The Impact of Finance on Willingness to Pay for Low-Cost Latrines in Rural Cambodia: Evidence from a Randomized-Controlled Trial

Pre-Analysis Plan

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1 Introduction

This pre-analysis[1] plan describes the methods to be employed in the study "The Impact of Finance on Willingness to Pay for Low-Cost Latrines in Rural Cambodia." The primary goals of this study are: (1) to measure the effect of access to finance on willingness to pay (WTP) for sanitary latrines among residents of rural Cambodia; (2) to determine whether this effect is particularly important for the poor. In future research, funding permitting, we will: (3) measure the relationship between WTP and use of the latrines; (4) determine whether access to finance affects this relationship; (5) determine whether there is any causal relationship between price paid and subsequent use, as well as whether access to finance affects this relationship; (6) measure any peer effects on subsequent use or adoption.

This plan's structure is as follows: Section (2) describes the study context, the sample and the intervention; Section (3) describes the randomization of treatment and the key sources of data; Section (4) lists the hypotheses to be tested and the empirical tests; Section (5) addresses a few remaining points. A companion Supplementary Materials document provides additional detail.

2 Sample and Intervention

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[1] This study is conducted in collaboration with Andrew Fraker, Neil Buddy Shah, Stuart Shirrell and Paul Wang, all of IDinsight. This document was written independently by BenYishay, Guiteras and Palloni and posted at the AEA RCT Registry (http://www.socialscienceregistry.org/) website before BenYishay, Guiteras and Palloni were given access to any outcome data other than descriptive statistics on participation rates.

2.1 Context

The study is conducted in rural Kampong Thom province, Cambodia. 15.8% of rural residents of the province are classified as IDPoor 1 and 15.2% as IDPoor 2.[2] As of 2012, 31% of rural residents had access to a hygienic latrine (iDE, 2012).

The implementation partners are iDE Cambodia and VisionFund Cambodia:

- Founded in 1982, iDE creates income and livelihood opportunities for poor rural households across Asia, Africa and Latin America. iDE works in a range of sectors, including agriculture, water, sanitation and rural marketing. In 2007, iDE Cambodia began a rural sanitation pilot program, which has since expanded into 8 provinces across the country. The program focuses on training concrete manufacturers to make and market sanitary latrines. The ultimate goal of the program is to develop a sustainable sanitation market in rural Cambodia that functions independently of outside demand- or supply-side support. iDE received the World Toilet Organization Hall of Fame Award in 2010 for its Sanitation Marketing program and resulting Easy Latrine.[3]
- VisionFund Cambodia (VFC) is a microfinance institution established in 1994 that has served over 140,000 clients with a total loan portfolio over US$37M. In 2011, VFC received the Platinum Award from MIX (Microfinance Information eXchange).[4]
- Data collection and fieldwork were carried out by IDInsight, a not-for-profit organization assisting clients in setting up, experimenting, and reporting on field trials of operationally relevant ideas.[5]

2.2 Study Sample and Randomization

The study sample consists of 1,500 households from 30 villages in Kampong Thom province, selected using a multi-stage random sampling process. First, from a list of all villages in Kampong Thom, villages above the 95th percentile and below the 5th percentile with respect to population and poverty level (ID Poor status) were dropped to facilitate the selection of a representative sample.

[2] IDPoor 1 and 2 are the government's official poverty lines: IDPoor 1 identifies "poorest or destitute" households; IDPoor 2 identifies "poor" households. IDPoor status is initially assigned based on a set of poverty indicators, then adjusted based on a consultation with village representatives to identify households with "special circumstances" (Ministry of Planning, 2008b).
[3] See http://www.ide-cambodia.org/ for more information on iDE Cambodia.
[4] See http://www.visionfund.com.kh/ for more information on VisionFund Cambodia.
[5] See http://idinsight.org/ for more information on IDInsight.

From the resulting list, samples of 30 villages were randomly selected without replacement and with a probability of selection weighted by village size. At the end of each draw, if the selected villages had significantly different sizes, poverty levels, or latrine coverage rates (measured at the province level) from the overall population averages then the draw was discarded. This procedure was repeated until 100 non-discarded samples were drawn. Of these 100 qualified samples, one was randomly selected as binding. Finally, 15 villages from this sample of 30 were randomly assigned to receive the financing treatment. In each village, a census was taken to obtain the names of the head of household and spouse, the IDPoor status of the household and to identify whether each household owned a latrine.[6,] From each village, 50 households were invited to participate in a group information session and sales meeting led by IDinsight field staff.[7] These 50 households were randomly selected from the village population without a latrine, after stratifying on ID Poor status so that 30% of the selected households (i.e. 15 in each village) were classified as IDPoor. In 4 villages, fewer than 50 households did not have a latrine. In these 4 villages, all non-latrine-owning households were invited, yielding a total sample size of 1,383. On average, 76% of invited households attended the sales meeting.[8], IDinsight field staff then followed up with non-attending households to conduct the same information and sales session, typically within one day of the initial session in the village.[9], Ultimately, 1,380 of 1,383 invited households (99.8%) participated.

2.3 Intervention

The core of the intervention is the group information session and sales meeting. Invited households gathered in a common location (e.g. school, village pagoda, village chief's house). iDE staff lead a 45-60 minute interactive session emphasizing the health and convenience benefits of having a latrine and its status as an aspirational good.

The latrine offered for sale includes three concrete rings, each 80 cm in diameter, a concrete pan, a concrete slab with a porcelain bowl that fits into the pan and a PVC pipe that connects the three rings to the concrete pan. While costs vary significantly based on local costs of materials, transportation and labor, on average materials and labor costs are approximately 160,000 KHR (40

[6] The full text of the census survey (English translation) is provided in Section 1 of the Supplementary Materials.
[7] The household could be represented by any household member older than 18 with the authority to make large purchase decisions for that household.
[8] Households did not know their villages' treatment status until the sales meeting. In fact, the possibility of a loan was not mentioned until the sales meeting in the Financing villages, and not at all in the Lump Sum villages.
[9] Since information circulates quickly within villages, a non-attending household could be aware of the treatment status of its village, making non-participation in this second stage potentially correlated with treatment.

USD).[10] Participants are not given information on the cost. The latrine is marketed as being easy to self-install, requiring approximately one day's labor to dig a 1.5x1m cylindrical pit to house the three concrete rings and a separate mound to keep the basin. No additional material is required to install the latrine after delivery, other than a shovel and some water to mix the mortar. The sale does not include a superstructure.[11]

At the end of the information session, attendees are offered an opportunity to purchase a latrine. The two treatment arms are Lump Sum (control) and Financing (treatment), which are randomly assigned at the village level (see Section 3). In Lump Sum villages, the household is required to pay the full agreed price upon delivery, which would occur within 10 days. In Financing villages, the household is offered a loan from VisionFund Cambodia, which can be repaid over a term of up to 12 months. The loans are group liability with monthly interest rates of approximately 2.8% (declining balance).

In both arms, the sales offer is made using the Becker-DeGroot-Marschak (BDM) mechanism (Becker, Degroot, & Marschak, 1964). The household tells the surveyor its maximum willingness to pay (WTP or "bid") for the latrine. An IDinsight enumerator then allows the household to choose from a set of sealed, unmarked envelopes, each containing a randomly chosen price.[12] If the price inside the chosen envelope is less than or equal to the subject's bid, then the subject purchases the latrine at the randomly determined price. If the price in the envelope is greater than the subject's bid, then the subject cannot purchase the latrine. The subject is not allowed to change his bid after the price is revealed. Under weak assumptions of rationality, it is in the subject's best interest to bid his true maximum willingness to pay.[13] The bids are given and the price is revealed in private. The sales mechanism is the same in Lump Sum and Financing villages, except that in Financing villages the

[10] The Cambodia Riel is pegged to the dollar. It fluctuates within a band of 3,900 KHR/USD to 4,100 KHR/USD. We use an exchange rate of 4,000 KHR/USD throughout this document.

[11] During previous iDE interventions in similar areas of Cambodia, three types of superstructure have been most commonly installed: (a) bamboo / thatch superstructure, made from locally gathered materials; (b) tin, which can be self-constructed using materials typically costing less than US$ 5 equivalent; (c) concrete, which requires hiring a mason and costs at least US$ 100 equivalent. Options (a) and (b) typically require less than half a day's labor.

[12] The distribution of prices was 80,000 KHR, 120,000 KHR, 160,000 KHR and 200,000 KHR (20, 30, 40 and 50 USD) with equal probability weights. Households were not informed of the distribution of prices. Although in principle the distribution of prices should not matter for an optimal bid, experimental data suggests it can (Mazar, Koszegi, & Ariely, 2010; Urbancic, 2011).

[13] See Horowitz (2006) for a discussion of the rationality assumption (expected utility maximization) required for BDM to be incentive-compatible. In this context, the notion of a single, stable maximum WTP is problematic, since an individual's WTP for sanitation plausibly depends on the choices of others in his community (Pattanayak & Pfaff, 2009). If this is true, then subject's optimal bid depends on his beliefs about what others in the meeting will bid and how many of them will win. These beliefs are not known to the researcher.

loan option is explained before the bidding so that subjects can take this information into account when deciding their maximum WTP. In addition, in Lump Sum villages bids are made in terms of the full payment amount, while in Financing villages bids are made in terms of the monthly installment payments.[14]

Households randomly selected for an invitation who do not attend the group meeting are visited by IDinsight enumerators within one day and offered an opportunity to participate at home. If they agree, the information session and sales exercise are very similar to those conducted at the group meeting.

In Financing villages, immediately after the group sales meeting, winning households met with a VisionFund underwriter, who use a basic battery of questions on the customer's age, income and assets to determine his eligibility for a loan. The underwriter then determines whether or not to extend the loan.

3 Data Collection

3.1 Census

The census, administered to all households in the village, obtains the name of the head of household and spouse, whether the household owns a latrine, and whether the household is classified as IDPoor.

3.2 Baseline Survey

The baseline survey is conducted with all invited, consenting households. The key topics covered are:[15]

- Basic identifying information, including GPS coordinates.
- Latrine ownership and type, whether the latrine has a shelter, whether the latrine appears and smells clean.
- Household roster, including relationship to head of household, sex, age, financial contribution to the household, and defecation habits over the last 15 days
- Borrowing of rice or money from other people
- Size and materials of house

[14] The BDM survey instrument is provided in Section 3 of the Supplementary Materials.
[15] The baseline survey instrument is provided in Section 2 of the Supplementary Materials.

- Main source of income
- Hectares of land cultivated, recent sales of main crops
- Seasonality of cash availability
- Knowledge of latrine components and costs

The baseline survey is designed so that we can reconstruct the index underlying IDPoor status (Ministry of Planning, 2008a, 2008b) and the Progress out of Poverty Index (Schreiner, 2009).

3.3 Sale

For each household (h) in each village (v), the sale provides data on willingness to pay (WTP_{hv}), the price offer (Draw_{hv}), whether the household won the latrine ($\text{Won}_{hv} = 1\{\text{WTP}_{hv} \geq \text{Draw}_{hv}\}$) and whether the household actually purchased the latrine (Bought_{hv}). If the household won the latrine but reneged, that is recorded as a refusal: $\text{Refuse}_{hv} = (\text{Won}_{hv} = 1) \cap (\text{Bought}_{hv} = 0)$. For households that purchase the latrine, the price paid is the price offer: $P_{hv} = Draw_{hv}$. The price paid is not defined for households that do not purchase. We also document whether households that lost attempted to bargain for the filter, and whether ex-post they wish they had bid more.

3.4 Payment Collection

Data on repayment and default will be recorded by VisionFund Cambodia when collecting on the loans.

3.5 Follow-Up Survey

We will seek funding for a follow-up survey, to be conducted approximately 6 months after the sale. Our first priority is to survey sample households, i.e. participants. The primary outcomes of interest are latrine installation and maintenance. The surveyors check whether the latrine has been partially or completely installed, whether the latrine (if installed) qualifies as an "improved latrine," based on the WHO / UNICEF Joint Monitoring Programme (JMP) definition,[16] and whether the latrine is clean, using questions adapted from Annex 5 of Hanchett, Krieger, Kahn, Kullmann, and Ahmed (2011). If funding permits, we will also measure spending on maintenance, improvements and complementary inputs.

[16] See http://www.wssinfo.org/definitions-methods/introduction/ for details.

The second priority will be to survey a random sample of villagers not selected for the sales meeting, again stratified by IDPoor status. In this brief survey we will ask about social connections with a random sample of the "first round" participants, and any investments in latrines since the first round. As discussed in Section 4 (Hypothesis 6), this will allow us to estimate peer effects on demand.

4 Hypotheses and Empirical Tests

The current study tests Hypotheses 1 and 2. We are applying for funding to conduct a follow-up survey that will allow us to test Hypotheses 4-6.

4.1 Current Study

Hypothesis 1: Access to finance increases willingness to pay for sanitary latrines (WTP)

Discussion: It is plausible that, for many households, the ability to pay for an investment by making small payments over time will increase willingness to pay. There are several possible mechanisms, including financial market constraints (difficulty borrowing or saving), high discount rates or non-exponential discounting, and intra-household conflict over spending priorities.

Outcome variable(s):

Household WTP, as measured in BDM. For households making a lump-sum payment, WTP is simply the nominal amount. For households receiving a loan, WTP is calculated as the present discounted value of the monthly payments. For our primary analysis, we apply a discount rate of 2.8% per month (declining balance), which is the approximate lending rate for VisionFund Cambodia. For robustness, we will also report results applying monthly discount rates of 1.8%, 2.3%, 3.3% and 3.8% per month.

There are three cases in which we will need to make assumptions on missing values: (a) households that decline to participate; (b) households that renege or cancel orders; (c) households in Financing villages that are refused a loan by VisionFund. We will conduct our analysis under three assumptions: (1) dropped (i.e. missing at random, for example if some idiosyncratic event prevented them from participating); (2) WTP of zero; (3) using Lee bounds.

When analyzing effects on WTP, we will present results using both the level and the log of WTP as the dependent variable. We view the log specification as more relevant for testing economic hypotheses, while the level is more relevant for a practitioner, e.g. an NGO considering offering financing.

Tests:

First, we test whether access to finance affects median[17] WTP with the simple quantile regression

$$q_{\text{WTP}}(\tau) = \beta_0(\tau) + \beta_1(\tau)T \quad (1)$$

for $\tau = 0.50$. Inference will be robust to clustering at the village level (level of randomization).[18]

Second, we test for effects on the distribution of WTP using quantile regression, estimating Equation (1) for $\tau = 0.25, 0.50, 0.75$. The coefficients $\{\beta_1(0.25), \beta_1(0.50), \beta_1(0.75)\}$ represent the impact of financing on the first, second (median) and third quartile of the distribution. Inference will be robust to clustering at the village level and conducted simultaneously over the three quantile estimates. For descriptive purposes, we will also report estimates at each decile, i.e. for $\tau = 0.1, 0.2, ..., 0.9$, with a uniform confidence band.

Third, we address two questions of policy interest: (a) the effect of finance on coverage with no subsidy and a 50% subsidy; (b) the effect of finance on the subsidy required to achieve 85% coverage, where epidemiological evidence suggests that large community health

[17] We focus on quantiles since we expect there to be households with zero WTP, either stated explicitly or imputed via our assumptions on missing values. We will also report results from mean regression as robustness checks, using the level and inverse hyperbolic sine of WTP as dependent variables. The inverse hyperbolic sine is defined as $\log\left(y+\left(y^2+1\right)^{1/2}\right)$. Its interpretation in regression is similar to $\log y$ but permits zero values.

[18] We plan to calculate cluster-robust standard errors using the methods of Santos Silva and Parente (2013), implemented in Stata using `qreg2` command. However, given that our number of clusters is relatively low (30), we will perform simulations to check that these cluster-robust standard errors are consistent. We will use the moments of the control village data (in particular, the within- and between-variation) to generate the simulation data. If the cluster-robust standard errors exhibit significant bias (an empirical size of $\alpha_{obs} \geq 0.15$ for a test with nominal size $\alpha_{\text{nom}} = 0.10$ over 10,000 simulations), then we will use the cluster-bootstrap recommended for small-G inference by Cameron, Gelbach, and Miller (2008). The same applies to the cluster-robust analyses discussed in the remainder of the document.

benefits occur. For (a), given a break-even price p_{BE}, and a subsidy price $p_{SUB} = 0.5 p_{BE}$, for each price p, we estimate the logit regression

$$\Lambda\left(\text{WTP}_{hv} \geq p\right) = \beta_{p,0} + \beta_{p,1} T_v . \tag{2}$$

The coefficients will then be used to estimate coverage with and without financing:

$$\text{S}_{p,LS} = \frac{\exp\left(\beta_{p,0}\right)}{1+\exp\left(\beta_{p,0}\right)}; \text{S}_{p,F} = \frac{\exp\left(\beta_{p,0}+\beta_{p,1}\right)}{1+\exp\left(\beta_{p,0}+\beta_{p,1}\right)}; \Delta S_p = S_{p,\text{F}} - S_{p,\text{LS}}, \tag{3}$$

where ΔS_p is the increase in coverage at price p from financing. For (b), we will use quantile regression as in Equation (1), evaluated at $\tau = 0.85$. The coefficient $\beta_1(0.85)$, when WTP is specified in levels, gives the difference in price required to achieve 85% coverage with financing.

Finally, while our primary interest is in the effect of finance on WTP, practitioners are additionally likely to be interested in whether finance increases their revenues net of collection expenses. As a secondary outcome, we will calculate the impact of finance on net revenues under a range of assumptions about collection costs and losses to default, and obtain bounds on these parameters such that financing increases net revenues.

Hypothesis 2: Access to finance increases WTP differentially for poorer households

Discussion: It is reasonable to think that poorer households' WTP will be relatively more responsive to access to financing. Poorer households have fewer financial assets (e.g. savings that can be drawn against to pay for a large lump-sum expense) and fewer physical assets (either for liquidation or to serve as collateral), and may already be at sufficiently low levels of consumption that cutting consumption to finance an investment in a durable good carries a high utility cost. On the other hand, perhaps even with the availability of finance, poor households may find other consumption needs to be higher priorities, whereas relatively better-off households may find that the financing option makes purchasing the latrine more attractive.

Outcome variable(s): as in Hypothesis 1.

Tests:

The tests of Hypothesis 2 are similar to those of Hypothesis 1, but we add intercept and interaction terms for IDPoor status to estimate differential impacts.

To test for a differential effect of access to finance on median WTP, we augment Equation (1) with intercept and interaction terms and estimate

$$q_{\text{WTP}}(\tau) = \beta_0(\tau) + \beta_1(\tau)T + \beta_2(\tau)\text{Poor} + \beta_3(\tau)(T \times \text{Poor}) \tag{4}$$

for $\tau = 0.50$. $\beta_2(0.50)$ represents the difference in median WTP between IDPoor and non-IDPoor households without financing, while $\beta_3(0.50)$ represents the difference in the impact of finance on median WTP for IDPoor households.

Second, we test whether finance has differential effects on the distribution of WTP, again via quantile regression, estimating Equation (4) for $\tau = 0.25, 0.50, 0.75$. Inference will be robust to clustering at the village level and conducted simultaneously over the three quantile estimates. For descriptive purposes, we will also report estimates at each decile, i.e. for $\tau = 0.1, 0.2, ..., 0.9$, with a uniform confidence band.

Third, we test whether financing differentially affects coverage for the poor at no subsidy and at a 50% subsidy, and whether finance differentially affects the subsidy required to achieve 85% coverage among the poor. Again, we augment equation (2) and estimate the logit regression

$$\Lambda(\text{WTP}_{hv} \geq p) = \beta_{p,0} + \beta_{p,1}T_v + \beta_{2,p}\text{Poor}_{hv} + \beta_{3,p}(T_v \times \text{Poor}_{hv}). \tag{5}$$

at the no subsidy price and the 50% subsidy price. We then test the double-difference $\Delta^2 S_p = \Delta_p(\text{Poor}) - \Delta_p(\text{Non-Poor})$ as in Equation (3). For the second of these policy questions, we estimate Equation (4) at $\tau = 0.85$. The coefficient $\beta_3(0.85)$ gives the difference in the impact of finance between the poor and the non-poor.

4.2 Future Research

Hypothesis 3A: Households with higher WTP are more likely to install and maintain the latrine they purchase.

Hypothesis 3B: Price paid has a causal effect on the probability of installation and maintenance.

Discussion: Optimal pricing for health goods requires an understanding of (a) whether households with higher WTP are more likely to use the product ("screening effect of pricing") and (b) whether the price paid itself has an effect on use ("sunk cost effect" or "causal effect of price paid") (Ashraf, Berry, & Shapiro, 2010; Cohen & Dupas, 2010). One methodological advantage of BDM is that it allows identification of both channels: WTP is revealed in the bidding process; the transaction price is random, conditional on winning and WTP (Berry, Fischer, & Guiteras, 2012; Hoffmann, 2009).

Outcome variable(s):

Measuring actual use of the latrine is not feasible given our budget,[19] and self-reports of health behaviors frequently suffer from serious social desirability bias (Gupta, Islam, Johnston, Ram, & Luby, 2008; van de Mortel, 2008). As a result, we plan to use two objective measures as proxies for use. The first is whether the latrine has been installed, which is a necessary condition for use. The second is a measure of whether the latrine appears to be clean and well-maintained. Specifically, we will use the number of criteria met from the Hanchett et al. (2011) checklist, with non-installed latrines coded as zero.

Tests:

The first test, of Hypothesis 3A alone, is an unconditional regression of the outcome measure on WTP. This assumes that there is no causal effect of price paid on use, which we test below. Since theory does not predict any particular shape of this relationship, we will use standard nonparametric regression (Li & Racine, 2006) to estimate

$$E\left[y_{hv} \middle| \mathrm{WTP}_{hv} \right] = g\left(\mathrm{WTP}_{hv} \right) \tag{6}$$

on the sample of winners (participants with WTP greater than or equal to the price drawn)

[19] Clasen et al. (2012) report on the development of an unobtrusive sensor that can measure the number of times someone enters the latrine and the duration of stay, with a materials cost of approximately US$ 60 per unit in 2012.

Second, we test Hypotheses 3A and 3B together by estimating the multivariate relationship between use (outcome variable) and WTP and price paid (explanatory variables).

A simple, transparent way to display this relationship is to divide the sample into (P, WTP) cells (e.g. by quintiles of WTP) and compute the mean within each cell. One cell (e.g. lowest WTP and P) can be normalized to zero to display differences:

	WTP (increasing)				
Price	1st quintile	2nd quintile	3rd quintile	4th quintile	5th quintile
1st quint.	$\overline{y}_{1,1}$ $(\text{s.e.}_{1,1})$	$\overline{y}_{1,2}$ $(\text{s.e.}_{1,2})$	$\overline{y}_{1,3}$ $(\text{s.e.}_{1,3})$	$\overline{y}_{1,4}$ $(\text{s.e.}_{1,4})$	$\overline{y}_{1,5}$ $(\text{s.e.}_{1,5})$
2nd quint.		$\overline{y}_{2,2}$ $(\text{s.e.}_{2,2})$	$\overline{y}_{2,3}$ $(\text{s.e.}_{2,3})$	$\overline{y}_{2,4}$ $(\text{s.e.}_{2,4})$	$\overline{y}_{2,5}$ $(\text{s.e.}_{2,5})$
3rd quint.			$\overline{y}_{3,3}$ $(\text{s.e.}_{3,3})$	$\overline{y}_{3,4}$ $(\text{s.e.}_{3,4})$	$\overline{y}_{3,5}$ $(\text{s.e.}_{3,5})$
4th quint.				$\overline{y}_{4,4}$ $(\text{s.e.}_{4,4})$	$\overline{y}_{4,5}$ $(\text{s.e.}_{4,5})$
5th quint.					$\overline{y}_{5,5}$ $(\text{s.e.}_{5,5})$

The matrix is triangular because we do not observe use for those who lost in BDM, i.e. with $WTP < P$. Screening (the association between use and WTP) can be seen by reading along rows, causal effects of price paid on use by reading down columns.

To obtain simple summary measures of the influence of each explanatory variable, we follow Ashraf et al. (2010) and estimate

$$\begin{aligned} E\left[y_{hv} \mid \text{WTP}_{hv}, P_{hv}\right] &= \beta_{\text{WTP}}\text{WTP}_{hv} + g_P\left(P_{hv}\right) \\ E\left[y_{hv} \mid \text{WTP}_{hv}, P_{hv}\right] &= \beta_P P_{hv} + g_{\text{WTP}}\left(\text{WTP}_{hv}\right). \end{aligned} \tag{7}$$

The first estimates the linear relationship between use and WTP, controlling flexibly for price paid, the second estimates the linear relationship between use and price paid, controlling flexibly for WTP. As with (6), we can only use the sample of winners, i.e. subjects with $\text{WTP}_{hv} \geq \text{Draw}_{hv}$.

A more general specification allows for a flexible functional form and interactions between the two explanatory variables:

$$E\left[y_{hv} \mid \text{WTP}_{hv}, P_{hv}\right] = g\left(\text{WTP}_{hv}, P_{hv}\right), \tag{8}$$

which we estimate nonparametrically. We will report these results graphically.

To obtain more succinct summary measures from this flexible specification, we will calculate average partial effects at the 25th, 50th and 75th quantiles of WTP. Specifically, let

$$\begin{aligned} M_{\text{WTP}}\left(b, p\right) &= \left.\frac{\partial y\left(\text{WTP}, P\right)}{\partial \text{WTP}}\right|_{\text{WTP}=b, P=p} \\ M_{\text{P}}\left(b, p\right) &= \left.\frac{\partial y\left(\text{WTP}, P\right)}{\partial P}\right|_{\text{WTP}=b, P=p} \end{aligned} \tag{9}$$

be the partial derivatives of use with respect to WTP and price paid, respectively, when $\text{WTP} = b$ and $P = p$. To calculate the average partial effect of WTP at price $P = p_0$, we take the weighted average of $M_{\text{WTP}}\left(b, p_0\right)$ over valuations (bids) $b \geq p_0$ (that is, the range of valuations for which we have data on use when the price is p_0, since those with $b < p_0$ do not win the latrine when the price is p_0). The weights are given by the demand curve: each $M_{\text{WTP}}\left(b, p_0\right)$ is weighted by the share of the population with $\text{WTP} \approx b$ among the population with $\text{WTP} \geq \text{p}_0$.[20] To calculate the average partial effect of price paid at $\text{WTP} = b_0$, we take the unweighted average of $M_P\left(b_0, p\right)$ over prices $p \leq b_0$, i.e. the range of prices paid by those with $\text{WTP} = b_0$.

[20] More precisely, we weight by $w_{p_0}\left(b\right) = f\left(b\right) / \left(1 - \text{F}\left(p_0\right)\right)$, where $f\left(.\right)$ is the density and $F\left(\cdot\right)$ the CDF of WTP.

Hypothesis 4A: Access to finance affects the relationship between WTP and the probability of installation and maintenance

Hypothesis 4B: Access to finance affects the causal relationship between price paid and the probability of installation and maintenance.

Discussion:

Screening: if it is primarily poverty or credit constraints, rather than low interest in health or lack of intent to use the product, that limits WTP, then financing could lead to better targeting of scarce subsidy resources, i.e. allocating goods to those most likely to use them.

Causal effect of price paid on use: access to finance could *increase* any sunk-cost effect during the term of the loan, since each time the household pays an installment on the loan, it effectively receives a reminder of the cost of the latrine. On the other hand, each payment is less, so the intensity of the sunk cost effect could be less than if the household had to pay all at once.

Outcome variable(s): As in Hypothesis 3.

Tests: As in Hypothesis 3, estimated separately for the Lump Sum and Financing arms. In order to compare results across arms, we must assume rank invariance, i.e. the household at the q^{th} quantile of WTP under Lump Sum would have been at (approximately) the q^{th} quantile of WTP under Financing. This is a strong assumption. It may be more plausible for households that are similar on observables, so we will also report results within IDPoor and non-IDPoor samples. However, this is likely to be very demanding of the data and may lack power.

Hypothesis 5: Households purchasing a latrine are more likely to install and maintain it if their social contacts also purchase latrines.

Discussion: After purchasing a latrine, households still face a decision of whether to install it. This decision may be influenced by the decisions of ones' peers and neighbors. We can estimate peer effects by using neighbors' draws in BDM as instruments for installation. Since the BDM draws are random, they are unrelated to other determinants of installation, breaking the reflection problem (Manski, 1993).

Outcome variable(s): As in Hypothesis 3.

Tests: We will identify two sets of social contacts that may influence household decisions to install and maintain latrines: (1) geographic neighbors (from the roster of invited households); (2) other households with blood or marital links to a given household (funds permitting, collected at followup). We will estimate the following system of equations by instrumental variables:

$$\begin{aligned} y_{hv} &= \sum_{n=1}^{N} \beta_n y_{nv} + x'_{hv}\delta + \varepsilon_{hv} \\ y_{nv} &= \gamma_{n,1} 1\{\text{WTP}_{nv} \geq \text{Draw}_{nv}\} + x'_{nv}\pi_1 + x'_{hv}\pi_2 + u_{nv} \\ n &= 1,...,N \end{aligned} \tag{10}$$

where y_{hv} is the outcome of interest for household h, $n = 1,...,N$ indexes household h's neighbors and $x_{hv} = \{\text{WTP}_{hv}, \text{Poor}_{hv}, T_v\}$ are covariates.[21] The excluded instrument $1\{\text{WTP}_{nv} \geq \text{Draw}_{nv}\}$ is random once we have conditioned on WTP_{nv}. We constrain the first-stage coefficients to be equal for all neighbors n. In the simplest specification, we will constrain the effect of each neighbor to be the same (i.e. $\beta_1 = \cdots = \beta_N$). We will also estimate a model where we order the neighbors and allow effects to differ by proximity. We will also conduct subgroup analysis by WTP (splitting above and below village median WTP) to test the hypothesis that high WTP households are more likely to have positive peer effects, and by IDPoor status.

If we find very strong sunk-cost effects, such that we can separately identify the effects of neighbor's purchase and installation (instrumenting with $1\{\text{WTP}_{nv} \geq \text{Draw}_{nv}\}$ and powers of $\text{Draw}_{nv} | 1\{\text{WTP}_{nv} \geq \text{Draw}_{nv}\}$), then we will run exploratory IV analyses with these as separate endogenous right-hand-side variables. In the absence of strong prior information on the shape of any sunk-cost effect, we are unable to pre-specify the IV regression precisely.

Hypothesis 6: Households whose social contacts purchase a latrine are more likely to purchase a latrine at follow-up.

Outcome variable(s): Recent investments in latrines among BDM losers and (if funds are available) households not invited to participate in the first round, as reported in the follow-up survey(s). The

[21] Note that even if there are sunk-cost effects (i.e. a low draw makes one less likely to install a purchased latrine than a high draw), the indicator variable $1\{\text{WTP}_{nv} \geq \text{Draw}_{nv}\}$ still satisfies monotonicity (even though $\text{Draw}_{nv} | 1\{\text{WTP}_{nv} \geq \text{Draw}_{nv}\}$ may not) as long as winners are more likely to install latrines than losers.

primary outcome variable will be the purchase of any latrine. We will also attempt to measure total sanitation spending, and use this as the dependent variable (censored below at zero for non-purchasers) in a secondary analysis.

Tests: Using the same two sets of social contacts, we will test for peer effects on purchase among those who did not purchase in the first round, either because they lost in BDM or because they were not invited to participate. As in Hypothesis 5, we will instrument for peer purchase using $1\{\text{WTP}_{nv} \geq \text{Draw}_{nv}\}$. For participants in BDM in the first round, their WTP will be available as a control, although this is not observed for those who did not participate in the first round. Again, we will conduct subgroup analysis by WTP (splitting above and below village median WTP) to test the hypothesis that high WTP households are more likely to have positive peer effects, and by IDPoor status. We will also test whether high WTP households and IDPoor households are more likely to be influenced. As above, if sunk-cost effects provide separate instruments for peer purchase and takeup, we will conduct exploratory analysis to estimate these separately, but we cannot specify the regression in advance.

5 Other

5.1 Multiple Hypothesis Testing

We will report both naïve (per-comparison) and Bonferonni-corrected p-values in the following cases:

- Significance of decile estimates of Equations (1) and (4).
- Subgroup analysis of Hypotheses 3A and 3B (differential effect on IDPoor households)
- Subgroup analysis of Hypotheses 4A and 4B (differential effect on IDPoor households)
- Use of two different peer groups in tests of Hypotheses 5 and 6 (geographical proximity and kin ties)
- Subgroup analysis of peer effects in Hypotheses 5 and 6 (differential effect by WTP above / below median; differential effect on IDPoor households)

5.2 Attrition

Procedures for dealing with households that "attrit" from the sale are discussed in Section 4.1, under Hypothesis 1.

For attrition from the follow-up survey, in keeping with the literature, we will test whether any observed characteristics are significant determinants of attrition/non-response. In addition, we will compute Lee bounds on the treatment effect to ensure that our results are not impacted by the attrition.

6 References

Ashraf, N., Berry, J., & Shapiro, J. M. (2010). Can Higher Prices Stimulate Product Use? Evidence from a Field Experiment in Zambia. *American Economic Review, 100*(5), 2383-2413. doi: 10.1257/aer.100.5.2383

Becker, G. M., Degroot, M. H., & Marschak, J. (1964). Measuring utility by a single-response sequential method. *Behavioral Science, 9*(3), 226-232. doi: 10.1002/bs.3830090304

Berry, J. M., Fischer, G. M., & Guiteras, R. P. (2012). *Eliciting and Utilizing Willingness to Pay: Evidence from Field Trials in Northern Ghana*. Working Paper.

Cameron, A. C., Gelbach, J. B., & Miller, D. L. (2008). Bootstrap-Based Improvements for Inference with Clustered Errors. *Review of Economics and Statistics, 90*(3), 414-427. doi: 10.1162/rest.90.3.414

Clasen, T., Fabini, D., Boisson, S., Taneja, J., Song, J., Aichinger, E., . . . Burt, Z. (2012). Making sanitation count: developing and testing a device for assessing latrine use in low-income settings. *Environmental Science & Technology, 46*(6), 3295-3303. doi: 10.1021/es2036702

Cohen, J., & Dupas, P. (2010). Free Distribution or Cost-Sharing? Evidence from a Randomized Malaria Prevention Experiment. *The Quarterly Journal of Economics, 125*(1), 1-45. doi: 10.1162/qjec.2010.125.1.1

Gupta, S. K., Islam, M. S., Johnston, R., Ram, P. K., & Luby, S. P. (2008). The chulli water purifier: acceptability and effectiveness of an innovative strategy for household water treatment in Bangladesh. *The American Journal of Tropical Medicine and Hygiene, 78*, 979-984.

Hanchett, D. S., Krieger, D. L., Kahn, M. H., Kullmann, C., & Ahmed, R. (2011). Long-Term Sustainability of Improved Sanitation in Rural Bangladesh *Water and Sanitation Program Technical Report*: World Bank.

Hoffmann, V. (2009). Intrahousehold allocation of free and purchased mosquito nets. *The American Economic Review, 99*(2), 236-241. doi: 10.1257/aer.99.2.236

Horowitz, J. K. (2006). The Becker-DeGroot-Marschak mechanism is not necessarily incentive compatible, even for non-random goods. *Economics Letters, 93*(1), 6-11.

Li, Q., & Racine, J. S. (2006). *Nonparametric Econometrics: Theory and Practice*: Princeton University Press.

Manski, C. F. (1993). Identification of Endogenous Social Effects: The Reflection Problem. *The Review of Economic Studies, 60*(3), 531-542. doi: 10.2307/2298123

Mazar, N., Koszegi, B., & Ariely, D. (2010). *Price-Sensitive Preferences*. SSRN eLibrary. Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1665017

Ministry of Planning. (2008a). IDPoor Questionnaire: Kingdom of Cambodia.

Ministry of Planning. (2008b). Implementation Manual on the Procedures for Identification of Poor Households: Kingdom of Cambodia.

Pattanayak, S. K., & Pfaff, A. (2009). Behavior, environment, and health in developing countries: evaluation and valuation. *Annual Review of Resource Economics, 1*(1), 183-217. doi: 10.1146/annurev.resource.050708.144053

Santos Silva, J. M. C., & Parente, P. M. D. C. (2013). Quantile regression with clustered data: University of Essex, Department of Economics.

Schreiner, M. (2009, December). *Progress out of Poverty Index: A Simple Poverty Scorecard for Cambodia.*

Urbancic, M. B. (2011). *Testing Distributional Dependence in the Becker-DeGroot-Marschak Mechanism.* Retrieved from http://urbancic.net/mike/Urbancic%20-%20Job%20Market%20Paper.pdf

van de Mortel, T. F. (2008). Faking it: social desirability response bias in self-report research. *Australian Journal of Advanced Nursing, 25*(4), 40-48.