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

Yonas Alem
University of Gothenburg

Eugenie Dugoua
London School of Economics

September 30, 2019

Abstract

Interactions among peers of the same social network play significant roles in facilitating adoption and diffusion of modern technologies in poor communities. We conduct a large-scale randomized controlled trial in rural India to identify the impact of information from friends on willingness to pay (WTP) for high-quality and multi-purpose solar lanterns. We offered solar lanterns to seed households from 200 non-electrified villages and randomly assigned three of their friends to two communication treatments (unincentivized and incentivized) that led them to different exposure to their seed friend. We also introduce a second treatment to investigate whether the seed's gender identity impacts the magnitude of peer effects. We show that, while unincentivized communication increases WTP for solar lanterns by 90% and incentivized communication by 145%, gender doesn't seem to matter. We also show that learning from others is the mechanism that drives the increase in WTP.

JEL: O33, D83, Q21, Q42

Keywords: Technology Adoption; Peer Effects; Information Flows; Solar Technologies

*Yonas Alem (Corresponding Author) is the Director of Academic Programs at the Environment for Development Network (EfD); School of Business, Economics and Law; University of Gothenburg; his email address is yonas.alem@gu.se. Eugenie Dugoua is an Assistant Professor in Environmental Economics at the London School of Economics; her email address is e.dugoua@lse.ac.uk. We thank Pascaline Dupas, Mudit Kappor, Simon Schurz, participants at the Economic Development in Africa annual conference at the University of Oxford, the Center for the Studies of African Economies (CSAE, Oxford); the Nordic Development Economics Conference (Oslo); the Association of Swedish Development Economists workshop (Gothenburg); the Institute for Economic Growth (New Delhi); and the 13th Annual Conference on Economic Growth, Indian Statistical Institute (New Delhi) for helpful comments on earlier versions of the paper. We offer our special thanks to Johannes Urpelainen for helpful inputs in all stages of the project and 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. Declarations of interest: none. All errors remain our own.

1 Introduction

Theories of economic growth hold technological progress as the main engine of economic development. In particular, endogenous growth models highlight the important role of social learning in technology diffusion: profit- or utility-maximizing agents invest, learn by doing and learn from each other through knowledge spillovers (Acemoglu, 2009; Aghion and Howitt, 1997; Barro and SalaiMartin, 2004; Lucas, 1988; Romer, 1986). This phenomenon has been especially documented for the diffusion of agricultural technologies in developing countries (Bandiera and Rasul, 2006; Bardhan and Udry, 1999; Conley and Udry, 2010; Foster and Rosenzweig, 1995). But peers, or broadly speaking of one's social network, also influence a host of other individual outcomes such as those related to education (e.g., Angrist and Lang, 2002; Figlio, 2005; Hoxby, 2000; Sacerdote, 2001; Zimmerman, 2003), health (e.g., Kling and Liebman, 2007; Munshi, 2003), labor productivity and consumption (e.g., Mas and Moretti, 2009; Mobius, Niehaus, and Rosenblat, 2005).

In this paper, we conduct a randomized controlled trial to investigate and quantify the magnitude of peer effects on willingness-to-pay (WTP) for a new solar-powered lantern in the Uttar Pradesh state of India. The solar lanterns are durable, multipurpose, and convenient to use. They sold for Indian rupees (INR) 1,200 (USD 18.5) in Lucknow, the capital of Uttar Pradesh state at the time of the fieldwork. The lanterns also have a mobile phone-charging feature, which makes them appealing. 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, to whom we offered the solar lantern for participating in the study. Each seed household gave three names of close peers (friends or relatives) with whom they regularly interact. We then randomly assigned these friends to a control group, an "unincentivized" communication treatment, and an "incentivized" communication treatment". We interviewed and elicited willingness to pay for the solar lanterns using the Becker-Degroot-Marschak (BDM) method (Becker, Degroot, and Marschak, 1964) from all the three friends, but at different points in time. We elicited WTP from the control group immediately after interviewing the seed household. This allows us to capture WTP when there is no prior knowledge of what lanterns are and how to use them. We elicited WTP for both the unincentivized and incentivized groups thirty days after the seed received the lantern. However, friends in the incentivized group were invited to a "tea meeting" during which the seed presented the solar lantern and shared his or her experience. We elicited WTP of this group right after the tea meeting.

Our experimental design therefore exploits the time lags to instrument for the possibility that peers exchange information about solar lanterns. Within thirty days, peers in the "unincentivized" treatment group have likely talked to their seed friend, who may have mentioned or even demonstrated the use of the lantern. We also introduce a second treatment to instrument the identity of the peer, the gender of the original seed: out of the 200 individuals, half are male and half female. Recent empirical research has documented that the social identity of the person who carries and diffuses information can have a critical influence on how such information is understood or interpreted. In the context of technology adoption, this means that potential adopters are more susceptible to information and advice from some communicators rather than others (BenYishay and Mobarak, 2018). A key determinant seems to be whether communicators and receivers share a common group identity. In India, gender roles structure a large part of social life. We therefore investigate whether women may be less-effective communicators, especially when it comes to transmitting information about new technologies.

The results suggest that both the "unincentivized" an "incentivized" treatments have large effects on WTP for solar lanterns, while the gender treatment is not statistically significant at conventional levels (although the point estimate is negative). Specifically, we find that, on average, the unincentivized group is willing to pay INR 120 more than the control group, and the incentivized group is willing to pay INR 190 more than the control group. These correspond to proportional treatment effects of 90% and 145% increases, respectively. It is notable that the unincentivized communication treatment almost doubled WTP, whereas the incentivized communication treatment added another 55 percentage points increase to the treatment effect.

This paper is broadly related to a body of research in economics on the impact of peers on outcomes. This strand of literature, focusing largely on developed countries, investigates the impact of peers or friends on several outcome variables of interest, including educational achievement (e.g., Angrist and Lang, 2002; Figlio, 2005; Hoxby, 2000; Sacerdote, 2001; Zimmerman, 2003), market and health outcomes (e.g., Kling and Liebman, 2007; Munshi, 2003), and, labor productivity and consumption (e.g., Mas and Moretti, 2009; Mobius, Niehaus, and Rosenblat, 2005). The extent of peer effects has also been examined in the development economics literature of social-learning, largely to explain agricultural technology adoption (Bandiera and Rasul, 2006; Bardhan and Udry, 1999; Conley and Udry, 2010; Foster and Rosenzweig, 1995).[1] A particularly important observation in this literature is that modern agricultural technologies significantly improve agricultural output and welfare, but their adoption or uptake rate has been disappointingly low. It demonstrates that farmers engage in learning-by-doing and learning from others. Thus, adoption of a new

[1] The only exceptions to this are the studies by Oster and Thornton (2012) and Jain and Kapoor (2015), which investigate the impact of peers on adoption of menstrual cups by school girls in Nepal and academic achievement by university students in India, respectively.

agricultural technology by a farmer is therefore a social process because it generates knowledge to all her peers and increases their expected yield Bardhan and Udry (1999); Foster and Rosenzweig (1995). More recently, BenYishay and Mobarak (2018) extend the theory of social learning in agriculture and show that farmers are more likely to adopt new technology if they share the same social identity as the person who communicates information about the new technology.

We use a novel technology (a solar lantern) and disentangle the impact of learning through incentivized and well-targeted communication from learning through unincentivized and regular communication of peers on adoption and willingness-to-pay for the technology. A solar lantern is a superior lighting technology, which has the potential to improve the welfare of all members of the household. Unlike agricultural technologies, which involve significant uncertainty, are sensitive to specific agro-ecological conditions, and require a long time to capture their payoff; the solar lanterns we consider in this study are easy to operate and users quickly learn about their benefits. Our design also allows us to aggregate revealed WTP, a figure important for policymakers and other stakeholders to design optimal subsidy and cost reduction strategies to encourage diffusion of the technology in cases when average WTP is lower than average cost.

The major challenge in identifying the impact of peers on the adoption of new technologies, even after tackling identification issues through a randomized assignment, is understanding the mechanisms that drive the observed results. It may be that peers imitate each other rather than learning from each other about the benefits of the new technology or learning how to operate the technology (Oster and Thornton, 2012). We collected detailed information about respondents' perception of the solar lanterns as well as gender norms. In particular, we find evidence that the increase in WTP is driven both by learning how to operate the technology and learning about its benefits. We also document that households in our sample appeared to give women some say in purchasing decisions, as well as when it comes to using new products. In particular, most respondents thought that women were as able as men to use new technologies. Consequently, despite their lower overall social status, women may still be perceived as a legitimate communicator when it comes to demonstrating the pros and cons of a household product such as solar lanterns.

The paper also speaks to the emerging literature on electrification and energy transition in developing countries (Dinkelman, 2011; Dugoua and Urpelainen, 2014; Furukawa, 2014; Grimm, Munyehirwe, Peters, and Sievert, 2014; Lee, Miguel, and Wolfram, 2016; Lee, Brewer, Christiano, Meyo, Miguel, Podolsky, Rosa, and Wolfram, 2016). The current level of electrification in developing regions such as Sub-Saharan Africa, South Asia, and Latin America remains low (International Energy Agency, 2014)[2] and extending the grid to

[2]It is estimated that around 1 billion people live without electricity access and many more without reliable electricity supply. See "https://www.iea.org/energyaccess/database/" for details.

the most rural regions requires high levels of investment that are often difficult to secure by governments. In order to meet lighting needs, households in poor communities regularly use kerosene lamps. In rural areas of India, for example, about half of the population uses kerosene for lighting (Jain, Tripathi, Mani, Patnaik, Shahidi, and Ganesan, 2018). Kerosene lamps have been documented to generate indoor air pollution and adversely affect health outcomes of household members, pose a risk of burns and fires, emit hazardous greenhouse gases, and require rural households to regularly travel long distance to buy kerosene (Lam, Smith, Gauthier, and Bates, 2012). Kerosene use in the Indian context also has a significant impact on public finances. Indeed, kerosene has a long history of generous subsidies, and it has been estimated that the government could save around INR 600 per year for every consumer switching from kerosene to solar lanterns (Jain and Ramji, 2016). Solar power therefore has the potential to serve as a decentralized solution to the problem of energy poverty (Sandwell, Wheeler, and Nelson, 2017).[3] Given the increased need to reduce greenhouse gas emission from the energy sector to mitigate climate change, exploring the options for switching to solar-powered lighting equipment, which emits no greenhouse gas, reduces indoor air pollution, and helps children allocate more time to studying is crucial. From a public policy point of view, this paper offers insights on how to facilitate this transition.

The rest of the paper is organized as follows. Section 2 lays out the conceptual framework and our key hypotheses about willingness to pay for solar lanterns. Section 3 describes the design and procedure of the randomized controlled trial, with results of the randomization checks. Section 4 presents the key empirical results. Section 5 concludes the paper.

2 Conceptual Framework

Drawing on the key papers on social learning (Bandiera and Rasul, 2006; Bardhan and Udry, 1999; BenYishay and Mobarak, 2018; Conley and Udry, 2010; Foster and Rosenzweig, 1995), we lay out a brief motivating framework for interpreting the main results from our randomized controlled trial. We begin by defining the following treatments:

- In the *unincentivized* group, subjects observe the use of the new technology by others without incentivized and tailored communication. Thus, learning from others is a result of the natural interaction through social networks, and in particular with the seed household.
- In the *incentivized* group, subjects both observe the use of the new technology by others and receive direct communication about the properties of the new technology just before WTP is elicited. Thus,

[3] UNEP (2013) estimated that the substitution of solar lighting for all traditional lighting in India would save about 34 million tonnes of carbon dioxide annually. This represented roughly 1% of India's energy-related emissions in 2013.

learning from others is the result of both the natural and incentivized interactions with the seed household.

To test the presence of social learning in agriculture, studies typically make use of the "target-input" model proposed by Wilson (1975) and Jovanovic and Nyarko (1994). According to this model, farmers know the basic form of the new technology with certainty (e.g., an improved seed), but do not know the target level, which is assumed to be random. Farm profits are inversely related to the difference between the actual level of input applied and the target level. Farmers realize what the actual level of input should be only after the input is applied and output realized. As a result, the farmer learns about the new technology over time through learning-by-doing. In this model, individuals can also learn from each other's experience when they share a similar distribution of the input target. Assume that two farmers belong to the same social network and share information 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, the adoption of new technologies in this model is a social process because its adoption by an individual generates information spillover to all her peers, which increases their expected welfare in the future (Bardhan and Udry, 1999).

Diffusion of solar lanterns can be modelled using an extended version of the social learning framework because, through their interactions with the solar lantern owners, peers learn about the service provided by the lanterns and 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. Our experimental design allows for a period of one month for information to diffuse, that is, for households in the unincentivized group to learn about the solar lantern.[4] In our context, one month seems sufficient because, 1) the technology is easily observable, and 2) we offer the technology to one of their closest friends who is expected to interact with them regularly. We will show later that, indeed, all unincentivized households report knowing what a solar lantern is, indicating that one month was sufficient to ensure respondents in the treatment groups were exposed to solar lanterns through their friend. Hence, we formulate Hypothesis 1 as follows:

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

An important extension of the "target-input" model by BenYishay and Mobarak (2018) is that the member of the social network who 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

[4] Allowing for longer than a month would increase the probability of other confounders.

new technology to other 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 communicator's efforts, diffusion of the technology may occur much faster. As a result, others will learn about the new technology and adopt it much more quickly than the case of unincentivized communication through ordinary social networks. In our case, we asked the seed households to invite one of their randomly selected peers for a tea meeting after the seed household used the solar lantern for a month. This is expected to increase the salience of the product and to result in transmission of more accurate information than in the case of unincentivized regular interactions. Consequently, peers who have been provided detailed information about the attributes of the solar lanterns are likely to pay more for the lanterns than peers who were not invited for the tea meeting. Thus, we formulate Hypothesis 2 follows:

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

Finally, BenYishay and Mobarak (2018) show that, when it comes to adopting a new technology, farmers appear most convinced by communicators who share a group identity with them. In our study, the social identity we focus on is gender because gender norms in India assign women to a particularly low social status. The knowledge externalities they generate through their experience with solar lanterns may then be less effectively captured by their peers. The idea that women are less influential than men has empirically been documented. Although in a context very different from ours, Aral and Walker (2012) show, using randomized experiments on 1.3 million of Facebook users, that men are more influential than women and that women influence men more than they influence other women.

In India, women's lower social status is apparent in the overall lower levels of educational attainment and lower participation in labour markets. Gender inequalities are also pervasive inside the household, where women display lower bargaining power over many of the household's decisions (e.g., purchase of durable goods). For example, recent studies (Alem, Hassen, and Köhlin, 2017; Miller and Mobarak, 2013) show that improved cookstoves, which enhance the quality of life of all household members, are valued at significantly higher levels by women than by men, but could not be adopted optimally because women have low decision-making power. Hence, inside or outside the households, women lack social prestige. We, therefore, hypothesize that, when they communicate about a new household technology, receivers of the information are likely to pay less attention or to discount the information they receive. This implies that the effect of our communication treatments on WTP would be weaker when the seed is female. This leads to our third Hypothesis:

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

3 Experimental Design

To test our hypotheses, we collaborated with a local organization to distribute solar lanterns and conduct a randomized controlled experiment[5] in 200 non-electrified habitations[6] in India, in the Gonda district in the state of Uttar Pradesh. At the time of the experiment, the study area was still non-electrified and households did not know about solar lanterns.

Solar lanterns are small lamps (about 35 centimetres or 1.15 feet high) powered by a battery that can be charged when exposed to solar radiation. The solar lanterns we used sold for INR 1,200 in Lucknow, the capital of Uttar Pradesh state.[7] Notably, these lanterns had a USB-port feature which allowed users to charge a mobile phone. As a point of comparison, in our sample, households spent on average about INR 42 on lighting needs per month per lamp (typically on kerosene), corresponding to about INR 500 per year. Hence, if households paid the market price of the solar lantern, they would amortize it in about two and a half years. 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 lighting quality and duration, and charging power by using them with the survey team for about a week. This way, we selected the model to be durable, multipurpose, and convenient to use.

In our experiment, the subjects were given an opportunity to purchase a solar lantern in a BDM game. The experiment was conducted in two rounds between the end of July and the beginning of October 2015. The study area was chosen because it had a low electricity access rate, with many non-electrified habitations. Prior to the randomized controlled trial, a detailed pre-analysis plan (PAP) listing all research hypotheses and our key empirical specifications was registered with the "Evidence in Governance and Politics" website.[8]

The primary specification equation can be written as follows:

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

where WTP_{ij} is the willingness to pay for a solar lantern by household i in habitation j; U_i is a dummy

[5]Before implementation, the experiment was approved on the 8th of April 2015 by the internal review board (IRB) of Columbia University (IRB-AAAP2110).

[6]Habitations (also called sub-villages or hamlets) are the lowest administrative units in India.

[7]This was equivalent to about USD 18.5 at the time of the time of the fieldwork (Fall, 2015). The solar lantern had a 3-watt solar panel, a 6V 4.5Ah battery, a 3-watt, 24-piece surface-mounted-device LED, and a mobile-charging socket. See Fig. 4 of the online appendix for a photo.

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

variable coding for whether household i is in the unincentivized group; F_i is a dummy variable coding for whether the lantern was offered to a female (i.e., 1, if household i is a friend of a female seed); I_i is a dummy variable coding for whether the household is in the incentivized group (i.e., household i attended a tea meeting with the seed); μ_j is a vector of habitation fixed effects ($N = 200$); ϵ_{ij} is a random error term with the standard distributional assumptions. A term for F_i does not appear in the equation because, by design, habitation fixed effects account for it. Our objective is to estimate $\beta_1, \beta_2, \gamma_1$, and γ_2. Throughout, we cluster standard errors by habitations. In this empirical 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 $\gamma_2 < 0$.

3.1 Outcome Variable

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 drawn price is below the stated WTP, the subject pays the *randomly drawn price*, not the stated WTP.[9] 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., Guiteras, Levine, Polley, and Quistorff, 2013; Hoffmann, 2009; Levine, Beltramo, Blalock, and Cotterman, 2012) 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 typical randomized-price WTP elicitation methods).[10]

The game was played in the field as follows. We asked households to announce their maximal willingness to pay on a 0-1,200 scale (in INR). Then, 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 ranges from INR 0 to INR 1,200 in increments of INR 100.[11] The respondent first makes a bid and then randomly draws a ball. If the price on the ball 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, she/he must make sure to have access to money. The respondent has only one chance to play, and she/he cannot change her/his bid after drawing a ball. Before playing for

[9] In fact, it is plausible to argue that the game sets up a real purchasing experience. In that sense, our WTP elicitation is captured through revealed preferences.

[10] In practice, prices are drawn from a distribution of discrete numbers so the demand curve is defined on these numbers only.

[11] The game is therefore incentive-compatible across increments of INR 100.

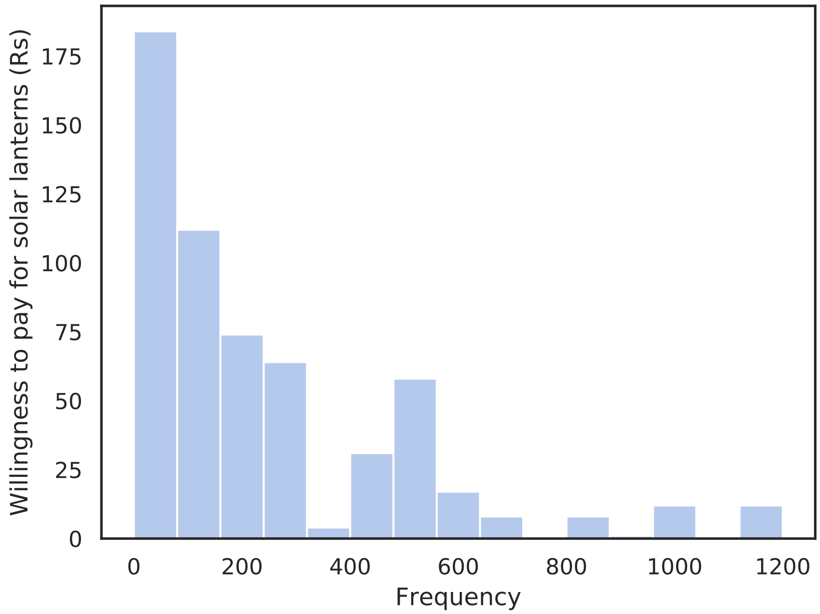

Figure 1: Histogram of bids for solar lanterns. Summary statistics are as follows: minimum = INR 0; maximum = INR 1200; mean = INR 239; standard deviation = INR 266.

'real', we conducted a practice round with a bar of soap to make sure the respondents fully understood the rules.

Figure 1 displays the distribution of the bids: we see that most subjects made a positive bid, but no subject offered the full market price of the lantern. We also note that WTP displays important variation across individuals, spanning 0 to 1200, with mean 239 and standard deviation 266. At the end, a total of 160 respondents (42 in the control group, 55 in the unincentivized group and 63 in the incentivized group) ended up purchasing the lantern because their bid was higher than or equal to their draw.

In measuring WTP, we paid a particular attention to training the enumerators so that they explained the procedure to the subjects carefully 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 when 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 pay any money.

3.2 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 Gonda City visited first and those farther away visited later. If a habitation was excluded because of safety concerns

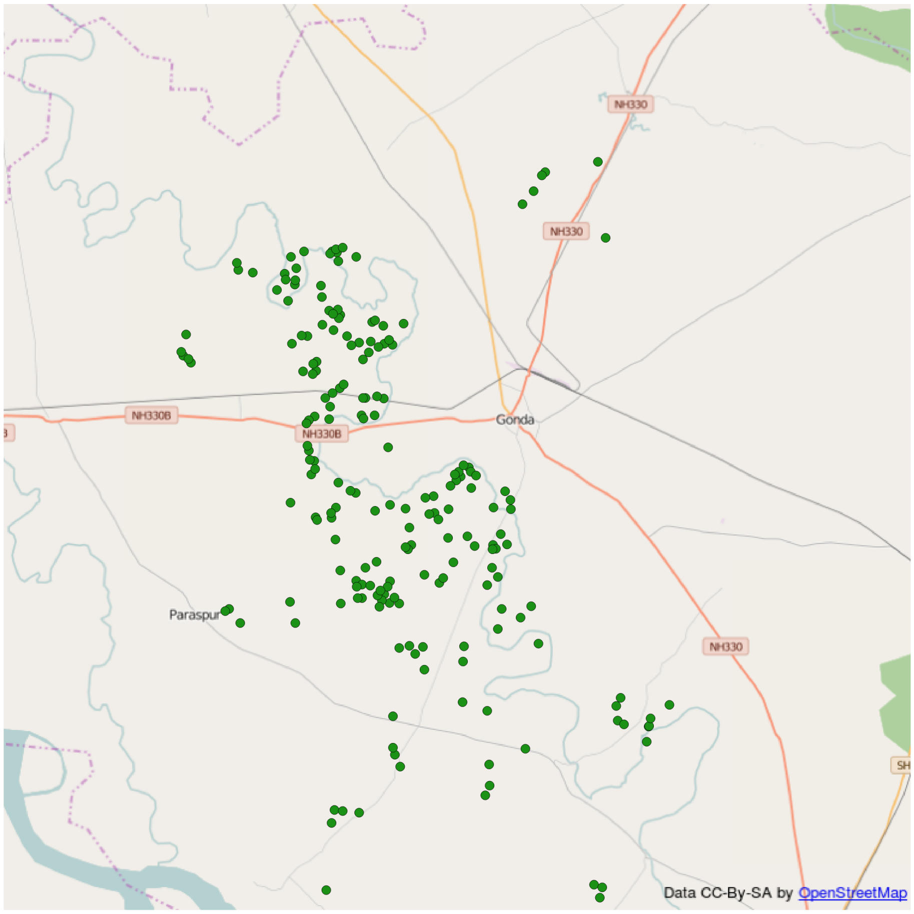

Figure 2: Map of study area around Gonda City. Green dots indicate the habitations included in the experiment

or because it had access to grid electricity, a randomly drawn replacement habitation was used instead. Overall, we had to exclude and replace only five habitations. The map of the study area depicting the sample habitations is presented in Figure 2.

Within each habitation, the enumerators approached a randomly chosen seed household and, depending on the treatment, interviewed either a male or female household member. The seed was requested to provide names of three friends with whom he or she interacts on a regular basis. The three friends were then randomly assigned to three groups: control, unincentivized and incentivized communication. The control group was interviewed immediately after the seed household provided names. This way, there was no time for information about the lantern to diffuse to the friends in the control group. The unincentivized and incentivized groups were interviewed approximately 30 days after the seed. We surveyed these two groups

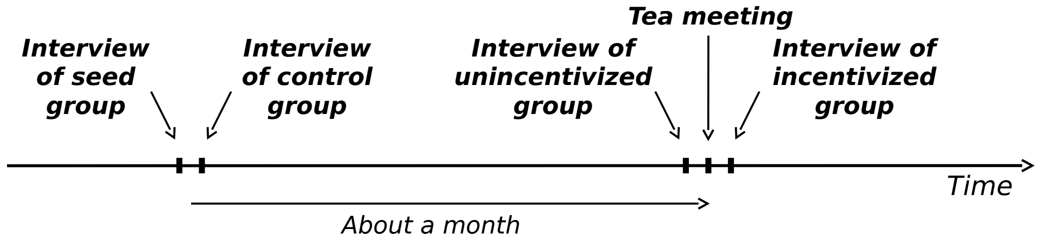

Figure 3: Timeline of the experiment

at the same time to avoid treatment spillovers. The timeline of the experiment is summarized in Figure 3. The experiment began with sampling and the interviews of the control group in July-August 2015.

We waited only 30 days because solar lanterns are products simple enough to learn about in a short time. Thirty days appeared to be reasonably long enough for information about the lantern to flow from the seed to the two treatment groups.[12] If the chosen friend was not the household head, we interviewed the head of the household to which that friend belonged.[13] Households in the three groups were all offered the possibility of buying a solar lantern through a BDM game. Before playing the BDM game with the incentivized household, the seed invited his/her "incentivized" friend over for a tea meeting to discuss his/her experience of the lantern. Table 1 summarizes the size of the different treatment groups. We visited a total of 197 habitations, 98 assigned to the male seed treatment and 99 to the female seed treatment. We dropped three habitations because the unincentivized and incentivized friends had moved away from the village and could no longer be surveyed.

The male-female treatment was randomized at the habitation level. One of the co-authors drew a random number for each habitation and assigned the highest 100 numbers to the female treatment. We gave all seed households a solar lantern and INR 100 (USD 1.54) in exchange for taking part in the survey and inviting one of the three friends for a tea meeting. Our survey team, consisting of enumerators who spoke the local dialect, attended all tea meetings. They specifically told the seed households that their goal was not to convince their friend to buy a lantern but only to share stories about their experience and the performance of the lanterns.

In order to minimize the likelihood that seeds felt unfairly privileged from receiving a solar lantern plus INR 100, we phrased the experiment to them that they won a lottery which awarded a solar lantern for

[12] We document this in the "Mechanisms" section of this paper.

[13] The person playing the game needs to be able to make a purchasing decision. That is why we always chose to interview and play the BDM game with the household head.

Table 1: Summary statistics on the size of the treatment groups

	Total number of habitations		
	Control	**Unincentivized**	**Incentivized**
Male Seed	98	98	98
Female Seed	99	99	99

Notes: In all treatments, we interviewed the household head. We randomized the gender treatment across habitations, and the other treatments within habitations.

participating in the study and INR 100 conditional on meeting again with the survey team in the presence of one of their three best friends. We also informed them that their friends would also participate in a lottery, without more information about the nature of the lottery. Hence, the seeds did not know that they would be getting INR 100 more than their friends, and the friends did not either. The seeds also did not know that their friends would play a BDM game. In this context, seed households likely felt no more lucky and privileged than their friends for participating in a lottery.

3.3 Covariate Balance and Power Analysis

Table 2 shows that 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 heads of household and about INR 450 less in savings compared to the unincentivized and incentivized groups. This is a potential source for concern given households with more savings would be in a better position to bid higher prices. We perform different robustness checks and control for these variables in additional regressions to re-estimate the treatment effects.

The balance table across seed genders is shown in Table 3. As could be expected, households referred by female seeds are more likely to be headed by a female, while households referred by male seeds are usually headed by a male. It follows that the groups display significant differences in variables such as education, consumption expenses and literacy.

Standard power analysis shows that the experiment can identify plausible treatment effects. Using the control group's mean and standard deviation (134 and 181 respectively), a standard deviation's uniform increase (to 315, with a standard deviation of 362) would be detected with a probability of $\alpha = 0.95$ if the control and treatment group each had at least 65 participants. In our setting, each group has 200 subjects, and we cluster standard errors at the habitation level ($N = 200$). We also control for habitation fixed effects, which enables us to estimate the treatment effects more precisely.

Table 2: Baseline summary statistics and test of balance for covariates

	Con.	Unin.	DIFF	Con.	Ince.	DIFF	Unin.	Ince.
1) Individual Characteristics:								
Female respondent	0.355	0.198	0.157***	0.355	0.254	0.102**	0.198	0.254
	(0.480)	(0.399)	(3.54)	(0.480)	(0.436)	(2.20)	(0.399)	(0.436)
Year of birth	1972.1	1971.8	0.239	1972.1	1970.7	1.345	1971.8	1970.7
	(14.76)	(14.24)	(0.16)	(14.76)	(12.91)	(0.96)	(14.24)	(12.91)
Education	1.944	2.041	-0.0964	1.944	1.893	0.0508	2.041	1.893
	(1.352)	(1.435)	(-0.69)	(1.352)	(1.255)	(0.39)	(1.435)	(1.255)
Reads Hindi	0.477	0.487	-0.0102	0.477	0.482	-0.00508	0.487	0.482
	(0.501)	(0.501)	(-0.20)	(0.501)	(0.501)	(-0.10)	(0.501)	(0.501)
2) Household Characteristics:								
Number of children	3.693	3.918	-0.225	3.693	4.015	-0.323	3.918	4.015
	(2.106)	(2.032)	(-1.07)	(2.106)	(2.085)	(-1.51)	(2.032)	(2.085)
Number of children in school	1.370	1.412	-0.0426	1.370	1.649	-0.280*	1.412	1.649
	(1.550)	(1.562)	(-0.27)	(1.550)	(1.657)	(-1.71)	(1.562)	(1.657)
Household size	7.310	7.183	0.127	7.310	7.289	0.0203	7.183	7.289
	(3.916)	(3.379)	(0.34)	(3.916)	(3.375)	(0.06)	(3.379)	(3.375)
3) Wealth-related variables:								
Monthly Expenses	4176.6	4376.6	-200	4176.6	4530.5	-353.8	4376.6	4530.5
	(2334.3)	(3412.5)	(-0.68)	(2334.3)	(2810.7)	(-1.36)	(3412.5)	(2810.7)
Amount of Savings	223.4	682.2	-458.9***	223.4	661.4	-438.1***	682.2	661.4
	(673.8)	(884.1)	(-5.79)	(673.8)	(1038.3)	(-4.97)	(884.1)	(1038.3)
In debt	0.467	0.609	-0.142***	0.467	0.477	-0.0102	0.609	0.477
	(0.500)	(0.489)	(-2.85)	(0.500)	(0.501)	(-0.20)	(0.489)	(0.501)
Owns a business	0.0355	0.0660	-0.0305	0.0355	0.0711	-0.0355	0.0660	0.0711
	(0.186)	(0.249)	(-1.38)	(0.186)	(0.258)	(-1.57)	(0.249)	(0.258)
Amount of land (acres)	1.310	1.443	-0.134	1.310	1.415	-0.106	1.443	1.415
	(1.888)	(1.936)	(-0.69)	(1.888)	(1.426)	(-0.63)	(1.936)	(1.426)
Owns cattle	0.873	0.873	0	0.873	0.929	-0.0558*	0.873	0.929
	(0.334)	(0.334)	(0.00)	(0.334)	(0.258)	(-1.86)	(0.334)	(0.258)
Owns a phone	0.853	0.838	0.0152	0.853	0.868	-0.0152	0.838	0.868
	(0.355)	(0.370)	(0.42)	(0.355)	(0.339)	(-0.44)	(0.370)	(0.339)
4) Lighting-related variables:								
Number of kerosene lamps	2.376	2.421	-0.0457	2.376	2.401	-0.0254	2.421	2.401
	(1.266)	(1.229)	(-0.36)	(1.266)	(1.043)	(-0.22)	(1.229)	(1.043)
Hours of lighting	5.178	4.782	0.396*	5.178	5.033	0.145	4.782	5.033
	(2.368)	(1.814)	(1.86)	(2.368)	(1.766)	(0.69)	(1.814)	(1.766)
Monthly spending per lamp	39.65	43.85	-4.196	39.65	43.78	-4.122	43.85	43.78
	(26.72)	(23.50)	(-1.62)	(26.72)	(34.85)	(-1.30)	(23.50)	(34.85)

Notes: Con = control group, Unin = unincentivized communication treatment group, Ince = incentivized communication treatment group, and DIFF = statistical t-test results on mean differences between the respective groups. ***, ** and * denote signicance at the 1, 5 and 10% levels, respectively. We also performed a rank-sum test (Wilcoxon-Mann-Whitney) for the variables that do not approximate a normal distribution. The only differences with the t-tests are as follows: 1) The difference between control and incentivized for the number of children that go to school is significant at the 10% level, and 2) The difference between unincentivized and incentivized for hours of lighting is now significant at the 10% level.

Table 3: Baseline summary statistics and test of balance for variables across treatments and seed gender

	Con. M	Con. F	DIFF	Unin. M	Unin. F	DIFF	Ince. M	Ince. F	DIFF
1) Individual Characteristics:									
Female respondent	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)
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)
2) Household Characteristics:									
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 in 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)
3) Wealth-related variables:									
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)
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)
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)
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)
Owns 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)
4) Lighting-related variables:									
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)
Monthly spending per lamp	38.79	40.48	-1.688	44.92	42.84	2.088	42.30	45.25	-2.952
	(22.00)	(30.64)	(-0.44)	(21.72)	(25.13)	(0.61)	(21.83)	(44.27)	(-0.59)

Notes: Con = control group, Unin = unincentivized communication treatment group, Ince = incentivized communication treatment group, DIFF = statistical t-test results on mean differences between the respective groups, M and F represent male seed and female seed respectively. ***, ** and * denote signicance at the 1, 5 and 10% levels, respectively. We also performed a rank-sum test (Wilcoxon-Mann-Whitney) for the variables that do not approximate a normal distribution. The only differences 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 unincentivized group, 3) The difference in savings of the seeds is significant at 10% in the incentivized group, 4) The difference in irrigated land is not significant in the incentivized group, 5) The difference in the number of kerosene lamps is not significant in the incentivized group.

4 Results

4.1 Main Estimates

We begin by reporting the distribution of bids across treatment groups in Figure 4. There is a noticeable change in the distribution of bids between the control group, the unincentivized group, and the incentivized group: the distributions become flatter and display fatter right tails. This likely indicates that our treatments have positive effects on WTP. We hardly notice important differences, however, when comparing the distribution across the gender of the seed, indicating that our gender treatment is not likely to have any effect.

We display box plots of WTP for the different treatment groups in Figure 5.[14] We find that the mean WTP in the unincentivized and incentivized treatments are significantly higher than in the control group. We also find a significant difference between the unincentivized and incentivized treatments when the sample is not split by gender.[15] However, when looking only at the sample with female seeds, there is no significant difference between the means of the unincentivized and incentivized treatments. Box plots in Figure 5 indicate that distributions for the male and female control groups seem to differ, but the difference is not statistically significant in the rank-sum test.

Mean comparisons, however, do not control for unobserved heterogeneity across habitations or for correlation between observations within the same habitation. We therefore proceed to using regressions with fixed effects. The main results are shown in Table 4. In all regressions, the 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 unincentivized treatment increased WTP by almost INR 120 compared to the control group. Given that the mean WTP in the control group was INR 134,[16] this corresponds to a 90% increase. Furthermore, compared to the control group, the incentivized treatment increased WTP by INR 195, which corresponds to a 145% increase. The coefficients both for the unincentivized and incentivized treatments are also statistically different at the 1% level.

On the other hand, as shown in column 2 of Table 4, the gender treatment is not statistically significant. However, the point estimates are negative and correspond to minus INR 34 for the unincentivized group and to minus INR 58 for the incentivized group. Some of the friends chosen by the female seeds were in fact female household heads. If women identify other women as belonging to the same social identity, then

[14]We also show the value of the mean WTP across treatments in the Table 7 in the online Appendix.
[15]We performed both t-tests and rank-sum tests.
[16]Similarly, the value of the intercept in model 1 of Table 4 is INR 134.5.

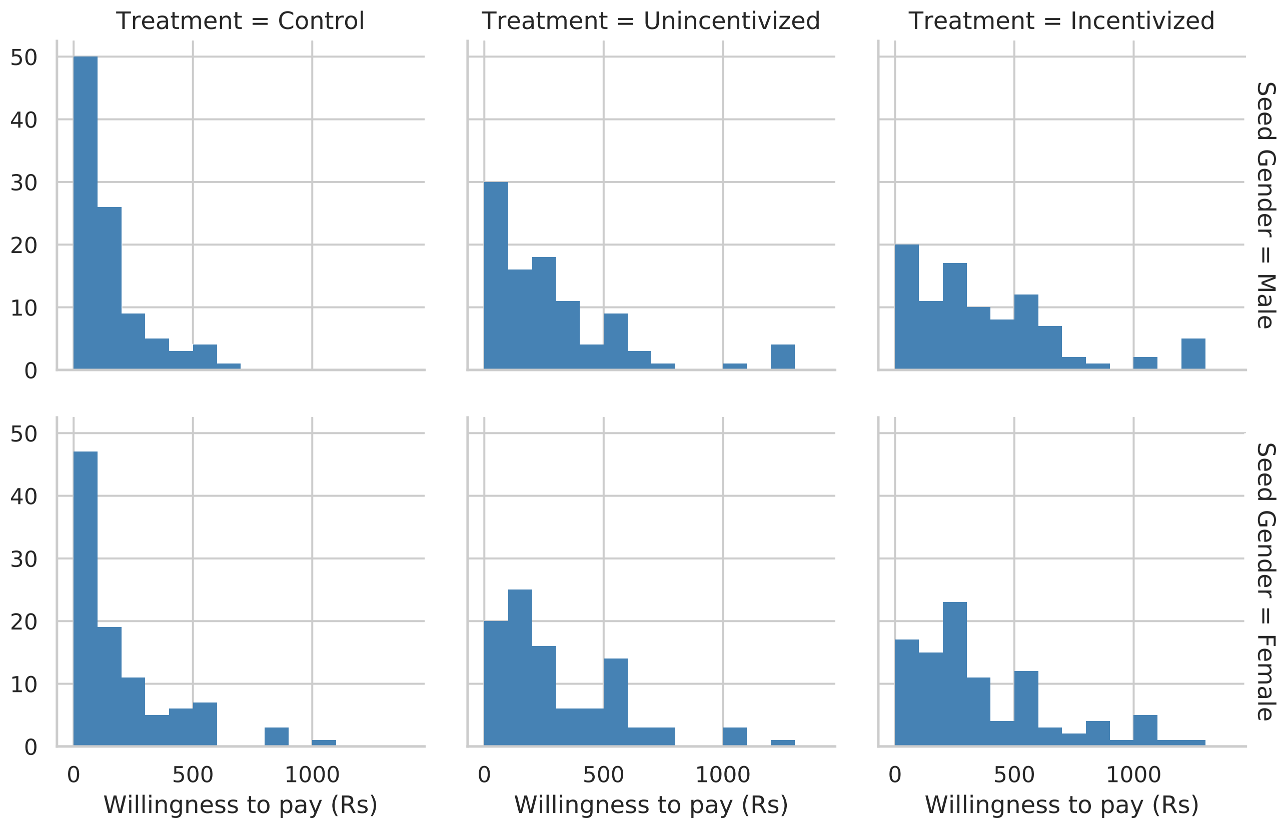

Figure 4: Faceted histogram of bids for solar lanterns across treatment groups

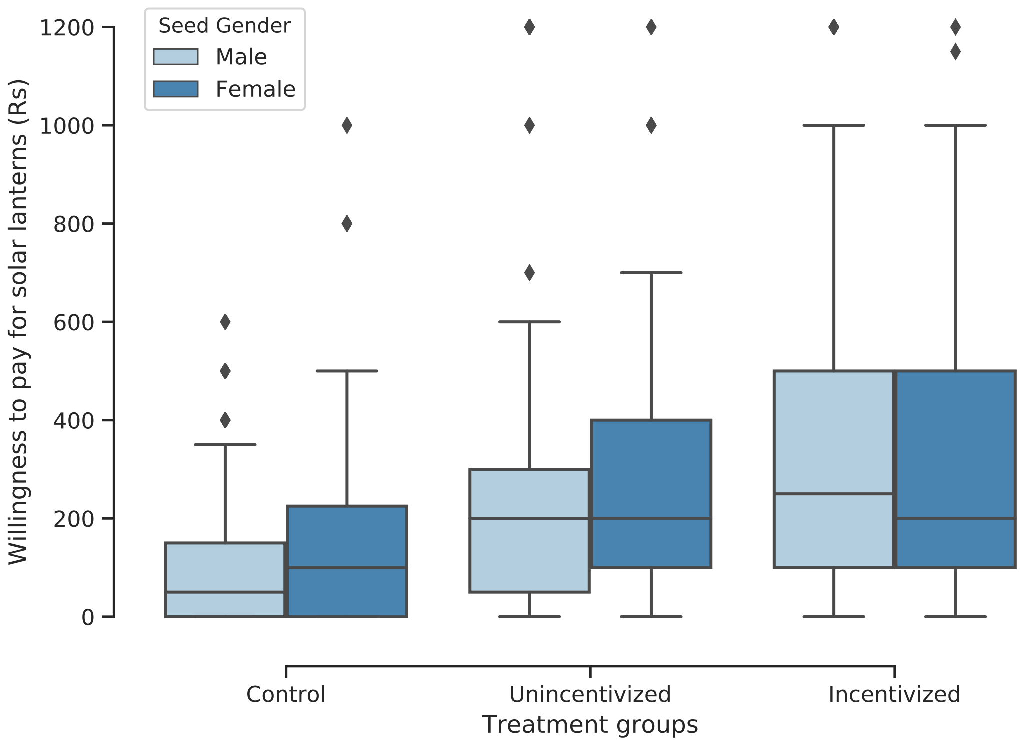

Figure 5: Boxplots of bids for solar lanterns across treatment groups

Table 4: The impact of unincentivized and incentivized communications on WTP

	(1) WTP	(2) WTP	(3) Male head only
Unincentivized	119.883***	136.988***	134.586***
	(22.115)	(30.847)	(35.014)
Incentivized	195.078***	224.416***	224.802***
	(22.925)	(32.086)	(36.442)
Unincentivized x Female Seed		-34.067	-10.586
		(44.229)	(62.968)
Incentivized x Female Seed		-57.749	-63.893
		(45.745)	(65.971)
Habitation fixed effects	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes
R-squared	0.157	0.161	0.165
Observations	585	585	426

Notes: This table shows the main regression results for the impact of both the unincentivized and incentivized communication treatments on WTP for solar lanterns. Column 1 shows the main treatment effects without interactions. Column 2 shows the treatment effects with an interaction term for the gender of the seed. Column 3 reports similar treatment effects as column 2, excluding the sample of households headed by women. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively.

possibly the gender effect that we hypothesized is stronger within the subsample of male household heads. In other words, we expect that the female identity of the communicator leads to more discounting of the information by males than by females. In column 3 of Table 4, we run a regression specification similar to column 2 but excluding households headed by women. Although the point estimate is indeed negative, the effect is not statistically significant. We exclude the possibility of not observing a gender effect due to a composition effect. Instead, it indicates that the mechanism we hypothesized and discussed earlier might not be in place.

4.2 Robustness Checks

We perform several robustness checks to examine the robustness of the treatment effects. First, we control for monthly savings - one of the imbalanced covariates - and estimate the treatment effects. The results reported in column 1 of Table 5 show that the treatment effects coefficients slightly decrease from 120 to INR 108 in the unincentivized group and from INR 195 to 184 in the incentivized group. Yet, the coefficients for the treatments remain statistically significant at the 1%. The coefficient for monthly savings is significant at the 5% level, but the magnitude is small: every additional Indian Rupee in savings correlates with a WTP increase of INR 0.026. Given the imbalance of savings across treatment groups,[17] this represents an average contribution to WTP of about INR 6 in the control group and about INR 17 to INR 18 in the

[17] On average, the unincentivized and incentivized groups have, INR 459 and INR 438 respectively more in savings than the control group.

unincentivized and incentivized groups respectively. The contribution of savings to the WTP is therefore an order of magnitude lower than the contribution of our information treatments. In fact, the raw correlation coefficient between WTP and savings is only 0.15. This can be visualized on the scatter plot of WTP for the entire sample, with the amount of savings shown in section 1 of the online Appendix: those who had the highest amount of savings are not those who revealed the highest WTP.

In column 2, we interact monthly savings with the treatment dummies. The coefficient for the interaction term with the incentivized treatment is, in fact, significant at the 10% level, indicating that savings and WTP correlate in this treatment group. But the coefficient is negative, indicating that, overall, more savings is not associated with higher WTP. We also run a regression using monthly savings in logs instead of levels and find similar results. Specifically, we note that the estimated treatment effect decreases slightly, from INR 120 to INR 103 in the unincentivized group and from INR 195 to INR 177 in the incentivized group, but, overall, the effects remain large and significant at the 1% level. Finally, column 5 reports the treatment effects for the sub-sample of respondents who declared having zero savings, which constitute more than half of our observations. We see that the treatment effects in this subsample are very similar to those found for the whole sample. This confirms that monthly savings are not the main driver of our treatment effects.

Second, we ran the regressions by adding other control variables and report the results in Table 6. Whether the household head was female or male was another unbalanced variable; we therefore control for it in column 1. Treatment effects for both the unincentivized and incentivized groups change little. In column 2, we control both for whether the household head is female and for the amount of monthly savings. The main treatment effects are slightly reduced but remain large and significant at the 1% level.

Finally, we control for the date when the household was surveyed and report the results in column 3 of Table 6. Harvesting of maize and rice in the study area started at the end of September and early October respectively, and about 20% of our treated households were interviewed after September 25. Hence harvesting partly coincided with our survey of the unincentivized and incentivized groups. If those sampled households began selling their harvest, they would likely have been able to afford greater expenditures, and consequently reveal higher WTP for the solar lanterns. We therefore investigate the robustness of our treatment effect to this possible "wealth effect".[18] [19] Thus, we control for the date of interview in our regression. Specifically,

[18]The Rice Knowledge Management Portal, maintained by the Indian Council of Agricultural Research (http://www.rkmp.co.in/content/rice-growing-seasons-of-uttar-pradesh) indicates that, in Uttar Pradesh, summer rice is harvested in April-May and Kharif rice in November-December. On the other hand, wheat is harvested around March-April in the eastern part of Uttar Pradesh, and around mid-April in the western part (see http://www.archive.india.gov.in/citizen/agriculture/index.php?id=11). Our local team, however, indicated that a reasonable estimate for the first day of harvest in the region around Gonda City was September 25 for maize and October 5 for rice, and we use these more conservative dates for our robustness check.

[19]We also checked for other possible campaigns promoting solar lanterns in the sample habitations, which are likely to be

Table 5: The impact of unincentivized and incentivized communications on WTP controlling for savings

	(1)	(2)	(3)	(4)	(5)
Unincentivized	107.560***	114.829***	103.161***	119.744***	117.944***
	(22.727)	(28.718)	(25.966)	(33.841)	(36.070)
Incentivized	183.525***	201.240***	177.301***	229.662***	214.382***
	(23.902)	(25.510)	(27.383)	(39.679)	(43.535)
Amount of savings (in Rupees)	0.026**	0.066**			
	(0.013)	(0.033)			
Unincentivized x Savings		-0.037			
		(0.039)			
Incentivized x Savings		-0.053*			
		(0.031)			
Savings (log)			5.689	19.353**	
			(4.340)	(7.478)	
Unincentivized x log Savings				-14.007	
				(8.860)	
Incentivized x log Savings				-22.412**	
				(9.470)	
Habitation fixed effects	Yes	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes	Yes
R-squared	0.165	0.170	0.162	0.173	0.180
Observations	585	585	585	585	315

Notes: This table shows the main regression results for the impact of both the unincentivized and incentivized communication treatments on WTP for solar lanterns controlling for savings. Column 1 and 3 show the main treatment effects controlling for savings and the log of savings respectively. Column 2 and 4 show the treatment effects with an interaction term for savings and the log of savings respectively. Column 5 reports the treatment effects for the sample of households who reported zero savings. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively.

the variable "Date" is the month and day of the month in which the respondent was interviewed. If there is a wealth effect from harvest sales, respondents interviewed toward the end of the experiment are more likely to have access to cash and bid a higher price. The coefficient on 'Date' then should be positive. Results in column 3 show that the coefficient is not significant and leans toward negative values.[20] This shows that respondents interviewed last were no more likely to bid higher amounts, which provides supporting evidence against a wealth effect from the harvest season. In column 4, our main results remain robust to the inclusion of seven additional control variables. Most variables, such as the level of education, expenditures, whether or not the respondent is in debt, household size and number of kerosene lamps display coefficients that are small and statistically insignificant. The number of children going to school shows a slightly larger coefficient; but the variable is also statistically insignificant.

4.3 Mechanisms

In order to shed light on the possible mechanisms on our treatment effects, we collected detailed data on several variables related to knowledge, use and cost of solar lanterns, gender norms and the position of women in the study areas. In this section, we investigate these mechanisms. Table 7 displays the mean response to various survey questions for each treatment group. The exact phrasing of the questions can be found in section 3 of the online Appendix. First, we note that almost every respondent thought that a solar lantern was *definitely* an innovative product, *definitely* a product superior to a kerosene lamp, and would *definitely* recommend it to others.

However, we note that, compared to the control group, respondents in the unincentivized and incentivized groups are much more likely to have seen a solar lantern before and they are much more likely to know someone who owns a lantern. This is fully consistent with our experimental design and provides evidence that our treatments were properly implemented. Furthermore, close to 90% of the respondents in the unincentivized and incentivized groups stated that they had conversations with that person more than three times a week. Hence, the major factor explaining the difference in WTP between the unincentivized and the incentivized groups is unlikely to be the level of the regular interactions with a friend who owns a solar lantern. Rather, it is likely the nature or the timing of these interactions - the tailored interaction introduced in the tea meetings with the incentivized treatment group.

The last two variables in the table provide additional insights as to why WTP has increased in the two treatment groups. Contrary to the control group, most people in the unincentivized and incentivized groups

correlated with our treatments. There were none.

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

Table 6: The impact of unincentivized and incentivized communications on WTP controlling for more covariates

	(1)	(2)	(3)	(4)
Unincentivized	115.107***	103.683***	388.290**	107.417***
	(22.469)	(22.937)	(180.316)	(23.648)
Incentivized	191.915***	181.072***	470.514***	180.440***
	(23.112)	(24.064)	(180.690)	(25.392)
Female Head	-31.046	-27.911	-29.942	-23.498
	(27.096)	(26.594)	(26.485)	(29.239)
Amount of savings (in Rupees)		0.026**	0.027**	0.025*
		(0.013)	(0.013)	(0.013)
Interview date			-7.698	
			(4.800)	
Education				4.435
				(11.774)
Monthly Expenses				-0.005
				(0.005)
If in debt				-26.111
				(26.150)
Household size				-2.581
				(3.973)
Number of children to school				11.891
				(7.441)
Number of kerosene lamps				19.689
				(11.929)
Hours of lighting				1.419
				(6.538)
Monthly spending on lighting				0.008
				(0.290)
Habitation fixed effects	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes
R-squared	0.160	0.167	0.176	0.181
Observations	585	585	584	574

Notes: This table shows the main regression results for the impact of both the unincentivized and incentivized communication treatments on WTP for solar lanterns controlling for savings, the date of the interview and other covariates. Column 1 shows the main treatment effects controlling for the gender of the household head. Column 2 shows the treatment effects controlling for the gender of the household head and savings. Column 3 reports similar treatment effects as column 2, but controlling for the date of the interview as well. Column 4 shows treatment effects controlling for seven additional baseline variables. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively.

Table 7: Summary statistics for some key solar lantern related variables highlighting possible mechanisms

	Cont.	Unin.	DIFF	Cont.	Incen.	DIFF	Unin.	Incen.	DIFF
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)
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)
Need maintenance 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)

Notes: This table shows summary statistics for some key solar lantern-related variables highlighting possible mechanisms that explain the treatment effects. Con = control group, Unin = unincentivized communication treatment group, Ince = incentivized communication treatment group, and DIFF = statistical t-test results on mean differences between the respective groups. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively.

now believe that, to function properly, a solar lantern needs proper maintenance. They also estimate the cost of such a product at a higher level than the control group. This might seem counterintuitive at first, but perception of higher cost and higher maintenance is consistent with a better appreciation of the technical properties of the product. It supports the hypothesis that, through interaction with peers, respondents discover how sophisticated the product really is. At first, villagers might expect that solar lanterns are nothing more than basic lamps, like kerosene lanterns. They then observe their friend taking care of it; they note the photovoltaic panel that is connected to the lamp, which allows the battery to be charged. They also observe the mobile charging ability of the solar lantern. As a result, they perceive the product as a sophisticated item that requires careful maintenance and are therefore willing to pay a higher price.

Finally, we attempt to explain why female seeds do not seem to act as ineffective communicators in our setting as we hypothesized. Our survey included a series of questions about gender norms in the sample villages. We report indicators of women's status in Table 8. The first set of questions reveal gender attitudes consistent with women holding lower social status. For example, we asked respondents whether they believed a woman should ask permission from her husband or a family member before going out. Almost all household heads said that women should ask for permission to go to the health center, to visit a friend or to go to the market. On the other hand, other questions reflect more egalitarian views. Only about 5% of the sample said that they never talked with their spouse about what to spend income on, and about two-thirds said they often had such discussions. In addition, virtually all households thought that women should have a say in how income is spent. Most respondents thought that it was definitely important that girls go to school. They

Table 8: Summary statistics on the status of women

	Male Seed Friends	Female Seed Friends
1. Should ask permission to go the health center	0.963	0.963
	(0.190)	(0.189)
2. Should ask permission to go visit a friend	0.980	0.973
	(0.142)	(0.162)
3. Should ask permission to go to the market	0.980	0.983
	(0.142)	(0.129)
4. Talk about what to spend money on with spouse	1.585	1.613
	(0.600)	(0.583)
5. Women should have a say on how to spend income	0.976	0.966
	(0.174)	(0.199)
6. It is importnat that girls go to school	4.980	4.970
	(0.164)	(0.223)
7. Women should work outside home or own a business	3.524	3.805
	(1.787)	(1.647)
8. Beating justified if she goes out without telling	0.500	0.559
	(0.501)	(0.497)
9. Beating justified if she argues with husband	0.592	0.670
	(0.492)	(0.471)
10. Beating justified if suspected of adultery	0.759	0.754
	(0.429)	(0.431)
11. Men are better able to use new technologies than women	3.299	3.128
	(1.713)	(1.714)

Notes: This table shows summary statistics on the status of women in the study area. Most of the variables are binary variables where 0 codes for no, and 1 for yes. Responses to question 4 are coded as follows: 0 for "Never", 1 for "Sometimes", 2 for "Often". Responses to questions 6, 7, and 11 are as follows: 1 for "Definitely not", 2 for "Not really", 3 for "Neutral", 4 for "Somewhat" and 5 for "Definitely".

further expressed the view that beating a woman was rarely justified. Finally, most respondents thought that women were as able as men to use new technologies. It appears that gender norms in our context give women some say in purchasing decisions, as well as when it comes to using new products. Possibly then, gender identity here does not seem to matter when it comes to communicating information about lanterns because women are perceived as legitimate users of the products and holding legitimate opinions and advice about household goods. This may therefore help to explain why overall our gender treatment has little effect on willingness to pay.

5 Conclusion

Adoption of new technologies is 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 its adoption by an individual creates a positive information externality to peers which increases their expected welfare (Bardhan and Udry, 1999). Does rewarding individuals who make a conscious effort to communicate information about new technologies increase WTP by members of a social network? What are the mechanisms that explain the increase in WTP? Whose social network in the household matters for the flow of information about new technologies? In this paper, we attempted to answer these questions

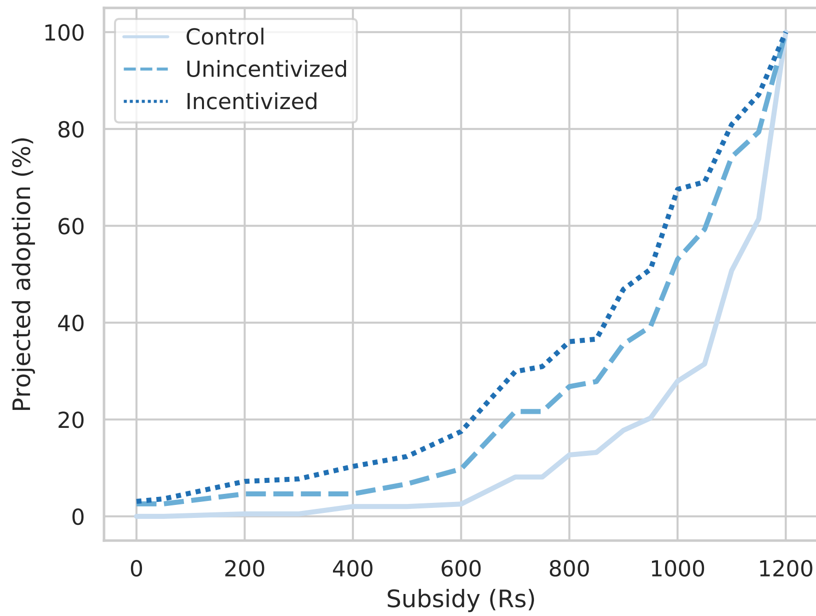

Figure 6: Projected adoption rate of solar lanterns as a function of offered subsidy

by crafting a randomized controlled trial which involves distribution of multi-purpose solar lanterns under unincentivized and incentivized communication treatments in 200 non-electrified villages of India.

Our results suggest that learning about the technology via peers can significantly increase WTP. The unincentivized communications treatment effect implies that having peers using solar lanterns in one's social network makes one more likely to be willing to purchase one as well. Typically, technology diffusion starts with a few early adopters trying out the new product. These first adopters generate knowledge externalities, "learning-by-using", which the next generation of adopters can use to update their beliefs regarding the costs and benefits of the technology. The unincentivized treatment effect may therefore be best understood as capturing the magnitude of the knowledge spillovers from one wave of adopter to the next. Even though the absolute magnitude is small (about INR 120), it represents almost a doubling of the initial WTP (about a 90% increase).

The incentivized communication treatment, on the other hand, investigates a way of increasing the intensity of information exchanges about solar lanterns. The key idea here is to leverage some actors to take a more active role in the diffusion of information within their social network. We found that attending a demonstration session led by a peer increased WTP by INR 195, a 145% increase compared to the control group. We also sought to investigate whether the social identity may be instrumental in how susceptible to information respondents may be. However, we found that the communicator's gender did not seem to matter. Our study experiments with one type of actor and one type of interaction, but our results motivate new questions and more research. In particular, who are the most efficient communicators? And what types of interactions should they use to engage potential adopters? We consider our experiment as a first proof of concept that should motivate further inquiry.

Our study also helps draw useful implications for policies that aim at promoting diffusion of new technologies in developing countries. Since the process of technology diffusion is rigged with positive externalities such as knowledge spillovers, subsidies are often advocated to foster adoption. The revealed WTP data generated in this experiment allows one to predict what the adoption rate would be under each treatment over varying subsidy rates. Such analysis is useful to governments and other stakeholders aiming at promoting adoption of solar lanterns in non-electrified low-income communities. Figure 6 illustrates that, starting from a blank slate where no household knows about solar lanterns (i.e. our control group), covering 20% of the population would require a subsidy of about INR 950 per lantern. But once information has started diffusing (for example, thanks to early adopters), a lower subsidy is required: covering 20% of the population would then require a INR 700 subsidy (unincentivized treatment). Finally, assuming a scheme that incentivize communication about the lanterns, the subsidy would decrease to INR 600. As a point of comparison, this is about the same amount that the Indian government is currently spending per household on kerosene subsidies, albeit per year (Garg, Sharma, Clarke, and Bridle, 2017).

References

Acemoglu, Daron. 2009. *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. 2017. "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.

Aral, Sinan, and Dylan Walker. 2012. "Identifying influential and susceptible members of social networks." *Science* 337 (6092): 337–341.

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 SalaiMartin. 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. 2018. "Social Learning and Incentives for Experimentation and Communication." pp. 1–34. NBER Working Paper 20139.

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.

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.

Garg, Vibhuti, Shruti Sharma, Kieran Clarke, and Richard Bridle. 2017. Kerosene to Solar Swap Policy Brief 1: Kerosene Subsidies in India: The status quo, challenges and the emerging path to reform. Technical report The International Institute for Sustainable Development.

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.

Jain, Abhishek, and Aditya Ramji. 2016. Reforming kerosene subsidies in India: Towards better alternatives. Technical report Council on Energy, Environment and Water.

Jain, Abhishek, Saurabh Tripathi, Sunil Mani, Sasmita Patnaik, Tauseef Shahidi, and Karthik Ganesan. 2018. Access to Clean Cooking Energy and Electricity Survey of States. Technical report CEEW.

Jain, Tarun, and Mudit Kapoor. 2015. "The Impact of Study Groups and Roommates on Academic Performance." *The Review of Economics and Statistics* 97 (1): 44–54.

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.

Lam, Nicholas L., Kirk R. Smith, Alison Gauthier, and Michael N. Bates. 2012. "Kerosene: A Review of Household Uses and Their Hazards in Low and Middle-Income Countries." *Journal of Toxicology and Environmental Health* 15 (6): 396–432.

Lee, Kenneth, Edward Miguel, and Catherine Wolfram. 2016. "Experimental Evidence on the Demand for and Costs of Rural Electrification." NBER Working Paper No. 22292.

Lee, Kenneth, Eric Brewer, Carson Christiano, Francis Meyo, Edward Miguel, Matthew Podolsky, Javier

Rosa, and Catherine Wolfram. 2016. "Electrification for "Under Grid" households in Rural Kenya." *Development Engineering* 1: 26–35.

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.

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

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.

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.

Sandwell, Philip, Scot Wheeler, and Jenny Nelson. 2017. "Supporting rural electrification in developing countries:." Grantham Institute Project Note.

UNEP. 2013. "Off-grid lighting assessment in India.".

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.