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The effect of marketing messages and payment over time on willingness to pay for fuel-efficient cookstoves

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ABSTRACT

Smoke from inefficient biomass cookstoves contributes to global climate change and kills approximately four million people per year. Cooking technologies, such as manufactured fuel-efficient cookstoves, that mitigate the negative effects of traditional cookstoves exist, but adoption rates are low. The international development community debates whether this low adoption of fuel-efficient cookstoves is due to a lack of adequate product information or due to household financial constraints. We ran Vickery second-price auctions in rural Uganda to elicit willingness to pay for fuel-efficient cookstoves, comparing the effect of informational marketing messages and time payments on willingness to pay. A randomized trial tested the following marketing messages: "This stove can improve health," "This stove can save time and money," and both messages combined. None of the messages consistently increased willingness to pay. In a second experiment we compared willingness to pay for two different contracts, one with payment due within a week and one with equal installment payments over 4 weeks. Consistent with household financial constraints, time payments raised willingness to pay by 40%.

1. Introduction

Traditional biomass cookstoves cause significant environmental degradation (Arnold et al., 2006), contribute to global climate change (Bailis et al., 2005; Bond et al., 2004), and cause an estimated 4 million deaths a year (Lim et al., 2012). Fuel-efficient cookstoves, depending on quality and construction, have the potential to reduce household air pollution substantially and improve the health of cooks and children. Further, fuel-efficient cookstoves can significantly reduce consumption of biomass fuels, which can reduce deforestation and environmental degradation (Bensch and Peters, 2013). Fuel savings can decrease household expenditure on fuel and/or reduce time spent collecting fuel. Because of these benefits, fuel-efficient cookstoves have a long history within the development community. While there have been some successes (Smith et al., 1993), most regions continue to adopt efficient stoves at "puzzlingly low rates" (Mobarak et al., 2012; see also World Bank, 2011; Lewis and Pattanayak, 2012).

Past stove projects have frequently provided sizeable subsidies for fuel-efficient cookstoves. While subsidies can sometimes be appropriate (Cohen and Dupas, 2010), the market for efficient stoves will grow more rapidly if stoves sell at or near

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market prices. The Global Alliance for Clean Cookstoves posits that willingness to pay is reduced by (among other factors) "low awareness of health, economic, and time-savings benefits" and by limited access to finance (Global Alliance for Clean Cookstoves, 2011).

We conducted a randomized controlled trial to test how willingness to pay for a fuel-efficient cookstoves varies with (1) marketing messages related to "low awareness of health, economic, and time-savings benefits" and (2) sales offers that address household financial constraints. Neither the marketing message "the stove can improve health" nor the message "the stove can save time and money" consistently increased willingness to pay. This result is counter to the common assumption that increased social marketing could increase adoption (Lewis and Pattanayak, 2012) but consistent with other studies finding modest effects of informational interventions on health behaviors (Albert et al., 2010; Luo et al., 2012; Madajewicz et al., 2007; Meredith et al., 2013). Using a within-subjects comparison, we tested the effect of time payments on willingness to pay. Allowing consumers to pay in four equal payments over 4 weeks raised willingness to pay for a fuel-efficient cookstove by about 40% ($p < 0.01$).

The findings of this study may have implications for products other than cookstoves. Millions of lives could be saved each year by adoption of health technologies, such as water filters, private latrines, and insecticide-treated bed nets. Understanding the constraints on adoption could increase the uptake for all of these important products.

2. Theory and related literature

The constraints that decrease willingness to pay and impede take-up of products similar to fuel-efficient cookstoves have been demonstrated by several studies. Poor households may lack information on the benefits and durability of the product (Conley and Udry, 2001; Feder and Slade, 1984; Giné and Yang, 2009). Consumers may also be liquidity- or credit-constrained (Cole et al., 2013; Giné et al., 2008; Tarozzi et al., 2014). In this section we first model how poor information affects willingness to pay and then model how liquidity constraints affect willingness to pay.

2.1. Modeling poor information

Assume a consumer has income y_t each period over an infinite number of years. She has to purchase Q_t units of energy each period to run her traditional cookstove (with the price of energy normalized to unity) and she receives utility from non-energy consumption c_t. She can borrow or save with a gross rate of return $R = 1 + r > 1$, and her subjective discount rate is δ (<1).

The consumer maximizes the present value of utility as

$$\sum_{t=0}^{\infty} u(c_t)\delta^t, \tag{1}$$

subject to a lifetime budget constraint that the present value of consumption is not more than her income:

$$\sum_{t=0}^{\infty} \frac{(Q_t + c_t)}{R^t} = \sum_{t=0}^{\infty} \frac{y_t}{R^t}. \tag{2}$$

Without loss of generality, normalize her utility without the cookstove, $u(y - Q)$ as zero. Assume an improved cooking technology comes on the market that increases the combustion efficiency, thereby lowering the fuel needed and exposure to household air pollution. The new appliance costs P in the first period and uses φQ of energy each period until the appliance dies, with $0 < \varphi < 1$. The appliance has a per-period exponential death rate ψ, with $0 < \psi < 1$ and upon the appliance's death, the consumer can return to her old technology at zero cost.

With perfect capital markets the consumer's willingness to pay for the new appliance is the expected present value of lower spending on energy during the lifetime of the appliance:

$$p^* \leq \sum_{t=0}^{\infty} \frac{((1-\varphi)Q_t(1-\psi)^t)}{R^t} = \frac{(1-\varphi)QR}{(R+\psi-1)}. \tag{3}$$

Call the critical price p^*, which defines the efficient willingness to pay (we assume indifferent consumers purchase the appliance). As expected, willingness to pay is higher if the appliance is very efficient (low φ), the household uses a lot of energy (high Q), the appliance usually lasts a long time (low ψ), and if other investment opportunities are poor (low R).

However, consider the market imperfection that the consumer lacks information on product benefits or doubts the firm's claims about energy savings. Assume the consumer is unsure of energy savings and discounts the firm's true claim by a factor $\gamma < 1$. The consumer continues to purchase if the price is below the present value of expected savings, but those savings are now discounted by γ. Thus, the highest willingness to pay with uncertain savings is

$$p^{us} = \gamma p^*. \tag{4}$$

Now assume the consumer is offered credible information on the product's energy savings through effective marketing messaging. As a result, assume the consumer's beliefs align with the product's true savings (that is, energy use falls to φQ

and $\gamma = 1$), which is the same as p^* calculated in Eq. (3). Therefore, it is plausible that if marketing messages address the obstacle of imperfect product information, products will be efficiently adopted.

2.2. Modeling liquidity constraints

Evidence exists that many consumers in poor nations face liquidity or credit constraints and are present biased and thus cannot come up with the entire purchase price of a durable good in one lump sum (Banerjee, 2003; Mullainathan and Shafir, 2011). We modeled an extreme version of liquidity constraints in which a liquidity-constrained consumer cannot save or borrow. Thus, the consumer consumes her income each period after buying energy and perhaps an appliance. The lifetime utility without the new appliance is the value of income minus energy costs:

$$\sum_{t=0}^{\infty} u(y_t - Q_t)\delta^t. \tag{5}$$

A liquidity-constrained consumer is unable to purchase the appliance when her period's disposable income is less than the price charged to liquidity-constrained consumers, p^{lc} (that is, if $Y_t - \varphi Q_t < p^{lc}$). If the appliance is potentially affordable (that is, $p^{lc} + \varphi Q_t < y_t$), then a buyer's initial-period consumption declines by the entire price:

$$c_0 = y_t - \varphi Q_t - p^{lc}. \tag{6}$$

Assume unbiased expectations of the appliance's savings and that the appliance never dies (i.e., $\gamma = 1$ and $\psi = \psi' = 0$). Then the liquidity-constrained consumer buys the new appliance if the expected lifetime utility with the new appliance is greater than without it. Initial period consumption is equal to $y_0 - \varphi Q_0 - p$, and expected lifetime utility is:

$$u(y_0 - \varphi Q_0 - p) + \sum_{t=1}^{\infty} u(y_t - \varphi Q_t)\delta^t > 0. \tag{7}$$

Otherwise, the initial period disutility of purchasing the appliance must be outweighed by the utility gain from energy savings of the appliance. In most cases willingness to pay is higher without liquidity constraints than with them. For example, if $\delta = 1/R$, a liquidity constraint always decreases demand. Jensen's inequality implies that inequality is not satisfied at the maximum willingness to pay for the unconstrained consumer (p^* from Eq. (3)). Intuitively, a lump-sum payment for the appliance reduces utility more than when the consumer could use savings or borrowing to spread out the cost of the appliance.[1]

With present bias the consumer maximizes a slightly different utility function (following the formulation of Laibson, 1997; O'Donoghue and Rabin, 1999):

$$u(c_0) + \beta \sum_{t=1}^{\infty} u(c_t)\delta^t. \tag{8}$$

Here, future benefits in period $t > 0$ are discounted not just by δ^t but also by an extra term ($0 < \beta < 1$). A consumer with present bias will purchase the appliance if her expectation of her future utility is positive:

$$u(y_0 - \varphi Q_0 - p) + \beta \sum_{t=1}^{\infty} u(y_t - \varphi Q_t)\delta^t(1 - \psi)^t > 0. \tag{9}$$

The implied willingness to pay is always lower than in cases without present bias because $0 < \beta < 1$.

3. Methods

3.1. Experimental design

We selected the southwestern region of Mbarara, Uganda, because at the time of the experiment almost all families cooked on traditional three-stone fires, there were no active fuel-efficient cookstove interventions or fuel-efficient cookstoves for sale in the local markets, it is less than a day's travel from Kampala, and local leaders indicated that wood is relatively scarce (Beltramo et al., 2012). The area is characterized by subsistence farming; common activities include growing *matooke* (a starchy unripe banana used as a staple food), Irish potatoes, and millet as well as raising livestock. Based on power calculations and the minimum detectable effect for experimentally testing marketing messages, a total of 36 parishes were selected. A parish is an administrative unit that covers a handful of villages and typically has about 5000–6300 residents.

In partnership with our local implementing partner the Center for Integrated Research and Community Development (CIRCODU), we worked with the local Community Development Officer, a quasi-governmental official who was tasked with

[1] An exception holds when the market interest rate is far above the consumer's impatience ($R \gg 1/\delta$).

recruiting a focal point person in each parish. The focal point person was paid a small fee to spread the word about the upcoming sales meeting and to gather roughly 60 people to attend the sales meeting on an agreed date.

Upon arrival, each participant took a survey detailing their cooking practices: how many people they cook for, type of stoves owned, fuel used, socio-demographic information, employment, and asset information. We generated a value of assets for each participant by multiplying the assets reported with the average purchase price of durable goods taken from the 2011–2012 round of the Uganda Living Standards Measurement Survey (World Bank, 2012). See Appendix Table A1 for the exact prices used to construct the aggregate asset values.

After all participants finished the household survey, participants were randomly placed into four groups corresponding to one of four marketing messages: (1) health benefits of the new stove, (2) time and money savings of the new stove, (3) both of the above, and (4) a control group with no marketing message. The control group engaged in a group discussion on common cooking practices, while the other groups received their marketing message. All participants then saw a live cooking demonstration with the fuel-efficient stove, and we described how the sealed second-price auction worked and asked for questions. We selected the Envirofit G3300 as the fuel-efficient stove for our study. The manufacturer reports that the Envirofit G3300 reduces biomass fuel consumption by up to 60%, reduces smoke and harmful gasses by up to 80%, reduces cooking time by up to 50%, and has a product lifespan of 5 years.

In each parish we ran two second-price auctions for the Envirofit G3300 that differed by sales contract. In a second-price auction, participants submit sealed bids for a product and the highest bidder wins the auction and pays the second-highest bid. (We discuss the second-price auction in more detail in Section 4.3.1.)

Each participant had the chance to participate in both auctions. The first auction was a pay within a week auction, which required participants to pay the second-highest bid for the stove within a week of the auction. The second auction offered time payments and required the winner to pay the second-highest bid for the stove in four equal weekly installments. Each of the auction winners was required to leave a deposit that same day – at least 25% of the winning price.

After revealing the auction outcomes, the sales team collected deposits from the two winning bidders,[2] one for the pay within a week offer and one for the auction with time payments. The pay within a week purchasers then had 7 days to bring the rest of their money to the pick-up location and receive their stove. Winners of the time payments auction paid the remaining sum (after the deposit) in 4 weekly time payments to the focal point person but received the stove immediately.

3.2. Marketing message design

We tested multiple marketing messages for the Envirofit G3300 during a 6-month feasibility stage. Testing included six focus groups from neighboring, but non-experimental, villages. The two most popular messages were about health and about saving time and money. The final marketing message related to health included: "Smoke from the cook fire is poison. It makes you feel light-headed or dizzy, makes you cough, and can cause sore eyes or a sore throat from the smoke. Smoke from cookstoves causes serious diseases, including pneumonia and bronchitis. These diseases from cookstove smoke caused as many child deaths in Uganda as malaria." To increase attention to health effects, we used a shock technique (as is common in many anti-smoking campaigns). In our case, one of our posters had a picture of a baby smoking a cigarette.

The marketing message related to saving time and money also focused on being concrete and vivid. During this presentation we piled up the wood needed to cook an average lunch meal on the traditional three-stone fire and a smaller pile for the Envirofit G3300. In addition, we included testimony from users about saving half the wood-gathering time. We demonstrated the math so consumers could see that savings might equal 40 freed-up hours per month.

3.3. Testing differences in willingness to pay

We tested the effect of the marketing messages on the amount bid for each auction type separately using the following specification:

$$Bid\_price_i = Marketing\_message_i'\gamma + D_i'\phi + W_i'\chi + S_i'\lambda + \upsilon_i, \tag{10}$$

where Bid_price_i is the amount bid by individual i; $Marketing\_message_i$ is a categorical variable for the marketing message received with no message as the omitted category; D_i is a vector of household demographic variables, including gender, age, marital status, whether the wife is the primary cook, and whether husband and wife make decisions jointly; W_i is a vector of wealth variables, including time employed and total asset value; and S_i is a vector of stove use variables, including whether a three-stone fire is the primary stove, whether the household purchased wood last month, and whether the household gathered wood last month. The vectors γ, ϕ, χ, λ are parameters associated with each control variable, and υ_i is an error term.

Because each respondent can participate in both auction offers, we used a simple ordinary least squares regression with individual fixed effects to determine the within-participant effect of time payments on willingness to pay,

$$Bid\_price_i = Offer_i'\beta + u_i'\delta + \varepsilon_i, \tag{11}$$

[2] In the case of a tie for the highest bid, we offered each winning bidder the chance to purchase the stove, so we had more winners than sales meetings.

Table 1
Household demographics: summary statistics.

Female respondent (share)	0.70
	(0.46)
Age of respondent	39.45
	(13.63)
Married (share)	0.79
	(0.41)
Wife is primary cook (share)	0.87
	(0.34)
Wife and husband make decisions jointly (share)	0.44
	(0.50)
Year round employment (share)	0.54
	(0.50)
Value of assets (USD)	434.54
	(863.47)
Three stone fire is primary stove (share)	0.73
	(0.44)
Already owns mud or charcoal stove (share)	0.23
	(0.42)
Purchased firewood last month (share)	0.26
	(0.44)
Gathered firewood last month (share)	0.87
	(0.34)
Wife is primary cook (share)	0.87
	(0.34)
Wife and husband make decisions jointly (share)	0.44
	(0.50)
Total demand determinant surveys administered (*N*)	2292

Note: Each variable includes the mean and standard deviation. To minimize the effect of outliers the value of assets is bottom and top coded at 2% and 98% of the distribution, respectively.

where Bid_price_i is the amount bid by individual i, $Offer_i$ is a binary variable for the auction offer, and u_i is individual fixed effects that control for time invariant characteristics, like assets, income, marketing message received, household demographics, and household stove use patterns. The terms β and δ are the parameters, and ε_i is an error term.

4. Results and discussion

Across 36 parishes, 2355 people attended the meetings and 2292 participated in the initial survey. Of those who took the survey, 2125 (93%) bid in the pay within a week auction and 2135 (93%) bid in the time payments auction. The main reasons participants gave for not bidding was that some participants came out of curiosity but had no intention of buying a stove. In addition, one household refused to give informed consent and did not take the survey. Failure to bid was uncorrelated with treatment status.

Both a pay within a week and a time payments auction were held in each of the 36 parishes for a total of 72 auctions. In 20 auctions there was a tie among the winning bids, and in this case both winners were given the opportunity to buy the stove. There were 47 stoves purchased in the pay within a week auction and 45 in the time payment auction.

We dropped 28 observations of initial auction winners that refused to pay as this refusal is evidence they were bidding above their true willingness to pay. Failing to remove these outliers would upwardly bias the amount bid in each auction offer.

4.1. Summary statistics

Table 1 reports basic household summary statistics. Most respondents are female (70%), the average age is 39-years old, the sample is largely married (79%), and the wife is the primary cook (87%). Husband and wife in 44% of households make household decisions jointly. A majority of households report earning a year-round income (54%), and the average value of household assets is USD$435. For stove and fuel use, 73% state that a three-stone fire is their primary stove and 23% own either a charcoal or mud stove, 26% purchased firewood last month, and 87% gathered firewood last month.

The average bids (Table 2) were USD$4.86 and USD$6.83 for the pay within a week and time payments auction, respectively. Furthermore, approximately 8% and 16% of participants bid more than USD$10 for pay within a week and time payments auction, respectively (Table 2). The difference by auction type between each of these amounts differs significantly from zero ($p < 0.01$). When considering purchases made (Table 3), the average winning bid was USD$15.78 and USD$23.03, while the second price paid was USD$12.87 and USD$16.78 for the pay within a week and time payments auctions, respectively. The difference by auction type between each of these amounts is significantly different from zero ($p < 0.01$). The average deposit paid was USD$5.61 and USD$5.06, 9% and 16% of stoves were returned, and 4% and 9% of stoves were

Table 2
Bids by auction type: pay within week versus time payments.

	Auction type		
	Pay within week	Time payments	Difference
Bid amount in USD	4.86	6.83	−1.97**
	(4.65)	(6.38)	(0.17)
Share of bids greater than $10	0.08	0.16	−0.07**
	(0.28)	(0.36)	(0.01)
Observations	2125	2135	

Note: The mean and standard deviation by auction type are presented in the first two columns, the difference between auction types and standard error is presented in the third column. Twenty-eight observations of initial auction winners who refused to pay the second-highest bid are dropped from the sample as this is evidence they did not understand the auction setup and were not bidding their true value. Values presented are rounded to two decimal places, the value in the difference column is calculated prior to rounding. All auction bids were converted from Ugandan Shillings to USD at the exchange rate of 2515 Uganda Shillings to 1 USD. The exchange rate is the official quarterly exchange rate from the United States Treasury exchange rate site found at: http://www.fms.treas.gov/intn.html.
Significance tests: the difference between auction types significant at: $^{**}p < 0.01$.

defaulted for the pay within a week and time payments auctions, respectively. None of these differences by auction type significantly differ from zero.

Table 4 presents bidding behavior by auction offer and marketing message. Table 5 presents randomization tests between those who received and those who did not receive a marketing message. Generally, the sample was balanced with no statistically significant difference between key variables, such as share of female respondents, age, share married, share with wife as primary cook, share where husbands and wives make decisions jointly, value of assets, share which own either a charcoal or mud stove, purchased firewood last month, and gathered firewood last month. Two variables showed significant differences between the two groups: share with year round employment and share with three-stone fire as primary stove. The differences between the means for each group are statistically significant (year round employment 51% vs. 56% and three-stone fire as primary stove 70% vs. 74%), but we argue that these differences are not economically meaningful and that we achieved proper randomization.

4.2. Regression results

4.2.1. Marketing messages have no consistent effect on willingness to pay

None of the marketing messages consistently increased willingness to pay. Table 6 shows the differences in bids by marketing message for the pay within a week auction offer. In the parsimonious specification (col. 1), none of the marketing messages have statistically significant coefficients on the amount bid. When adding demographic controls (col. 2), none of the marketing messages have statistically significant coefficients; however, the coefficient for female respondents is −0.99

Table 3
Purchase statistics by auction type: pay within week versus time payments.

	Auction type		
	Pay within week	Time payments	Difference
Winning bid amount	15.78	23.03	−7.24**
	(8.56)	(14.95)	(2.53)
Second price paid	12.87	16.78	−3.91**
	(5.07)	(6.38)	(1.20)
Deposit paid for stove	5.61	5.06	0.55
	(4.37)	(2.77)	(0.77)
Share of stoves returned	0.09	0.16	−0.07
	(0.28)	(0.37)	(0.07)
Share of defaults	0.04	0.09	−0.05
	(0.20)	(0.29)	(0.05)
Observations	47	45	

Note: The mean and standard deviation by auction type are presented in the first two columns, the difference between auction types and standard error is presented in the third column. Twenty-eight observations of initial auction winners who refused to pay the second-highest bid are dropped from the sample as this is evidence they did not understand the auction setup and were not bidding their true value. The pay within a week auction and time payment auction were each completed 36 times. The number of auction winners is greater than 36 due to tie bids. In the event of a tie both bidders were given the opportunity to purchase the stove at the second highest price. Values presented are rounded to two decimal places, the value in the difference column is calculated prior to rounding. All auction bids were converted from Ugandan Shillings to USD at the exchange rate of 2515 Uganda Shillings to 1 USD. The exchange rate is the official quarterly exchange rate from the United States Treasury exchange rate site found at: http://www.fms.treas.gov/intn.html.
Significance tests: the difference between auction types significant at: $^{**}p < 0.01$.

Table 4
Bidding behavior by auction offer and marketing message.

Marketing message received	*N*	Mean bid (SD)	Median bid	Mean deposit (SD)	Median deposit	Count and percentage of winners by auction	Count and percent of bids above 10 USD$
Pay within a week auction offer							
No message	546	4.58	3.98	6.26	5.96	10	26
		(4.82)		(3.69)		21%	5%
Saves time and money	513	4.47	3.98	5.14	5.96	7	34
		(4.14)		(5.43)		15%	7%
Improves health	525	5.50	3.98	6.45	3.98	19	68
		(5.22)		(4.67)		40%	13%
Time, money and health	541	4.88	3.98	3.87	1.99	11	49
		(4.28)		(3.64)		23%	9%
Time payment auction offer							
No message	544	6.73	4.77	5.28	4.97	9	73
		(6.87)		(3.57)		20%	13%
Saves time and money	535	7.17	5.96	4.76	3.98	20	86
		(6.38)		(2.61)		44%	16%
Improves health	514	6.82	4.77	5.14	3.98	8	85
		(6.35)		(3.61)		18%	17%
Time, money and health	542	6.61	4.77	5.47	5.47	8	92
		(5.90)		(1.30)		18%	17%

Note: Twenty-eight observations of initial auction winners who refused to pay the second-highest bid are dropped from the sample as this is evidence they did not understand the auction setup and were not bidding their true value. The pay within a week auction and time payment auction were each completed 36 times. The number of auction winners is greater than 36 due to tie bids. In the event of a tie both bidders were given the opportunity to purchase the stove at the second highest price. All auction bids were converted from Ugandan Shillings to USD at the exchange rate of 2515 Uganda Shillings to 1 USD. The exchange rate is the official quarterly exchange rate from the United States Treasury exchange rate site found at: http://www.fms.treas.gov/intn.html.

Table 5
Randomization tests.

	Marketing message status		
	No message	Received message	Difference
Female respondent (share)	0.69	0.72	−0.03
	(0.46)	(0.45)	(0.02)
Age of respondent	38.77	39.66	−0.89
	(13.56)	(13.48)	(0.66)
Married (share)	0.78	0.80	−0.03
	(0.42)	(0.40)	(0.02)
Wife is primary cook (share)	0.86	0.88	−0.02
	(0.35)	(0.33)	(0.02)
Wife and husband make decisions jointly (share)	0.43	0.45	−0.02
	(0.50)	(0.50)	(0.02)
Year round employment (share)	0.51	0.56	−0.05*
	(0.50)	(0.50)	(0.02)
Value of assets (USD)	475.37	422.13	53.24
	(931.33)	(845.94)	(42.19)
Three stone fire is primary stove (share)	0.70	0.74	−0.05*
	(0.46)	(0.44)	(0.02)
Already owns mud or charcoal stove (share)	0.25	0.23	0.02
	(0.43)	(0.42)	(0.02)
Purchased firewood last month (share)	0.26	0.27	−0.00
	(0.44)	(0.44)	(0.02)
Gathered firewood last month (share)	0.85	0.88	−0.02
	(0.35)	(0.33)	(0.02)
Wife is primary cook (share)	0.86	0.88	−0.02
	(0.35)	(0.33)	(0.02)
Wife and husband make decisions jointly (share)	0.43	0.45	−0.02
	(0.50)	(0.50)	(0.02)
Observations	570	1654	

Note: The mean and standard deviation by marketing message group are presented in the first two colums, the difference between no marketing message and groups that received a message and standard error is presented in the third column. To minimize the effect of outliers the value of assets is bottom and top coded at 2% and 98% of the distribution, respectively. Values presented are rounded to two decimal places, the value in the difference column is calculated prior to rounding.
Significance tests: the difference between no message group and those receiving a marketing message significant at: $^{*}p < 0.05$.

Table 6
Differences in bids across marketing messsages for pay within week auction.

	(1) Bid amount	(2) Bid amount	(3) Bid amount	(4) Bid amount	(5) Bid amount
Saves time and money	−0.10	−0.08	0.01	−0.06	0.04
	(0.33)	(0.33)	(0.34)	(0.34)	(0.35)
Improves health	0.92	0.99	0.94	0.99	1.03*
	(0.49)	(0.49)	(0.49)	(0.50)	(0.49)
Both messages	0.30	0.27	0.18	0.28	0.19
	(0.36)	(0.38)	(0.38)	(0.37)	(0.39)
Female respondent		−0.99*			−0.91*
		(0.39)			(0.39)
Age of respondent		−0.01			−0.01
		(0.01)			(0.01)
Married		0.14			0.10
		(0.31)			(0.31)
Wife is primary cook		−0.30			−0.19
		(0.43)			(0.40)
Wife and husband make decisions jointly		0.32			0.16
		(0.31)			(0.30)
Year round employment			0.58*		0.38
			(0.25)		(0.24)
Value of assets (100's USD)			0.06**		0.05**
			(0.02)		(0.02)
Three stone fire is primary stove				−0.85	−0.34
				(0.50)	(0.45)
Already owns mud or charcoal stove				0.13	0.45
				(0.61)	(0.56)
Purchased firewood last month				0.19	0.21
				(0.29)	(0.30)
Gathered firewood last month				0.28	0.39
				(0.27)	(0.28)
Constant	4.58**	5.67**	3.99**	4.84**	4.96**
	(0.32)	(0.72)	(0.38)	(0.58)	(0.85)
Observations	2125	2119	2125	2117	2117
R-squared	0.01	0.02	0.03	0.02	0.04
F-test	2.270	2.308	2.023	2.225	2.125
Prob > *F*	0.0965	0.0925	0.128	0.102	0.114

Note: The *F*-tests presented test whether marketing messages are jointly statistically significantly different than zero. Twenty-eight observations of initial auction winners who refused to pay the second-highest bid are dropped from the sample as this is evidence they did not understand the auction setup and were not bidding their true value. To minimize the effect of outliers the value of assets is bottom and top coded at 2% and 98% of the distribution, respectively. Standard errors are clustered at the parish level.
Significance tests: $^{**}p < 0.01$, $^{*}p < 0.05$.

($p < 0.05$). When adding only wealth controls (col. 3), the coefficients on year round employment (0.58, $p < 0.05$) and value of assets (0.06, $p < 0.01$) are significant, but none of the coefficients on marketing messages are statistically different from zero. None of the coefficients (col. 4) for stove use variables or marketing messages are statistically different than zero. When including all control variables (col. 5), the marketing message "Improves Health" increases bids by 1.03 ($p < 0.05$). Additionally, the coefficient on female respondents is −0.91 ($p < 0.05$), and an increase of assets of USD$100 is associated with an increased bid of 0.05 ($p < 0.05$). Marketing messages are not jointly statistically significant in any of the five specifications.

Table 7 shows the differences in bids by marketing message for the time payments auction. In the parsimonious specification (col. 1), none of the marketing messages have statistically significant coefficients. When including demographic controls (col. 2), the coefficient on female respondents is −1.38 ($p < 0.05$), but none of the marketing messages have coefficients significantly different from zero. When including only wealth controls (col. 3), both year round employment (0.83, $p < 0.01$) and value of assets (0.07, $p < 0.01$) are statistically significant, but none of the marketing messages have statistically significant coefficients. None of the coefficients (col. 4) for stove use variables or marketing messages are statistically different than zero. When including all control variables (col. 5), no marketing messages have a statistically significant coefficient. Being a female respondent (−1.27, $p < 0.05$) is associated with a lower bid, increasing the value of assets by USD$100 is associated with an increased bid of 0.06 ($p < 0.05$). Marketing messages are not jointly statistically significant in any of the specifications.

4.2.2. The option to pay over time greatly increases willingness to pay

The within-individual difference in bid amount by auction type was large (Table 8). Bidding on the time payment auction increased the average bid by USD$1.96 compared to USD$4.87. This increase of 40% is both economically large and statistically significant ($p < 0.01$). This is depicted graphically in Fig. 1, which presents the ratio of time payment bid to the total amount bid on both auctions. A ratio larger than 0.5 is indicative of an individual preferring time payments; approximately 96% of respondents have bid ratios of 0.5 or larger, indicating they preferred time payments at least as much as the pay within a week auction. Fig. 2 shows the sample-wide preference for time payments by plotting the share of the sample by bid amount

Table 7
Differences in bids across marketing messsages for time payments auction.

	(1) Bid amount	(2) Bid amount	(3) Bid amount	(4) Bid amount	(5) Bid amount
Saves time and money	0.44	0.47	0.58	0.48	0.61
	(0.49)	(0.50)	(0.51)	(0.51)	(0.52)
Improves health	0.08	0.15	0.09	0.15	0.18
	(0.58)	(0.57)	(0.58)	(0.59)	(0.57)
Both messages	−0.12	−0.14	−0.30	−0.14	−0.27
	(0.54)	(0.57)	(0.59)	(0.54)	(0.59)
Female respondent		−1.38*			−1.27*
		(0.54)			(0.53)
Age of respondent		−0.01			−0.01
		(0.01)			(0.01)
Married		0.25			0.20
		(0.38)			(0.39)
Wife is primary cook		−0.17			−0.04
		(0.53)			(0.52)
Wife and husband make decisions jointly		0.41			0.23
		(0.39)			(0.39)
Year round employment			0.83**		0.52
			(0.30)		(0.28)
Value of assets (100's USD)			0.07**		0.06*
			(0.02)		(0.02)
Three stone fire is primary stove				−0.77	−0.19
				(0.69)	(0.63)
Already owns mud or charcoal stove				0.47	0.82
				(0.80)	(0.75)
Purchased firewood last month				0.34	0.33
				(0.44)	(0.45)
Gathered firewood last month				0.03	0.17
				(0.49)	(0.51)
Constant	6.73**	7.95**	5.99**	7.03**	7.06**
	(0.46)	(0.88)	(0.49)	(0.88)	(1.10)
Observations	2135	2129	2135	2127	2127
R-squared	0.00	0.01	0.02	0.01	0.03
F-test	0.568	0.632	1.240	0.650	1.149
Prob > *F*	0.639	0.599	0.309	0.588	0.342

Note: The *F*-tests presented test whether marketing messages are jointly statistically significantly different than zero. Twenty-eight observations of initial auction winners who refused to pay the second-highest bid are dropped from the sample as this is evidence they did not understand the auction setup and were not bidding their true value. To minimize the effect of outliers the value of assets is bottom and top coded at 2% and 98% of the distribution, respectively. Standard errors are clustered at the parish level.
Significance tests: $^{**}p < 0.01$, $^{*}p < 0.05$.

Table 8
Within-individual differences in bids between auction types.

	(1) Bid amounts
Time payment auction	1.96**
	(0.14)
Constant	4.87**
	(0.07)
Observations	4260
Number of households	2161
R-squared	0.22
F-test	192.1
Prob > *F*	0.00

Note: Twenty-eight observations of initial auction winners who refused to pay the second-highest bid are dropped from the sample as this is evidence they did not understand the auction setup and were not bidding their true value. Standard errors are clustered at the parish level.
Significance tests: $^{**}p < 0.01$.

for each auction type. The auction with time payments lies to the right of the pay within a week curve, indicating that at any given price a larger share of respondents bid higher on the time payments auction than the pay within a week auction.

4.3. Extensions

4.3.1. Do bids reflect true willingness to pay?

The Vickrey second-price auction is frequently used to elicit willingness to pay because under fairly modest assumptions bidders have incentives to bid their true willingness to pay (Shogren et al., 1994; Vickrey, 1961).

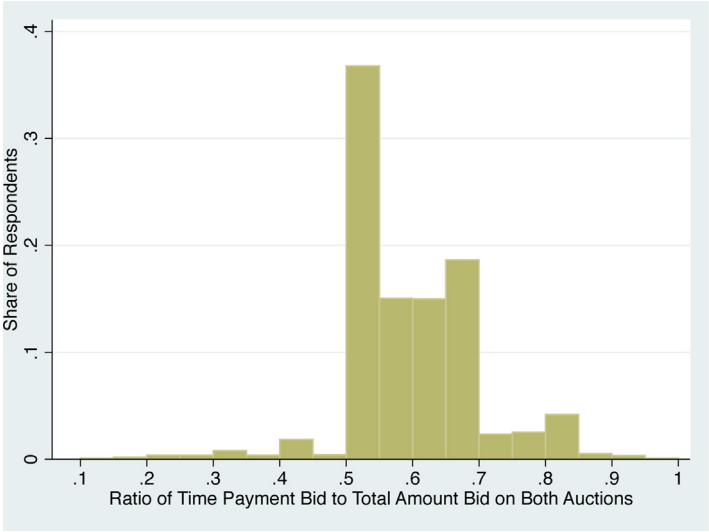

Fig. 1. Within person preference for time payments: ratio of time payment bid to total amount bid on both auctions.

There are mixed results on how well second-price auctions reveal true willingness to pay. Some studies have found no evidence against truthful bidding (Johannesson et al., 1997), while others have found bids in second-price auctions may take considerable time to converge to their theoretically predicted value (Coppinger et al., 1980) or do not converge at all (Kagel and Levin, 1993; Lusk et al., 2001). Participants may not realize (even when told) that their incentive is to bid their true willingness to pay (Lusk et al., 2001). Furthermore, bidders in auctions compete with one another, which does not mimic a consumer's decision-making process in a retail setting with a posted price (Hoffman et al., 1993).

We found that the bids that respondents submitted did not always measure true willingness to pay. First, 28 winning bidders (with very high bids) refused to pay. Second, based on the findings of our qualitative researcher, some respondents who knew they would not win bid zero even though they had a positive willingness to pay. Third, it is likely that many other bidders used a general bidding heuristic to shade their stated willingness to pay (as in Guiteras et al., 2014).

As noted above, some but not all studies found that second-price auctions predict demand with a posted price (Coppinger et al., 1980; Hoffman et al., 1993; Lusk et al., 2001; Noussair et al., 2004). To compare how the second price auction predicts purchases with a posted price, we compared a sales offer with a posted price in a second sales study in neighboring villages within Mbarara, using the same fuel-efficient cookstove (Levine et al., 2013). The populations are very similar in observable characteristics (Harrell et al., 2013), and the marketing meetings were implemented using similar procedures.

In 10 parishes we offered the same pay within a week sales offer as in our auction. At two parishes the posted price was \$12 (n = 63 respondents), and at eight parishes the posted price was \$16 (n = 349). Only 4% bid at least \$12 in the second-price

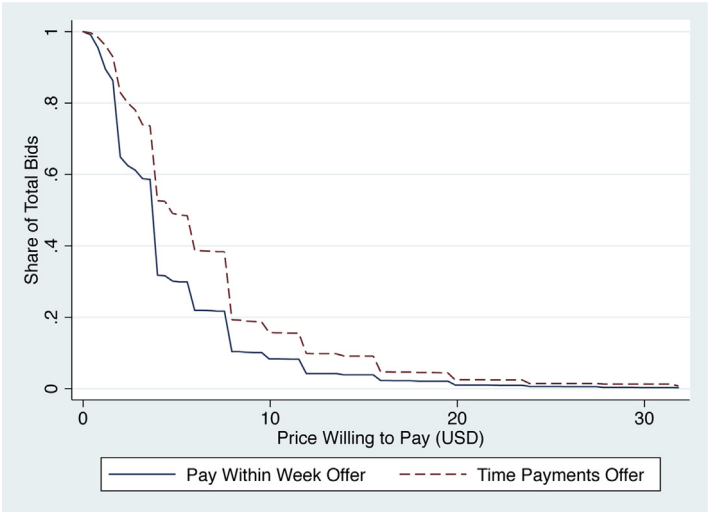

Fig. 2. Sample-wide preference for time payments: share of bids by willingness to pay.

auction (Fig. 2, this study), while 35% of respondents purchased the stove at the posted price of $12. Similarly, although less dramatically, only 2% bid $16 in the auction (Fig. 2, this study), while 4% of respondents purchased the stove at the posted price of $16. Although the posted price sales meetings were a few months later, it is plausible that the higher share willing to pay $12 or $16 in posted price meetings as compared to the second-price auction is due to auction participants modestly reducing their stated willingness to pay (as was found, for example, by Guiteras et al., 2014).

At the same time, we have no reason to believe any potential under bidding was correlated with randomized marketing messages or with auction type (pay within a week vs. time payments). Thus, potential under bidding should not have biased our main results that our marketing messages had little to no effect on bidding behavior but that time payments increased bids substantially.

4.3.2. Male vs. female bidders

As noted above, men bid $0.91 (21%) (Table 6, col. 5) more than women in the pay within a week auction and $1.27 (20%) (Table 7, col. 5) more than women in the time payments auction. This result is slightly surprising as other studies have found men have a lower willingness to pay than women for products whose primary beneficiaries are women and children (Ashraf, 2009; Meredith et al., 2013; Miller and Mobarak, 2013). The higher willingness to pay of men may be due to women controlling fewer financial resources. This effect is plausible in Uganda as women have traditionally had low control of finances (Uganda Bureau of Statistics and ICF International Inc., 2012).

We did not collect data explicitly, but our enumerators reported that when both husband and wife were present, the husband was typically the respondent. Thus, female respondents did not have their husbands present, while some male respondents did have their wives present. In that case, the higher willingness to pay of male respondents may partly capture higher willingness to pay when both spouses are present and thus can agree on the value of the new stove. (The difference in willingness to pay could also capture self-selection of which men were present.)

While not definitive, the fact that men bid higher than women suggests the importance of marketing durable products that women use (such as cookstoves) to both husbands and wives. This result is also consistent with the hypothesis that willingness to pay for a fuel-efficient cookstove will increase if the new stove includes additional features particularly valuable to men.

5. Conclusion

Our main results can be summarized as follows:

1. Our randomized trial found no consistent evidence that information on how fuel-efficient cookstoves can improve health or save time and money improved willingness to pay.
2. In a within-subject comparison, willingness to pay was 40% higher with time payments than when paying within 1 week.

It is possible that more vivid or convincing messages about improved health or savings would be effective. Alternatively, messages emphasizing the high status of the new stove or other features of the stove (convenience, safety) or messages delivered by other sources (village elders, neighbors) might have more impact. Nevertheless, our results suggest that economic barriers are more important than informational barriers.

The large effects of time payments suggest liquidity constraints and/or present bias reduce demand, but good will, quality signaling, and other factors could have a role too. Thus, broad dissemination of cookstoves (and presumably other health-related durable goods, such as water filters or bed nets) will require reducing the transaction costs of collecting payments over time. It is possible that mobile phone payments (Luoto and Levine, 2014), switching to layaway where consumers make payments prior to receiving the stove (Guiteras et al., 2014), linking with microfinance or others who already collect regular payments, or using a network of local vendors to collect the time payments can reduce transaction costs substantially. More innovation and testing are required to identify effective business models in different settings.

Even with time payments, only 5% of participants bid the market price of $19. This result suggests stoves can only be widely distributed if there are subsidies or substantial reductions in production and distribution costs. However, in a subsequent experiment when we combined time payments with a free trial and had a posted price (not an auction), over half of participants purchased the fuel-efficient stove for $16 (Levine et al., 2013). Thus, unless transaction costs are very high, it is likely that any subsidy for stoves should be used first to cover the transaction costs of payments made over time before they are used to reduce the purchase price.

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Appendix A.

See Appendix Table A1.

Table A1
Prices used for construction of aggregate asset values.

	Price in USD
Television	134.27
Bicycle	69.70
Radio	13.83
Vehicle	4509.61
Motorcycle	783.78
Mobile phone	34.26
Indigenous cow	252.23

Note: Price data used to construct value of assets are average purchase prices of durable goods taken from the 2011–2012 round of the Uganda Living Standards Measurement Study (LSMS). This data is publicly available at: www.econ.worldbank.org.

Appendix B. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jebo.2015.04.025.

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