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Learning about New Technologies Through Opinion Leaders and Social Networks

Experimental Evidence on Non-Traditional Stoves in Rural Bangladesh

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LEARNING ABOUT NEW TECHNOLOGIES THROUGH OPINION LEADERS AND SOCIAL NETWORKS: EXPERIMENTAL EVIDENCE ON NON-TRADITIONAL STOVES IN RURAL BANGLADESH*

Grant Miller and A. Mushfiq Mobarak*

Abstract

This paper studies how learning through opinion leaders and social networks influences demand for non-traditional cookstoves – a technology with important health and environmental consequences in low-income countries. Specifically, we conduct field experiments in rural Bangladesh to assess how (1) learning the stove adoption choices of locally-identified "opinion leaders" and (2) learning about stoves through social networks each effect a household's own cookstove adoption decisions. We find that both types of learning are more important for stoves with less evident benefits – and that households draw *negative* inferences about stoves through network members' experience. Overall, our results suggest that external information and marketing campaigns can induce initial adoption and experiential learning about unfamiliar technologies, but sustained use ultimately requires that new technologies match local preferences.

JEL Codes: Q52, O1, Q4
Keywords: Technology Adoption, Cookstoves, Bangladesh, Opinion Leaders, Social Networks

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1. Introduction

Despite the availability of efficacious, seemingly cost-effective health technologies that address important low-income country diseases, rates of adoption and use are low. Notable examples include point-of-use drinking water disinfectants (Luby et al., 2008; Kremer et al., 2009), deworming drugs (Kremer & Miguel, 2007), condoms (Kamali et al., 2003; Martinez Donate et al., 2004), and non-traditional cookstoves (Duflo et al., 2012; Mobarak et al., 2012) among many others. Limited sources of trustworthy information and opportunities to learn about these technologies through experience may be an important reason why demand for them is low. Understanding how developing country households learn about health technologies may therefore be important for the design of effective foreign aid and global health marketing programs.

Research on social learning and the diffusion of new technologies through social ties has a long history in the fields of sociology and marketing (Rogers 2003). Sociologists have proposed two distinct mechanisms of diffusion through social connections: "contagion by cohesion" and "contagion by equivalence" (Merton, 1968; Burt, 1999). Contagion by cohesion refers to the transmission of information by brokers across social boundaries between dissimilar groups, such as between as development organizations and rural villagers. This concept is reflected in the use of product "promoters", "ambassadors," or "extension partners" by marketing studies of new technologies in developing countries (Kremer et al., 2009; Luoto, 2009; BenYishay & Mobarak, 2011). On the other hand, contagion by equivalence refers to transmission within groups among similar types of people, reflecting hands-on learning through personal experience (and has been studied relatively more by economists, see Foster &

Rosenzweig, 1995; Conley & Udry, 2001; Munshi, 2004; Bandiera & Rasul, 2006; Pattanayak et al., 2009).[1]

In this paper we use field experiments to study both types of learning through social connections in rural Bangladesh. In our first round of experiments, we market a new health technology to locally-identified "opinion leaders" – and we then examine how learning opinion leaders' technology adoption decisions influences a household's own adoption decision.[2] Opinion leaders are prominent or highly regarded community members whom other members of a community emulate. Inferences drawn from the choices of opinion leaders may therefore be informative when external information about a new health technology is otherwise dubious (Becker, 1970; Feder & Savastano, 2006). In our second round of experiments, after marketing the technology to the initial subset of households, we then study how subsequent technology adoption choices by other households vary by relatedness to initial households through social networks. In both cases, our experiments focus on a technology thought to address important health and environmental problems in low-income countries: non-traditional cookstoves.

Nearly half of the world's population uses traditional cookstoves despite evidence that the indoor air pollution (IAP) produced by traditional cooking practices has harmful health and environmental consequences (World Health Organization, 2002). Most of these stoves burn biomass fuels, releasing smoke containing high concentrations of particulate matter, carbon monoxide, and other pollutants shown to be toxic in animal studies and associated with increased

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[1] Griliches (1957) produced pioneering early work in economics.

[2] Harnessing the influence of 'opinion leaders' is a common strategy used in 'social marketing' campaigns conducted by non-profit organizations. Population Services International (PSI) has developed a catalogue of "Behavior Change Communication" materials, with which they target key community members to create a snowball effect in information diffusion on topics ranging from malaria prevention to family planning. A safe-sex campaign successfully used opinion leaders to change social norms surrounding condom use in the gay community (Kelly et al., 1992). The concept of opinion leadership has played an important role in marketing research as well because leaders can help increase the effectiveness of marketing campaigns (Weimann et al., 2007).

rates of infant mortality, acute respiratory and eye infections, and lung cancer (Chay & Greenstone, 2003a; Chay & Greenstone, 2003b). Traditional cooking practices also cause environmental harm. Black carbon, a common by-product of biomass combustion, is an important contributor to climate change (Bond et al., 2004; Ramanathan & Carmichael, 2008; The New York Times, 2009), and collection of biomass fuels has been linked to deforestation (Kammen, 2011).

Indoor air pollution has received considerable attention from aid agencies and policy-makers in recent years. In 2010, the United Nations Foundation and Secretary of State Hillary Clinton launched the Global Alliance for Clean Cookstoves, a multi-million dollar initiative to increase the use of cleaner-burning non-traditional cookstoves with the ultimate objective of reducing IAP exposure and decreasing the use of biomass fuels. Many non-traditional (or "improved[3]") stoves have been developed and marketed at reasonably low prices (US$0-20). When built to design specifications and used correctly, some studies suggest that these stoves reduce firewood consumption and lower the prevalence of eye and respiratory infections (Smith-Sivertsen et al., 2009; Bensch & Peters, 2012).[4] However, in many parts of the world, they remain unpopular with consumers.[5]

Many explanations for low adoption rates of non-traditional stoves emphasize cultural factors and "tradition"-based aversion (Manibog, 1984). For example, the decision to adopt and

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[3]A recent editorial challenged the "improved" label placed on many cookstoves and suggested that it always be written with quotes to convey the idea that improvements are subjective and that some improvements in performance may come at the expense of reduced performance in other areas (Smith & Dutta, 2011). In this paper, we use the label "non-traditional cookstoves" to distinguish these new cookstove designs from the "homemade" traditional clay cookstoves commonly used in rural Bangladesh.

[4] There is also considerable controversy about the benefits of some non-traditional stoves (The New York Times, 2012; Duflo et al., 2012; The Washington Post, 2012).

[5] Since the early 1980s, both the government-affiliated Bangladesh Council of Scientific and Industrial Research (BCSIR) and over 100 national and local NGOs have developed and attempted to disseminate a variety of low-cost non-traditional cookstoves supposedly tailored to local needs (Sarkar et al., 2006; ESMAP, 2010). Nonetheless, 98% of households in rural Bangladesh still cook over an open fire (NIPORT, 2009).

use a non-traditional stove may be determined more by what it conveys about social status than by what its economic and health benefits might be. Social status considerations can have two opposing effects. On one hand, households may choose to adopt non-traditional stoves if others are adopting out of concern that not adopting will lessen their household's status in the eyes of peers (Van den Bulte & Joshi, 2007). On the other hand, if non-traditional stoves are considered at odds with local practice, adoption will be low (Rogers, 2003). Food cooked on new stoves may also taste different from food cooked on traditional stoves, and it may take time to learn how to properly use the new stove for cooking (Stewart, 1987; Troncoso et al., 2007; Slaski & Thurber, 2009). When cultural factors like these present obstacles to adoption, learning and diffusion through social structures (including opinion leaders and social networks) are central.

Through our opinion leader experiment, we find that villagers' decisions to adopt non-traditional stoves are related to the choices of opinion leaders – and more so for types of stoves with less-apparent benefits. As we describe in Section 2, we market two types of stoves: health-saving "chimney" stoves (which reduce exposure to particulate matter by removing smoke from the home through a chimney) and "efficiency" stoves (which reduce fuel consumption by burning fuel more efficiently). The chimney stove's salient attribute is more readily apparent, while the efficiency stove's combustion properties are much less obvious. Participating households' adoption decisions for efficiency stoves change more than do their adoption decisions for chimney stoves when we reveal opinion leaders' choices.[6] Moreover, the

[6] We draw inferences about preferences and behavior on the basis of household reactions to experiments and interactions over which the randomization was stratified (i.e., price, marketing, and stove type). However, when we stratify on stove type, we are forced to offer two real-world technologies (the chimney and the efficiency stove), each of which is composed of a bundle of characteristics, as opposed to a lab experimental setting where we might have hypothetically varied just one targeted feature of the stove, leaving all other characteristics unchanged. In the penultimate section of the paper we examine whether the differential responses across the two stove types could be related to some other features of the stoves.

relationship between opinion leader choices and other villager choices dissipates over time (as village residents gain first-hand experience with the new technology).

Our social network experiment results indicate that on average, having social connections to first round participants *reduces* the likelihood that a household will purchase a stove in the second round. This finding suggests that second round participants updated negatively when learning about non-traditional stoves through the experiences of network members. We also find that social network learning is more important for efficiency stoves than for chimney stoves, which is consistent with our opinion leader results: learning is more important for stoves with more less obvious benefits.

Overall, our findings have several important broader implications. First, a central implication is that persuasion techniques promoted by psychology and marketing research (Saltiel et al., 1994; Fernandez et al., 2003; Bertrand et al., 2010) may produce only temporary increases in adoption. Second, external influence and the provision of information may be less effective for technologies that households can evaluate for themselves (Iyengar et al., 2011), and the value of external signals and influence may decline with experience over time (Dupas, 2010). Third, for experiential learning induced by external information and marketing efforts to result in sustained adoption and use, a new technology fundamentally must meet local needs at least as well as, if not better than, traditional technologies do.

The rest of the paper is organized as follows. Section 2 describes our experimental research design. Section 3 presents empirical results. Section 4 examines concerns relating to our approach and considers competing explanations for the results that we find. Section 5 concludes.

2. Study Design

2.1 Study Sites, Stove Types, Data Collection Activities, and Timeline

We conducted our demand experiments in 42 villages in two ecologically diverse rural districts of Bangladesh: Jamalpur in the north and Hatia in the south (Figure 2). Jamalpur is an agrarian area of about 490 sq. km. It is densely populated, and its landscape has been largely deforested. Most residents rely on agricultural residue as their primary cooking fuel. Hatia is an isolated 1500 sq km island in southern Bangladesh. Firewood for cooking is readily available, but because of Hatia's coastal deltaic land, clay soil needed to build stoves is relatively scarce.

We marketed two types of stoves in our study areas. The first is a "chimney" stove designed to reduce IAP via a cement chimney that removes a substantial amount of the smoke produced during cooking from the kitchen. The second is an "efficiency" stove designed to burn fuel more efficiently, reducing fuel costs to the home. While it does not otherwise reduce smoke emissions, it is small enough to be portable and can therefore be used outdoors during dry seasons. Both types of stoves are manufactured locally using materials similar to those used for traditional stoves – but according to very precise design specifications. [7]

The trial profile (Figure 1) describes sample sizes by experimental condition in detail. We first conducted a village level survey to identify distinct neighborhoods (or "*paras*") within each village, and to identify "opinion leaders" within each of these neighborhoods. We randomly selected 50 households per village, and randomly assigned all 2280 project households to the 4 experimental conditions. We then conducted baseline surveys and marketing visits in July – September 2008. Cookstove orders were then given to manufacturers, and cookstoves

[7] Together, these two types of stoves reflect stove models commonly promoted by development organizations in Bangladesh. We conducted our own emissions and fuel consumption tests in the field to confirm their salient features (see (Miller & Mobarak, 2011) for details).

were delivered over the period November 2008 – February 2009. In December 2009 - January, 2010, we conducted our second round of experiments, returning to the villages to offer stoves to randomly selected members of the social networks of the round one participants.

2.2 Experiments on Price and Opinion Leader Influence

We randomized stove price (50% subsidy vs. full price) at the village level and information about opinion leader choices within villages at the neighborhood (or *para*) level using the following procedure:

i. Eleven of the 21 villages in each of the two districts (or 22 of the 42 villages in total) were randomly assigned to the full price condition (cells A and C). The other 20 were assigned to the 50% subsidy condition (cells B and D)

ii. All 42 villages were divided into *paras*. There were approximately 3 *paras* per village, yielding a total of 126 *para* clusters. *Paras* have natural boundaries, which we demarcated in consultation with village residents.

iii. 30 out of 66 *paras* in the full price villages and 30 out of 60 paras in the half-price villages were randomly assigned to the opinion leader treatment (groups C and D).

All respondents received the same simple, culturally-salient health education message about IAP and non-traditional stoves. Our pure control arm (group A in Figure 1) therefore allows us to estimate adoption rates under ordinary circumstances in the presence of health education.

<u>Subsidies</u>: We set our full prices at procurement cost: Tk. 400 (about US$5.80) for efficiency stoves and Tk. 750 (about US$ 11) for chimney stoves. As shown in Figure 1, we charged these prices in groups A and C, while in groups B and D we charged Tk. 200 and Tk. 375, respectively. Households were not told that the prices were being subsidized (all prices

were portrayed as full stove prices), and our village-level randomization minimizes information spillovers between households assigned to different prices.

Opinion Leaders: We identified three opinion leaders in each *para* through focus group discussions. Specifically, we asked villagers to nominate leaders in each of three domains that are important in rural Bangladeshi society: economics, politics, and education/literacy. For economic leadership, we asked villagers to nominate those owning the most land (the most important durable asset in Jamalpur and Hatia). For political leadership, we solicited nominations of local elected politicians and informal "village elders" (respected individuals who mediate or resolve disputes, etc.). Finally, we asked villagers to nominate the most educated individuals from the neighborhood not already chosen as an economic or political leader.[8]

For the opinion leader treatment, we first offered stoves to the three opinion leaders at the prices assigned to a given village (at full price to group C and at half price to group D). We then told villagers in treatment *paras* what the opinion leaders' adoption decisions were.

Stove Types: 10 of 21 villages in each district were randomly assigned to receive efficiency stoves, and the other 11 received chimney stoves. Stove type assignment cuts across all four experimental cells A-D, and the random assignment of stove type was orthogonal to the random assignment of price (see Figure 1 for sample size details).

2.3 Initial Decision (Stove orders) versus Final Decision (Purchase)

Several weeks passed between the time participants in our study were first offered a stove and when BRAC employees returned to deliver the stoves and collect payment. Because many

[8] While research has shown that opinion leaders in one area (say, politics) may not be opinion leaders in other areas (e.g. technology) (Van den Bulte & Joshi, 2007), they may well still be drivers of cultural change and thus still may impact the perceived risk (in this case social risk) of adopting a new technology. We used focus groups to identify opinion leaders, as opinion leaders identified in this manner have been shown to most reliably be first adopters (Iyengar et al., 2011).

households across all four of our treatment arms refused to make payments after ordering stoves, we analyze stove orders separately from final stove purchases to gain additional insight into the process of household decision-making.

The differences between stove orders and stove purchase are also relevant for understanding the process of information diffusion through social networks, as much more information about the stoves gets publicized between the two decision points. Villagers are able to observe the stoves received by others in their neighborhood and village. The differences between orders and purchases are therefore informative about how changes in the information set affect the demand for stoves. The stove order is a meaningful outcome even though it can be reversed, because households are relaying their initial acceptance of the stove offer to BRAC, the largest NGO in the country (and in the world) which offers a number of other development programs (in micro-credit, health, business development, employment) to this same population. Refusing delivery when staff arrive to install a stove is also naturally uncomfortable, causing loss of face.

2.4 Follow-up Survey and Social Network Experiment

Following our first round of interventions in 2008, we returned to the villages where we had initially made offers of stoves to again offer the same stoves to members of the village who had not been in our initial sample. While information about the choices of opinion leaders may be key to spurring initial uptake, models of herd behavior suggest that one person's decision to adopt a new technology can set off a cascade effect if others assume that the initial adopter has access to information that they do not (Banerjee, 1992). Thus we wanted to test whether knowing someone who had purchased a stove in the first round of interventions would impact whether those offered a stove in the second round would choose to purchase.

Using village-level census data, we generated a random sample of households who had not received a stove offer in the previous round. We then provided them with the same information about the stoves as had been provided to their neighbors. All households in this round were offered the stoves at half price (Tk. 200 for efficiency stoves and Tk. 375 for chimney stoves), eliminating the variation in price that we had used in round one. We then surveyed them regarding their relationships with the households who had received (and either accepted or rejected) a stove offer in the first round. Our measures of social ties to first round participants are characterized by type (friends, relatives, neighbors, and acquaintances), by "closeness" of the relationship (as reported by the respondent), and by how intelligent the respondent considers the members of the first round household to be.

3. Results

Before beginning the analysis of take-up rates across treatment groups, Table 1 presents results on balance in observables across the different treatment groups. Panel A shows baseline characteristics of round one households stratified by the price they were offered, and Panel B shows summary statistics for round two households stratified by the price originally offered to the members of their village in round one. The results are consistent with successful randomization – there are no systematic differences in the set of baseline characteristics across the (randomly assigned) treatment conditions. In regressions reported later, we control for the few variables that show significant differences at baseline.[9]

3.1 Effects of Revealing Opinion Leader Choices on Stove Orders

[9] A Bonferroni multiple comparison correction for 23 independent tests requires a significance threshold of $\alpha=0.002$ for each test to recover an overall significance level of $\alpha=0.05$. Using this criterion, no differences at baseline are statistically meaningful.

Tables 2, 3, 4 and 5 consider the role of credible local information about a technology conveyed by learning the choices of opinion leaders. Table 2 provides the overall stove acceptance rates for each condition, and Table 3 studies the variation using regressions. The first and seventh columns in Table 3 suggest that knowledge of opinion leader choices *per se* is unrelated to the ordinary village residents' cookstove orders. To probe heterogeneity in this effect, the other specifications in this table divide up the set of opinion leader choices into (a) *paras* (neighborhoods) where the three opinion leaders were unanimous in choosing to order the stove (*OLaccept*), and (b) *paras* where they unanimously rejected the stove (*OLreject*), with the intermediate outcomes acting as the omitted category in the regression. We are naturally unable to randomize the adoption decisions made by opinion leaders, but studying heterogeneous effects allows us to learn more about the role that opinions leaders play as information brokers. Although there are important concerns with our empirical implementation (which we describe below), we attempt to address the concerns below using multiple strategies.

The estimating equation for a household *h* in para *p* in village *v*:

$$\Pr(\text{Stove Acceptance})_{hpv} = \alpha + \beta_1 \cdot OLaccept_{pv} + \beta_2 \cdot OLreject_{pv} + \gamma \sum X_{pv} + \varepsilon_{hv} \quad (1)$$

Because we are unable to randomize opinion leader choices, the coefficients β_1 and β_2 could reflect a spurious relationship driven by a village-level or para-level unobservable (if both leaders and residents of a sophisticated village choose to adopt, while the leaders and residents of an unsophisticated village choose not to adopt, for example). We control for this effect directly by including in $\boldsymbol{X}$ measures of the average village-level and the *para*-level stove order rate (excluding self). The *para* (village)-level order rate would capture the effects of such *para* (village) level correlated unobservables, allowing β_1 and β_2 to reflect the influence of opinion leader choices on para residents' adoption. In some specifications we also control for a full set of village dummies to address this concern. Furthermore, we document important (and sensible) heterogeneity in opinion leader influence across the two stove types, and an asymmetry in effects when opinion leaders accept or reject the marketing offer. It is more difficult to generate these specific patterns of asymmetry on the basis of a competing explanation that simple unobservable heterogeneity drives these differences.

Rows 4 and 5 (specifications 2-6 and 8-12) in Table 3 show that there is (a) some asymmetry in the effect of unanimous opinion leader adoption versus rejection in influencing the subsequent choices of *para* residents and (b) an asymmetry in the effects of opinion leader choices on the two stove types. In the most conservative specification, the propensity to order efficiency stoves in a neighborhood increases by 14 percentage points (41% gain at the mean order rate) when residents are told that the leaders all order the stoves, and decreases by 28 percentage points (82%) when all three leaders reject the stove, relative to the intermediate case of leader disagreement on stove orders. In contrast, only opinion leader rejection has a significant negative effect on *chimney* stoves orders of 22 percentage points (69%), while unanimous opinion leader acceptance does not increase villagers' propensity to order chimney stoves.[10]

The first asymmetry (in the effects of OL acceptance versus rejection) is statistically significant (see p-value for chi-square test) and may be related to the socio-economic characteristics of opinion leaders relative to the other villagers. Opinion leaders are among the most well-educated and affluent, so even if a technology is good for them, it might not necessarily be appropriate for the modal villager (Munshi, 2004; Feder & Savastano, 2006). On

[10] The various specifications in this table show that the effects of opinion leader acceptance and rejection are robust to alternative ways to account for village and para level unobservables, such as controlling for the village or para average adoption rate, or for village fixed effects.

the other hand, if it is not beneficial (on net) for an opinion leader, then it is almost surely not beneficial for the typical villager.

The second asymmetry is apparent when we combine the efficiency and chimney stove samples and run regressions with interaction terms between stove type and opinion leader choices. We find that opinion leader influence on other households' purchase decisions is indeed significantly larger for efficiency compared to chimney stoves (see p-values reported at the bottom of the table). Our early-stage focus groups suggested that the value of the chimney in reducing indoor smoke is immediately apparent, while the precise design benefits of the clay efficiency stove are more difficult for households to comprehend. This asymmetry may therefore mean that households rely more heavily on external cues when it is more difficult to evaluate the technology by oneself. This type of asymmetry has been noted for other products in the industrial organization, marketing (Ackerberg, 2001; Ackerberg, 2003), and sociology (Sapp & Korsching, 2004) literatures as well.

Specifications 6 and 12 add interaction terms between opinion leader choices and the randomized 50% subsidy condition, showing that external influence is 10-18 percentage points larger when more is charged for the efficiency stove. This may be because households pay closer attention to such information inputs when making decisions with larger financial consequences. In a separate paper (Mobarak et al., 2012), we find that liquidity constraints are a significant deterrent to purchase of cookstoves. Thus it would make sense that households would want to gather as much information as possible before making a purchasing decision.

3.2 Opinion Leader Choices and Stove Purchase

Table 4 considers the role of opinion leader influence in final stove purchase. Comparing Tables 3 and 4 suggests considerable attenuation of opinion leader estimates when we move from stove orders to the final purchase decisions. The initial stove order decisions occurred almost simultaneously across all households within a village, with very limited information about the new technologies available in the village except for the opinion leader purchase decisions that we revealed. After orders were placed, cookstoves were delivered over a period of several weeks within a given village, and those receiving cookstoves later could learn about non-traditional cookstoves from those receiving early deliveries. If so, this pattern of attenuation may suggest a declining value of information acquired from opinion leader choices as common experience with the technologies grows.[11] With the smaller coefficients on *OLaccept* and *OLreject* variables, the asymmetric effects on chimney and efficiency stoves become statistically insignificant in some specifications, but the asymmetry in the influence of unanimous acceptance versus rejection is retained.

Overall, the pattern of results suggests that people may rely more heavily on external information that they find trustworthy when they possess less information about the product themselves, or when that information is noisier (McKelvey & Page, 1990; Ackerberg, 2001). An important implication of this is that social marketing programs – which often attempt to use opinion leader influence to increase the adoption of health technologies – are probably less effective in the long run (even if effective in the short run) as common experience with technologies grows (Dupas, 2010). This is in contrast to claims from psychology and sociology about persistent influence of opinion leaders (Fernandez et al., 2003; Sapp & Korsching, 2004).

We also document important heterogeneity in the influence of different types of opinion leaders. In Table 5, rich and educated leaders appear more influential in households' stove order

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[11] Purchase rates are lower than order rates across all experimental conditions, but this inference is based on how correlated opinion leaders' orders are to other households' stove orders and stove purchases.

decisions than political leaders. Furthermore, when we examine the determinants of refusal (from stove order to a decline to purchase), we find that refusal rates are greater if the initial purchase was influenced by the 'political' opinion leader. This suggests that some types of external influence have longer-lasting effects than others.

3.3 Stove purchase decisions of social network members

Table 6 looks at the effect of knowing someone who purchased a stove in round one on the decision to purchase a stove in a subsequent year. Columns 1, 2, 3 and 4 present simple OLS estimates. Because the decision to buy a stove in round one was not randomly determined, we cannot say that knowing someone with a stove is exogenous. However, because stove purchase rates in the first round are causally related to the randomized variation in the price of the stoves offered, we are able to use this as an instrument for knowing someone with a non-traditional stove.

Our model is as follows:

First stage: $Stove\_Network_h = \alpha + \beta(blockBD)_h + \varepsilon_h$

Second stage: $PR(Stove\ Purchase) = \gamma + \theta(\widehat{Stove\_Network_h}) + \epsilon_h, \quad (2)$

where *Stove_Network* is an indication of the number (or, in alternative specifications, the percent) of households in the index household's social network having a non-traditional stove and *blockBD* is a dummy variable indicating whether or not the index household belongs to a village in which round one households were offered a stove at half price. Appendix Table 1 shows first stage estimates; our instrument has a positive, statistically significant relationship to the numbers of people in the respondents' network who purchased stoves in the first round. Table 6 also reports the first stage partial R-squared and the first stage F-test. While our instrument is relatively weaker for the chimney stove than for the efficiency stove, we are able to reject the hypothesis that our model is weakly identified at conventional levels of significance in all specifications.

Columns 5-8 of Table 6 report second stage results. On average, having social ties to first round participants appears to actually *reduce* the likelihood that a household will purchase a stove in the second round. Specifically, one additional stove-owning household in a second round respondent's social network is associated with a 10 percentage point (54%) reduction in the probability of purchasing either stove. This relationship suggests that second round participants were initially overly-optimistic about non-traditional stoves and updated negatively when learning about them through social connections.

This appears to be particularly true of the efficiency stoves: knowing one additional household with an efficiency stove is associated with an 11 percentage point (69%) reduction in the likelihood of purchase, while knowing an additional household with a chimney stove is associated with an 8 percentage point (37%) reduction (and is not statistically distinguishable from zero at conventional levels). This finding is broadly consistent with our opinion leader results: learning about stoves (either from opinion leaders or through the experience of social network members) is less important for stoves with more self-evident benefits (in this case, chimney stoves vs. efficiency stoves). Drawing negative inferences about non-traditional stoves – and efficiency stoves in particular – when learning about them through social networks is also consistent with the additional descriptive statistics shown in Appendix Table 3. These data suggest that one year after stoves were delivered to first round participants, the efficiency stoves were more likely than the chimney stoves to have broken, less likely to be in use, and efficiency stove owners were less likely to recommend them to others.[12]

We then examine how our social network estimates vary by type of relationship. To do so, we estimate equation (2) separately for four types of network members.

Bari members: Members of the same compound as the index household (whom respondents are likely to watch cook, share meals with, etc.)

Relatives: Includes aunts and uncles, parents, grandparents, children, grandchildren, siblings, nieces and nephews, in-laws, and "other" (which includes cousins).

Close relationships: Households with which the index household is relatively "close" as measured by an answer of 1-4 on a 10 point scale.

'Smart' people: Households which the index household considers "smart" (which might indicate greater respect for their opinion), as measured by an answer of 1-4 on a 10 point scale.

Table 7 shows these results (first stage results reported in Appendix Table 2). Overall the basic pattern of results matches those in Table 6: knowing more people with non-traditional stoves is associated with a reduction in the likelihood of stove purchase – and relatively more so for efficiency stoves. However, there is also heterogeneity by type of social relationship. For example, our social network estimates are larger in magnitude for 'smart' network members than others, possibly suggesting the opinions of households considered more intelligent carry greater weight. However, these estimates are not statistically distinguishable from each other.

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[12] At the time of the social network study, we re-surveyed a sub-sample of households who had participated in round one. This sub-sample included all households that purchased stoves as well as randomly selected households that refused stove offers.

4. Alternative Explanations

An alternative interpretation of our opinion leader findings is that they could be produced by revealing the stove adoption choices of any three randomly selected villagers. We did not test our opinion leader intervention against this procedure, and the experiment cannot rule out the possibility that the "leader" label does not really matter, and all that matters is the knowledge that someone else in the village either accepted or rejected the stove. However, the fact that we observe heterogeneity in the influence of the three types of leaders (the economic, the political or the educated leader) appears inconsistent with this simpler interpretation. Table 5 shows that the political leader is both less influential at the outset, and that the refusal rate is greater for stove order decisions that were originally influenced by him. The fact that the relationship between opinion leader adoption and own adoption dissipates over time does suggest that own experience or the experience of peers (that are more slowly revealed) can substitute for opinion leader influence.

Our research design with opinion leaders was inspired by leader-based social marketing approaches commonly used to promote new technologies in the both the NGO and policy worlds, as well as private sector marketing campaigns (Weimann et al., 2007; Population Services International, 2011). Documenting the effects of revealing leader choices is therefore independently valuable for policy, and these results complement a much larger literature on the effects of peer influence in technology adoption (Foster & Rosenzweig, 1995; Munshi, 2004; Oster & Thornton, 2009; Godlonton & Thornton, 2012).

5. Conclusion

We conducted multi-pronged demand experiments to study low adoption rates of non-traditional cookstoves, an important technology with important implications for population health and the environment. Stove purchase rates at full price were very low, reflecting the disappointing experiences of non-traditional cookstove promotion programs globally. Our experiments specifically analyze learning by observing choices made by locally-identified opinion leaders and through the experiences of social network members. Sociological research suggests that salient types of external information depend on the characteristics of the person making the decision, the environment in which the decision is made, and the characteristics of the technology under consideration (Thomas et al., 1990; Saltiel et al., 1994; Sapp & Korsching, 2004).

Our opinion leader experiment suggests that receiving external information from opinion leaders matters more when the costs and benefits of a technology are not readily apparent and when people are unfamiliar with it. These findings are consistent with empirical observations made in industrial organization, marketing, and development sociology literatures. Sapp and Korsching (2004), for example, postulate that when the costs and benefits of a technology cannot be easily observed, opinion leader endorsement is important. On the other hand, when a technology's characteristics are easily observable, additional promotion of the product has little effect (Ackerberg, 2001). This is supported in our data by the fact that the relationship between opinion leader choices and other villager choices dissipates over time as village residents gain first-hand experience with the new technology (learning through experience demonstrated by (Dupas, 2010)).

We also find that learning through the experience of social network members leads households to update negatively about non-traditional stoves, *reducing* the likelihood of adoption. This effect is stronger for efficiency stoves than for chimney stoves, presumably because the costs or benefits (or both) of efficiency stoves are less obvious. Information provided about the stoves from friends and family members is therefore more valuable.

Overall, we find that persuasion campaigns are likely to have short-lived effects in many cases unless a technology's benefits are particularly difficult to observe. Subsidies can effectively increase adoption rates (as noted in many studies, c.f. Kremer & Miguel, 2007; Cohen & Dupas, 2010; Dupas, 2010), but even free distribution of a health-improving product may fall short of socially optimal levels of adoption unless aversions to non-price attributes of a technology are understood and addressed (Mobarak et al., 2012).

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Figure 1: Experimental design

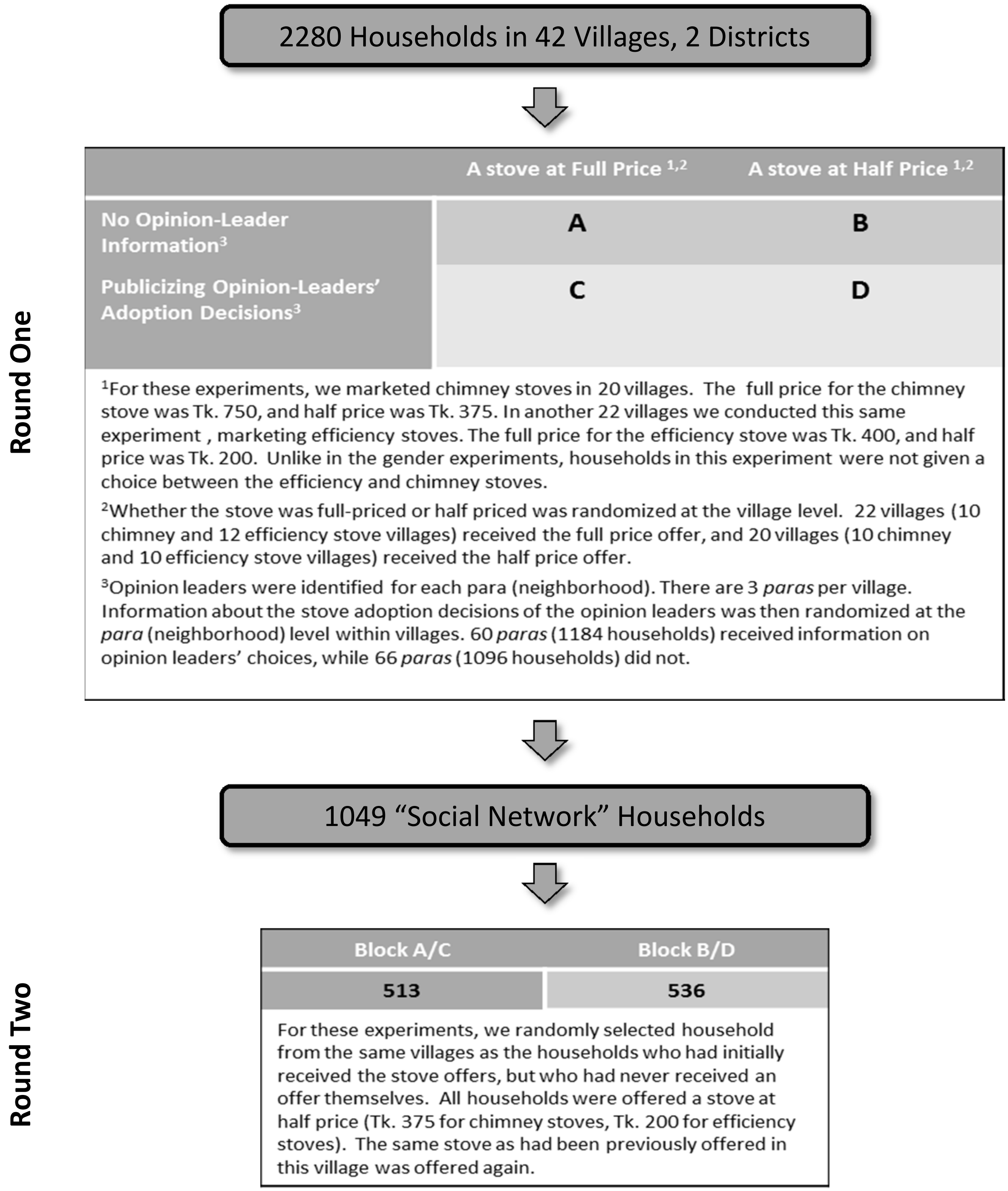
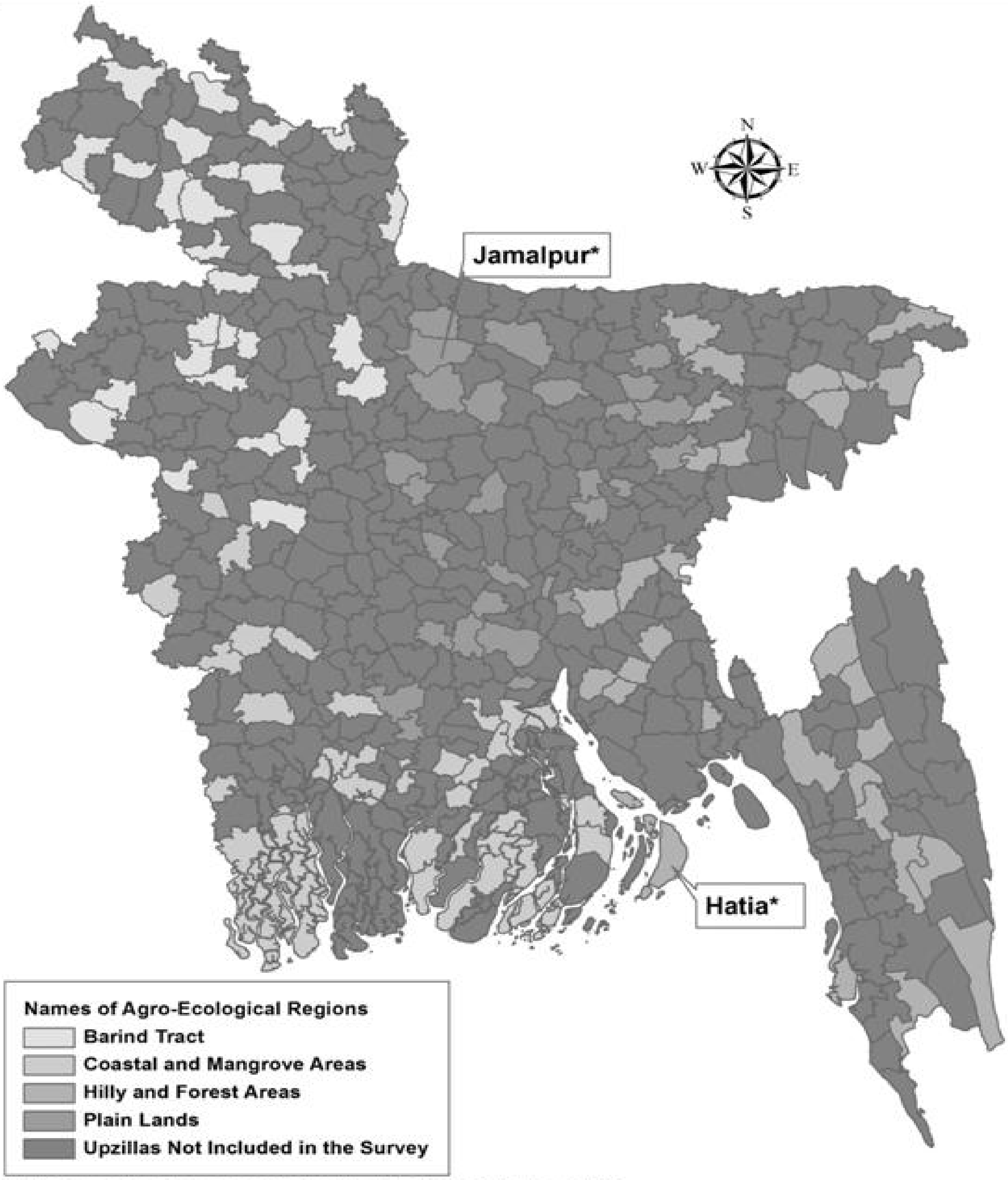


Figure 2: Map



* Price experiments were carried out in Jamalpur and Hatia upzillas.

Table 1: Summary Statistics

	Panel A: Baseline (Round 1) Data					Panel B: Social Network Data				
	Block A/C (Full Price)	Block B/D (Half Price)	Total	Diff	P-value	Full Price (Round one)	Half Price (Round one)	Total	Diff	P-value
N	1,190	1,090				498	526	1,024		
Accepted Stove Offer	0.27	0.41	0.34	-0.14	0.02	0.24	0.13	0.18	-0.12	0.02
Household Characteristics										
Total Number of Household Members	6.52	6.44	6.48	-0.08	0.77	5.32	4.89	5.10	-0.43	0.20
Number of Wage Earners	1.83	1.99	1.91	0.16	0.07	2.08	2.06	2.07	-0.01	0.96
Total Number of Female HH members	3.38	3.28	3.33	-0.10	0.50	2.56	2.34	2.44	-0.22	0.13
Total Number of Male HH members	3.14	3.16	3.15	0.02	0.90	2.76	2.55	2.65	-0.21	0.31
Number of Children <= Age 5	0.80	0.71	0.76	-0.08	0.25	0.59	0.51	0.55	-0.08	0.26
Number of Children <= Age 18	2.80	2.49	2.65	-0.30	0.14	2.26	2.04	2.15	-0.22	0.35
Average monthly income (in Taka)	5,908	6,368	6,128	460	0.38	Not available	Not available	Not available	Not available	Not available
Average monthly expenses (in Taka)	5,432	5,888	5,650	456	0.38	Not available	Not available	Not available	Not available	Not available
Wealth Index*	-0.08	0.20	0.05	0.28	0.02	Not available	Not available	Not available	Not available	Not available
Household owes money	0.20	0.25	0.23	0.04	0.28	Not available	Not available	Not available	Not available	Not available
Female Characteristics						Not available	Not available	Not available	Not available	Not available
Age	36.18	37.66	36.89	1.48	0.02	38.18	36.66	37.39	-1.52	0.11
Married	0.99	1.00	0.99	0.00	0.35	Not available	Not available	Not available	Not available	Not available
Education (in years)	3.19	3.09	3.14	-0.10	0.67	3.56	3.16	3.35	-0.40	0.21
Wage Earner	0.17	0.25	0.21	0.08	0.27	0.37	0.48	0.42	0.11	0.25
Male Characteristics										
Age	44.23	46.11	45.13	1.88	0.01	45.98	44.77	45.36	-1.21	0.17
Education (in years)	3.98	4.27	4.12	0.29	0.39	4.13	3.91	4.02	-0.22	0.63
Wage Earner	0.98	0.98	0.98	-0.00	0.97	0.96	0.98	0.97	0.02	0.04
Male Occupations										
Agriculture (Own)	0.44	0.40	0.42	-0.04	0.47	0.36	0.36	0.36	-0.01	0.86
Business	0.23	0.24	0.23	0.01	0.75	0.22	0.20	0.21	-0.02	0.65
Day labour (Agriculture)	0.10	0.10	0.10	0.00	0.87	0.10	0.09	0.10	-0.01	0.64
Day labour (Non agriculture)	0.09	0.07	0.08	-0.02	0.22	0.11	0.14	0.13	0.03	0.29
Service	0.07	0.08	0.08	0.01	0.65	0.13	0.13	0.13	0.00	0.83
Other	0.07	0.10	0.09	0.03	0.35	0.05	0.05	0.05	0.00	0.84

*Wealth index is constructed using principal component analysis of variables indicating if the household owns land, a vehicle, or other assets.

Table 2: Stove Acceptance rates

Cluster	Stove	Group	Households	Initial Acceptance	Final Acceptance
Full Price (Block A/C)	Chimney	A – No OL Information	268	29%	2%
		C – Public OL information	274	33%	2%
	Efficiency	A – No OL Information	332	25%	4%
		C – Public OL information	316	22%	6%
Half-price (Block B/D)	Chimney	B – No OL Information	200	34%	7%
		D – Public OL information	354	35%	8%
	Efficiency	B – No OL Information	296	49%	19%
		D – Public OL information	240	48%	13%
		Total	2280	34%	7%

Table 3: Probit regression results for the effects of Opinion Leader choices on initial stove orders

	Efficiency Stove Orders							Chimney Stove Orders				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Publicizing Opinion Leaders' Decisions Groups VII and VIII	-0.042						0.038					
	[0.079]						[0.054]					
50% Subsidy Groups VI and VIII	0.237**					0.020	0.046					-0.005
	[0.105]					[0.038]	[0.084]					[0.051]
Interaction: Subsidy*Publicizing OL decisions	0.032						-0.031					
	[0.114]						[0.105]					
Indicator of unanimous initial acceptance among opinion leaders (OLaccept)[2]		0.338***	0.206***	0.143**	0.262***	0.238***		0.016	0.072	0.044	0.062	0.020
		[0.077]	[0.061]	[0.058]	[0.097]	[0.059]		[0.053]	[0.044]	[0.027]	[0.088]	[0.046]
Indicator of unanimous initial rejection among opinion leaders (OLreject)[2]		-0.334***	-0.393***	-0.284***	-0.419***	-0.330***		-0.294***	-0.229***	-0.227***	-0.309***	-0.228***
		[0.048]	[0.016]	[0.026]	[0.032]	[0.030]		[0.056]	[0.081]	[0.056]	[0.104]	[0.088]
Average stated acceptance in para - Initial				0.215	-0.272	0.181				0.372*	-0.918**	0.359*
				[0.145]	[0.264]	[0.169]				[0.192]	[0.457]	[0.210]
Average stated acceptance in village - Initial				0.448***		0.463***				0.070		0.053
				[0.109]		[0.148]				[0.204]		[0.212]
Interaction term: Subsidy*OLaccept						-0.105***						0.048
						[0.037]						[0.074]
Interaction term: Subsidy*OLreject						0.184**						-0.009
						[0.091]						[0.122]
Village fixed effects?	No	No	Yes	No	Yes	No	No	No	Yes	No	Yes	No
Observations[1]	1184	556	517	556	517	556	1096	628	608	628	608	628
Chi-squared test (OLaccept=OLreject)		1.302	52.92	10.77	26.43	11.16		8.171	1.967	5.856	1.993	2.643
Prob > chi2		0.254	0	0.00103	2.73e-07	0.000836		0.00426	0.161	0.0155	0.158	0.104
P-value for difference in OL acceptance effect between Efficiency and Chimney								0.001	0.065	0.029	0.06	0.021
P-value for difference in OL rejection effect between Efficiency and Chimney								0.303	0.001	0.075	0.002	0.057
Mean of dependent variable				0.347						0.329		

Robust standard errors in brackets. Standard errors are clustered at the para level for all but regressions (1), (6), (7) and (12), for which s.e.'s are clustered by village.

*** p<0.01, ** p<0.05, * p<0.1

[1] 1184 households were offered efficiency stoves, while 1096 were offered chimney stoves. Sample size numbers subsequently drop to 556 and 628 for efficiency and portable stoves, respectively, as the independent variables "unanimous initial acceptance among opinion leaders (OLaccept)" and "unanimous initial rejection among opinion leaders (OLreject)" are only defined for those households in groups VII and VIII (publicizing opinion leaders' decisions). When village-level fixed effects were included, an additional 39 observations were dropped in the efficiency stove group and 20 observations in the chimney

[2] OLaccept and OLreject are only defined for paras in groups VII and VIII, where the opinion leaders' choices were publicized.

Table 4: OLS regression results for the effects of Opinion Leader choices on final stove purchase[(1)]

	Efficiency Stove Purchases						Chimney Stove Purchases					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Publicizing Opinion Leaders' Decisions	0.021						0.003					
Groups VII and VIII	[0.028]						[0.019]					
50% Subsidy	0.156**					0.024	0.046					0.077**
Groups VI and VIII	[0.063]					[0.059]	[0.035]					[0.034]
Interaction: Subsidy*Publicizing OL decisions	-0.088						0.011					
	[0.060]						[0.049]					
Indicator of unanimous initial acceptance among opinion leaders		0.055	0.073*	-0.017	0.101*	0.118**		-0.028	-0.003	-0.025	-0.006	-0.011
(OLaccept)[(3)]		[0.064]	[0.038]	[0.043]	[0.053]	[0.044]		[0.034]	[0.017]	[0.036]	[0.020]	[0.014]
Indicator of unanimous initial rejection		-0.095***	-0.125***	-0.062**	-0.171**	-0.043		-0.079***	-0.117**	-0.093**	-0.133**	-0.053
among opinion leaders (OLreject)[(3)]		[0.019]	[0.039]	[0.028]	[0.062]	[0.031]		[0.021]	[0.049]	[0.038]	[0.059]	[0.034]
Average stated acceptance in para - Initial				0.057	-0.152	-0.014				0.106	-0.144*	0.101*
				[0.119]	[0.116]	[0.144]				[0.084]	[0.085]	[0.053]
Average stated acceptance in village - Initial				0.197		0.296				-0.180		-0.223
				[0.170]		[0.220]				[0.139]		[0.146]
Interaction term: Subsidy*OLaccept						-0.184**						-0.005
						[0.079]						[0.033]
Interaction term: Subsidy*OLreject						-0.074						-0.081**
						[0.057]						[0.033]
Village Fixed Effects?	No	No	Yes	No	Yes	No	No	No	Yes	No	Yes	No
Constant	0.036*	0.095***	0.125***	0.030	0.188**	0.015	0.019**	0.079***	0.117**	0.107*	0.133**	0.076
	[0.021]	[0.019]	[0.039]	[0.033]	[0.071]	[0.036]	[0.008]	[0.021]	[0.049]	[0.056]	[0.059]	[0.053]
Observations[(2)]	1184	556	556	556	556	556	1096	628	628	628	628	628
R-squared	0.044	0.032	0.119	0.053	0.122	0.064	0.016	0.019	0.103	0.025	0.106	0.045
F-test (OLaccept=OLreject)		0.295	0.924	1.863	0.964	1.798		3.639	4.896	4.699	4.388	1.768
Prob > F		0.591	0.345	0.183	0.335	0.200		0.0657	0.0344	0.0380	0.0444	0.201
P-value for difference in OL acceptance effect between Efficiency and Chimney								0.253	0.0704	0.672	0.0550	0.805
P-value for difference in OL rejection effect between Efficiency and Chimney								0.590	0.893	0.404	0.629	0.145
Mean of dependent variable				0.099						0.047		

Robust standard errors in brackets, standard errors are clustered at the para level for all but regressions (1), (6), (7) and (12), for which s.e.'s are clustered by village.

*** p<0.01, ** p<0.05, * p<0.1

(1) OLS rather than probit estimates were used for this table because, given the low stove purchase rates, under the probit model some independent variables were dropped due to perfect prediction of failure

(2) 1184 households were offered efficiency stoves, while 1096 were offered chimney stoves. Sample size numbers subsequently drop to 556 and 628 for efficiency and portable stoves, respectively, as the independent variables "unanimous initial acceptance among opinion leaders (OLaccept)" and "unanimous initial rejection among opinion leaders (OLreject)" are only defined for those households in groups VII and VIII (publicizing opinion leaders' decisions).

(3) OLaccept and OLreject are only defined for paras in groups VII and VIII, where the opinion leaders' choices were publicized.

Table 5: Heterogeneity in Influence Across Types of Opinion Leaders

	Order	Purchase	Refusal Rates [1]			
50% Subsidy	0.077	0.045	-0.092	-0.099	-0.075	-0.109*
	[0.061]	[0.031]	[0.055]	[0.060]	[0.051]	[0.057]
Rich opinion leader said yes - initial	0.143**	0.032		0.037		
	[0.061]	[0.030]		[0.061]		
Elected opinion leader said yes - initial	0.025	-0.031			0.105**	
	[0.055]	[0.021]			[0.052]	
Educated opinion leader said yes - initial	0.113*	0.009				0.071
	[0.057]	[0.027]				[0.058]
Constant	0.195***	0.044***	1.053***	0.835***	0.790***	0.825***
	[0.040]	[0.016]	[0.039]	[0.043]	[0.045]	[0.044]
Observations	1184	1184	397	397	397	397
R-squared	0.059	0.016	0.025	0.015	0.029	0.020

Robust standard errors in brackets, clustered at the para level

*** p<0.01, ** p<0.05, * p<0.1

[1] The dependent variable refusal is defined only for those households who initially said they would buy the stove and then refused at the time of sale, within the groups for which the opinion leaders' decisions were publicized (C and D)

Table 6: Effects of Knowing Others with Stoves on Own Stove Purchase

		OLS				IV[(2)]			
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
All Stoves	Number of network members with a stove	-0.036***	-0.033***			-0.102**	-0.094**		
		(0.008)	(0.008)			(0.042)	(0.039)		
	Percent of network members with a stove			-0.293***	-0.297***			-0.798**	-0.691***
				(0.046)	(0.051)			(0.321)	(0.264)
	1st partial R2					0.0999	0.104	0.0812	0.0969
	1st F-test					7.275	9.107	7.047	10.27
	1rst F-test pvalue					0.0102	0.00441	0.0113	0.00266
	Mean of dependent variable	0.186							
Efficiency Stove	Number of network members with a stove	-0.035***	-0.034***			-0.112**	-0.108**		
		(0.010)	(0.009)			(0.052)	(0.048)		
	Percent of network members with a stove			-0.284***	-0.281***			-0.839**	-0.750**
				(0.060)	(0.059)			(0.377)	(0.309)
	1st partial R2					0.100	0.103	0.0844	0.102
	1st F-test					4.256	5.512	4.230	6.143
	1rst F-test pvalue					0.0517	0.0288	0.0524	0.0218
	Mean of dependent variable	0.160							
Chimney Stove	Number of network members with a stove	-0.036**	-0.027			-0.085	-0.076		
		(0.014)	(0.016)			(0.075)	(0.065)		
	Percent of network members with a stove			-0.255**	-0.228*			-0.712	-0.621
				(0.101)	(0.124)			(0.609)	(0.505)
	1st partial R2					0.107	0.126	0.101	0.122
	1st F-test					3.365	4.668	5.600	9.596
	1rst F-test pvalue					0.0832	0.0445	0.0294	0.00621
	Mean of dependent variable	0.216							
	Controls?	No	Yes	No	Yes	No	Yes	No	Yes

Robust standard errors, clustered by village, in parenthesis

*** p<0.01, ** p<0.05, * p<0.1

(1) Controls include the number of wage earners, the number of female hh members, the number of male hh members, the number of children under 5, the number of children under 18, the age of the female head of household, the age of the male head of household, the years of education of the female head of household, the years of education of the male head of household, and whether the female and males heads of household are wage earners.

(2) The excluded instrument in each case ia a dummy variable indicating whether the respondent was located in a village where participants in the first round were offered a half-price stove (i.e., were members of groups B or D)

Table 7: Effects of Knowing Others with Stoves on Own Stove Purchase [(1)]

		All Stoves							
		OLS				IV[(3)]			
		Number		Percent		Number		Percent	
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
All Stoves	Bari members with a stove	-0.055***	-0.048**	-0.160*	-0.137*	-0.265**	-0.249**	-0.533	-0.527
		(0.016)	(0.019)	(0.092)	(0.080)	(0.123)	(0.119)	(0.333)	(0.400)
	Relatives with a stove	-0.056***	-0.054***	-0.187***	-0.191***	-0.288**	-0.262**	-0.558**	-0.475**
		(0.013)	(0.015)	(0.038)	(0.040)	(0.117)	(0.109)	(0.257)	(0.217)
	Close friends with stoves	-0.042***	-0.033***	-0.212***	-0.220***	-0.223**	-0.214**	-0.654***	-0.539**
		(0.011)	(0.011)	(0.065)	(0.070)	(0.109)	(0.107)	(0.248)	(0.223)
	Smart network members with stoves	-0.027	-0.011	-0.157**	-0.145*	-0.364*	-0.349*	-0.989**	-0.768**
		(0.019)	(0.021)	(0.074)	(0.075)	(0.189)	(0.187)	(0.400)	(0.337)
Efficiency Stove	Bari members with a stove	-0.086***	-0.083***	-0.369**	-0.297*	-0.403**	-0.385**	-0.649**	-0.539*
		(0.024)	(0.023)	(0.160)	(0.149)	(0.174)	(0.159)	(0.320)	(0.316)
	Relatives with a stove	-0.063***	-0.064***	-0.208***	-0.207***	-0.326**	-0.319**	-0.553**	-0.519**
		(0.016)	(0.017)	(0.049)	(0.051)	(0.136)	(0.125)	(0.237)	(0.214)
	Close friends with stoves	-0.045***	-0.045***	-0.121	-0.113	-0.309*	-0.319*	-0.492*	-0.453*
		(0.014)	(0.015)	(0.071)	(0.075)	(0.170)	(0.173)	(0.270)	(0.260)
	Smart network members with stoves	-0.061***	-0.059***	-0.122	-0.101	-0.549**	-0.607**	-0.701**	-0.606*
		(0.018)	(0.019)	(0.073)	(0.072)	(0.269)	(0.290)	(0.345)	(0.319)
Chimney Stove	Bari members with a stove	-0.040**	-0.029	0.034	0.034	-0.152	-0.139	-0.242	-0.343
		(0.014)	(0.017)	(0.075)	(0.094)	(0.143)	(0.129)	(0.971)	(1.219)
	Relatives with a stove	-0.043*	-0.033	-0.098	-0.108	-0.231	-0.201	-0.578	-0.451
		(0.021)	(0.027)	(0.068)	(0.079)	(0.205)	(0.184)	(0.721)	(0.525)
	Close friends with stoves	-0.037**	-0.023	-0.375***	-0.341***	-0.139	-0.127	-0.823*	-0.543
		(0.015)	(0.014)	(0.111)	(0.105)	(0.135)	(0.120)	(0.463)	(0.343)
	Smart network members with stoves	-0.005	0.021	-0.144	-0.033	-0.211	-0.183	-1.407	-0.942
		(0.017)	(0.017)	(0.146)	(0.118)	(0.215)	(0.182)	(0.938)	(0.746)
	Controls?[(2)]	No	Yes	No	Yes	No	Yes	No	Yes

Robust standard errors, clustered by village, in parenthesis

*** p<0.01, ** p<0.05, * p<0.1

[(1)] Each coefficient represents the results of a separate regression in which the dependent variable is a dummy whose value is 1 if the household purchased a stove, and the variable in the second column is the independent variable of interest.

[(2)] Controls include the number of wage earners, the number of female hh members, the number of male hh members, the number of children under 5, the number of children under 18, the age of the female head of household, the age of the male head of household, the years of education of the female head of household, the years of education of the male head of household, and whether the female and males heads of household are wage earners.

[(3)] The excluded instrument in each case ia a dummy variable indicating whether the respondent was located in a village where participants in the first round were offered a half-price stove (i.e., were members of groups B or D)

Appendix Tables
For Online Publication

Table A1: First stage: Effects of discount in Round 1 on numbers/percentages of network members with stoves

	All Stoves				Portable Stove				Chimney Stove			
	Number		Percent		Number		Percent		Number		Percent	
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Network members with stoves received half price offer	1.136**	1.169***	0.147**	0.161***	1.255*	1.302**	0.172*	0.192**	0.983*	1.047**	0.117**	0.127***
	(0.421)	(0.387)	(0.055)	(0.050)	(0.608)	(0.555)	(0.083)	(0.077)	(0.536)	(0.485)	(0.050)	(0.041)
Number of Wage Earners		0.074		-0.008		0.113		-0.003		0.024		-0.011
		(0.060)		(0.010)		(0.089)		(0.017)		(0.060)		(0.010)
Total Number of Female HH members		-0.107*		-0.000		-0.253***		-0.017		0.061		0.014
		(0.062)		(0.011)		(0.088)		(0.016)		(0.061)		(0.012)
Total Number of Male HH members		-0.141**		-0.012		-0.157		-0.019		-0.083		0.000
		(0.063)		(0.010)		(0.096)		(0.014)		(0.066)		(0.011)
Number of Children <= Age 5		-0.212		-0.009		-0.187		-0.008		-0.241		-0.011
		(0.128)		(0.012)		(0.182)		(0.021)		(0.191)		(0.013)
Number of Children <= Age 18		0.067		0.004		0.121		0.018		-0.001		-0.012
		(0.080)		(0.013)		(0.119)		(0.018)		(0.088)		(0.011)
Female head age		0.006		0.002		0.028		0.004		-0.022		-0.002
		(0.013)		(0.002)		(0.017)		(0.002)		(0.014)		(0.001)
Male head age		-0.008		-0.002		-0.018		-0.002		0.005		0.000
		(0.008)		(0.001)		(0.013)		(0.002)		(0.007)		(0.001)
Female head education (in years)		-0.021		-0.000		-0.015		0.001		-0.028		-0.002
		(0.017)		(0.002)		(0.018)		(0.003)		(0.036)		(0.003)
Male head education (in years)		0.006		0.004		0.007		0.005		0.001		0.002
		(0.016)		(0.003)		(0.024)		(0.003)		(0.018)		(0.003)
Female head earns a wage		-0.536**		-0.086***		-0.469		-0.095**		-0.610**		-0.070***
		(0.210)		(0.026)		(0.335)		(0.045)		(0.247)		(0.022)
Male head earns a wage		-0.801*		-0.109**		-0.536		-0.166*		-1.056		-0.032
		(0.463)		(0.048)		(0.501)		(0.080)		(0.818)		(0.037)
Constant	0.343***	1.992***	0.078***	0.239***	0.378**	1.532*	0.101**	0.279*	0.294**	2.405*	0.044**	0.170**
	(0.110)	(0.705)	(0.024)	(0.087)	(0.162)	(0.742)	(0.038)	(0.138)	(0.136)	(1.301)	(0.021)	(0.072)
Observations	1,024	971	1,023	970	593	560	592	559	431	411	431	411
R-squared	0.100	0.139	0.081	0.136	0.100	0.136	0.084	0.134	0.107	0.195	0.101	0.188

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A2: First stage: Effects of discount in Round 1 on numbers/percentages of network members with stoves [(1)]

	All Stoves				Portable Stove				Chimney Stove			
	Number		Percent		Number		Percent		Number		Percent	
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Bari members with a stove	0.436***	0.439***	0.128	0.113	0.350**	0.367**	0.166	0.148	0.549*	0.567*	0.081	0.067
	(0.153)	(0.146)	(0.080)	(0.084)	(0.144)	(0.137)	(0.099)	(0.093)	(0.311)	(0.285)	(0.135)	(0.138)
Relatives with a stove	0.402***	0.419***	0.179***	0.198***	0.432**	0.442**	0.242**	0.263***	0.362	0.393*	0.102	0.122**
	(0.145)	(0.134)	(0.066)	(0.058)	(0.191)	(0.174)	(0.097)	(0.087)	(0.225)	(0.201)	(0.063)	(0.047)
Close friends with stoves	0.518**	0.512**	0.219***	0.226***	0.456*	0.443*	0.232**	0.232**	0.602	0.624*	0.184***	0.193***
	(0.203)	(0.193)	(0.063)	(0.058)	(0.251)	(0.230)	(0.094)	(0.084)	(0.351)	(0.333)	(0.056)	(0.047)
Smart network members with stoves	0.317**	0.314**	0.166***	0.167***	0.257**	0.232**	0.197**	0.204**	0.396	0.431*	0.125**	0.114**
	(0.130)	(0.124)	(0.049)	(0.048)	(0.120)	(0.104)	(0.076)	(0.076)	(0.265)	(0.247)	(0.057)	(0.051)
Controls?	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

[(1)] Each coefficient presents results from a different regression, in which the dependent variable is given in the first column, and the independent variable is a dummy whose value is one if the responde lived in a village where the half-priced stove offer was made.

Table A3: Experience with Stoves in Follow up Group, by Stove Type and Price Offer

	Efficiency	Chimney	Total	Diff	Std. Err	P-value
N	117	52	169			
Stove still works	0.46	0.78	0.56	0.32	0.08	0.00
Stove broke	0.54	0.22	0.44	-0.32	0.08	0.00
Has used stove consistently	0.07	0.57	0.25	0.51	0.07	0.00
Does the hh still use the stove?	0.04	0.52	0.19	0.48	0.06	0.00
Stove reduces cooking time	0.54	0.70	0.60	0.16	0.09	0.07
Stove reduces smoke emissions	0.66	0.94	0.75	0.28	0.07	0.00
Stove burns food less	0.45	0.79	0.57	0.34	0.09	0.00
Stove uses less fuel	0.33	0.64	0.44	0.30	0.09	0.00
Stove does not reduce cooking time	0.46	0.30	0.40	-0.16	0.09	0.07
Stove increases smoke emissions	0.06	0.04	0.05	-0.01	0.04	0.71
Stove burns food more	0.06	0.06	0.06	0.01	0.04	0.88
Stove uses more fuel	0.07	0.19	0.11	0.12	0.06	0.03
Would recommend stove to others	0.15	0.72	0.35	0.57	0.07	0.00
Would not recommend stove to others	0.85	0.28	0.65	-0.57	0.07	0.00
Index of positive experience w stove (4=totally positive)	1.98	3.06	2.36	1.09	0.21	0.00
Index of negative experience w stove (3=totally negative)	0.64	0.60	0.63	-0.05	0.13	0.72

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