Passive Learning and Incentivized Communication: A Randomized Controlled Trial in India*

Yonas Alem[†]
University of Gothenburg

Eugenie Dugoua[‡]
Columbia University

February 15, 2017

Abstract

New technologies are important to improve the well-being of poor communities but many barriers prevent adoption from reaching its socially optimal level. In this study, we designed a randomized controlled trial on willingness to pay (WTP) for solar lanterns in India in order to better understand the extent the informational barriers for a simple household product. In a non-electrified region of the state of Uttar Pradesh, we gave randomly selected 'seed' households high quality solar lanterns. Each seed household gave three names of friends whom we randomly assigned to one of the three following groups: control, passive learning and incentivized communication. Friends in the passive learning and incentivized communication groups were interviewed and elicited WTP thirty days after their seed friend received the solar lantern. However in the incentivized communication treatment, the seed was given a small reward for arranging a tea meeting with his friend to showcase the usage of the solar lantern and share his or her user experience. WTP was elicitated from the control group at the same time as the seed received the lantern. Our results reveal that both passive learning and incentivized communication have large positive effects on WTP. Passive learning increases WTP by 90% and incentivized communication by 145% relative to the control group. These results suggest that learning has powerful effects on WTP even in the case of simple household technologies.

JEL: D83, O33, Q21, Q42

*We thank Johannes Urpelainen for helpful inputs in all stages of the project, seminar participants at the Nordic Development Economics Conference (Oslo) and at the Association of Swedish Development Economists conference (Gothenburg) for useful comments. We are also grateful to MORSEL India for administering the field work and data collection. The randomized controlled trial was financed by the Swedish Research Council Formas through the program Human Cooperation to Manage Natural Resources (COMMONS) at the Department of Economics, University of Gothenburg. All errors remain our own.
[†]Vasagatan 1, Box, 640 405 30, Gothenburg, Sweden, e-mail: yonas.alem@economics.gu.se.
[‡]420 W. 118th Street, New York, NY 10027, USA, e-mail: ed2571@columbia.edu.

1 Introduction

The literature on economic growth models technological progress as engine of economic development and prosperity. The recent version of this literature uses endogenous growth models to highlight the important role of social learning in technology diffusion (Romer, 1986; Lucas, 1988; Aghion and Howitt, 1997; Barro and i Martin, 2004; Acemoglu, 2008). Economic growth in this set-up is characterized to be driven endogenously within the economy through investment in human capital, knowledge and innovation. Profit maximizing firms invest, learn by doing and learn from each other through knowledge spillovers; these processes induce smooth technological diffusion in the economy. The theory has in recent years been extended to understand the feature of technological innovation and diffusion in agriculture in developing countries (Foster and Rosenzweig, 1995; Bardhan and Udry, 1999; Bandiera and Rasul, 2006; Conley and Udry, 2010). Using state-of-the-art empirical strategies, this strand of literature identifies the role of social networks in promoting social learning and adoption of new agricultural technologies.

One feature of earlier studies on the role of social networks is the assumption of “passive learning”, a situation in which peers learn about new technologies from their peers without cost. However, in a recent research, (BenYishay and Mobarak (2014)) shows that the power of social networks in diffusion of new technologies could be enhanced by incentivizing information communication. In this paper, we attempt to shed light on the role and magnitude of incentivizing information communication by one’s peers on willingness to pay (WTP) for new technology using a randomized controlled trial (RCT) in India. Motivated by theories of intra-household decision-making, we also investigate the role of gender in information communication and willingness to pay for the new technology.

We collaborated with a local organization and distributed a new solar-powered lantern to households in Gonda district of Uttar Pradesh state of India. The solar lanterns are durable, multipurpose, and convenient to use worth 1,200 rupees (USD 18.5) in Lucknow, the capital of Uttar Pradesh state. Notably, the lanterns have a mobile-charging feature which allows the user to charge a mobile phone. The study area is still non-electrified and households did not have knowledge about the solar lanterns prior to the study. We randomly selected 200 seed individuals, half of them male and half of them female, to whom we offered a solar lantern for free. Each seed household gave three names of peers (friends or relatives), and these were randomly assigned into a “network treatment”, a “communication treatment” and a “control group”. We elicited willingness to pay for the solar lanterns from the control group immediately after interviewing the seed household using the Becker-Degroot-Marschak (BDM) method (Becker, Degroot, and Marschak, 1964).

In the network group, the subjects, who were designated as friends by the seed, were interviewed 30 days after the seed received the solar lantern to elicit their willingness to pay. We refer to the learning captured through this process as "passive learning". In the communication group, the 30-day delay was followed by a tea meeting at which the seed presented the solar lantern and shared his or her experience with the friend in return for a payment of 100 rupees (USD 1.54).[1] We refer to the learning captured through this process as "incentivized communication".

The results show that peers who most probably learned about the solar lantern through their relationship with the seed household are on average willing to pay 120 rupees more than the control group a month after the lanterns have been distributed. Peers who were invited to a demonstration tea meeting by the seed households a month after the lanterns have been distributed on the other hand are willing to pay 190 rupees more than the control group. With a mean WTP of 134 in the control group, the proportional treatment effects are 90% and 145%, respectively. Both treatment effects appear to be large. It is notable that the passive learning treatment effect almost doubled WTP, whereas incentivized communication added another 55 percentage points increase in the treatment effect.

This paper is broadly related to a body of research in economics on the impact of peers on one's outcomes. This strand of literature, focusing mostly in developed countries, investigates the impact of peers or friends on several outcome variables of interest including educational achievement (e.g., Hoxby, 2000; Sacerdote, 2001; Angrist and Lang, 2002; Zimmerman, 2003; Figlio, 2005), market and health outcomes (e.g., Munshi, 2003; Kling and Liebman, 2007), labor productivity and consumption (e.g., Mobius, Niehaus, and Rosenblat, 2005; Mas and Moretti, 2009) and adoption of technology (Oster and Thornton, 2012). The extent of peer effects has also been examined in the development economics literature mainly to explain agricultural technology adoption (Foster and Rosenzweig, 1995; Bardhan and Udry, 1999; Bandiera and Rasul, 2006; Conley and Udry, 2010). A particularly important observation in this literature is that modern agricultural technologies promote yield significantly but their adoption or uptake rate has been disappointingly low. It has been documented that farmers are likely to trust recommendations about a new technology from their peers, friends or member of their social networks who have experienced the technology rather than from others external to their community.

More recently, BenYishay and Mobarak (2014) investigate this further by designing a randomized controlled trial to vary the method of dissemination for two agricultural technologies - pit planting and Chinese composting - that promote maize yield in rural Malawi. These authors specifically investigate whether pro-

[1] At the time of the survey, 1 USD = 65 rupees.

vision of performance-based rewards to information communicators about the new technologies results in better adoption of the technologies. Among the three types of information communicators they chose - government employed extension workers, lead farmers, and peer farmers - adoption of the technologies by others was much very likely in response to the information provided by peer farmers. We extend this literature by exploring how incentivizing information communication by peers or friends influences willingness to pay for the new technology. Our design allows us to elicit revealed willingness to pay for the new technology, a figure important to policymakers to design optimal subsidy and cost reduction strategies to encourage diffusion of the technology.

The paper also speaks to the emerging literature on electrification in developing countries (Dinkelman, 2011; Dugoua and Urpelainen, 2014; Furukawa, 2014; Grimm et al., 2014), an area of research that overlaps with development and energy economics. The current level of electrification in developing regions such as Sub-Saharan Africa, South Asia, and Latin America remains low (International Energy Agency, 2014). Extending the grid to the most rural regions requires high levels of investment that are often difficult to be secured by governments. Solar power serves as a decentralized solution to the problem of energy poverty, and is slowly diffusing throughout rural Africa and rural South Asia. However, tight household budget constraints, poor product quality and little local expertise in photovoltaic technologies have been hindering faster adoption (cite source). In addition, given the increased need to reduce greenhouse gas emission from the energy sector, exploring the role of solar-powered lighting equipment, which literally emits no greenhouse gas would have large benefits to the society at large. From public policy point of view, the findings from this paper would therefore be significant in providing useful information on willingness to uptake such technologies and the factors that drive their quick diffusion.

Section 2 discusses relationship of the current paper to existing literature. Section 3 lays out our key hypotheses about willingness to pay for solar lanterns. Section 4 describes the design and procedure of the randomized controlled trial, with results of the randomization checks. Section 5 presents the key empirical results. Section 6 concludes.

2 Relationship to Existing Literature

This paper contributes to a large and growing literature on the role of peers - co-workers, friends, acquaintances on one's behavior and outcome that builds off the work of (Sacerdote, 2001; Hoxby, 2000; Munshi, 2003; Mobius, Niehaus, and Rosenblat, 2005). Friends and members of social networks influence one's beliefs and consequently decisions. These studies, almost exclusively focused in developed countries, document the impact of peers on one's educational achievement, labor productivity, and consumption behavior respectively. Roommates affect one's freshman GPA, the decision to join social organizations, and classmates influence reading scores in elementary schools in the United States (Sacerdote, 2001; Hoxby, 2000). Peers and networks members help Mexican migrants in the United States find a higher-paying job (Munshi, 2003). Peers have also been shown to have as large of an effect as advertising on consumer demand (Mobius, Niehaus, and Rosenblat, 2005). Other studies in similar settings (e.g., Zimmerman, 2003; Angrist and Lang, 2002; Figlio, 2005; Kling and Liebman, 2007; Mas and Moretti, 2009) further documented the role of peers in influencing one's behavior and decisions.

There are studies (e.g., Foster and Rosenzweig, 1995; Bandiera and Rasul, 2006; Conley and Udry, 2010) investigating the role of peers in social networks in adoption and diffusion of productivity-enhancing modern agricultural technologies in developing countries. These studies were mainly motivated by the fact that modern agricultural technologies promote yield significantly and improve welfare, but their adoption and diffusion rate has been sub-optimally low. Adoption of a new agricultural technology by a farmer is a social process because it generates knowledge to all her peers and increases their expected yield (Bardhan and Udry, 1999). This literature implies that farmers in developing countries are likely to trust recommendations by fellow farmers than by those from other people external to their community. In view of this, social networks play a significant role in diffusion of new technologies. Outside an agricultural set-up, recently Oster and Thornton (2012) investigates the role of peer effects in adoption of menstrual cups by school girls in Nepal and documents a strong effect on learning how to use the technology.

There are methodological challenges in identifying the impact of social networks on technology adoption using observational data. First, when two friends are both adopting a certain technology, it is difficult to distinguish whether it is because the two friends learn from each other or individuals who are open to try out a new technology also have friends with similar characteristics that are unobservable (Manski (1993)). Second, it is difficult to precisely define the social network of adopter of a new technology and even so, it may be that individuals are just imitating each other rather than learning from each other (Conley and Udry, 2010)). Recent studies used the method of randomization to tackle this identification problem (Sacerdote, 2001; Kremer and Levy, 2008; Rao, Mobius, and Rosenblat, 2007; Duflo and Saez, 2003; Godlonton and Thornton, 2012; Miguel and Kremer, 2004; Duflo, Kremer, and Robinson, 2011; Kremer and Miguel, 2007; Oster and Thornton, 2012).

A key feature of previous studies on the role of peers on adoption of new technologies (Bandiera and Rasul, 2006; Conley and Udry, 2010; Oster and Thornton, 2012) is the implicit assumption of learning from peers without a cost, i.e., “passive learning” (BenYishay and Mobarak, 2014). New technologies could be adopted and diffused faster if peers that communicate information about the new technology are rewarded. This is the key argument of the study by BenYishay and Mobarak (2014) who design a randomized controlled trial to vary the method of dissemination for two agricultural technologies - pit planting and Chinese composting - which are believed to improve maize yield in rural Malawi. These authors confirm the importance of social networks in diffusion of agricultural technologies, but argue that their power can be significantly improved by remunerating the peer who adopts the technology and makes a conscious effort to communicate and convince other fellow farmers.

Our paper contributes to this literature in three main ways. First, this paper is the first to examine the impact of rewarding communication about a new technology on willingness to pay - as opposed to a binary measure of adoption - outside an agricultural set-up. We clearly identify the impact and magnitude of both passive networks and incentivized communication by spouses about a new solar lantern technology on willingness to pay using a randomized controlled trial. This distinction is important because estimating average willingness to pay allows policymakers to estimate whether new technologies could be distributed profitably and the amount of resources needed in case revealed willingness to pay is lower than the cost of the new technology. Second, unlike agricultural technologies, which take time and involve risk, solar lanterns are easy technologies to learn about in a short period of time. As a result, biophysical and climatic factors, which seem to differ markedly even between closely located plots would not be a problem. Third, we consider a technology which is not only quick to learn about, but also has a significant welfare effect on all members of households. The current rate of electrification in developing regions of the world is very low and households very often use kerosene lamps for lighting. Using kerosene lamps has been documented to generate indoor air pollution and affect health outcomes of members adversely, emit hazardous greenhouse gases, and requires households to regularly travel long distance to markets for kerosene purchase. The solar lanterns we randomly distributed among other things, are multi-purpose, affordable, and reasonably-priced with a significant potential to enhance health outcomes of all household members, reduce greenhouse gas emissions and help children allocate more time to studying.

3 Conceptual Framework

We now lay out a brief motivating framework for interpreting the main results, drawing on Foster and Rosenzweig (1995); Bardhan and Udry (1999); Bandiera and Rasul (2006); Conley and Udry (2010); BenYishay and Mobarak (2014). In order to do so, we define the following treatments:

- In the *network treatment* group, subjects observe the use of a new technology by others without incentivized communication. Thus, learning from others is passive.
- In the *communication treatment* group, subjects both observe the use of new technology by others and receive direct communication about the properties of the new technology just before WTP is elicited. Thus, learning from others might be thought of as 'active'.

To test the presence of social learning – that is, learning from others – in agriculture, these studies make use of the "target-input" model proposed by Wilson (1975) and Jovanovic and Nyarko (1994). According to this model, the farmer knows the basic form of the new technology (e.g., an improved seed) with certainty, but does not know the target level, which is assumed to be random. Farm profit is inversely related to the difference between the actual level of input applied and the target level. The farmer realizes what the actual level of input should have been only after the input has been applied and output has been realized. As a result, the farmer learns about the new technology over time through learning-by-doing.

In the target-input model, individuals can also learn from each other's experience when they share similar distribution of the input target. Assume two farmers who belong to a certain social network and share information with each other or costlessly observe each other's input choice. In each period, farmers use Bayes' rule to update their prior belief on the variance of the optimal input level making use of information from their own experience and the experience of their network members. Thus, adoption of a new technology in this model is a social process because it's adoption by an individual generates information spill-over to all her peers which increases their expected welfare in the future (Bardhan and Udry, 1999). Diffusion of solar lanterns can be modelled using the social learning framework because peers of seed households observe (without any cost) the service provided by the lanterns and immediately update their belief about the quality of the lanterns. Consequently, these individuals would be willing to pay more than those who did not have prior information about the lanterns.

Hypothesis 1. *The network treatment increases willingness to pay.*

An important extension of the 'target-input" model by BenYishay and Mobarak (2014) is that the member of the social network that communicates information about the new technology, i.e., the "communicator" knows the optimal level of the technology. However, it would be costly to transfer her knowledge about the new technology to other fellow farmers. If there is an intervention that rewards the information communicator based on what proportion of farmers adopted the new technology as a result of the information transmitted by the sender, diffusion of the technology occurs much faster. Such type of incentives induce the communicator to make a conscious effort and bear the cost of communication and transmit information about the new technology to others. As a result, others will learn about the new technology and adopt it much faster than the case of unincentivized communication through ordinary social networks. In our case, rewarding seed households to invite one of their randomly selected peers for a tea meeting after using the solar lanterns for a month will result in transmission of more accurate information. As a result, peers who have been provided detailed information about the attributes of the solar lanterns in such a way are likely to pay more for the lanterns than peers that were not invited for the tea meeting (the network treatment group).

Hypothesis 2. *The communication treatment increases willingness to pay more than the network treatment.*

Another aim of our RCT is testing the role of gender in communication about a new technology. Early studies (Chiappori, 1992; Browning and Chiappori, 1998; Chiappori, Fortin, and Lacroix, 2002; Bourguignon, Browning, and Chiappori, 2009) from industrialized countries show that although members of a household (most importantly, couples) often have different preferences and intra-household bargaining power is asymmetric in favor men, they still achieve Pareto-efficient outcomes in household decision-making. However, studies in developing countries document rejection of Pareto-efficiency in household decision-making, most importantly because of preference and intra-household bargaining power difference between husbands and wives. Udry (1996) documents that total yield by farm households in Burkina Faso could be improved by relocating inputs from male-cultivated plots to female-cultivated plots.[2] Schaner (2015) provides evidence indicating that households in Kenya make sub-optimal saving decisions as a result of differences in discount rates of couples. More recently, Miller and Mobarak (2013) and Alem, Hassen, and Köhlin (2016) show that improved cookstoves, which enhance the quality of life of all household members, are valued significantly higher by women compared to men, but could not be adopted optimally because women have low bargaining-power (autonomy).

Drawing on these studies, we test the hypothesis that female social networks are less effective in promoting technology adoption. If female members of a household have less bargaining power than male members, then female social networks, compared to male social networks, are channels of information transmission that focus on a less-influential decision-maker. Because the female member who learns information through her social network lacks the autonomy to make the purchase, we expect the information to be less relevant than in the case of male social networks. Thus, when either passive learning or incentivized communication occurs through female networks, women's lack of decision-making power impedes learning by the relevant

[2] A related study, Robinson (2012), documents that the response in private consumption to an exogenous shock is significantly different between wives and husbands in western Kenya implying that informal risk-sharing mechanisms within households are not Pareto-efficient.

decision-maker, and thus the effect of the treatment on WTP in the household should be of lesser magnitude.

Hypothesis 3. *Learning through male social networks increases willingness to pay by more than learning through female social networks.*

4 Experimental Design

To test our hypotheses, conducted a WTP experiment in 200 unelectrified habitations of Gonda district in the state of Uttar Pradesh, India.[3] Habitations (also called sub-villages or hamlets) are the lowest administrative units in India. The subjects were given an opportunity to purchase a solar lantern in a BDM game. We compared the effects of a network treatment and a communication treatment using randomly assigned male and female contacts. The experiment was conducted in two rounds between July and September 2015. The study area was chosen because it had a low electricity access rate, with many unelectrified habitations near to the district capital, Gonda City. To avoid data mining and bias from multiple comparisons, a detailed pre-analysis plan (PAP) listing all research hypotheses and our key empirical specification was registered with the experiment in the Governance and Politics website.[4]

The primary specification equation can be written as follows:

$$WTP_{ij} = \alpha + \beta_1 N_i + \beta_2 N_i F_i + \gamma_1 N_i C_i + \gamma_2 N_i C_i F_i + \mu_j + \epsilon_{ij}, \tag{1}$$

where WTP_i is the willingness to pay for a solar lantern of household i within habitations j; N_i is a dummy variable coding for whether household i knows a lantern user through its social network (either through the social network of the head or that of the spouse); F_i is a dummy variable coding for whether the lantern user is known through the social network of the female spouse; C_i is a dummy variable coding for whether the household engaged in active communication with the lantern user of his network; μ_j is a vector of habitation fixed effects ($N = 200$); ϵ_{ij} is a random error term. Our objective is to estimate $\beta_1, \beta_2, \gamma_1, \gamma_2$. Throughout, we cluster standard errors by habitations. In this estimation framework, the hypotheses can be expressed as follows. Hypothesis 1 is equivalent to $\beta_1 > 0$ and $\beta_1 + \beta_2 > 0$; Hypothesis 2 to $\gamma_1 > 0$ and $\gamma_1 + \gamma_2 > 0$; Hypothesis 3 to $\beta_2 < 0$ and $\gamma_2 < 0$.

[3]Before implementation, the experiment was reviewed and approved by the internal review board (IRB) of Columbia University.

[4]The PAP is publicly available at `http://egap.org/registration/1420`.

4.1 Outcome Variable

In the experiment, the subjects were given an opportunity to purchase a solar lantern. Photos of the lantern can be found in the appendix. The retail price of the lantern was 1,200 rupees. The product features included a 3-watt solar panel, a 6V 4.5Ah battery, a 3-watt, 24-piece surface-mounted-device LED, and a mobile charging socket. We chose the product based on a review of solar lanterns available among Uttar Pradesh distributors. We confirmed the performance of the lanterns - in terms of the quality and duration of the lighting, and the charging power - by using them with the survey team for about a week.

The outcome variable is the subject's WTP measured in the BDM game. As Becker, Degroot, and Marschak (1964) show, the BDM game recovers the subject's true preference by removing incentives to misrepresent WTP for strategic reasons. In the game, the subject is requested to provide his or her highest WTP for an item, and the price of the item is then drawn from a random distribution. If the price is below the stated WTP, the subject pays the *randomly drawn price*, not the stated WTP. Therefore, the subject has no incentive to understate WTP to obtain a better bargain. This method has been widely applied in development economics to measure WTP (e.g., Hoffmann, 2009; Levine et al., 2012; Guiteras et al., 2013) because it is incentive-compatible and provides a continuous demand curve, as opposed to demand estimates for a discrete number of price points (as is the case in a typical randomized-price WTP measurement).

The game was played in the field as follows. Each household is requested to announce their maximal willingness to pay on a 0-1,200 rupee scale, and the actual price is determined by a random draw from a bag which contains 21 balls, each one of them with a number written on it. The number goes from 0-1,200 rupees in increments of 100 rupees. The respondent first makes a bid and then randomly draws a ball. If the price on the ball the respondent draws is higher than the bid, the respondent is not allowed to purchase the lantern. If the price on the ball is lower than the bid, the respondent must purchase the lantern at the price that was drawn. As a result, when the respondent makes a bid, he must make sure he has access to the funds. The respondent has only one chance to play, and he cannot change his bid after drawing a ball. Before the respondent gets to play for 'real', the game is played for a bar of soap to make sure the respondent fully understands the rules.

Figure 1 shows the distribution of the bids. As the distribution shows, most subjects made a positive bid, but no subject offered the non-subsidized market price of the lantern. We also note that the willingness to pay displays important variation across individuals spanning from 0 to 1200 with mean 239 and standard deviation 266. Figure 2 further shows the distribution of bids across treatment groups.

[Figure 1 about here.]

[Figure 2 about here.]

In measuring WTP, we paid particular attention to training the enumerators so that they explained the procedure to the subjects carefully enough and always conducted the practice round with soap. Based on our observation of the WTP measurement, the subjects understood the rules of the game. No subject complained afterwards or refused to pay in case they won the solar lantern. The subjects were sometimes disappointed if they did not win the lantern, but in that case they also did not have to give any money.

4.2 Sampling and Treatments

The data collection began with a mapping of 200 primary habitations and 25 replacement habitations around Gonda City. The enumerators approached the habitations in expanding circles, with habitations near to Gonda City visited first and those further away visited later. If a habitation was excluded because of safety concerns or lack of suitability, a randomly drawn replacement habitation was used instead. Overall, we had to exclude and replace five habitations. The map of the study area and habitations is shown in Figure 3.

[Figure 3 about here.]

Within each habitation, the enumerators approached a randomly chosen 'seed' household and, depending on the treatment, interviewed either an adult male or female member. The seed was requested to provide names of three friends, and the three friends were then randomly assigned to three groups: control, network, and communication. The control group was interviewed on the same day and the network and communication treatments approximately 30 days after the initial interview. All the households in the control, network and communication groups will be offered the possibility to buy a solar lantern through a BDM game.

The timeline of the experiment is summarized in Figure 4 and treatment groups in Table 1. As the figure shows, the experiment began with the sampling and control group interviews in July-August 2015. In each habitation, the network and communication groups were sampled approximately one month after the sampling. The network and communication were surveyed at the same time to avoid treatment spillovers.

[Figure 4 about here.]

[Table 1 about here.]

The male versus female treatment was randomized at the habitation level. One of the researchers draw a random number for each habitation and assigned the highest (lowest) 100 numbers to female (male) treatment. All seed households were given a free solar lantern for taking part in the survey. They were also paid 100 rupees conditional on inviting one of the three friends for a tea meeting to introduce the solar lanterns and discuss their user experience. The seed households were informed not to pursue their friends to buy the solar lanterns, but only to share their experience and the performance of the lanterns. Our survey team, consisting of enumerators who speak the local dialect attended all tea meetings by seeds and thir peers.

Within each habitation, the three friends or relatives named by the seed were then randomly assigned to the control, the network, or the communication treatment. The household of the friend in the control group is visited and asked for WTP immediately after the seed household provides the name of three friends. The procedure for the household of those in the network and communication is similar except for the two following differences. First, the visit to the network and communication households takes place about a month later. A one month lag is a way to ensure that knowledge about the lantern can naturally diffuse from the seed household to peer households. Second, before playing the BDM game with the communication household, the seed invites his/her communication friend over to discuss his/her experience of the lantern.

Harvesting of maize and rice in the study area started end of September and early October respectively. This timing party coincided with our survey of the network and communication groups. There is a therefore a valid concern about a possible "wealth effect" on willingness to pay to be confounded in our treatment effects. In order to investigate robustness of our treatment effects, we will control for the date of interview in our regression.

4.3 Covariate Balance and Power Analysis

The balance table for the information treatments is shown in Table 2. As the table shows, the treatment groups are balanced across most covariates, with a few exceptions: gender of the respondent, savings and indebtedness. The control group has significantly more female head of household and about 450 rupees less in savings compared to the network and communication groups. This is a potential source for concern given households with more savings would be in a better position to bid higher prices. For this reason, as a robustness check, we include these variables in additional regression analysis.

[Table 2 about here.]

The balance table across the seed gender treatments is shown in Table 3. We note that, as could be expected, within each information treatment group the households referred by the female seeds are usually more likely to be headed by a female, while the households referred by the male seeds are usually headed by a male. It follows that the different groups display significant differences for variables such as education, expenses or literacy.

[Table 3 about here.]

Standard power analysis shows that the experiment can identify plausible treatment effects. Using the control group's mean and standard deviation (134 and 181), a standard deviation's uniform increase (to 315, with a standard deviation of 362) would be detected with an $\alpha = 0.95$ probability if the control and treatment group each had at least 65 participants. In our setting, each group has 200 subjects and, although we cluster standard errors by habitation ($N = 200$), the precision of our estimates is improved by habitation fixed effects.

5 Results

5.1 Main Estimates

Figure 5 displays a boxplot of WTP for the different treatment groups. The mean WTP across treatments is shown in Table 4. Whether the differences between these various means are significant is reported in Table 5 and Table 6; both t-tests and rank-sum tests were performed. We note that the mean WTP is much higher in the network and communication treatments. There also appears to be a significant difference between the network and communication treatments. The gender treatment however seems to have no effect. Mean comparisons do not control for unobserved heterogeneity across habitations and for correlation between observations within the same habitation. We therefore proceed to use regression analysis with fixed effects and clustering of the standard errors at the habitation level.

[Figure 5 about here.]

[Table 4 about here.]

[Table 5 about here.]

The main results from regression analysis are shown in Table 7. In all models, standard errors are clustered at the habitation level. Habitation fixed effects are not included in the second column because the gender treatment was randomized across habitations. Results show that the network treatment increased WTP by 120 Rupees compared to the control group. Given the mean WTP of the control group was 134 Rupees[5], this corresponds to a 90% increase. Furthermore, the communication treatment increased WTP by

[5] Similarly, the value of the intercept in model 1 of Table 7 is 134.5 Rupees.

195 Rupees which corresponds to a 145% increase. The gender treatment however does not appear to have an effect. The inclusion of habitation fixed effects in column 4 reduces further the coefficient for the interaction of the gender treatment with the information treatment in the negative values. This would indicate that the gender treatment is detrimental to WTP, at least qualitatively.

[Table 6 about here.]

In Table 8, we include controls for the two imbalanced covariates, that is, the gender of the respondent and their monthly savings. We see that controlling for those variables lowers slightly the coefficient from 120 to 104 Rupees in the network group and from 195 to 181 Rupees in the communication group, but the treatment effects remain extremely robust. The coefficient for the monthly savings is significant at the 5% level but the magnitude is small: for every additional Rupees in savings, the WTP would increase by 0.026 Rupees. Given the imbalance of savings across treatment groups, this represents an average contribution to the WTP of about 6 Rupees in the control group and 17 to 18 Rupees in the network and communication groups. The contribution of savings to the WTP is therefore an order of magnitude lower than the contribution of our information treatments.

Column 3 and 4 serve as a test of a potential ‘harvest’ effect as discussed earlier. The variable ‘Date’ is the month and day of the month on which the respondent was interviewed. If a harvest effect took place, the later in time the interview, the more likely a respondent was to have access to cash and bid a higher price. If so, then the coefficient on ‘Date’ should be positive. Results show that the coefficient is not significant and leans towards negative values[6]. This implies that respondents interviewed last were no more likely to bid higher amounts, which provides support against a wealth effect from the harvest season. In the last two columns, we include seven additional control variables but our main results remain robust. Of all the added covariates, only the number of kerosene lamps appears to be significant.

[Table 7 about here.]

5.2 Why Did Learning Affect Willingness to Pay?

In this section, we look into some of the survey questions to shed light on why our treatments were effective. Table 10 displays how the various groups (control, network and communication) answered some key questions of our survey. Everyone, even those in the control group, believe that a solar lantern is innovative and superior to a kerosene lamp, and they would recommend it to a friend over a kerosene lamp. This is despite the fact

[6]Standard errors and coefficients are very large in this case due to the collinearity between our treatment dummies and the date variable.

that most of those in the control group confirm they have never seen a solar lantern before and do not know anybody who owns one.

Contrary to the control group, most people in the network and communication groups now believe that, to function properly, a solar lantern needs proper maintenance; they also estimate the cost of such a product to a higher level than the control group. This might indicate that a key learning from their friend's experience is about the technical quality of the product. In a sense, villagers might first expect that a solar lantern is nothing more sophisticated than a kerosene lantern, but as they get to see their friend taking care of the photovoltaic panel that is connected to the lamp and allows the battery to be charged, they now perceive the product as a more sophisticated piece of technology and are willing to pay a higher price for it.

[Table 8 about here.]

5.3 Why Did Gender not Affect Willingness to Pay?

In this section, we investigate to what extent the male seeds differed from the female seeds, as well as to what extent the friends chosen by the male seeds differed from the friends chosen the female seeds. Table 12 displays differences between the male seeds and female seeds. Characteristically of gender inequalities in India, we observe that female seeds are less likely to be educated and literate. We also see that female seeds have a weaker connection to the village's social life: not only are they less likely to participate to village meetings or religious and political events, but they also somewhat have less trust in other villagers and declare having less friends and spending less time with these friends compared to male seeds. Notably, they are much more likely to be born outside the village which might play a role in explaining these findings. One question in the survey asked seeds who they thought would mostly be using the lanterns. It is interesting to see that 70% of female seeds declare that they will be the one to use the lantern. Furthermore 30% of male seeds said that it is their spouse that would mostly use the product. Hence it appears that overall both genders agree that the lantern is a product useful to women more so than to men.

Given these important differences between the two seed groups, we can expect that they choose friends that are different along household characteristics. And indeed, table 13 reports the variables for which the friends selected by female seed and male seeds differed. First of all, female seeds were more likely to choose households headed by a woman. It is likely that the differences in education, literacy, savings and household size follow from the fact that more households are headed by women in the group chosen by female seeds.

[Table 9 about here.]

[Table 10 about here.]

[Table 11 about here.]

6 Conclusion

Adoption and diffusion of new technologies is a crucial to improve the livelihood of poor communities. One important factor that promotes this process is information sharing through social networks. Adoption of a new technology is a social process because it's adoption by an individual creates positive information externality to peers and this increases their expected welfare (Bardhan and Udry, 1999). Does rewarding individuals who make conscious effort to communicate information about new technologies increase willingness to pay by social network members? Whose social network in the household matter for the flow of information about new technologies? In this paper, we attempted to answer these questions by crafting a randomized controlled trial which involves distribution of multi-purpose solar lanterns under different treatments.

We collaborated with a local institution in rural India and assigned three peers of randomly recruited seed individuals (half of them male and half females) into a "network treatment", a "communication treatment" and a "control group". We elicited willingness to pay for the solar lanterns from the control group right after interviewing the seed household using the Becker-Degroot-Marschak (BDM) method (Becker, Degroot, and Marschak, 1964). We elicited willingness to pay for the lanterns from the "network" group one month after the seed households have used the lantern. We finally asked the seed households to invite one of the peers (the communication group) for a tea meeting to demonstrate and share their experiences in using the lantern after a month in return for an incentive payment of 100 rupees. The study area is non-electrified and households did not have previous information about the solar lanterns. These facts allowed us to explore the flow of information and the value households put into technologies that have large potential to improve quality of life by all household members.

Our results show that households who most likely learned about the solar lantern technology through their network (passive network) are willing to pay 120 Rupees more compared to the control group. Given the control group is willing to pay 134 Rupees on average, this corresponds to a 90% increase in WTP. On the other hand, households who attended a demonstration session by their peers (the communication treatment) are willing to pay 195 Rupees (145%) more than the control group. We do not find a statistically significant difference in WTP between male and female networks in both treatments.

Our findings have significant implications for policies that aim at promoting adoption and diffusion of new technologies in developing countries. If rewarding information communicator peers promotes information spill-over and willingness to pay, this implies that reducing the cost of the technology and allocating resources to communication will have significant welfare impact on society. The results also highlight the potential role solar technologies could play in electrification. A significant proportion of households in developing countries do not have access to electricity and governments lack the required resources to extend the grid. Solar power has a large potential to tackle energy poverty by serving as a decentralized solution. In this regard, identifying the impact of incentivizing communication in inducing adoption and diffusion of such types of low-cost and environmental friendly technologies in rural set-ups provides useful information to policymakers and stakeholders who aim at improving the living conditions of poor households while protecting the environment.

References

Acemoglu, Daron. 2008. *Introduction to Modern Economic Growth.* Princeton: Princeton University Press.

Aghion, Philippe, and Peter Howitt. 1997. *Endogenous Growth Theory.* Cambridge: MIT Press.

Alem, Yonas, Sied Hassen, and Gunnar Köhlin. 2016. "Decision-making within the Household: The Role of Differences in Preference and Autonomy." Department of Economics, University of Gothenburg Working Paper.

Angrist, Joshua David, and Kevin Lang. 2002. "How Important are Classroom Peer Effects? Evidence from Boston's Metco Program." NBER Working Paper 02-85.

Bandiera, Oriana, and Imran Rasul. 2006. "Social Networks and Technology Adoption in Northern Mozambique." *The Economic Journal* 116 (514): 869–902.

Bardhan, Pranab, and Christopher Udry. 1999. *Development Microeconomics.* New York: Oxford University Press.

Barro, Robert J., and Xavier Sala i Martin. 2004. *Economic Growth.* 2 ed. MIT Press.

Becker, Gordon M., Morris H. Degroot, and Jacob Marschak. 1964. "Measuring Utility by a Single-Response Sequential Method." *Behavioral Science* 9 (3): 226–232.

BenYishay, Ariel, and A. Mushfiq Mobarak. 2014. "Social Learning and Communication." NBER Working Paper 20139.

Bourguignon, Francois, Martin Browning, and Pierre-Andre Chiappori. 2009. "Efficient Intra-Household Allocations and Distribution Factors: Implications and Identification." *Review of Economic Studies* 76 (2): 503–528.

Browning, Martin, and Pierre-André Chiappori. 1998. "Efficient Intra-Household Allocations: A General Characterization and Empirical Tests." *Econometrica* 66 (6): 1241–1278.

Chiappori, Pierre-André. 1992. "Collective Labor Supply and Welfare." *Journal of Political Economy* 100 (3): 437–467.

Chiappori, Pierre-Andre, Bernard Fortin, and Guy Lacroix. 2002. "Marriage Market, Divorce Legislation, and Household Labor Supply." *Journal of Political Economy* 110 (1): 37–72.

Conley, Timothy G., and Christopher R. Udry. 2010. "Learning About a New Technology: Pineapple in Ghana." *American Economic Review* 100 (1): 35–69.

Dinkelman, Taryn. 2011. "The Effects of Rural Electrification on Employment: New Evidence from South Africa." *American Economic Review* 101 (7): 3078–3108.

Duflo, Esther, and Emmanuel Saez. 2003. "The Role of Information and Social Interactions in Retirement Plan Decisions: Evidence from a Randomized Experiment." *The Quarterly Journal of Economics* 118 (3): 815–842.

Duflo, Esther, Michael Kremer, and Jonathan Robinson. 2011. "Nudging Farmers to Use Fertilizer: Theory and Experimental Evidence from Kenya." *American Economic Review* 101 (6): 2350–2390.

Dugoua, Eugenie, and Johannes Urpelainen. 2014. "Relative Deprivation and Energy Poverty: When Does Unequal Access to Electricity Cause Dissatisfaction?" *International Journal of Energy Research* 38 (13): 1727–1740.

Figlio, David N. 2005. "Boys Named Sue: Disruptive Children and Their Peers." NBER Working Paper No. 11277.

Foster, Andrew D., and Mark R. Rosenzweig. 1995. "Learning by Doing and Learning from Others: Human Capital and Technical Changes in Agriculture." *Journal of Political Economy* 103 (6): 1176–1209.

Furukawa, Chishio. 2014. "Do Solar Lamps Help Children Study? Contrary Evidence from a Pilot Study in Uganda." *Journal of Development Studies* 50 (2): 319–341.

Godlonton, Susan, and Rebecca Thornton. 2012. "Peer Effects in Learning HIV Results." *Journal of Development Economics* 97 (1): 118–129.

Grimm, Michael, Anicet Munyehirwe, Jörg Peters, and Maximiliane Sievert. 2014. "A First Step up the Energy Ladder? Low Cost Solar Kits and Household's Welfare in Rural Rwanda." USAEE Working Paper 14-189.

Guiteras, R., D.I. Levine, T. Polley, and B. Quistorff. 2013. "Credit Constraints, Present Bias and Investment in Health: Evidence from Micropayments for Clean Water in Dhaka." Unpublished Working Paper.

Hoffmann, Vivian. 2009. "Intrahousehold Allocation of Free and Purchased Mosquito Nets." *American Economic Review* 99 (2): 236–41.

Hoxby, Caroline Minter. 2000. "Peer Effects in the Classroom: Learning from Gender and Race Variation." NBER Working Paper 7867.

International Energy Agency. 2014. *World Energy Outlook*. Paris: International Energy Agency.

Jovanovic, Boyan, and Yaw Nyarko. 1994. "The Bayesian Foundations of Learning by Doing." NBER Working Paper 4739.

Kling, Jeffrey R., and Jeffrey B Liebman. 2007. "Experimental Analysis of Neighborhood Effects." *Econometrica* 75 (1): 83–119.

Kremer, Michael, and Dan Levy. 2008. "Peer Effects and Alcohol Use among College Students." *Journal of Economic Perspectives* 22 (3): 189–206.

Kremer, Michael, and Edward Miguel. 2007. "The Illusion of Sustainability." *Quarterly Journal of Economics* 122 (3): 1007–1065.

Levine, David I., Theresa Beltramo, Garrick Blalock, and Carolyn Cotterman. 2012. "What Impedes Efficient Adoption of Products? Evidence from Randomized Variation in Sales Offers for Improved Cookstoves in Uganda." Working Paper Series, Institute for Research on Labor and Employment, University of California, Berkeley.

Lucas, Robert E. 1988. "On the Mechanics of Economic Development." *Journal of Monetary Economics* 22 (1): 3–42.

Manski, Charles F. 1993. "Identification of Encogenous Social Effects: The Reflection Problem." *Review of Economic Studies* 60 (3): 531–542.

Mas, Alexandre, and Enrico Moretti. 2009. "Peers at Work." *American Economic Review* 99 (1): 112–145.

Miguel, Edward, and Michael Kremer. 2004. "Worms: Identifying Impacts on Education and Health in the Presence of Treatment Externalities." *Econometrica* 72 (1): 159–217.

Miller, Grant, and A. Mushfiq Mobarak. 2013. "Gender Differences in Preferences, Intra-household Externalities, and Low Demand for Improved Cookstoves." NBER Working Paper 18964.

Mobius, Markus M., Paul Niehaus, and Tanya S. Rosenblat. 2005. "Social Learning and Consumer Demand." NBER Working Paper.

Munshi, Kaivan. 2003. “Networks in the Modern Economy: Mexican Migrants in the U.S. Labor Market.” *The Quarterly Journal of Economics* 118 (2): 549–599.

Oster, Emily, and Rebecca Thornton. 2012. “Determinants of Technology Adoption: Peer Effects in Menstrual Cup Take-Up.” *Journal of the European Economic Association* 10 (6): 1263–1293.

Rao, Neel, Markus M. Mobius, and Tanya Rosenblat. 2007. “Social Networks and Vaccination Decisions.” Federal Researve Bank of Boston Working Paper No. 07-12.

Robinson, Jonathan. 2012. “Limited Insurance within the Household: Evidence from a Field Experiment in Kenya.” *American Economic Journal: Applied Economics* 4 (4): 140–164.

Romer, Paul M. 1986. “Increasing Returns and Long-Run growth.” *Journal of Political Economy* 94 (5): 1002–1037.

Sacerdote, Bruce. 2001. “Peer Effects with Random Assignment: Results for Dartmouth Roommates.” *The Quarterly Journal of Economics* 116 (2): 681–704.

Schaner, Simone. 2015. “Do Opposites Detract? Intrahousehold Preference Heterogeneity and Inefficient Strategic Savings.” *American Economic Journal: Applied Economics* 7 (2): 135–174.

Udry, Christopher. 1996. “Gender, Agricultural Production, and the Theory of the Household.” *Journal of Political Economy* 104 (5): 1010–1046.

Wilson, Robert. 1975. “Informational Economies of Scale.” *Bell Journal of Economics* 6 (1): 184–195.

Zimmerman, David J. 2003. “Peer Effects in Academic Outcomes: Evidence from a Natural Experiment.” *The Review of Economics and Statistics* 85 (1): 9–23.

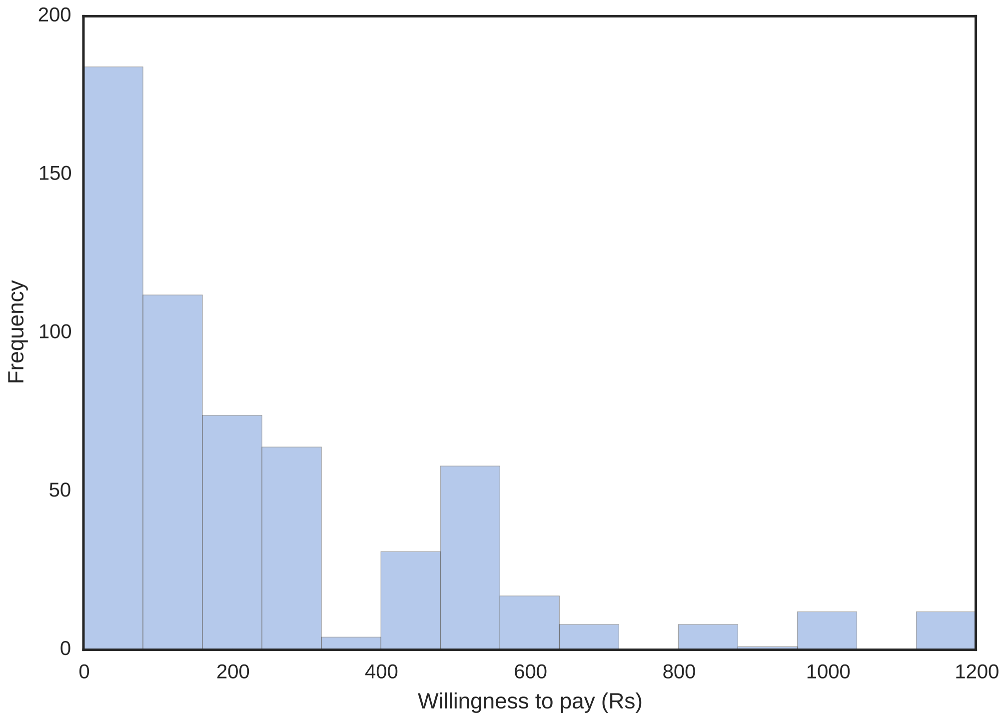

Figure 1: Histogram of bids for the solar lantern. Summary statistics are as follows: minimum = 0; maximum = 1200; mean = 239; standard deviation = 266.

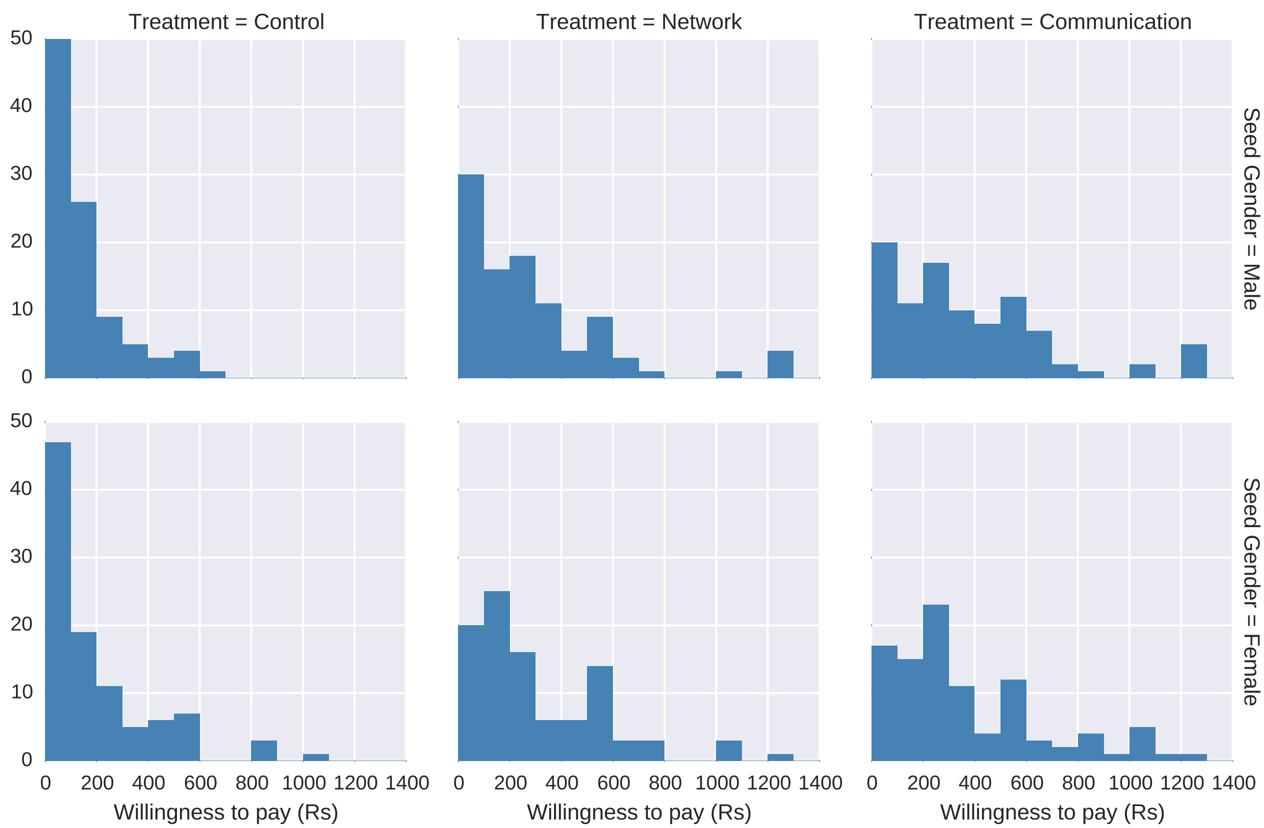

Figure 2: Faceted histogram of bids for the solar lantern.

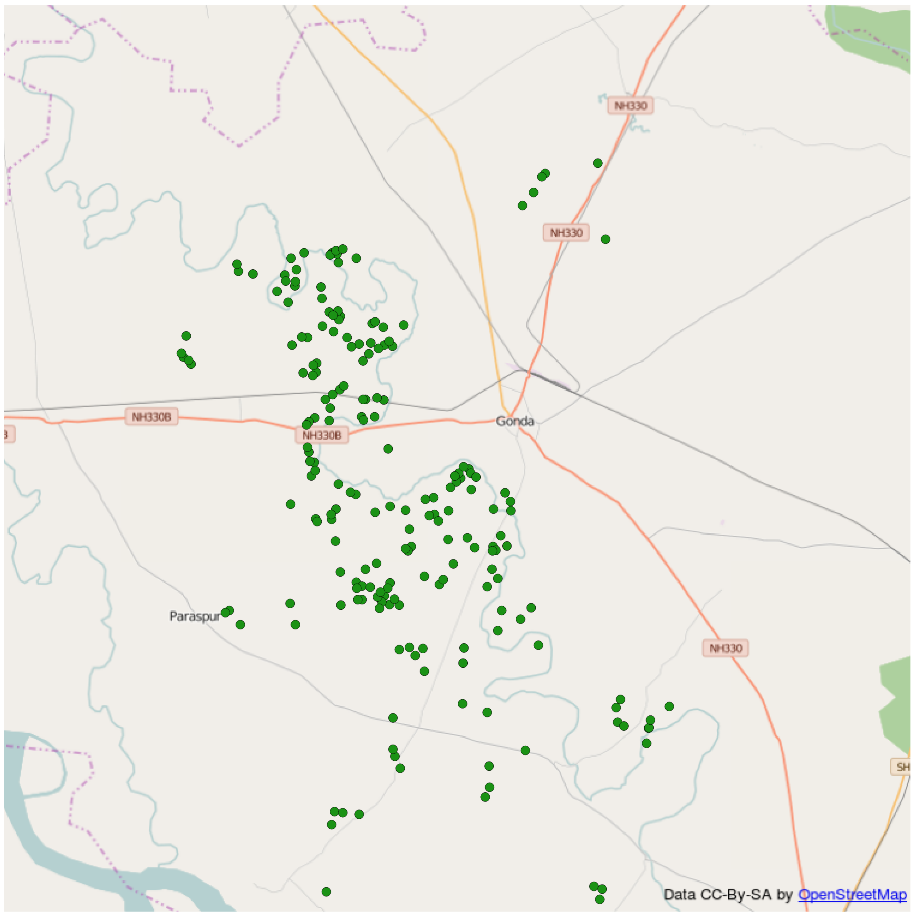

Figure 3: Map of study area around Gonda City. The green dots indicate the study habitations.

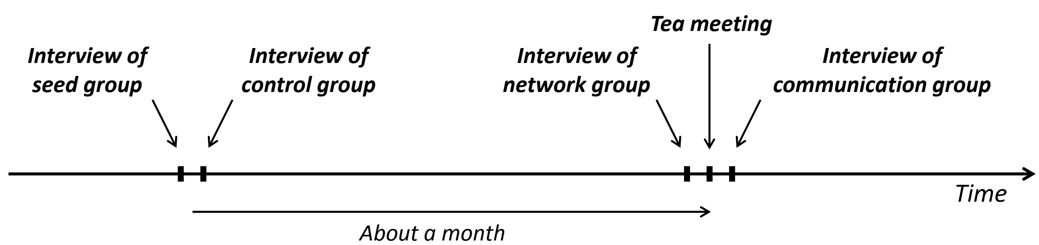

Figure 4: Timeline of the experiment.

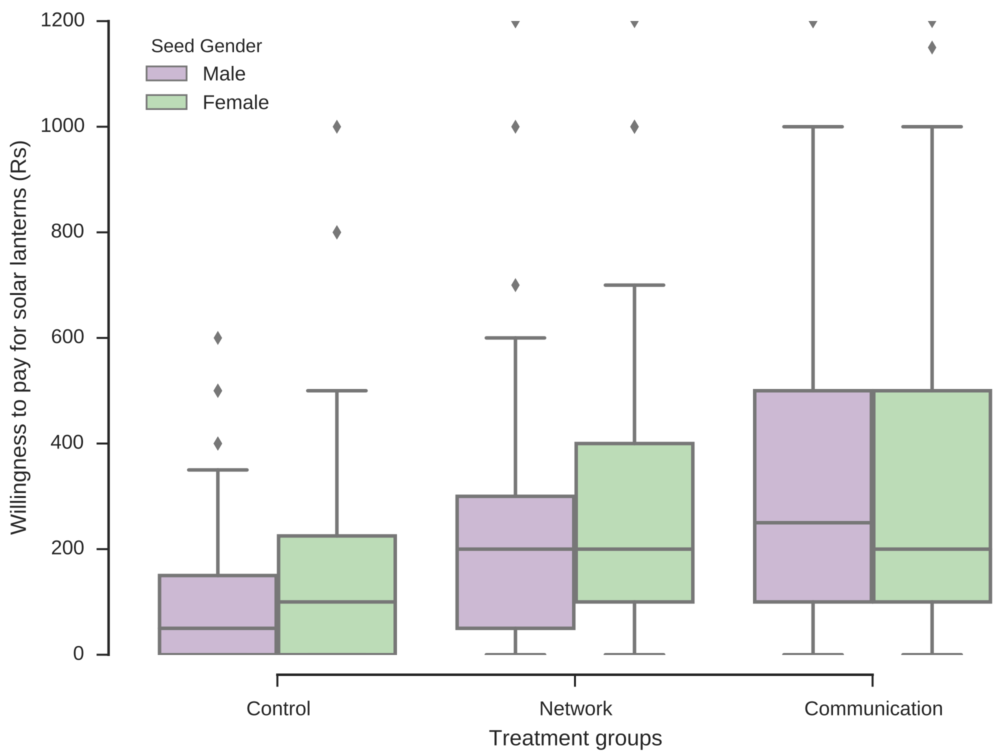

Figure 5: Faceted histogram of bids for the solar lantern.

		Information treatment		
		Control	**Network**	**Communication**
Gender	**Male**	98	98	98
treatment	**Female**	99	99	99

Table 1: Summary of treatment group sizes. In all treatments, the sample household's head is interviewed. The gender treatment is randomized across habitations; the information treatment is randomized within habitations.

	Cont	Net	DIFF	Cont	Comm	DIFF	Net	Comm	DIFF
If respondent is female	0.355	0.198	0.157***	0.355	0.254	0.102**	0.198	0.254	-0.0558
	(0.480)	(0.399)	(3.54)	(0.480)	(0.436)	(2.20)	(0.399)	(0.436)	(-1.32)
Year of birth	1972.1	1971.8	0.239	1972.1	1970.7	1.345	1971.8	1970.7	1.107
	(14.76)	(14.24)	(0.16)	(14.76)	(12.91)	(0.96)	(14.24)	(12.91)	(0.81)
Education	1.944	2.041	-0.0964	1.944	1.893	0.0508	2.041	1.893	0.147
	(1.352)	(1.435)	(-0.69)	(1.352)	(1.255)	(0.39)	(1.435)	(1.255)	(1.08)
If reads hindi	0.477	0.487	-0.0102	0.477	0.482	-0.00508	0.487	0.482	0.00508
	(0.501)	(0.501)	(-0.20)	(0.501)	(0.501)	(-0.10)	(0.501)	(0.501)	(0.10)
Number of children	3.693	3.918	-0.225	3.693	4.015	-0.323	3.918	4.015	-0.0979
	(2.106)	(2.032)	(-1.07)	(2.106)	(2.085)	(-1.51)	(2.032)	(2.085)	(-0.47)
Number of children to school	1.370	1.412	-0.0426	1.370	1.649	-0.280*	1.412	1.649	-0.237
	(1.550)	(1.562)	(-0.27)	(1.550)	(1.657)	(-1.71)	(1.562)	(1.657)	(-1.45)
Household size	7.310	7.183	0.127	7.310	7.289	0.0203	7.183	7.289	-0.107
	(3.916)	(3.379)	(0.34)	(3.916)	(3.375)	(0.06)	(3.379)	(3.375)	(-0.31)
Monthly Expenses	4176.6	4376.6	-200	4176.6	4530.5	-353.8	4376.6	4530.5	-153.8
	(2334.3)	(3412.5)	(-0.68)	(2334.3)	(2810.7)	(-1.36)	(3412.5)	(2810.7)	(-0.49)
Amount of Savings	223.4	682.2	-458.9***	223.4	661.4	-438.1***	682.2	661.4	20.81
	(673.8)	(884.1)	(-5.79)	(673.8)	(1038.3)	(-4.97)	(884.1)	(1038.3)	(0.21)
If in debt	0.467	0.609	-0.142***	0.467	0.477	-0.0102	0.609	0.477	0.132***
	(0.500)	(0.489)	(-2.85)	(0.500)	(0.501)	(-0.20)	(0.489)	(0.501)	(2.65)
If owns a business	0.0355	0.0660	-0.0305	0.0355	0.0711	-0.0355	0.0660	0.0711	-0.00508
	(0.186)	(0.249)	(-1.38)	(0.186)	(0.258)	(-1.57)	(0.249)	(0.258)	(-0.20)
Amount of land (acres)	1.310	1.443	-0.134	1.310	1.415	-0.106	1.443	1.415	0.0278
	(1.888)	(1.936)	(-0.69)	(1.888)	(1.426)	(-0.63)	(1.936)	(1.426)	(0.16)
If owns cattle	0.873	0.873	0	0.873	0.929	-0.0558*	0.873	0.929	-0.0558*
	(0.334)	(0.334)	(0.00)	(0.334)	(0.258)	(-1.86)	(0.334)	(0.258)	(-1.86)
If has a phone	0.853	0.838	0.0152	0.853	0.868	-0.0152	0.838	0.868	-0.0305
	(0.355)	(0.370)	(0.42)	(0.355)	(0.339)	(-0.44)	(0.370)	(0.339)	(-0.85)
Number of kerosene lamps	2.376	2.421	-0.0457	2.376	2.401	-0.0254	2.421	2.401	0.0203
	(1.266)	(1.229)	(-0.36)	(1.266)	(1.043)	(-0.22)	(1.229)	(1.043)	(0.18)
Hours of lighting	5.178	4.782	0.396*	5.178	5.033	0.145	4.782	5.033	-0.251
	(2.368)	(1.814)	(1.86)	(2.368)	(1.766)	(0.69)	(1.814)	(1.766)	(-1.39)

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2: Balance table across treatments and associated T-tests. A rank-sum test (Wilcoxon-Mann-Whitney) was also performed for the variables that do not approximate a normal distribution. The only difference with the t tests are as follows. 1) The difference between control and communication for the number of children that go to school is significant at the 10% level. 2) The difference between network and communication for hours of lighting is now significant at the 10% level.

	Cont M	Cont F	DIFF	Net M	Net F	DIFF	Comm M	Comm F	DIFF
If respondent is female	0.153	0.556	-0.402***	0.102	0.293	-0.191***	0.153	0.354	-0.200***
	(0.362)	(0.499)	(-6.47)	(0.304)	(0.457)	(-3.45)	(0.362)	(0.480)	(-3.31)
Year of birth	1971.3	1972.8	1.532	1971.6	1972.1	-0.529	1969.7	1971.8	-2.043
	(15.89)	(13.58)	(-0.73)	(15.06)	(13.44)	(-0.26)	(12.82)	(12.97)	(-1.11)
Education	2.051	1.838	.213	2.265	1.818	0.447**	1.980	1.808	0.172
	(1.357)	(1.345)	(1.10)	(1.544)	(1.289)	(2.21)	(1.284)	(1.226)	(0.96)
If reads hindi	0.541	0.414	0.127*	0.592	0.384	0.208***	0.490	0.475	0.0150
	(0.501)	(0.495)	(1.79)	(0.494)	(0.489)	(2.97)	(0.502)	(0.502)	(0.21)
Number of children	3.543	3.837	-0.294	3.823	4.010	-0.187	3.918	4.113	-0.196
	(2.077)	(2.133)	(-0.97)	(2.026)	(2.043)	(-0.64)	(2.045)	(2.131)	(-0.65)
Number of children to school	1.223	1.510	-0.287	1.417	1.408	0.00850	1.526	1.773	-0.247
	(1.489)	(1.601)	(-1.28)	(1.499)	(1.630)	(0.04)	(1.690)	(1.623)	(-1.04)
Household size	7.357	7.263	0.0945	7.765	6.606	1.159**	7.939	6.646	1.292***
	(3.946)	(3.906)	(0.17)	(3.705)	(2.927)	(2.44)	(3.472)	(3.163)	(2.73)
Monthly Expenses	3899.0	4451.5	-552.5*	4844.9	3913.1	931.8*	4940.8	4124.2	816.6**
	(2240.9)	(2403.0)	(-1.67)	(4403.4)	(1913.7)	(1.93)	(3206.4)	(2299.6)	(2.06)
Amount of Savings	278.6	168.7	109.9	717.3	647.5	69.87	672.4	650.5	21.94
	(776.2)	(552.7)	(1.15)	(914.5)	(856.1)	(0.55)	(740.3)	(1270.3)	(0.15)
If in debt	0.480	0.455	0.0250	0.582	0.636	-0.0547	0.480	0.475	0.00484
	(0.502)	(0.500)	(0.35)	(0.496)	(0.483)	(-0.78)	(0.502)	(0.502)	(0.07)
If owns a business	0.0510	0.0202	0.0308	0.0816	0.0505	0.0311	0.0612	0.0808	-0.0196
	(0.221)	(0.141)	(1.17)	(0.275)	(0.220)	(0.88)	(0.241)	(0.274)	(-0.53)
Amount of land (acres)	1.196	1.422	-0.226	1.431	1.455	-0.0248	1.604	1.228	0.375*
	(1.157)	(2.404)	(-0.84)	(1.678)	(2.170)	(-0.09)	(1.638)	(1.158)	(1.86)
If owns cattle	0.827	0.919	-0.0927*	0.867	0.879	-0.0114	0.918	0.939	-0.0210
	(0.381)	(0.274)	(-1.96)	(0.341)	(0.328)	(-0.24)	(0.275)	(0.240)	(-0.57)
If has a phone	0.816	0.889	-0.0726	0.806	0.869	-0.0626	0.908	0.828	0.0799*
	(0.389)	(0.316)	(-1.44)	(0.397)	(0.339)	(-1.19)	(0.290)	(0.379)	(1.66)
Number of kerosene lamps	2.235	2.515	-0.280	2.439	2.404	0.0347	2.541	2.263	0.278*
	(1.250)	(1.273)	(-1.56)	(1.332)	(1.124)	(0.20)	(1.141)	(0.921)	(1.88)
Hours of lighting	5.082	5.273	-0.191	4.806	4.758	0.0485	5.005	5.061	-0.0555
	(2.218)	(2.515)	(-0.57)	(1.892)	(1.743)	(0.19)	(1.709)	(1.828)	(-0.22)

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Balance table across treatments and seed gender and associated T-tests. A rank-sum test (Wilcoxon-Mann-Whitney) was also performed for the variables that do not approximate a normal distribution. The only difference with the t tests are as follows. 1) The difference in education level is significant at 10% in the control group. 2) The difference in household expenses is not significant in the network group. 3) The difference in savings seeds is significant at 10% in the communication group. 4) The difference in irrigated land is not significant in the communication group. 5) The difference in the number of kerosene lamps is not significant in the communication group.

	Control	Network	Communication
WTP - All seeds	133.5	254.9	330.2
	(180.6)	(267.0)	(300.4)
WTP - Male Seed	107.1	245.4	334.2
	(141.6)	(278.9)	(308.1)
WTP - Female Seed	159.6	264.4	326.3
	(209.8)	(255.8)	(294.5)

Variable: Willingness to Pay. Means and standard deviations.

Table 4: Means across treatments.

	Differences		
	Control - Network	Control - Communication	Network - Communication
WTP - All seeds	-121.4***	-196.7***	-75.26***
	(-5.27)	(-7.86)	(-2.61)
WTP - Male Seed	-138.2***	-227.1***	-88.85**
	(-4.37)	(-6.61)	(-2.10)
WTP - Female Seed	-104.8***	-166.7***	-61.83
	(-3.14)	(-4.59)	(-1.57)

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Tests for means across treatments. Chi square tests for whether the mean WTP is the same in all treatment groups always yield that the three coefficients are different at the 1% level in the whole sample as well as in the subsample of female seeds and the subsample of male seeds. Rank-sum tests were also performed for each of the t-tests and p-values were found identical. The χ^2 test statistic for identical mean WTP across treatment groups is 94.17; with 34 degrees of freedom, the associated p-value equals 0. The χ^2 test statistic for the WTP to be equal in all treatment groups within the subsample of male seed is 60.99; with 30 degrees of freedom, the associated p-value equals 0.001. The χ^2 test statistic for the WTP to be equal in all treatment groups within the subsample of female seed is 55.69; with 32 degrees of freedom, the associated p-value equals 0.006. The z statistics for the rank-sum tests are as follows. First row: -5.5; -7.9; -2.8. Second row: -4.2; -6.2; -2.4. Third row: -3.6; -5.0; -1.5.

	Differences Male - Female
WTP - Control	-52.45**
	(-2.05)
WTP - Network	-19.07
	(-0.50)
WTP - Communication	7.948
	(0.18)

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Tests for means across seed gender. Rank-sum tests: CONTROL) z = -1.463, Prob > |z| = 0.1435. NETWORK) z =-0.876, Prob > |z| = 0.3811. COMMUNICATION) z = 0.166, Prob > |z| = 0.8682. Control not significant in rank-sum test.

	(1) WTP	(2) WTP	(3) WTP	(4) WTP
Network	119.883***		116.383***	136.988***
	(22.115)		(30.297)	(30.847)
Communication	195.078***		204.785***	224.416***
	(22.925)		(32.325)	(32.086)
Seed Gender		22.241		
		(24.674)		
Network x Female Seed			9.080	-34.067
			(38.292)	(44.229)
Communication x Female Seed			-16.890	-57.749
			(42.631)	(45.745)
Habitation fixed effects	Yes	No	No	Yes
Clustered SE	Yes	Yes	Yes	Yes
R-squared	0.157	0.002		0.161
Observations	585	585	585	585

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Main results for experimental treatments. In column 1, the coefficients for Network and Communication are different at the 1% level.

	(1) WTP	(2) WTP	(3) WTP	(4) WTP	(5) WTP	(6) WTP
Network	103.683***	123.854***	388.290**	412.646**	107.520***	125.457***
	(22.937)	(31.026)	(180.316)	(189.415)	(23.925)	(32.834)
Communication	181.072***	214.322***	470.514***	512.705***	180.476***	212.441***
	(24.064)	(32.395)	(180.690)	(191.691)	(25.348)	(34.565)
If respondent is female	-27.911	-33.277	-29.942	-35.104	-23.510	-28.749
	(26.594)	(26.889)	(26.485)	(26.841)	(29.275)	(29.427)
Amount of Savings	0.026**	0.026**	0.027**	0.027**	0.025**	0.025**
	(0.013)	(0.013)	(0.013)	(0.013)	(0.012)	(0.012)
Network x Female Seed		-42.230		-35.277		-37.572
		(43.469)		(42.528)		(45.246)
Communication x Female Seed		-66.918		-69.409		-64.079
		(47.236)		(47.383)		(50.326)
Interview date			-7.698	-7.901		
			(4.800)	(4.921)		
Education					4.459	4.131
					(11.716)	(11.761)
Monthly Expenses					-0.005	-0.006
					(0.005)	(0.005)
If in debt					-26.115	-24.736
					(26.128)	(26.222)
Household size					-2.565	-2.594
					(3.855)	(3.801)
Number of children to school					11.893	11.873
					(7.433)	(7.445)
Number of kerosene lamps					19.780*	18.352
					(11.547)	(11.842)
Hours of lighting					1.415	1.431
					(6.504)	(6.609)
Habitation fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.167	0.171	0.176	0.181	0.181	0.185
Observations	585	585	584	584	574	574

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Main results for experimental treatments with control variables included.

Question	**Answer type**	**Label used in table**
Had you seen a solar lantern before?	Yes or no.	Seen lantern before
Do you know someone with a solar lantern?	Yes or no.	Know someone with lantern
Do you think a solar lantern can function properly without many maintenance problems?	Yes or no.	If can function
How much would you say this solar lantern costs?	Amount in Rupees.	Cost estimate
Do you think that the solar lantern is an innovative product?	Definitively not, Not really, Neutral, Somewhat, Definitively.	Innovative product
Would you say that a solar lantern is a superior product compared to a kerosene lamp?	Definitively not, Not really, Neutral, Somewhat, Definitively.	Superior to kerosene lamps
Do you think you will recommend others to use a solar lantern instead of a kerosene lamp?	Definitively not, Not really, Neutral, Somewhat, Definitively.	Will recommend to others
Would you feel safer if there was more light?	Definitively not, Not really, Neutral, Somewhat, Definitively.	Would feel safer if more light
Have you ever been victim of a kerosene fire?	Yes = 1, No = 0	Was victim of kerosene fire
Do you know someone who has been victim of a kerosene fire?	Yes = 1, No = 0	Knows a victim of a kerosene fire

Table 9: Description of questions used in Table 10.

	Cont.	Net.	DIFF	Cont.	Comm.	DIFF	Net.	Comm.	DIFF
Seen lantern before	0.244	0.934	-0.690***	0.244	0.949	-0.706***	0.934	0.949	-0.0152
	(0.430)	(0.249)	(-19.49)	(0.430)	(0.220)	(-20.49)	(0.249)	(0.220)	(-0.64)
Know someone with lantern	0.132	0.924	-0.792***	0.132	0.944	-0.812***	0.924	0.944	-0.0203
	(0.339)	(0.266)	(-25.78)	(0.339)	(0.230)	(-27.80)	(0.266)	(0.230)	(-0.81)
If can function properly	0.533	0.0508	0.482***	0.533	0.0914	0.442***	0.0508	0.0914	-0.0406
	(0.500)	(0.220)	(12.39)	(0.500)	(0.289)	(10.73)	(0.220)	(0.289)	(-1.57)
Cost estimate	627.1	838.7	-211.6***	627.1	736.6	-109.5**	838.7	736.6	102.1*
	(558.7)	(647.9)	(-3.47)	(558.7)	(538.9)	(-1.98)	(647.9)	(538.9)	(1.70)
Innovative product	4.939	4.980	-0.0405	4.939	4.970	-0.0305	4.980	4.970	0.0100
	(0.373)	(0.226)	(-1.30)	(0.373)	(0.200)	(-1.01)	(0.226)	(0.200)	(0.47)
Superior to kerosene lamps	4.995	4.980	0.0152	4.995	4.985	0.0101	4.980	4.985	-0.00508
	(0.0714)	(0.174)	(1.13)	(0.0714)	(0.123)	(1.00)	(0.174)	(0.123)	(-0.33)
Will recommend to others	4.995	4.975	0.0203	4.995	4.949	0.0457*	4.975	4.949	0.0254
	(0.0712)	(0.187)	(1.42)	(0.0712)	(0.346)	(1.81)	(0.187)	(0.346)	(0.91)

* See precise phrasing of the questions in previous table.

Table 10: Summary statistics for some key variables highlighting possible mechanisms.

Question	**Answer type**	**Label used in table**
Do your children use lighting for studying	Yes or No.	If children use lighting for studying
Do you believe your current lighting solution is bad for your eyesight?	Definitively not = 1, Not really = 2, Neutral = 3, Somewhat = 4, Definitively = 5.	Current lighting bad for eyesight
Who in your household do you think will/would mostly be using the solar lantern?	Myself, My spouse, My children, No one, Other	Mostly be using: myself and Mostly be using: my spouse
Do you and your spouse talk about what to spend money on?	Never = 0, Sometimes = 1, Often = 2	Talk about how to spend money
Do you think more women should work outside of the household or own a business?	Definitively not = 1, Not really = 2, Neutral = 3, Somewhat = 4, Definitively = 5	More women should work outside
How often did you participate in village meetings during the past six months?	Almost all of them = 2, Some of them = 1, None of them = 0	Participation in village meetings
How often did you participate in farmers' cooperative meetings during the past six months?	Almost all of them = 2, Some of them = 1, None of them = 0	Participation in farmers' cooperative meetings
How often did you participate in religious group events during the past six months?	Almost all of them = 2, Some of them = 1, None of them = 0	Participation in religious group events
How often did you participate in political events during the past six months?	Almost all of them = 2, Some of them = 1, None of them = 0	Participation in political events
Do you trust other villagers?	Definitively not = 1, Not really = 2, Neutral = 3, Somewhat = 4, Definitively = 5	Trust other villagers
In your spare time, do you mostly spend time with your friends or stay home?	Spend time with friends = 1, Stay home = 0	Spend time with friends (dummy)
How many friends do you have in this village?	number of friends	Number of friends

Table 11: Description of questions used it Table 12 and 13.

	Male Seeds	Female Seeds	Difference
If born in village	0.970	0.140	0.830***
	(0.171)	(0.349)	(11.78)
Number of children	3.714	4.530	-0.816**
	(2.021)	(2.418)	(-2.11)
Education	2.090	1.480	0.610***
	(1.296)	(0.990)	(3.86)
Education of spouse	1.265	2.360	-1.095***
	(0.807)	(1.345)	(-7.10)
If reads hindi	0.530	0.310	0.220***
	(0.502)	(0.465)	(3.15)
Amount of savings	387	228	159**
	(1197.5)	(1076.1)	(2.18)
If children use lighting for studying	0.560	0.700	-0.140**
	(0.499)	(0.461)	(-2.05)
Current lighting bad	4.175	4.544	-0.369**
	(1.315)	(0.876)	(-1.77)
Mostly be using: myself	0.490	0.700	-0.210***
	(0.502)	(0.461)	(-3.02)
Mostly be using: my spouse	0.300	0.0500	0.250***
	(0.461)	(0.219)	(4.64)
Talk about how to spend money	1.600	-0.180**	
	(0.684)	(0.603)	(-1.96)
Women should work outside	3.690	4.470	-0.780***
	(1.733)	(1.132)	(-3.10)
Participation in village meetings	0.280	0.140	0.140**
	(0.570)	(0.377)	(1.77)
Participation in farmers' cooperative meetings	0.140	0.0200	0.120***
	(0.377)	(0.200)	(3.28)
Participation in religious group events	1.050	0.800	0.250**
	(0.702)	(0.739)	(2.46)
Participation in political events	0.370	0.100	0.270***
	(0.630)	(0.333)	(3.66)
Trust other villagers	3.830	3.280	0.550**
	(1.436)	(1.694)	(2.14)
Spend time with friends (dummy)	0.380	0.240	0.140**
	(0.488)	(0.429)	(2.14)
Number of friends	10.02	6.390	3.630***
	(11.52)	(4.722)	(3.05)

Table 12: Summary statistics for the two seed groups (male and female), with the corresponding z statistics of the rank-sum test. Variables with significant differences only are shown.

	Male Seed Friends	Female Seed Friends	Difference
If respondent is female	0.136	0.401	-0.265***
	(0.343)	(0.491)	(-7.25)
Education	2.099	1.822	0.277***
	(1.400)	(1.283)	(2.95)
If reads hindi	0.541	0.424	0.117***
	(0.499)	(0.495)	(2.83)
Amount of savings	556.1	488.9	67.23**
	(834.7)	(964.1)	(2.12)
Household size	7.687	6.838	0.849***
	(3.708)	(3.360)	(2.90)
If can function properly	0.255	0.195	0.0598*
	(0.437)	(0.397)	(1.74)
Would feel safer if more light	4.990	4.959	0.0303*
	(0.130)	(0.270)	(1.90)
Was victim of kerosene fire	0.184	0.108	0.0759***
	(0.388)	(0.311)	(2.62)
Knows a victim of a kerosene fire	0.323	0.249	0.0740**
	(0.468)	(0.433)	(1.99)
Mostly be using: myself	0.257	0.332	-0.0755**
	(0.438)	(0.472)	(-2.02)
Mostly be using: spouse	0.436	0.322	0.114***
	(0.497)	(0.468)	(2.85)

Table 13: Social network analysis: characteristics of the friends chosen by the male seeds and the female seeds, with the corresponding z statistics of the rank-sum test. Variables with significant differences only are shown.