Does Peer Use Influence Adoption of Efficient Cookstoves? Evidence from a randomized controlled trial in Uganda

Authors: Theresa Beltramo, Garrick Blalock, David I. Levine, and Andrew M. Simons*

Abstract

We examine the effect of peer usage on consumer demand for efficient cookstoves with a randomized controlled trial in rural Uganda. We test if the neighbors of buyers who ordered and received a stove are more likely to purchase an efficient cookstove than the neighbors of buyers who ordered but have not yet received a stove. We find that neighbors of buyers who have experience with the stove are not detectably more likely to purchase a stove than neighbors of buyers who have not yet received their stove. We do find evidence of peer effects in opinions about efficient cookstoves. Knowing that a prominent member of the community has the efficient stove predicts 17–22 percentage points higher odds of strongly favoring the stove. But this more favorable opinion seemingly has no impact on purchase decisions.

Keywords: cookstoves, technology adoption, social networks, peer effects, randomized control trial

* Beltramo, lead author: Impact Carbon, (tbeltramo@impactcarbon.org). Blalock and Simons: Charles H. Dyson School of Applied Economics and Management, Cornell University (garrick.blalock@cornell.edu and ams727@cornell.edu). Levine: Haas School of Business, University of California, Berkeley (levine@haas.berkeley.edu).

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Introduction

Half the world cooks with inefficient stoves that burn solid fuels such as wood and charcoal. Smoke from these stoves kills four million people a year (Lim et al. 2012), and their inefficiency contributes to deforestation and global climate change. Increasing the adoption of more efficient, cleaner cookstoves is a public health priority and policy makers must choose one or more strategies to achieve this goal. Potential strategies include subsidized prices, financing, marketing campaigns, and peer influence. This paper examines the latter strategy by observing how one person's purchase and use of a stove affects peer attitudes and purchase behaviors. The former strategies are the subject of other papers stemming from the same research program (Levine, Beltramo, Blalock, and Cotterman 2013).

The findings of this study are potentially generalizable to products other than cookstoves. Millions of lives are lost each year because households do not purchase products that protect from mosquitoes, treat drinking water, or reduce household air pollution. Understanding how peers influence an individual's adoption decision could provide insights for increasing the purchase of products that improve health and well-being. For products such as safer cookstoves or water filters, such knowledge has the potential to save many lives.

Learning from others is important because it can generate a social multiplier that speeds product adoption (Glaeser, Sacerdote, and Scheinkman 2003). Estimating the role of peers or social interactions in driving adoption is made difficult by the problem of correlated unobservables between peers and, especially, between friends (Manski 1993). Economists and others have focused on a variety of econometric techniques to disentangle peer effects from correlated unobservables (Foster and Rosenzweig 1995; Conley and Udry 2010; Munshi 2003; Bandiera and Rasul 2006) including explicit randomization (Sacerdote 2000; Oster and Thornton 2009; Miguel and Kremer 2004). This paper contributes to the literature that uses individual-level data to measure the learning from others (Bandiera and Rasul 2006; Brock and Durlauf 2009; Manski 2006; Munshi 2004; Skinner and Staiger 2009; Young 2007) and uses randomization to eliminate the problem of correlated unobservables.

Our randomized trial delayed delivery of a new stove, the Envirofit G-3300, for some households but not others. We then compare purchasing behaviors of the neighbors of those two groups. Both groups are neighbors of someone who agreed to buy the stove, but one group witnessed delivery of the stove before the other group. We can examine the strength of a demonstration effect (stove is physically present for neighbors to see, feel, observe) versus an ordering effect (only that the household has

agreed to purchase a stove). We also test the causal pathways that underlie the theory of peer effects, such as familiarity with the new stove, having seen the new stove cook a meal, and beliefs related to the new stove is effective in saving fuel, easy to use, improves health. Because we randomize the timing of when stoves are delivered to each group, we are able to distinguish the causal effects of an additional peer physically having a stove (demonstration effect) as opposed to the effect of a peer endorsing the purchase of a stove (ordering effect).

Theory and literature review

Literature review

Individuals often learn from and imitate he behavior of others within their social network. For example, numerous studies suggest that social groups influence individual's behaviors in ways spanning from the trivial, like what movie to see, to more serious issues like drug use, financial management, school attendance and even criminal behavior (Bayer, Pintoff, and Pozen 2004; Bursztyn et al. 2012; Duncan et al. 2005; Mbondo 2013; Moretti 2011; Sacerdote 2011). Evidence of learning from others is ample in rural agrarian settings (Bandiera and Rasul 2006; Conley and Udry 2010; Foster and Rosenzweig 1995), but is not always present. Some recent studies fail to find peer spillovers (Beltramo 2010; Guryan, Kroft, and Notowidigdo 2009; Luoto et al. 2012).

Neighbors often behave similarly because of a common environment (e.g., prices, connectedness to cities, infrastructure) and because neighbors have self-selected into a community. Even if many neighbors are born in a community, there is self-selection of who *remains* in a community. This makes social interaction effects difficult to distinguish from unobserved factors that are correlated across neighbors (Manski 1993; Moffitt 2001).

Some studies randomly allocate people into peer groups to overcome potential endogeneity issues, for example randomized allocation of roommates (Duncan et al. 2005) and randomized allocation of housing vouchers (Kling, Liebman, and Katz 2007). Other studies look at randomized allocations of interventions across naturally occurring groups (Miguel and Kremer 2004; Oster and Thornton 2009). We utilize the second strategy and randomize the timing of the delivery of cookstoves.

Theory of Peer Effects

We test the incremental effect of having one close neighbor in a person's social network who ordered the stove but had not received it—the ordering effect—versus the incremental effect of having one close neighbor who both ordered and received the stove—the demonstration effect. The objective is to measure the incremental difference of having a neighbor who physically owns and perhaps demonstrates the new stove to his/her neighbors, above any potential endorsement that comes from just ordering the new stove. I.e.,, we compare neighbors of "early buyers," those who ordered the stove and had taken delivery, to the neighbors of "late buyers," those who had ordered the stove but not yet taken delivery. We follow Rogers' diffusion of innovation theory and hypothesize that close neighbors—both geographically and socially—share ideas and as a result influence the purchase of the new stove (Rogers 2003).

Geographic and social closeness

The theory of peer effects among neighbors assumes high communication and trust, which in our setting in rural Mbarara, Uganda implies:

Assumption 1: Neighbors are geographically close;

Assumption 2: Neighbors communicate frequently;

Assumption 3: Neighbors consult each other if they have problems.

Living near an early buyer increases familiarity with the Envirofit

Because neighbors share information, we assume when someone gets a new product neighbors typically know about it. Early buyers' neighbors have lived for a month near the early buyers' new stove. We thus hypothesize:

$$Hypothesis_1 =$$
$$Neighbors\ of\ early\ buyers\ are\ more\ likely\ to\ have\ heard\ about\ the\ Envirofit$$

$$Hypothesis_2 =$$
$$Neighbors\ of\ early\ buyers\ have\ seen\ more\ people\ cook\ with\ the\ Envirofit$$

Peer effects are only likely to increase uptake if the product is popular. Thus, the theory of peer effects requires:

Assumption 4: The stove is popular among those who use it.

Given high communication and favorable opinions, the theory of peer effects implies if early buyers hear more about the stove and most of what they hear is good:

$$Hypothesis_3 = Living\ near\ an\ early\ buyer\ improves\ opinions\ of\ the\ Envirofit$$

Living near an early buyer increases purchase of the Envirofit

Evidence from the marketing literature (though stated and actual preferences may vary) posits: favorable opinions predict purchase (Arts, Frambach, and Bijmolt 2011; Arndt 1967; Morrison 1979).

$$Hypothesis_4 = Living\ near\ an\ early\ buyer\ should\ increase\ the\ likelihood\ of\ purchase$$

Peer effects are stronger for the geographically and socially close

Any theory of peer effects among neighbors suggests the effects will be strongest among those who are geographically and socially close. We have three measures of closeness. First, we look at geographic distance. Second, we create an "Index of Social Closeness" based on a combination of frequency of communication, common activities, and evidence of trust measured by whether the neighbor would solicit advice from the early/late buyer neighbor. Third we analyze reciprocated friendships. Card and Giuliano (2012) find stronger peer effects in reciprocated friendships, i.e., both members of a pair name the other as a close friend.

Bandiera and Rasul (2006) in their experiment testing farmers' decision to adopt a new crop find that adoption decisions are uncorrelated among individuals belonging to different religion networks. Conley and Urdy (2010) use data on farmers' communication patterns to define each individual's information neighborhood. They find farmers do adopt practices of successful neighbor farmers but conditional on a set of common agricultural and socio-cultural conditions including growing conditions, clan membership and religion. Following this finding, we also test separately if neighbors who attend the same church impacts the decision to purchase the nontraditional cookstove.

Methods and data

Experimental design

The study spans 14 parishes where the randomization is within parish.[1] The Centre for Integrated Research and Community Development (CIRCODU), an NGO based in Kampala that specializes in market research related to household energy, acted as the in-country data collection and sales team partner.

This study builds on two previous experiments that distributed the same efficient cookstove, the Envirofit G-3300, in these parishes. The first, a study from March to June, 2012, sold stoves in 24 parishes (Levine et al. 2013). We recruited a focal point person in each parish who we paid a small fee to spread the word about the upcoming sales meeting and to gather roughly 60 people to each meeting. This study takes place in 14 of the same parishes and a total of 720 participants attended sales meetings in the sales study. Of those who attended in the previous study, 57% (n=410) purchased a stove (Levine et al. 2013) when a free trial and time payments were offered.

A second study took place in the same 14 parishes used for this study. Among the 410 buyers from the first study, an impact evaluation occurred in the second and third quarters of 2012 to measure the effect of an efficient cookstove on health, fuel use, and stove adoption (Beltramo, Blalock, Levine, and Simons, forthcoming). Households were eligible to participate in the impact evaluation if they mainly used wood as a fuel source, regularly cooked for eight or fewer persons (the Envirofit is able to cook portions for at most eight people), were generally home every day, and cooked in an enclosed kitchen (Harrell et al. 2013). The sample was randomized across eligible buyers within each parish. Half the buyers were randomly selected to receive their stove early, while half the group received their stoves late (Harrell et al. 2013). Of the eligible 410 buyers, we randomly chose 12 households (6 early buyers and 6 late buyers) per parish to participate in the impact evaluation study, resulting in a total of 168 randomized participants across 14 parishes. We use an intention-to-treat framework to analyze these households based on their assignment.

This experiment utilizes the same 168 early and late buyers of the impact evaluation and interviews 763 of their neighbors. To identify neighbors we visited the 168 early and late buyers and asked them to identify up to five neighbors who lived within a five-minute walk with whom they talk frequently. We then measure if these neighbors' decisions to purchase an efficient cookstove depend on whether they

[1] A parish is an administrative unit that in typically includes 3–5 villages and has about 5000–6300 residents.

live next to early buyers (who had ordered and received a new stove) or late buyers (who had ordered the new stove but not yet received it). I.e., we measure the extra effect of a neighbor owning and perhaps demonstrating the use of the new stove, above any effect that comes from a neighbor endorsing the stove by ordering it.

The sample

To identify neighbors who were socially close, we first visited our early or late buyers and asked them "Who among your neighbors within a five minute walk do you speak to frequently?" We recorded up to five neighbors of each early or late buyer. The data collection team then made several attempts on multiple days to visit and interview the neighbors listed by the early and late buyers. When visiting these neighbors, the enumerators asked (without prompt about the early or late buyer) "Who among your neighbors within a five minute walk do you speak to frequently?" If the neighbor listed the neighboring early/late buyer household, the enumerator then silently recorded the early/late buyer. This identification strategy was deliberate so as to ensure unbiased measures of "reciprocated neighbors".

When they had time, enumerators also visited households near the early or late buyer, but not listed by the early or late buyer as ones they "speak to frequently."

Measures

Favoring a stove

We asked respondents to rank the main attributes of the Envirofit including improves health, reduces fuel use, and ease of use compared to the traditional three stone fire. For each dimension, neighbors were shown a visual ten-point scale and asked to place a coin on the scale, where a 1 (on the left) indicated the Envirofit is better and a 10 indicated the three-stone fire is better. As an example to solicit opinions about the Envirofit improves health, neighbors were asked to mark to the left on the ten point scale if they believe the Envirofit is better for your health or to the right if the three-stone fire is better for your health. To ensure accurate responses, respondents first played a trial game ranking preferences between two common local meals. Enumerators through a series of survey questions then made sure that each participant understood the game before ranking preferences between the Envirofit and the three-stone fire. We classified either a 1 or 2 in favor of the Envirofit as selecting the Envirofit over the three-stone fire (Table 1c).

Geographical and Social closeness

To measure geographic closeness using GPS readings we measured the kilometers apart between early and late buyers and the individual neighbor.

To measure social closeness we created an index of self-reported frequency and timeliness of communication between the respondent and the experimental neighbor, number of shared activities with the experimental neighbor, and whether the respondent would solicit advice from the experimental neighbor (Table 1b). For each of these four items, we create a standardized score:

- "Frequency of contact between neighbors" each month (daily=6, three times a week=5, once a week=4, twice a month=3, monthly=2, and less than a month=1).
- "Last reported contact between neighbors" (today=5, two to six days ago=4, a week ago=3, two weeks ago=2, a month or more prior=1).
- The count of "Type of activities reported by neighbors" the neighbor reports sharing with the experimental neighbor (1–4).
- Could you go to this neighbor if you had a problem and needed advice? (Yes=1; No=0).

The four measures of social closeness summed ranges from 0–14 with zero being the least close. To ensure cross-comparability of the four reported measures of social closeness, we created an Index of Social Closeness using a standardized score. Each of the four variables were standardized (known as z scores) such that the mean of each variable is zero and the standard deviation is 1 (Table 1b). The standardized score is appropriate for this index because it normalizes the four inputs to one normal distribution.

Asset index

Based on field testing in two test villages during the feasibility stage and analysis of the moDemographic and Health (DHS) survey (Uganda Bureau of Statistics and ICF International Inc. 2012) we select a households' ownership of a television, radio, cell phone, and cows to proxy for wealth. We generated an asset index equal to the number of these four assets they owned.

Specification

Our general specification for outcome *y* at household *i* who is neighbor of an early or late buyer *j* in parish *p* is:

$$Y_{ijp} = \beta\, Early_{jp} + \Sigma_k\, \gamma_{ijpk} X_{ijpk} + \Sigma_p\, \alpha_p\, FE_p + u_{jp} + \epsilon_{ijp} \qquad (1)$$

where X_{ijpk} is a vector of control variables, FE_p is a fixed effect for each parish, u_{jp} is a random effect for each early or late buyer, and $Early_{jp}$ is an indicator variable equal to one if the neighbor is an early buyer and zero for a late buyer. β is the coefficient of interest. We run a series of regressions changing the outcome variable Y_{ijp} each time. The outcome variable Y_{ijp} alternates between: purchase decision, number of people the neighbor knows who own an Envirofit, number of people the neighbor has seen cook with the Envirofit, and the ranking of the three beliefs between the Envirofit with the three-stone fire including: the Envirofit is better for your health, is easier to use, and the Envirofit uses less fuel. We cluster standard errors at the level of the early or late buyer and used the Huber-White heteroskedasticity correction.

For the interaction of geographic and social closeness, we ran:

$$Y_{ijp} = \beta\, Early_{jp} + \delta\, Close_{ijp} + \phi\, Close_{ijp} * Early_{jp} + \Sigma_k \gamma_{ijpk} X_{ijpk} + \Sigma_p \alpha_p FE_p + u_{jp} + \epsilon_{ijp} \qquad (2)$$

Here the estimate of ϕ captures the interaction of geographic or of social closeness with an early buyer.

Because of the experimental design, no control variables are needed with a sufficiently large sample size to randomize household variation. Because sample size is limited, we included a few control variables in our main specification including asset count and household never cooks.[2]

Other information on the stoves, besides the 168 early and late buyers, is in the community. In the previous sales experiment 242 other households purchased an Envirofit. Among the 763 neighbors sampled, 95 of the neighbors had purchased a stove in the previous study (Table 1a). As a result, the 95 households are dropped from analysis. It is possible that the 95 neighbors who previously purchased the stove also exert social or peer influence over the neighbors in addition to the early or late buyer. Thus, we include the count of other neighbors who previously purchased the stove as an explanatory variable.

In addition, the focal point person in each of the 14 parishes owns an Envirofit. Because the focal point person was actively involved in both organizing the meetings and raising awareness, we control for whether the respondent knows the focal point person.

[2] To select the relevant control variables we first predicted stove uptake using control variables including age, asset index, primary fuel used for cooking is wood, dummy if neighbor receives income in cash only or in cash and in-kind or in-kind only, average household size at a typical meal and household never cooks without $Early_{jp}$. Only the asset index and lack of currently cooking at home predicted purchase ($p<0.10$).

Results

The setting

Social and demographic attributes

The average age of neighbors (excluding those who already purchased a stove) is 25 for both early and late buyer neighbors and the average number of people who ate lunch yesterday is constant across both groups of neighbors—13 (Table 1d).

A higher percentage of neighbors of early buyers report cooking with wood than neighbors of late buyers—97% and 92% respectively, $p<0.01$, Table 1d). Both groups report that dinner is the largest meal—~66%. A sizeable proportion of both neighbors of early buyers (24%) and neighbors of late buyers (18%) report they never cook at their house (Table 1d). We include a control variable for household does not cook in subsequent regression analysis.

A higher percentage of neighbors of early buyers report earning income than neighbors of late buyers—91% and 89% respectively, Table 1d, $p<0.01$. For neighbors which earn income, the majority report earning income in cash and in-kind- 60% of neighbors of early buyers and 55% of neighbors of late buyers. 40% of neighbors of late buyers report earning income in cash in comparison with 32% of neighbors of early buyers. The modality of how neighbors report earning income—in cash, in kind or both—is balanced across the two groups and t-tests do not show a significant difference between the two means.

Based on analysis of the most recent DHS survey, four relevant assets were selected based on a simple rule of thumb that one asset (tv) would be owned by upper quartile of wealth, two assets (cows and cell phone) would be owned by the median level of wealth, and one asset (radio) would be owned by the upper three quartiles of wealth (Uganda Bureau of Statistics and ICF International Inc. 2012). We generate an asset index by counting ownership of the four assets and find 7% of households have none, 25% own one, 48% own two, 17% own three, and 4% own all four assets (Table 1d).

Among the neighbors who have not purchased a stove 9% of both early and late buyers' neighbors attended the original sales meeting where the early and late buyers purchased their stove.

Geographic and social closeness of the early or late buyers and their neighbors

Of the 617 neighbors the early or late buyers listed as ones they "speak to frequently," half (n=312) independently mentioned the early or late buyer as someone they speak to frequently and are thus classified as "reciprocated friendships" (Table 1a).[3] Among the other neighbors who were not recommended by the experimental sample, 28% identified the early or late buyer as someone they speak to frequently (Table 1a).

On average neighbors of both early and late buyers are geographically close—0.2 kilometers (0.13 median, standard deviation 0.32), or about a four-minute walk (Table 1a). This is consistent with the study design and regression results show no effect of distance on our outcome variables.[4]

Neighbors sampled communicate frequently—63% report communicating daily, and 42% had spoken to their neighbor on the day of the survey. Further, 89% of early and late buyers' neighbors report consulting with their nearby early or late buyer if they had a problem (Table 1b).

We worked with our implementing partner CIRCODU to measure the most common social activities in our setting. Field testing identified activities participants were likely to share including: farming, family events, savings groups, church, and *kwesika* (a community burial service group). In total, 84% of neighbors report sharing at least one of these activities with their neighboring early or late buyer (Table 1b). A third of neighbors report attending church with the experimental early or late buyer, 22% are part of the same *kwesika* group, 23% farm together, 20% attend family events together, and 18% are part of the same Rotating Savings and Credit Association (ROSCA).

To test if attending the same church mattered we run a separate regression on all our outcome variables, but find no evidence to support this effect. To test the wider effect of shared activities, frequency of contact between neighbors and trust we include the Index of Social Closeness, in our main regression specification as a control variable.

[3] One late buyer and one early buyer are missing a survey. Despite these two surveys being missing, we have survey data from their neighbors. This accounts for the discrepancy between 312 total recommended neighbors who list early or late buyer in general statistics and 308 with a matched survey in later analysis.

The experiment

Pipeline

We interviewed 159 of the 168 early or late buyers (80 early buyers and 79 late buyers). Despite four visits to each household, nine early or late buyers were not home at the time of any of these visits. The enumerator's surveyed 617 neighbors the early or late buyers listed as a neighbor they "spoke to frequently." Enumerators also had time to collect data from 146 other neighbors not listed by the buyers. Of the neighbors surveyed, 95 had already purchased the stove in the earlier sales study. We dropped these participants from the analysis of uptake.

Balance tests

We ran t-tests on all explanatory variables to compare the means of neighbors of both early and late buyers (Table 1). Results are in embedded in Tables 1a–1d. The samples are mostly balanced. One exception is early buyers' neighbors are slightly closer than late buyers' neighbors (Table 1, $p<0.01$), though when we test if distance predicts purchase (specification 2) distance has no effect on neighbors' decision to purchase the Envirofit.

Evidence on Peer effects

Living near an early buyer increases familiarity with the Envirofit

We asked neighbors if they had heard about the Envirofit and 26% of all neighbors—22% of early (29% of late) buyers' neighbors reported having heard about the stove (Table 1c, $p<0.01$). This is inconsistent with Hypothesis 1 that more neighbors of early buyers will have heard about the Envirofit. Though, consistent with Hypothesis 1, of those who report knowing about the Envirofit, more neighbors of early buyers—68%—than neighbors of late buyers—50%—report hearing about the Envirofit from the experimental sample (early or late buyer, Table 1c, $p<0.01$). Given a larger portion of neighbors of late buyers have heard about the stove, it is possible they are more exposed to other peer influences related to the Envirofit in the community. Subsequently, neighbors were asked how many people they know who own an Envirofit stove.

Consistent with our theory of behavior change and Hypothesis 2, more neighbors of early buyers report knowing at least one person who owns the Envirofit. 62% (48%) of neighbors of early (late) buyers report knowing at least one neighbor who owns the Envirofit (Table 1c,$p<0.01$)). And almost twice as many neighbors of early buyers (19%) report knowing more than one person who own an Envirofit, than

neighbors of late buyers (10%), (Table 1c, p<0.01). Because "knowing about the stove" implies some knowledge of the stove's characteristics, the number of respondents indicating yes is lower than the number indicating that they "know someone who owns the stove."

Table 3, column A (specification 2) tests if the number of people that the neighbor knows owns the Envirofit is correlated with being an early buyers' neighbor (β=0.20;p<0.01), with knowing the focal point person (β=0.55, p<0.01), or with the presence of other neighbors who are also an early or late buyer (β=0.13, p<0.01). The results show that the number of people is only partially associated with being an early buyer neighbor; a larger effect is knowing the focal point person, and to a lesser extent other neighbors who are also early or late buyers.

Consistent with Hypothesis 2, neighbors of early buyers are much more likely (31%) to have seen someone cook with an Enviroft than neighbors of late buyers (20%, Table 1c, p<0.01). And a third more neighbors of early buyers have seen more than one person cook with the Envirofit—9% vs. 6% of neighbors of late buyers (Table 1c, p<0.01).

Table 3, column B (specification 4) estimates if the number of people the neighbor saw using the Envirofit is explained by being an early buyers' neighbor (β=0.13; p<0.01), by knowing the focal point person (β=0.42, p<0.01), or by the number of other neighbors who are also an early or late buyer (β=0.13, p<0.01). Seeing someone cook with the Envirofit is associated with being the neighbor of an early buyer neighbor, though is more correlated with knowing the focal point person and to a lesser extent with having other neighbors who are also early or late buyers.

But living near an early buyer does not lead to a better opinion of the Envirofit

We found support for Assumption 4 that buyers in our community like the Envirofit—57% of the 866 total attendees in the previous sales meeting purchased and own the stove (Levine et al. 2013). An additional piece of evidence is the previous sales offer included a free trial and only 0.2% returned the stove after the free trial (Levine et al. 2013).

Nevertheless, living near an early buyer does not lead to better opinion of the Envirofit (Table 1c). Neighbors of early buyers are slightly *less* likely to strongly favor the Envirofit for all three dimensions: health (20% of neighbors of early buyers vs. 26% of neighbors late buyers, p<0.05), ease of use (18% vs. 23%, p < 00.10) and fuel savings (20% vs. 25% P <0.10).

Table 4, column A (specification 1), estimates if the opinion that the Envirofit is better for your health than the three stone fire is predicted by being an early buyers' neighbor (β=-0.06; p<0.10), by the neighbor knowing the focal point person (β=0.22, p<0.01), or by the number of neighbors who are also an early or late buyer (β=0.02, not statistically significant). The main predictor for the Envirofit improves health is knowing the focal point person and to a lesser degree being a neighbor of a late buyer. Table 4, column B (specification 2), which estimates if the opinion the Envirofit is better for your health, finds the only predictor is knowing the focal point person (β=0.17; p<0.01). Similarly, Table 4, column C (specification 3), which estimates if the opinion the Envirofit uses less fuel, finds the only predictor is knowing the focal point person (β=0.19; p<0.01). The regression results, consistent with the summary statistics, reject Hypothesis 3: Living near an early buyer improves opinions of the Envirofit.

Neighbors of late buyers report hearing both more good *and* more bad things about the Envirofit than the neighbors of early buyers. 24% of neighbors of late buyers report hearing good things about the Envirofit versus 19% of neighbors of early buyers (Table 1c, p < 0.10). At the same time, 5% of neighbors of late buyers report hearing bad things about the Envirofit vs. 2% of neighbors of early buyers (Table 1c, p<0.05).

We conclude that there is little evidence that having an early buyer as a neighbor raises opinions of the stove. In contrast, knowing the focal point person has the new stove predicts 17–22 percentage points higher odds of strongly favoring the new stove (Table 4 all specifications, p<0.01). Thus, peer effects on favorable opinions may operate, but not primarily through neighbors. We cannot tell if the focal point people (compared to neighbors) have more favorable opinions, are more influential, and/or are more likely to report favorable opinions. Though due to the focal point person's role in the study, including collecting payments and organizing the sales meetings, they are familiar with the Envirofit's merits.

Living near an early buyer does not detectably increase purchase of the Envirofit

Uptake of both early and late buyers' neighbors of improved cookstoves is 9% for all neighbors (61 of 617 neighbors, Table 2) offered the opportunity to purchase the stove. The main results of the experiment are summarized in Table 5, where we observe no effect of being an early buyer neighbor on purchase of the Envirofit stove (Specification 1). Though wealth (proxied by number of assets owned) has a positive effect on a neighbor's decision to purchase an Envirofit (Table 4, specification 1, β= 0.04, p<0.01). This suggests that households purchase decision may be limited by liquidity.

Peer effects are not detectably stronger for the geographically and socially close

It is possible that peer effects occur, but only for those who are socially close to the early buyer. Based on findings from Card and Giuliano (2012) that peer effects are stronger in reciprocated friendships (that is, when both members of a pair name the other as a close friend) and Bandiera and Rasul (2006), we repeat the analyses on the subset of reciprocated friendships. Table 5 column 3 and 4 represent the sample of reciprocated friendships and show there is no change from the wider sample and no effect of being an early buyer neighbor on purchase of the Envirofit stove. Importantly, unlike related studies which find a large effect of social closeness in estimating peer effects (Bandiera and Rasul 2006; Card and Giuliano 2012), when we estimate both the effect of social closeness and the interaction of early buyer with our index of social closeness, the coefficient is tiny (-0.01, SE = 0.01) and not statistically significant (Table 5). Separately we test if purchase is predicted by attending the same church and find no effect.

Focal point people have no mean detectable effect on purchase rates

Despite focal point people's large effect on driving opinions of the Envirofit, knowing the focal point person has no effect on purchase rates. This evidence could suggest that liquidity is the most important factor for households in our sample in predicting purchase decisions.

Discussion

We do find evidence of peer demonstration effects in opinions about the Envirofit. In particular, knowing the focal point person has the new stove predicts 17–22 percentage points higher odds of strongly favoring the new stove. But despite evidence of peer effects changing opinions positively about the Envirofit in our community, there is no evidence of impact on purchase decision among neighbors. Thus, our results don't suggest a large social multiplier for efficient cookstoves similar to the Envirofit. A lack of positive peer effects is understandable for unpopular products (e.g., chlorine for water treatment, as in Luoto et al. 2012). But in our setting the Envirofit seems popular.

One possibility for the absence of detectable peer effects on purchase is that households have other information sources. For example, our late buyers all had ordered the new stove and focal point people all owned stoves. More generally, knowledge of stoves does not appear to be a determining factor in adoption. In another experiment we led in the same region, but different communities, we conducted a randomized controlled trial testing whether marketing messages related to the Envirofit improves

health or saves times and money had an effect on willingness to pay. Neither marketing message consistently increased willingness to pay (Beltramo, Blalock, Levine, and Simons 2014)

Another possibility is that efficient stoves are widely desired already—most people want one with or without seeing the product in use—but lack the cash. Indeed, we found that each additional asset increased purchase by 4%. This possibility is consistent a previous study finds that a free trial and time payments increase the likelihood of purchase from 5% to 57%. Further, each additional household asset owned increased willingness to pay by 10% (Beltramo, Blalock and Levine, and 2014). This result implies concerns about product durability and liquidity are far more important limiting factors in health and welfare improving products. This is consistent with other experimental evidence from Kenya, Guatemala, India, and Uganda which find no effect of providing information about health preventative products, although genuine learning about the products occur, nor do they find evidence for peer effects though subjects discussed the product purchase decision extensively. Alternatively they find large effects of liquidity constraints on consumer's purchase of health improving products (Meredith et al. 2012).

In sum, our results do not find that observing peer use of cookstoves influences adoption. A stove promotion strategy of inciting "word of mouth" by seeding communities with a few demonstration stoves shows little promise. To the extent that our results are generalizable, public health officials should instead direct resources to other strategies such as financing for efficient stoves.

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Table 1a: Summary Statistics of Matched Early and Late buyers and their Neighbors

General summary statistics	**N**	**%**		
Experimental sample- early and late buyers- who took survey[a]	159	100		
Count of female participants among experimental sample	131	82		
Neighbors of early and late buyers who took survey	763	100		
Neighbors surveyed who already own Envirofit	95	13		
Neighbors excluding those who already own Envirofit	**668**	**100**		
Neighbors surveyed listed frequent communication with early or late buyer	353	53		
Total neighbors who are non-recommended by early or late buyer[b]	146	19		
of whom already own stoves	7	5		
of whom listed frequent communication with early or late buyer	41	28		
Total recommended neighbors by early or late buyer Neighbors	617	92		
of whom already own stoves	88	14		
of whom listed frequent communication with early or late buyer	312	50		
Envirofit stove sales to neighbors	**N**	**%**		
Total Neighbors who purchase a stove	61	100		
of whom are neighbors of early buyers	21	34		
of whom are neighbors of late buyers	40	66		
Other community members who purchase a stove[c]	51	N.A.		
Neighbors excluding those who already own stoves	**N**	**Mean**	**S.D.**	**Median**
Average geographic distance between neighbors[d] *(kilometers)*	641	0.20	0.32	0.13
of which distance from neighbors of early buyers	303	0.20	0.13	0.28
of which distance from neighbors of late buyers	361	0.25	0.13	0.36
Neighbors only who have not yet purchased an Envirofit	**Early buyers**		**Late buyers**	
	N	**%**	**N**	**%**
Total sample	304	100	364	100
Neighbor attended original sales meeting	27	9	34	9
Reciprocated friendships[e]	160	53	193	53

Notes: [a]One late buyer and one early buyer survey are missing a survey. Despite these two surveys being missing, we have survey data from their neighbors. This accounts for the discrepancy between 312 total recommended neighbors who list early or late buyer in general statistics and 308 with a matched survey in later analysis. [b] 19% represents a percentage of the total 763 sample. [c]Notably, it is feasible that among the 412 original buyers in the 14 parishes, additional neighbors own an Envirofit from the previous sales study. Thus, the total sample of non-recommended neighbors close to a neighbor is unknown. [d]The variable average geographic distance is topcoded at 1.5 kilometers.[e] Reciprocated friendships represent neighbors who also listed closest early or late buyer as close friend.

Table 1b. Summary statistics related to communication and shared activities between neighbors

Neighbors who have not purchased an Envirofit	**Total sample**		**Early buyers**	**Late buyers**
	N	**%**	**%**	**%**
Total sample	668	100	100	100
Neighbors who list experimental early or late buyer	353	53	53	53
Frequency of contact between neighbors	355	100	100	100
Daily	226	64	63	64
Three times a week	70	20	21	19
Once a week	44	12	12	12
Twice a month	3	1	2	0
Monthly	7	2	1	3
Less than once a month	5	1	1	2
Last reported contact between neighbors	354	100	100	100
Today	147	42	45	39
Two to six days ago	174	49	47	51
A week ago	14	4	3	5
Two weeks ago	8	2	2	3
A month ago	11	3	3	3
Type of activities reported reported by neighbors*	358	100	100	100
Attend family events together**	70	20	24	16
Farm together	82	23	22	24
Attend church together	118	33	35	31
Are part of same ROSCA[a]*	66	18	22	16
Are part of same Kwesika group that assists with burials	77	22	21	22
Report no shared activities	58	16	17	16
Participant consults experimental neighbor with problems	315	89	89	89
If yes, how frequently do you consult experimental neighbor				
All the time	51	16	15	17
Most of the time	140	44	43	46
Some of the time	95	30	33	28
Not very frequently	29	9	8	10
	N	**Mean**	**Mean**	**Mean**
Index of social closeness[b]	354	12	12	12
Standardized index of social closeness[b]	354	0.01	0.17	-0.12

Notes: The sample includes both recommended and non-recommended buyers, but drops 95 neighbors who previously purchased a stove in an earlier study. The data presented is based on survey responses from neighbors of the experimental sample. [a]ROSCA is the abbreviation for Rotating Savings and Credit Association. [b]The "Index of social closeness" is a combination of the variables- "Frequency of contact between neighbors","Last reported contact between neighbors", the count of "Type of activities reported by neighbors" and "Yes participant consults with the experimental neighbor if had a problem." The "Index of social closeness" has been constructed such that all four variables are coded so 0 indicates least socially close. As a result the count variable of the four measures of social closeness ranges from 0-14 with zero being the least close and 14 being highest on the social closeness index. For regression analysis the "'Standardized index of social closeness"' has been constructed such that each of the four variables has a mean of zero and a standard deviation of 1. Statistical significance from t-tests indicated by * p< 0.10, ** p< 0.05, *** p< 0.01.

Table 1c: Summary Statistics of neighbors' knowledge and experience with Envirofit cookstove

All Neighbors who have not yet purchased a stove	**Total sample**		**Early buyers**	**Late buyers**
	N	**%**	**%**	**%**
Total sample	668	100	100	100
Knowledge about the Envirofit cookstove				
Participant knows about the stove,***	172	26	22	29
of whom, knows about stove from the experiment***	99	57	68	50
Participant knows one person who owns stove***	267	40	43	38
Participant knows at least two people who own stove***	95	14	19	10
Participant seen one person cook with stove***	167	25	31	20
Participant seen more than one person use stove***	51	8	9	6
Participant knows focal point person	433	65	65	65
Participant knows focal point person owns stove	121	28	27	29
Participant seen focal point person cook with stove	29	24	28	21
Other neighbor(s) bought Envirofit**				
1 other	183	27	26	29
2 others	38	6	6	5
3 others	23	3	2	5
Opinions about the Envirofit cookstove				
Participant selects Envirofit is better for your health**	153	23	20	26
Participant selects Envirofit is easier to use*	141	21	18	23
Participant selects Envirofit uses less fuel*	150	23	20	25
Participant heard good things about Envirofit stove*	144	22	19	24
Participant heard bad things about Envirofit stove**	25	4	2	5

Notes: For the following variables:"Participant selects the Envirofit is better for your health;" "Participant selects the Envirofit is easier to use;" "Participant selects the Envirofit uses less fuel (compared to three stone fire)"; respondents were asked to rank the Envirofit from 1 to 10. Here 1 represents the Envirofit was strongly better than a three stone fire. These variables have been constructed as dummy variables assigned a 1 if the ranking given was a 1 or 2 (indicating a strong preference for the Envirofit) or a 0 for rankings 3 through 10. Other neighbor(s) bought Envirofit- represents other neighbors (those not verbally mentioned as neighbors, but who lived in close geographic proximity) that purchased an Envirofit at the same time as the early or late buyer neighbor. In total, 95 additional buyers are part of the Other neighbor(s) who bought Envirofit group. Statistical significance from t-tests indicated by * p< 0.10, ** p< 0.05, *** p< 0.01.

Table 1d: Summary Statistics of socio-demographics for neighbors related to cooking

	Total sample		Early buyers	Late buyers
	Mean	**Median**	**Mean**	**Mean**
Average age	25	30	25	26
# of people who ate lunch yesterday[a]	13	12	13	13
Typical # of people who eat lunch[a]	13	13	13	13
	N	**%**	**%**	**%**
Wood is the fuel used for cooking* **	664	94	97	92
The largest meal cooked in the household	664	100	100	100
Breakfast	7	1	1	1
Lunch	84	13	9	16
Dinner	435	66	66	65
We never cook at our house	138	21	24	18
Neighbors gather wood last week or month	662	18	19	19
Yes, neighbor reports earning income* **	664	90	91	89
of which is earned in Cash only	219	36	32	40
of which is earned In-kind only	37	6	8	5
of which is earned in both Cash & In-kind	345	57	60	55
of which is not paid	3	0.5	1	0
Yes, neighbor has a television	664	8	9	8
Yes, neighbor has a radio	664	88	88	87
Yes, neighbor has a cell phone	664	70	68	72
Yes, neighbor owns cows	664	21	21	21
Count of four assets owned	664	100	100	100
of which 0 assets owned	46	7	7	7
of which 1 asset owned	163	25	26	23
of which 2 assets owned	317	48	46	49
of which 3 assets owned	110	17	17	16
of which 4 assets owned	28	4	4	5

Notes: [a]Both the average number of people who ate lunch yesterday and eat lunch on a typical basis includes only those who report a positive number. Statistical significance from t-tests indicated by * p< 0.10, ** p< 0.05, *** p< 0.01.

Table 2: Summary statistics for neighbors who have not purchased an Envirofit

	Total sample		**Early buyers**	**Late buyers**
	N	%	%	%
Interested in lump sum payment***				
Yes	157	24	21	26
Maybe	134	20	19	21
No	373	56	60	53
Interested in pay half now and half in 4 weeks*				
Yes	197	30	28	32
Maybe	208	31	33	30
No	259	39	28	38
Purchased the Envirofit**	61	9	7	11
Of whom paid half now and half in 4 weeks	52	85	85	85
Of whom paid one lump sum payment	9	15	14	15

Notes: Statistical significance from t-tests indicated by * p< 0.10, ** p< 0.05, *** p< 0.01.

Table 3: The effect of a neighbor's ownership of an Envirofit on familiarity and opinions about the Envirofit The dependent varaible for specification A is # of people neighbor knows who own Envirofit; Specification B is # of people neighbor has seen cook with Envirofit

	(A)	(A)	(B)	(B)
Neighbor of early buyer	0.17***	0.20***	0.11*	0.13***
	(0.07)	(0.06)	(0.06)	(0.05)
Asset count	0.01	0.01	0.12	0.12
	(0.03)	(0.03)	(0.03)	(0.03)
Household never cooks	-0.01	-0.05	0.05	-0.01
	(0.07)	(0.06)	(0.06)	(0.06)
Other neighbor(s) bought Envirofit		0.13***		0.13***
		(0.04)		(0.05)
Knows focal person		0.55***		0.42***
		(0.06)		(0.06)
Constant	1.09***	0.86***	1.02***	0.82***
	(0.15)	(0.16)	(0.15)	(0.16)
Parish fixed effects	Yes	Yes	Yes	Yes
Observations	658	658	658	658
R-squared	0.11	0.21	0.16	0.24

Notes: Other neighbor(s) bought Envirofit- represents other neighbors (those not verbally mentioned as neighbors, but who lived in close geographic proximity) that purchased an Envirofit at the same time as the early or late buyer neighbor. In total, 95 additional buyers are part of the Other neighbor(s) who bought Envirofit group. Standard errors, clustered by shared early or late buyer, in parentheses. Statistical significance indicated by * p< 0.10, ** p< 0.05, *** p< 0.01.

Table 4: The effect of a neighbor's ownership of an Envirofit on familiarity and opinions about the Envirofit. The dependent variable for specification A is neighbor believes Envirofit improves health; specification B is neighbor believes Envirofit is easier to use; specification C is neighbor believes Envirofit uses less fuel.

	A	B	C
	(Improves health)	(Easier to use)	(Uses less fuel)
Neighbor of early buyer	-0.06*	-0.04	-0.05
	(0.04)	(0.04)	(0.04)
Asset count	0.02	0.01	0.02
	(0.02)	(0.02)	(0.02)
Household never cooks	-0.05	-0.01	-0.15
	(0.04)	(0.04)	(0.04)
Other neighbor(s) bought Envirofit	0.02	0.01	0.02
	(0.03)	(0.03)	(0.03)
Knows focal person owns Envirofit	0.22***	0.17***	0.19***
	(0.06)	(0.06)	(0.06)
Constant	0.31***	0.33***	0.31***
	(0.09)	(0.09)	(0.09)
Parish fixed effects	Yes	Yes	Yes
Observations	658	658	658
R-squared	0.09	0.07	0.08

Notes: Other neighbor(s) bought Envirofit- represents other neighbors (those not verbally mentioned as neighbors, but who lived in close geographic proximity) that purchased an Envirofit at the same time as the early or late buyer neighbor. In total, 95 additional buyers are part of the Other neighbor(s) who bought Envirofit group. Standard errors, clustered by shared early or late buyer, in parentheses. Statistical significance indicated by * p< 0.10, ** p< 0.05, *** p< 0.01.

Table 5: Predicting purchase of the Envirofit. Specifications 1-2 use the total sample and specifications 3-4 use the sub-sample of symmetric strong linked neighbors with experimental early/late buyers

	Purchase (1)	Purchase (2)	Purchase (3)	Purchase (4)
Neighbor of early buyer	-0.03	-0.02	-0.01	-0.01
	(0.02)	(0.03)	(0.03)	(0.03)
Asset count	0.04***	0.04*	0.04*	0.04*
	(0.01)	(0.02)	(0.02)	(0.02)
Household never cooks	0.05*	0.03	0.04	0.04
	(0.03)	(0.04)	(0.04)	(0.04)
Other neighbor(s) are early or late buyer	0.01		0.02	
	(0.02)		(0.03)	
Knows focal person owns Envirofit	-0.01		0.03	
	(0.03)		(0.05)	
Social closeness index		0.01		0.01
		(0.01)		(0.01)
Neighbor of early buyer * Social Closeness		0.01		0.01
		(0.01)		(0.01)
Constant	-0.03	-0.06	-0.08	-0.06
	(0.04)	(0.04)	(0.05)	(0.04)
Parish fixed effects	Yes	Yes	Yes	Yes
Observations	658	348	308	308
R-squared	0.08	0.12	0.12	0.13

Notes: To measure social closeness we created an index of self-reported frequency of communication between the respondent and the experimental neighbor, number of shared activities with the experimental neighbor, and whether the respondent would solicit advice from the experimental neighbor. For each of the four variables we create a standardized score so that each variable has a mean of 0 and standard deviation of 1. Further, the sample size drops for the social closeness variable because enumerators generally recorded data only for the subset of households who selected the early or late buyer as someone they speak to frequently. Standard errors, clustered by shared early or late buyer, in parentheses. Statistical significance indicated by * p< 0.10, ** p< 0.05, *** p< 0.01.