin four weeks from Visit 2. A participant in the monthly payments group could therefore choose to pay according to their equivalent in the weekly payments by simply making payments sooner, but the converse is not true. Other than demand for commitment, the monthly scheme is therefore weakly preferred to the weekly scheme. To address the confounding demand for commitment, participants in L2 may choose to opt into L1 after the BDM is completed. They will be informed that they will have this option prior to the BDM.

2.2 Attention Treatment Arms

To understand the effect of inattention on adoption, we assign each participant to one of three attention treatment arms:

1. **Attention - Control ("A0")**
   Participants are informed that the stove manufacturer says that it can be expected to reduce charcoal consumption by 50%. They will be informed of the Ksh equivalent of these savings, based on the participant's stated weekly charcoal spending. They are also given a calculator, and are allowed to use it to perform calculations regarding their expected savings if they choose.
2. **Attention - Benefits ("A1")**
   Participants receive everything that A0 receives. In addition, the enumerator assists them in filling in an Attention Sheet, writing down the amount of money they think they will save each week for the next year if they owned an energy efficient stove. This should be around 50% of their expected spending in each week, and would be higher in weeks where the participant expects to spend more on charcoal for cooking, for example during religious holidays, other festivities, or periods of the year where temporary migrants return to the home. The enumerator then assists the participant in summing up the expected savings for each of

the twelve months, and asks them to think about and write down what they would do with those savings each month. For example, in January they may pay school fees, or in December they may spending money on holiday festivities or travel. Finally, the enumerator assists the participant in summing the expected savings amounts over the whole year.

3. **Attention - Benefits and Costs ("A2")**
   Participants receive everything that A1 receives. In addition, during the BDM they are informed of the cost during each period, alongside the benefit of each period as listed in their Attention Sheet. The cost per period will be calculated and presented in line with the participant's credit treatment group (L0, L1, or L2). The net benefit (cost - benefit) for each period will also be calculated and presented to the participant.

3 Implementation

3.1 Implementation timeline

Participation in the study will consist of three in-person visits held one month apart (thus spanning a two-month period for each participant), as well as a recurring SMS survey that will be conducted throughout the two-month period. This section presents an overview of each visit.

3.1.1 Visit 1

- The participant is enrolled in the study by an enumerator and completes a baseline survey designed to measure energy spending, socioeconomic well-being, and other baseline characteristics.
- The participant completes a stove attribute sheet to determine what attributes they prioritize when purchasing a stove.
- The participant receives a pamphlet containing basic information about the stove, including that the stove manufacturer says that the stove reduces charcoal spending by 50%.
- The participant completes a math test. They are allowed to use a calculator for this.
- The participant answers questions related to their prior beliefs about the health and financial benefits of the stove.
- The participant completes the 3 required effort tasks for the Present Bias measurement and then makes selections for additional effort tasks to be completed during visits 2 and 3.
- The participant selects an investment amount in a game aimed at measuring their risk aversion.
- All participants are informed that we will return in one month and they that will have an opportunity to purchase the stove at that time, although we do not say at what price. They also receive information about the SMS survey, which will begin one week after Visit 1.

Between Visits 1 and 2 the participant receives an SMS once every three days asking them about either their charcoal spending or their matatu usage over the past three days.

One week before Visit 2 the participant receives an SMS reminding them that a field officer will visit them in one week. Participants in one of the installment treatment groups will be informed that they will be allowed to pay in installments.

3.1.2 Visit 2

- The participant makes another 5 decisions, trading off effort tasks between Visits 2 and 3 as part of the Present Bias measurement. The 'decision that counts' is then selected from

among the 10 decisions that the participant made during Visits 1 and 2. The participant then completes the 3 required effort tasks and any additional tasks that were selected.
- The participant receives additional information about the stove.
- The participant completes a practice BDM as well as a TIOLI with a bar of soap and a lollipop (or equivalent goods) to help them understand the mechanism and to confirm that the BDM mechanism reflects TIOLI decisions.
- The relevant attention treatments arms are implemented for the participants in the relevant treatment groups.
- Participants in the credit treatment arms are informed of the payment plan and options available to them.
- We implement a BDM mechanism to elicit participants' willingness to pay for an energy efficient charcoal cookstove.
- The participant answers questions related to their posterior beliefs about the financial benefits of the stove.
- The surveyor and the participant jointly open an envelope containing the participant's hidden BDM price. If the participant's WTP exceeds the BDM price, they receive the stove, which the surveyor carries with them to the participant's residence in a closed bag.
- The participant receives a bucket in which they will collect their used charcoal, which will be used as an additional measurement of charcoal consumption.

Between Visits 2 and 3, all participants receive an SMS once every three days asking them about their charcoal spending over the past three days. Participants in the credit treatment groups make their required payments during this time.

3.1.3 Visit 3

- The participant completes the 3 required effort tasks and any additional tasks that were selected as part of the Present Bias measurement.
- The participant completes an endline survey to measure energy spending and socioeconomic well-being.
- The field officer weighs the charcoal bucket.

Subject to funding constraints participants may continue to receive an SMS once every three days asking them about their charcoal spending over the past three days, for an additional month after visit 3.

3.2 Eliciting prior and posterior beliefs

During Visit 1 each respondent is asked to state their prior beliefs about the stove's energy savings over the first year of ownership. Respondents are first asked to state the absolute minimum and the absolute maximum they would expect to save in the worst and best case scenarios of stove performance, respectively. Then, respondents are asked to allocate 20 beans to a set of intervals that are each Ksh 1,250 wide, with each bean representing a 5% likelihood that they will save an amount in that interval over the first year of ownership. Respondents may only allocate beans to intervals that overlap with the interval between their stated minimum and maximum. We then elicit posterior beliefs after the implementation of the treatments and after the selection of the maximum WTP through the BDM, but before the hidden price z_i is revealed, using an identical mechanism.

We use the midpoint of each interval to define each respondent's beliefs distribution, and we then define μ_i to be the mean and σ_i to be the standard deviation of the distribution of individual i's posterior beliefs about the stove's annual future savings.

3.3 Eliciting willingness-to-pay (WTP) using a Becker-DeGroot-Marschak (BDM) mechanism

We implement a BDM mechanism to elicit each participant's WTP for an energy efficient charcoal cookstove and then randomly assign cookstove ownership across participants.

3.3.1 Methodological overview

The BDM mechanism is implemented in a carefully executed series of steps, as follows:

1. Prior to visit 2, each participant is randomly assigned a BDM Price, according to the distribution of BDM prices (described below). Randomization is stratified on baseline characteristics.
2. The enumerator receives a sealed envelope that contains the BDM price (in Ksh) for the particular participant they are visiting.
3. The enumerator places the closed envelope in plain view.
4. Beginning with a starting price of Ksh 1,500, the enumerator asks if the participant would be willing to purchase the stove for this price. If the participant agrees, the enumerator increases the price to the midpoint of the remaining interval immediately above (starting with a ceiling of the market price of Ksh 2990). If the participant disagrees, the enumerator decreases the price to the midpoint of the remaining interval immediately below. As more questions are answered, the interval becomes smaller and smaller, and after 11 questions the participant will have chosen their maximum WTP to within 1 Ksh. In practice, this works as follows:

   (a) If the envelope said the price was Ksh 1,500, would you choose to purchase the stove?

      i. If yes: If the envelope said the price was Ksh 2,250, would you choose to purchase the stove?

         A. If yes: If the envelope said the price was Ksh 2,625, would you choose to purchase the stove?

            - Etc.

         B. If no: If the envelope said the price was Ksh 1,875, would you choose to purchase the stove?

            - Etc.

      ii. If no: If the envelope said the price was Ksh 750, would you choose to purchase the stove?

         A. If yes: If the envelope said the price was Ksh 1,125, would you choose to purchase the stove?

            - Etc.

         B. If no: If the envelope said the price was Ksh 375, would you choose to purchase the stove?

            - Etc.

   The enumerator then completes a series of questions to confirm that the participant understands their decision, understands the consequences of their decision once the envelope is opened, and allows the participant to change their mind if they decide to do so at this point.

5. Once the participant has confirmed the threshold at which they would no longer be willing to purchase the stove, the participant and the enumerator together open the envelope containing the participant's randomly assigned hidden BDM price.
6. If the participant's maximum WTP is lower than the BDM price in the envelope, the participant will not be able to purchase the stove.
7. If the participant's maximum WTP is at least as high as the BDM price in the envelope, the participant receives the stove that day, paying the price that was written inside the envelope. If the participant is in L0 they must pay the full amount during Visit 2.
8. If the participant is in L1 or L2 they will then be offered the choice to pay any amount during Visit 2, if they choose, and are then reminded of the remaining payments required. Participants in L2 will then be allowed to opt in to the L1 schedule as a commitment device, if they wish.

Because the participant pays the price in the envelope rather than their maximum WTP, this process is incentive compatible, and a welfare-maximizing participant should reveal their true maximum WTP.

3.3.2 Distribution of BDM prices

We designed the distribution of BDM prices to increase compliance and maximize power in the instrumental variables regression while maintaining incentive compatibility, such that every participant has an incentive to name their true willingness to pay, as well as obtaining a meaningful demographic distribution of adopters. This resulted in the following distribution. 5% of participants are allocated a price of Ksh 400, 40% of participants are allocated a price of 1,100 Ksh, 45% of participants are allocated a price of Ksh 2,600, and 10% of participants are allocated a randomly selected price between Ksh 1 and Ksh 2,989. None of these prices exceed the market price of Ksh 2,990, at which price the cookstove is widely available in most relevant stores and supermarkets as of March 2019.

These prices will be randomly assigned to participants after baseline Visit 1. To maximize power, after we collect baseline data we will stratify participant price allocation by baseline characteristics.

3.4 Sample sizes

We plan to enroll at least 903 participants into our study. Figure 1 below displays the targeted sample size for each treatment arm.

Table 1: Sample Sizes

		Credit Treatment Arms			
		Loan - Control	**Loan - Monthly**	**Loan - Weekly**	**Total**
Behavioral Treatment Arms	**Attention – Control**	86	86	86	258
	Attention – Benefits	86	86	86	258
	Attention – Benefits and Costs	129	129	129	387
	Total	301	301	301	903

4 Analysis

We run all regressions specified below at the household level. Unless stated otherwise, all regressions control for baseline charcoal expenditures, baseline household income, and baseline number of household residents. Depending on the level of variation and correlation of demographic variables, we may include more or fewer variables as controls.

4.1 Effect of stove ownership on charcoal expenditures

Our experimental design allows us to estimate the causal effect of ownership of an energy efficient charcoal cookstove on charcoal spending. We employ an instrumental variables approach to estimate the causal effect of stove ownership on charcoal spending, controlling for household WTP. In the first stage we use the randomly assigned BDM price z_i as an instrument for household i's stove ownership d_i. In the second stage we regress average weekly charcoal spending on the predicted value of stove ownership $\hat{d}_i$. Because the BDM price was randomly assigned, this regression identifies a causal effect. Econometrically, this proceeds as follows:

$$(First\ stage) \qquad d_i = \gamma_0 + \gamma_1 z_i + \gamma_2 X_i + u_i$$

$$(Second\ stage) \qquad y_{it} = \beta_0 + \beta_1 \hat{d}_i + \beta_2 X_i + \epsilon_i$$

Where y_{it} is the log of charcoal spending by household i during 3-day cycle $t \in (1, T)$, $3t$ days since adoption of the energy efficient cookstove. z_i is the household's randomly assigned BDM price, and X_i is the vector of baseline characteristics described above. β_1 can be interpreted as the causal effect of stove ownership on weekly energy spending in percentage terms. We cluster our errors by household i.

Our preferred regression uses log of charcoal spending, because the stove is expected to reduce energy charcoal usage by a fixed percentage relative to baseline usage rather than a fixed amount. In the case of frequent 0s in charcoal spending, we implement this transformation using inverse hyperbolic sine (IHS) rather than a regular logarithmic conversion. However, we also run a regression using charcoal spending in Ksh as the outcome variable to place the result in the context of the cost of the stove, which is fixed in Ksh.

We also run this regression estimating causal effects β_{t1} for each of the 3-day SMS cycles separately. This allows us to flexibly test whether the effect of stove ownership changes over time. Econometrically, this proceeds as follows:

$$(First\ stage) \qquad d_{it} = \gamma_0 + \gamma_1 z_{it} + \gamma_2 X_i + \tau_t + u_i$$

$$(Second\ stage) \qquad y_{it} = \beta_0 + \sum_t \beta_{t1} \hat{d}_{it} + \beta_2 X_i + \tau_t + \epsilon_i$$

where z_{it} is equal to z_i in period t and zero otherwise. In this specification, each β_{t1} represents the impact of the stove on charcoal spending in percentage terms $3 \cdot t$ days after adoption of the stove.

If we see significant heterogeneity in LATE estimates across levels of WTP and different complier groups, we will estimate these regressions more flexibly. We will also test for heterogeneity in these estimates by demographic characteristics. Since different treatments may induce different types of individuals to increase their WTP, we will also test whether the impact of the stove differs for compliers of the different treatment groups or individuals with different levels of WTP.

4.2 Testing for barriers to adoption

4.2.1 Primary Predictions

This experimental design allows us to test our primary predictions below by testing the following list of null hypotheses. To be conservative, we use two-sided tests for all predictions.

- **Prediction 1: Attention to benefits**
  An increase in attention to benefits will increase WTP.
  $WTP_i = \beta_0 + \beta_1 \mathbf{I}[A = 1, 2] + \beta_2 X_i + \epsilon_i$
  $H_0 : \beta_1 = 0$

- **Prediction 2: Access to credit**
  An increase in access to credit will increase WTP due to credit constraints and an increased inattention to costs.
  $WTP_i = \beta_0 + \beta_1 \mathbf{I}[L = 1, 2] + \beta_2 X_i + \epsilon_i$
  $H_0 : \beta_1 = 0$

As a robustness check, we will also test $H_0 : \beta_1 = 0$ and $H_0 : \beta_2 = 0$ in the fully interacted specification:

$$WTP_i = \beta_0 + \beta_1 \mathbf{I}[L = 1, 2] + \beta_2 \mathbf{I}[A = 1, 2] + \beta_3 \mathbf{I}[L = 1, 2] \cdot \mathbf{I}[A = 1, 2] + \beta_4 X_i + \epsilon_i \quad (1)$$

4.2.2 Secondary Predictions

We intend to identify the channels through which these treatment arms affect adoption by testing the following mechanism predictions.

- **Prediction S-1: Attention and credit**
  - **S-1-A: Access to credit will increase the effect of attention to benefits.**
    See regression (1) above
    $H_0 : \beta_3 = 0$
  - **S-1-B: Among people paying full attention to benefits and costs in all periods [$A = 2$], relaxing the credit constraint will affect WTP due to credit constraints alone.**
    $WTP_i = \beta_0 + \beta_1 \mathbf{I}[L = 1, 2] + \beta_2 X_i + \epsilon_i$
    $H_0 : \beta_1 = 0$

- **Prediction S-2: Benefits vs. Costs**
  Among people with full attention to benefits [$A = 1, 2$] increasing attention to costs reduces WTP.
  $WTP_i = \beta_0 + \beta_1 \mathbf{I}[A = 2] + \beta_2 X_i + \epsilon_i$
  $H_0 : \beta_1 = 0$

- **Prediction S-3: Concentration bias**
  Among people receiving access to credit [$L = 1, 2$], framing credit payments in smaller, weekly amounts relative to larger, monthly amounts will increase WTP due to concentration bias.
  $WTP_i = \beta_0 + \beta_1 \mathbf{I}[L = 1] + \beta_2 X_i + \epsilon_i$
  $H_0 : \beta_1 = 0$

- **Prediction S-4: Beliefs**
  - **S-4-A: Attention to benefits will increase mean posterior beliefs about future savings.**
    $\mu_i = \beta_0 + \beta_1 \mathbf{I}[A = 1, 2] + \beta_2 X_i + \epsilon_i$
    $H_0 : \beta_1 = 0$
  - **S-4-B: Attention to benefits will decrease the standard deviation of posterior beliefs about future savings.**
    $\sigma_i = \beta_0 + \beta_1 \mathbf{I}[A = 1, 2] + \beta_2 X_i + \epsilon_i$
    $H_0 : \beta_1 = 0$

To test for mechanisms we will conduct additional exploratory analysis, including heterogeneity analysis with respect to:

- Present bias
- Baseline charcoal spending
- Baseline prior beliefs
- Baseline demographics (including income and savings)
- Baseline risk aversion