Determinants of Technology Adoption: Peer Effects in Menstrual Cup Take-Up

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Abstract

We estimate the role of peer effects in technology adoption using data from a randomized distribution of menstrual cups in Nepal. Using individual randomization, we estimate causal effects of peer exposure on adoption. We find strong evidence of peer effects: two months after distribution, one additional friend with access to the menstrual cup increases usage by 18.6 percentage points. Using the fact that we observe both trial and usage of the product over time, we examine the mechanisms driving peer effects. Our results suggest that successful uses by peers are more important than peer unsuccessful usage attempts. In addition, we argue that peers matter because individuals learn how to use the technology from their friends, but that peers do not affect an individual's desire to use or attempt to use.

1 Introduction

Understanding the influence of individual's peers – friends, acquaintances, neighbors, classmates – on behavior has been of interest to economists in a wide variety of fields, including education (e.g. Sacerdote 2000; Hoxby 2000; Zimmerman 2002; Angrist and Lang 2002; Figlio 2003), labor (e.g. Kling, Liebman and Katz 2007; Munshi 2003), development (e.g. Foster and Rosenzweig 1995; Miguel and Kremer 2004) and industrial organization (e.g., Mas and Moretti 2009; Mobius, Niehaus and Rosenblat 2007). Of particular interest has been the role of peers in technology adoption, either by firms or individuals. Within the field of development, peer effects may have normative implications: new technologies frequently have the potential to dramatically improve

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quality of life, but adoption is often sub-optimally slow (see, among others, Foster and Rozensweig 1995; Conley and Udry *forthcoming*; Duflo, Kremer, and Robinson 2008; Miguel and Kremer 2004; Munshi 2003; Bandiera and Rasul 2006).

Estimating the role of peers or social interactions in driving technology adoption is made difficult by the problem of correlated unobservables between peers (Manski, 1993). When the econometrician observes two friends both adopting a new technology, it is difficult to separate whether they learn from each other or if fast-adopter individuals simply have fast-adopter friends. As a result, 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 *forthcoming*; Munshi 2003; Figlio 2003; Bandiera and Rasul 2006) including, more recently, explicit randomization (Sacerdote 2000; Kremer and Levy 2008; Mobius, Rao and Rosenblat 2007; Duflo and Saez 2003; Godlonton and Thornton 2008; Miguel and Kremer 2004; Duflo, Kremer, and Robinson 2008; Miguel and Kremer 2007).

The results on peer effects in technology adoption are somewhat mixed. Much of the literature (e.g. Foster and Rosenzweig, 1995; Conley and Udry, *forthcoming*) finds peer exposure has a positive impact on technology adoption, while recent, randomized, work has found either negative peer effects (Miguel and Kremer, 2007) or no effects (Duflo, Kremer, and Robinson, 2008). One way to make progress on reconciling these results is to examine what mechanisms drive the effects. There are at least three possible drivers of positive peer effects: individuals benefit from behaving like their friends, individuals learn about the benefits of the technology from their friends, and individuals learn about how to use a new technology from their friends. We can see immediately that some of these drivers – for example, learning from friends about how to use a technology – are likely to operate in cases where the technology is hard to use, which could be useful in explaining differences across technologies in the existing literature. However, even with randomization it typically has not been possible to identify which of these factors are most important in driving peer effects (Duflo and Saez 2003; Munshi and Myaux, 2006).[1]

In this paper we use data from a randomized evaluation of menstrual cup distribution in Nepal

[1]The few cases, primarily in sociology and demography, in which efforts have been made to distinguish between these mechanisms tend to be plagued by the same type of identification problems inherent in all non-experimental estimates of peer effects (Kohler, Behrman and Watkins, 2001). A partial exception is Miguel and Kremer (2007) who find negative peer effects, which effectively rules out two of the three explanations above (wanting to behave like friends and learning from friends); this is discussed in more detail below.

to: (1) estimate the role of peer influence in adoption of a new technology and (2) provide initial evidence on what mechanisms drive the peer effects we observe. A menstrual cup is a small, silicone, bell-shaped device which is used internally during menstruation; it is completely unfamiliar to our subjects at the start of the study and is unavailable for purchase in Nepal. We enrolled a sample of 198 adolescent girls and their mothers in four schools in Chitwan, Nepal and randomized (at the individual level) allocation of menstrual cups to half of the sample. Subjects were followed for approximately eighteen months and detailed data was collected on cup adoption over this time.[2]

While the menstrual cup may not be *per se* as important as some other technologies (i.e. fertilizer, vaccines, contraceptives), this setting has a number of advantages for understanding patterns of technology adoption. First, the individual randomization allows us to estimate causal peer effects. Second, we have data on cup adoption over time, which allows us to observe whether these effects change as the product becomes more familiar. Finally, we have data on successful usage attempts and unsuccessful attempts over time which allow us to identify mechanisms through which peers affect adoption. Overall, we argue that the features of the study allow us to draw fairly sharp conclusions which contribute significantly to understanding technology adoption patterns, and are informative about other technologies which may be similar but more difficult to study directly.

We begin by using our data to estimate the influence of peers on individual usage of the menstrual cup. The variation we use to estimate the effect of peers on individual use is generated by the randomization: at the baseline survey, girls were asked to list their closest friends who were also part of the study, allowing us to identify friendships. Since access to the cups was randomized at the individual level, number of friends in the treatment group with access to cups is random (conditional on number of total friends). This allows us to estimate causal peer effects.

We find strong evidence of positive peer effects. Two months into the study, one additional treatment friend increases cup usage by 18.6 percentage points. This effect dissipates over time: by six months after cup distribution, the effect of friend ownership on usage is no longer significant. This suggests the primary peer effect in this case is to increase speed of adoption. These effects do not appear to be driven by effects of maternal cup ownership and are largest for stronger friendships (where both girls list each other as friends).

These primary effects focus on peer cup *ownership*; in addition, we use ownership as an

[2]This study also evaluated the impact of menstrual cups on school enrollment; those results are reported in Oster and Thornton, 2009.

instrument for usage behavior. We estimate the effect of *successful friend usage* of the cup and the effect of *failed friend usage attempts*. We first estimate these effects separately using cup ownership alone as an instrument. In order to estimate the effects jointly, we use variation in friend menstrual frequency as a second instrument.[3] Both sets of results suggest that peer successful usage is a more important driver of adoption than failed usage attempts.

After establishing there are positive peer effects driving adoption, we attempt to gain a deeper understanding of the mechanisms through which this occurs. As noted above, there are at least three possible mechanisms through which peers could affect adoption: (1) individuals want to act like their friends (imitation), (2) individuals learn about the value of the technology from their friends, and (3) individuals learn about how to use a new technology from friends. We collapse these three mechanisms into two broader categories. In particular, we separate them into peers influencing individual's *wanting to use* (reflecting either imitation or learning about value) and peers influencing individual's *success at usage* (reflecting learning how to use).

To separate these effects empirically, we introduce some additional structure. We present a simple two-stage model of the adoption process in which friends can affect whether individuals want to use the cup, and also can affect whether they will be successful at using. The model generates a strategy for separately estimating these two types of peer effects, making use of the fact that we observe both successful and failed usage attempts. Intuitively, we draw a parallel between attempting to use and *wanting to use,* and successful use conditional on attempting and *success at usage.* In practice, the additional structure provided by the model is necessary to map the data we observe onto the theoretical objects of interest.

Our results suggest that friends are very important in learning how to use the cup; they significantly affect *success at usage*. In early months, having one additional treatment friend-month of exposure to the cup increases the probability of successful usage by 3 percentage points. In contrast, we find no evidence that peer exposure impacts *wanting to use* the new technology. This finding suggests that with an easy to use product there may be only limited scope for peer-based targeting, because there are no gains of learning from peers. In contrast, with a difficult to use product, peer-based targeting could have large effects on the speed of adoption. To the extent that peer effects are more often found in cases where the product is difficult to use (for example, adoption

[3] The second instrument is necessary since we want to estimate the effect of both successful and unsuccessful attempts, and the randomization provides only a single source of variation.

of high yield varieties of seeds), and not in cases where the product is easy to use (i.e. adoption of de-worming drugs), these results may shed some light on why that occurs.[4]

The rest of the paper is organized as follows. Section 2 describes the setting, the experimental design, the menstrual cup, and the data that we will be using. Section 3 presents our estimates of the role of peer exposure in driving adoption. Section 4 analyses the mechanisms that drive these effects, focusing on whether peers affect wanting to use or success at usage. Section 5 concludes.

2 Experimental Design, Survey and Data

The data and results in this paper come from a randomized evaluation of menstrual cups in Chitwan, a district in South-western Nepal. Women and girls in this area, as in much of the rest of Nepal, traditionally use cloths during menstruation to soak menstrual blood. These cloths can be unsanitary if not washed carefully, but most importantly, are reported to be inconvenient and uncomfortable. Sanitary pads are typically familiar to people, but not widely available or used, and the use of tampons is extremely rare. In the evaluation, menstrual cups were distributed randomly to half of the participants, as an alternative to rags, and usage was observed over time.

2.1 Participants and Survey Timeline

Four schools in and around Bharatpur City in Chitwan District, Nepal were chosen in November of 2006 to participate in the study; of these, two were urban schools and two were peri-urban. Based on the school roster of girls who were enrolled at the start of the school year, 60 seventh-grade and eighth-grade girls from each school were invited, with their mothers, to participate in the study (this represented most of the 7th and 8th graders). Participation was contingent on attendance at the first study meeting. The girls were told that they would receive a gift (pens and stickers) at the meeting, and their mothers received 100 Nepali Rupees (about $1.45). If a mother was not available, girls were told they could bring an older female relative or guardian to the meeting. Column 1 of Panel A of Table 1 shows the total number of girl participants in each school; between 7 and 12 of the invited students in each school were not able to attend the meeting and

[4] Our results also show that peer effects dissipate over time. To the extent that most existing work focuses on measuring peer effects at the end of a study, rather than over time periodically, this could explain why in some cases they are not observed.

therefore did not participate in the study. Columns 2 and 3 in Panel A show the composition of the older female participants: 79% of girls participated with their mothers, and 21% with a female guardian. Throughout the paper we will refer to all female guardians as "mothers".

At the initial study meeting, a baseline survey was administered to the girls and their mothers. This survey included basic demographic information, as well as questions about school performance and menstruation. At the end of this initial meeting, girls were given identification numbers and a public lottery was held in which twenty-five identification numbers were drawn out of a bag. Girls whose numbers were drawn were assigned to the treatment group with their mother or guardian (we did not separately randomize mothers). The treatment girls and their mothers were asked to remain at the meeting and each were given a menstrual cup. A nurse gave detailed instructions to those in the treatment group on the use of the menstrual cup.[5]

After the initial meeting, girls were followed for approximately fifteen months (through January, 2008). During this time, there was an in-school nurse visit approximately once per month, at which time the treatment girls were asked about their experiences with the menstrual cup. The number of girls interviewed at each visit varied; although there was close to complete coverage in the first few months, on average 80% of treatment girls were available at each visit in later months. As we detail below, there is no systematic attrition across groups, so this is unlikely to drive our results.

In February, 2008 a second meeting was held in each school. At this meeting, a follow-up survey, similar to the baseline survey, was administered. The control girls and their female guardians were given the menstrual cup. Ninety-two percent of the girls in the study attended the follow-up meeting. Of the 15 girls not able to attend the meeting all but one were interviewed by enumerators at a later date (these included 7 treatment and 7 control girls).

2.2 Sanitary Technology

The sanitary technology we use is a menstrual cup, specifically the MoonCup brand cup, shown in Figure 1 (similar cups are sold under the name Keeper and Diva Cup).[6] This product is a small, silicone, bell-shaped cup which is inserted in the vagina to collect menstrual blood. For most

[5] One of the mother-daughter pairs randomized to the treatment group decided not to accept the menstrual cup. We analyze the intention to treat effect, and keep this girl in our sample for analysis. This girl and her mother were each interviewed at the follow-up survey.

[6] For more information, see http://www.mooncup.co.uk/.

women the cup will have to be emptied approximately every twelve hours during menstruation. Between uses, the cup is washed with soap and water and stored in a cloth bag. With proper care, the cup is re-usable for up to a decade.[7]

In the area of Nepal where our experiment takes place, the primary protection women use during their period is menstrual cloths. These cloths are placed inside a woman's underwear to soak up menstrual blood. The cloths are washed and re-used. The menstrual cup may be a significant improvement over this cloth technology for several reasons. First, if correctly inserted, women should not noticed the presence of the menstrual cup and it will not affect mobility. Indeed, anecdotal evidence from Nepali women to whom we gave the cup as a pilot suggested that increased mobility was a major advantage – women said they were able to bicycle, and that they even forgot they were having their period. Second, cleaning the menstrual cup for re-use is significantly easier than cleaning the menstrual cloths. The cup is washed with soap and water, which takes only a minute or two; the cloths must be boiled and laundered, typically by hand, which takes a (reported) average of 30 minutes per month. All of these factors – increased mobility, ease of use, and no need to wash rags – were mentioned by girls at the follow-up survey as advantages of the cup.[8]

We argue that the menstrual cup is well suited for studying determinants of technology adoption. First, the technology is not available for purchase in Nepal, meaning we do not have to contend with the concern that some girls know more about the technology initially than others do. Second, although the cup is comfortable to use for most women, it often takes time for people to learn how to insert and remove it comfortably; indeed, when girls in our sample were asked about disadvantages of the cup, the most common response (reported by 30% of the girls in the sample) was "difficult to insert". The cup must be flattened and folded in half in order to insert it into the vagina and it takes some practice to position it correctly to prevent leakage. Given that insertable reproductive devices are rare in Nepal, and that our main respondents were young adolescent girls who were just becoming familiar with their reproductive health, using this technology was likely to take some practice. This suggests that there is scope for understanding the learning component of

[7]There is no risk of Toxic Shock Syndrome, and generally no risk of complications from the cup. This menstrual cup has been FDA approved in the United States.

[8]In a second paper using the data from this study (Oster and Thornton, 2009) we evaluate whether these mobility benefits translate into increases in school enrollment; we find they do not and, further, argue that menstruation plays only a small role in school absence. That paper relates to a small literature within economics on menstruation and work/school absence: Ichino and Moretti (2009) find evidence of cyclicality in the absences of female Italian bank workers, which they attribute to menstruation, although these conclusions have been questioned by Rockoff and Herrmann (2009).

technology adoption.

2.3 Data

This paper uses four primary elements of the data from the menstrual cup experiment: demographic and cup value data, data on cup adoption, data on friendships and data on mothers' behavior.

Demographics and Cup Value: From the baseline survey we make use of a number of control variables on demographics (age, grade, etc), which are summarized in Panel B of Table 1. The average age is 14, and girls are evenly divided between the 7th and 8th grades, as was designed by the stratified randomization. Forty-seven percent of the girls are of Hindu ethnicity (while other ethnic groups consist of Tibetan-Burmese, Tharu, or Newari). Eight-seven percent of girls have had their period at the baseline survey. Education rates among parents are low, but not zero: mothers have an average of about 2.7 years of education, fathers an average of 5.6 years.

In addition, we include several controls for the value of the cup, to address the fact that girls may differ in how effective they find the cup relative to the alternative.[9] These include whether the girls works for pay (related to the need for mobility) and reported time it takes to wash menstrual cloths (as a measure of how costly the alternative technology is). These variables are summarized in Panel B of Table 1. Roughly 22% of the girls in the sample ever work for pay and they spend an average of 30 minutes per month washing menstrual cloths.

Data on Cup Adoption: As mentioned in Section 2.1, after the menstrual cups were distributed at the baseline survey a nurse followed up with roughly monthly visits to the school, at which time data was collected about cup usage. During the nurse visit, each girl in the treatment group was asked if she had used the menstrual cup during her period that month. Although the verbal responses differ across girls, typical responses include quotes such as, "I use it and feel it is easy", "I couldn't insert so I haven't used it" or "I am afraid to try it". From these responses we coded whether the girls attempted to use the menstrual cup and whether they were successful at their attempt. For example, the first quote here would be coded as a successful usage attempt, the second quote would be coded as an unsuccessful usage attempt and the third would be coded as not attempting to use.

[9] The concept that individual differences in productivity could map into differences in technology adoption references, of course, a large literature on the role of individual productivity differences in driving adoption rates (e.g. Griliches, 1957; Oster and Quigley, 1977; Oster, 1982; Caselli and Coleman, 2001; David, 1990; Luque, 2002; Duflo et al, 2005).

To give a sense of the basic patterns of adoption, Figure 2 shows the share of girls attempting to use, and share who successfully used, each month over the course of the study; the numbers above each data point report the sample size in that month. Although the nurse affiliated with our study made an effort to talk with each individual in each month, some girls were not in school during the visits. On average, we observe 81% of girls in each month; we demonstrate there is no differential rate of attendance by number of treatment friends in the next section.

Successful usage of the menstrual cup increased dramatically in the first six months, from 10% in January to 60% in June. After this, usage was fairly constant, with little movement from June, 2007 to January, 2008. The pattern for total usage attempts is similar, although the line is flatter. The share of girls attempting to use increased from only 60% to 80% over the first months of the study and declined some in the period after that, likely reflecting a decrease in girls who continued to attempt to use without success. One thing that is important to note is that once a girl used the cup once, continued usage was extremely high. After one month of successful usage, girls used the cup in 91% of subsequent periods. Given this extremely high later usage rate, we will often refer to girls "adopting" the cup at the first successful usage.[10]

Given our reliance on the adoption data, a central issue is whether girls reported cup usage accurately reflect their actual usage. Although we are unable to determine this entirely, we have evidence of high levels of cup usage using other features of the data. First, in the follow-up data, girls were asked about their use of the cups as well as the use of other menstrual technologies such as pads or rags. Comparing the answers to questions on menstrual sanitary product use between girls in the treatment group and control, in the baseline and at the follow-up surveys, we find that treatment girls at the follow-up were 35 percentage points less likely to report using any rags than the control at the follow-up and they reported using on average 1.09 rags less per period. There were no significant differences in the reported use of pads between the treatment and control girls. While this still relies on self-reported data, this provides some evidence of the level of substitution between sanitary products.

A second piece of evidence on adoption comes from time-diary data collected from the girls. For the first 10 months of the project, we collected monthly time diaries from each girl. Girls

[10] We have run our primary analyses replacing the current measure of usage with a new measure which defines girls as using the cup only if they continue to use the cup in subsequent months. This change makes almost no difference, and results are available from the authors.

reported their activities for the first 6 days of each month including their time spent on cooking, domestic and agriculture work, and schooling, for example. Using these time diaries, we observe significant differences in time use on days girls are menstruating. We observe that girls in the control group spend approximately 22 minutes more doing laundry on days when they are menstruating. This is presumably due to the extra time needed to wash their menstrual rags. In contrast, treatment girls who are menstruating spend 20 minutes less time doing laundry than control girls who are menstruating. While both the time diary and the follow-up survey are also self-reports, they point to a level of internal consistency which we think is supportive of the validity of our adoption data.

Data on Friendships: The object of interest when we consider effects of peers on technology adoption will be the number of friends who also received the cup. We generate this measure using data on friendships collected in the baseline survey. In this survey, before the randomization took place, each of the girls was asked to list their three closest friends who were also at the initial meeting.[11] Our primary measure of friendships is total friends, which includes everyone whom the individual lists as a friend and anyone who lists them as a friend. On average, girls listed 2.6 close friends with 68 percent listing 3 friends and 25 percent listing 2 friends; when we add in people who list the girl a as a friend, the average girl has 3.8 total friends, with a maximum of 7 (Table 1, Panel C). Consistent with the randomization, we see that an average of 50% of a girl's friends are in the treatment group (Table 1, Panel C). In addition to the total number of friends, we also consider the strength of friendships, distinguishing between strong friendships (bi-directional links) and weak friendships (uni-directional links).[12]

Data on Mothers: In Section 3 we will talk briefly about cup usage of mothers. Mothers of the treatment girls were also given access to the cup. We measure maternal usage only at the follow-up survey, when we ask them whether or not they use the cup. Usage rates for mothers at the follow-up meeting are quite high, at 73%. We considered asking mothers about their friends among participants at the meeting, in pilot surveys this question was poorly received, and women indicated

[11] In our survey we asked only about the three closest friends; we did not allow respondents to list all of their possible friends. In practice, this truncation likely does not miss very many friends: in the follow-up survey, we asked how many girls the respondent considered to be her close friend (without truncating the total permissible friends) and 75% answered four or fewer, with a median number of 3. In addition, given the randomization, we are able to obtain an unbiased estimate of the impact of additional treatment friends even if we do not observe all of an individual's friends.

[12] It would also be possible, in principle, to separate weak friends into two groups by the direction of who lists whom. In the analysis, when we make this distinction in the direction of listing, we find no differences and therefore focus on the weak versus strong friendship type distinction only.

that for the most part they were not friends with others at the meeting. We have, however, one measure of maternal friend exposure: at the follow-up survey, we ask mothers whether they discussed the cup with any other mothers in the study. Forty percent report doing this (Panel C of Table 1).

3 Peer Effects on Technology Adoption

This section presents our baseline estimates of the effect of peers on adoption of the menstrual cup. The first subsection below presents our empirical strategy detailing how we estimate causal effects of peers; the second subsection presents our results.

3.1 Empirical Strategy

Identifying causal effects of peers is challenging. The main concern, as outlined by Manski (1993) relates to the issue of correlated unobservables: friends often have similar characteristics, meaning if we observe friends acting similarly, it is difficult to separate whether they act similarly because they are influencing each other or because they were *ex ante* similar.

Consider first the case without randomization in which researchers have access to cross-sectional data including girls for whom they observe menstrual product ownership/usage and friendships. It would certainly be possible to run a regression to estimate the effect of friend ownership on product use in this setting. However, it would not be correct to interpret these estimated coefficients causally: if individual characteristics are correlated with friend characteristics, it is likely that individuals who own the cup also have friends who own the cup *not* because they are affected by their friends, but because they are similar to them.

In our case, we use explicit randomization to causally identify the peer effects. Ownership of the menstrual cup is randomly allocated. Because randomization is at the individual level, not only is individual ownership random, but the number of friends who own the cup is also random conditional on total number of friends.[13] For example, a girl in the treatment group with two total

[13] Our measure of friend exposure is number of treatment friends. Number of treatment friends is only random conditional on total number of friends; we will therefore condition on total number of friends when we do this analysis. To see why conditioning on total number of friends address this issue, denote $Y \in \{0, 1\}$ the individual binary outcome (uses or not) and D as the number of friends in the treatment group. The object we hope to estimate is $\Lambda = Pr(Y = 1|D = \Phi) - Pr(Y = 1|D = \Phi - 1)$ that is, the difference in the potential outcome (using the technology) when the individual has one fewer friend. We do not observe the same person with both Φ and $\Phi - 1$ friends, and what we estimate empirically is $\hat{\Lambda} = Pr(Y_\Phi = 1|D = \Phi) - Pr(Y_{\Phi-1} = 1|D = \Phi - 1)$ Assume that each individual has a constant number of total friends H (empirically, this is achieved by controlling for total number of friends). Whether each of these friends

friends has a 50% chance that each of her friends will also be in the treatment group. This means there is a randomly generated 25% chance she has no treatment friends, 50% chance of one treatment friend and 25% chance of two treatment friends. This randomization allows us estimate the causal effect of the number of treatment friends (who own the cup) on cup adoption. Note that the analyses are run only among girls in the treatment group; however, the existence of the control individuals (i.e. the randomization) is crucial to the identification, because it drives the exogenous variation in number of treatment friends.

We begin by estimating the relationship between cup usage and number of treatment friends at three different points in time (February, 2007; August, 2007 and January, 2008), which gives a sense of how the coefficients vary over time. In each case, the variable for usage is equal to one if the individual reported successfully using the cup in that month and zero otherwise. We estimate a Probit model, specified in Equation (1) below.

$$Pr(Used_i = 1) = \Phi(\gamma + \delta_1(\#\text{Treatment Friends}_i) + \mathbf{\Pi X_i} + \mu_i) \tag{1}$$

$\mathbf{X_i}$ is a vector of controls (e.g., number of total friends, age, grade, test scores, school fixed effects, parental education, family income and measures of cup value), and "# Treatment Friends$_i$" is the number of friends in the treatment group. When we estimate this regression we report marginal effects from the Probit model. Specifically, we report the average of the marginal effects: for each variable we estimate the marginal effect on usage for every individual and we take the average of those effects and that is the reported coefficient. Note that this is distinct from what is done by the Stata "dprobit" command, which reports the marginal effect for the *average* individual. Although these estimates are typically similar in most settings, in our setting the effects from "dprobit" are similar in terms of significance but in some cases much larger. This appears to be due to the inclusion of school fixed effects. Since we have two schools with very high levels of usage and two schools with very low levels of usage, once we include school fixed effects in the regression we do have an "average" individual. The estimate of the marginal effect for the average individual is therefore arbitrary (alternative specification results are available upon request).

is in the treatment group is random. As a result, conditional on H, the number of treatment friends is random. This means that $Pr(Y_\Phi = 1|D = \Phi) = Pr(Y_{\Phi-1} = 1|D = \Phi) = Pr(Y|D = \Phi)$ and similarly for $Pr(Y_{\Phi-1})$. As a result, $\Lambda = \hat{\Lambda}$ and the estimation generates unbiased estimates of the treatment effect of friends on adoption.

In addition to looking at the effects on usage at these three points in time we will undertake three additional analyses. First, a probit model measuring whether an individual ever uses the cup during the entire time period. Second, a simple linear model to estimate the effect of friends on the first month of successful usage, conditional on ever using. Finally, a hazard model for date of adoption; in that case, the unit of observation is an individual-month.

One important note is that we will first estimate the effect of friend *ownership* on cup adoption, rather than friend usage. Because of the structure of the randomization, ownership is what is determined randomly; friend usage may be correlated with individual usage for all of the same reasons that correlated unobservables are a problem without randomization. In Section 3.3 we use ownership as an instrument for usage, which allows us to interpret the coefficients as an effect of usage, but makes the implicit assumption that ownership only matters through successful usage.

Balancing on Observables: The central assumption in the empirical strategy is that, conditional on the total number of friends, the number of treatment friends is randomly assigned. To test the validity of this randomization, we look at balancing on observables. In particular, we compare baseline characteristics among girls with different numbers of treatment friends, conditional on their total number of friends.

We regress each baseline characteristic of interest on indicators for number of treatment friends and number of total friends. Coefficients on the number of treatment friends from these regressions are shown in Table 2. In most cases, these coefficients are small and statistically insignificant, suggesting the randomization was successful, at least in terms of observables. One exception is the variable indicating whether a girl had ever worked for pay. Girls in our sample who have more treatment friends are significantly more likely to work at baseline; this likely reflects our small sample size, and appears to have occurred by chance. We include this control in all regressions which will address this difference.[14]

3.2 Results: Peer Effects on Technology Adoption

We begin by showing our central results of the effects of the number of treatment friends in

[14]The length of time working, conditional on working at all, *is* balanced across number of treatment friends, suggesting this lack of balance is not likely to be systematic. Moreover, there are no significant differences in working between treatment and control girls, or differences in the likelihood that mothers were working for pay, suggesting there wasn't some targeting on girls who work (and who have more treatment friends).

graphical form. As noted in Table 1, the total number of friends that an individual has (including friends an individual lists, and friends who lists them) ranges from 1 to 7. The majority of individuals (60 percent) have either 3 or 4 total friends. Focusing on these two groups, Figure 3A shows the average usage probability during the first three months of the sample, grouped by number of treatment friends. Within each group (3 total friends or 4 total friends), the number of treatment friends is experimentally generated by the randomization. We can therefore interpret differences in usage across the bars as the causal effect of additional friend exposure.

Figure 3A shows strong evidence of peer effects. Within either group, we see cup usage increasing in the number of treatment friends. For example, among the group with 4 total friends, there is no usage in the first three months for those with zero treatment friends, and then usage increases as the number of treatment friends increases, to as high as 100% for the (very small) sample of individuals who have 4 treatment friends. Figure 3B shows an identical graph, but focuses on usage in the *last* three months of the study, rather than the first three. In this case, we see that the peer effects have diminished – usage rates among those with no friends in the treatment group are similar to usage for individuals with many friends.

In Table 3 we provide statistical evidence on peer effects. In this case, we include all individuals and control for number of total friends.[15] The first three columns estimate the impact of treatment friends on adoption at three specific months: February, 2007 (2 months after distribution), August, 2007 and January, 2008 (the last month before the follow-up survey). Consistent with Figure 3A, we find strong evidence of peer effects in February 2007: one additional treatment friend increases the chance of of adoption by 18.6 percentage points. This effects dissipates in the later months, consistent with Figure 3B: by August, those with more treatment friends are not using at higher rates than those with fewer treatment friends. Figure 4 explores the timing of these effects in more detail and shows the effect of peer exposure is large and significant in early months (through March) and positive but not significant in the later months.

Columns 4-6 of Table 3 show additional estimates of the effects of peers on adoption. In Column 4 we find that having more treatment friends does not increase the chance of ever using the cup successfully. Columns 5 and 6 reinforce our finding that friends affect timing of adoption: Column 5 shows each additional treatment friend decreases time to adoption by 0.7 months[16], and

[15]The results are similar if we include dummies for number of treatment friends.

[16]Recall from Section 3 that once an individual uses the cup once, 90% of them continue using it, so early usage leads

Column 6 shows this effect is also present when we estimate using a hazard model.

To generate a final visual representation of the data, we run the regression from Equation (1) using all months in the sample, and estimate the impact of dummy variables for "treatment-friend-months". This variable measures the number of months of friend exposure to the cup; for example, for someone with three treatment friends, they would have 3 months of exposure in the first month, 6 in the second, etc, whereas for someone with only one treatment friend, they would have 1 month of exposure in the first month, 2 in the second and so on. Figure 5 shows these coefficients. Consistent with the regressions in Table 3, we see strong evidence that initial exposure to treatment friends matters, with some flattening of this effect over time. The regression corresponding to Figure 5 is shown in the Online Appendix.

Taken together, the evidence in Table 3 and Figures 3-5 suggest strong evidence of peer effects. These seem to operate through encouraging earlier adoption of the cup: those with more friends start using faster, although by the end of the sample period usage rates are fairly similar.

Looking briefly at the other controls, we see some evidence that indicators of the potential benefit of adopting the cup mattered in overall use. Girls who work for pay and who take longer to wash their menstrual cloths at the baseline survey adopted at higher rates. Time spent washing rags, in particular, had long-lasting effects; girls who reported taking longer at this activity were more likely to ever use the cup, and more likely to use early on. In general, we see very little effect of other demographic controls on adoption.[17] We *do* find large variations across schools in adoption, with highest adoption in school 1 and lowest in schools 3 and 4, but because of the small sample size of the number of schools, it is not possible to attribute the lower or higher rates of adoption in the schools to one particular factor.[18]

Incorporating Mothers Cup Use: Given that our project included mothers at the baseline meeting, and that mothers were given the menstrual cup, it is possible that mothers – and the peer

to earlier continual adoption in nearly all cases.

[17] Particularly notable is the relationship, or lack thereof, between adoption and human capital . The literature on technology adoption frequently cites levels of human capital as predictive of early adoption (Oster and Quigley, 1977; Caselli and Coleman, 2001). While in our sample we do not have variation in years of schooling we do have variation in baseline exam scores, an alternative measure of human capital. Although the coefficients on this variable are positive, they are not consistently significant. Similarly, parents' education and income seem to have little effect on adoption, suggesting that socioeconomic status does not play a role.

[18] Maternal education is slightly lower at the high-adoption schools, and working is also slightly higher. However, there is no trend in test scores, and no differences in the number of treatment friends or share of friends in the treatment group. Ultimately, without more schools it is impossible to attribute these differences to one particular factor.

effects between mothers – might play a role in driving adoption. If mothers are friends with their daughters' friends' mothers, then the effects we see above could be driven by peer effects influencing maternal adoption, and maternal adoption affecting child adoption. Although this would still be a peer effect, it would have a somewhat different interpretation.

We use our data on mothers – usage at the follow-up survey and whether they talk to other mothers about the cup – to explore the role mothers play. We estimate the regressions in Table 3, but also include these two variables for mothers. If it is the case that peers matter only because there is a maternal peer effect *and* mother's usage matters for adoption, we would expect to observe the effects of treatment friends to be much smaller once we control for maternal usage and her discussions with friends.

These regressions are shown in Table 4. Daughters are more likely to ever use if their mothers use, although they do not adopt more quickly. In fact, mother's eventual usage seems to negatively impact usage in February, although this may simply be due to noise. Mother's interacting with their friend about the MoonCup seems to have some positive effect on usage. However, the coefficients on treatment friends are largely unaffected by including these controls for maternal characteristics. This suggests that the peer effects are *not* being driven by maternal peer effects.[19]

Effects by Friendship Type: We next examine the effects of different friendship types on cup use. Recall that we classify friendships into two categories: strong friends (both girls list each other) and weak friends (only one individual lists the other). The regressions in Table 5 replicate Table 3, but report effects by friendship type. Other controls (those reported in Table 3) are included but not shown. We find that strong friendships are more important than weak friendships in cup use. This is particularly true later in the study. The effect of weak friendships falls off very quickly, but the effect of strong friendships persists.

3.3 Effects of Peer Cup Usage

In the results above, we demonstrate that peer *ownership* of the menstrual cup affects the speed of adoption. A natural following question is *how* friend cup ownership affects adoption. Specifically,

[19] One obvious question we might ask is whether there is a "peer effect" from mothers. Unfortunately, we cannot observe that here: we did not randomize girls separately from their mothers, so all treatment girls also have treatment mothers, and we cannot provide causal estimates of the role of mothers. This was a purposeful decision; we were concerned that mothers would not be comfortable with their daughters being given a menstrual product without their also having access to it. With a larger sample size it would have been interesting to separately randomize girls and their mothers, but we do not analyze this here.

can we interpret the effect of ownership as an effect of peers' actual cup usage (their successful attempts), or is information also gained from peers' failed attempts to use. In this subsection, we work to measure the separate effects of friend successful and unsuccessful attempts at usage on adoption, using the fact that we observe both of these outcomes in the data (discussed in Section 2). Note that there may also be other reasons why friend ownership might matter such as stigma or peer pressure; we do not focus on those here.

We begin with a simple instrumental variables analysis, instrumenting for either successful peer usage attempts or failed attempts with the randomly generated peer ownership. We estimate these regressions at the individual-month level: one observation is the usage of an individual in each month, and the right hand side variables are number of successful or unsuccessful usage attempts by friends cumulatively up until that month. The instruments used are dummies for number of treatment-friend months of ownership. This parallels the regression used to estimate Figure 5; in fact, the regressions which generate Figure 5 can be seen as the reduced form second stage analysis. The coefficients have a simple interpretation: what is the increase in individual probability of usage as a result of an additional successful friend usage (or failed attempt).[20]

Columns 1 and 2 of Table 6 show the results from these regressions; in both cases, F-statistics are reported at the bottom of the table (first stage regressions are available in the Online Appendix). Column 1 suggests that successful friend uses are positively related to own uses; the coefficient is around 0.02, indicating a 2 percentage point increase in the probability of use for each friend usage thus far. In Column 2 the coefficient on failed attempts is positive, but not significant. We cannot reject the claim that failed attempts do not contribute to the peer effects. However, the coefficient is fairly large.

Ideally, we would like to estimate the effect of successful and unsuccessful attempts together. The results in Columns 1 and 2 leave open the possibility that the large coefficient on failed attempts by peers simply reflects failed attempts *contributing* to successful attempts later, and successful attempts affecting peers. A randomized evaluation to determine the causal effects of successful and unsuccessful attempts would involve randomizing the probability that friends attempts are successful. In our study, we did not do this and our randomization alone provides only one source of variation. Instead, to estimate the two variables simultaneously we use an additional instrument.

[20] We use cumulative versions of these variables rather than attempts in the current month, since the former has a more obvious interpretation in regressions like this at the individual-month level.

The instrument we use is variation in treatment friend menstrual frequency. This takes advantage of two facts about our sample: (a) some girls do not yet have their period at the start of the study and (b) even within girls who are menstruating, many do not get their period every month. Both of these factors generate arguably exogenous variation in whether a friend has the opportunity to attempt to use the menstrual cup in a given month. Not having a period strongly predicts attempts in a given month: 0% of girls attempt (either successfully or unsuccessfully) if they do not have their period.[21] The exclusion restriction is that whether a friend has their period, and how regular their period is, is unrelated to the girl's cup usage *except* through the effects on friends. Although we argue that this instrument is reasonable, we note that this does not rely on pure randomization and the results should be interpreted with this in mind.

In Column 3 of Table 6 we estimate the effect of trials and uses jointly, adding in this instrument. The results reinforce and strengthen what we observe in Columns 1 and 2. Successful usage attempts by friends drive individual usage, with a coefficient of around 0.02. Failed friend attempts do not appear to matter; here, in fact, the coefficient is negative. This suggests the results in Column 2 may be driven by failed attempts generating successful attempts later, as described above.

To summarize, the results in Section 3 overall indicate that peer ownership of the menstrual cup increases speed of cup adoption, that strong friends matter more and, in this last subsection, that there is suggestive evidence that these peer effects operate through friends successful usage. We turn now to the question of what mechanisms drive these effects.

4 Peer Effect Mechanisms: Wanting to Use or Success at Usage

The results in the previous section suggest that friend cup ownership matters, and that this appears to be due to an effect of successful friend usage. However, thus far we have not made progress on the more fundamental question of *why or how* friends matter for cup adoption. In this section we address this question.

[21] We do not report coefficients on "no period" in Table 3. This is due to the fact that our primary estimates are Probit models. Because not having ones period *perfectly* predicts not using the menstrual cup, it is not possible to estimate a coefficient on that variable in the Probit setup. In OLS regressions of the form used to generate Figure 5, the coefficient on not having a period during the month is -0.489, with a standard error of 0.070.

Peer exposure may matter because peers affect whether an individual wants to use the technology. This could occur either because of imitation (individuals want to act like their friends) or because peers affect individual perceptions about technology value (Miguel and Kremer, 2007; Kohler, Behrman and Watkins, 2001). Peers could also matter if people learn how to use the technology from their friends (Duflo and Saez 2003; Munshi and Myaux, 2006; Miguel and Kremer, 2007). Existing literature has generally been unable to separate these mechanisms. An exception is Miguel and Kremer (2007), who estimate peer effects on adoption of de-worming drugs, and explicitly distinguish between these avenues. They find *negative* peer effects – individuals with more peers in early adopter schools are less likely to adopt – which effectively rules out either imitation or learning about how to use the technology as drivers, since both of those would produce positive effects. In our case, since we find *positive* peer effects, we cannot rule out any of these possibilities.

To address the mechanisms, we present a two-stage model of the adoption decision and argue that using this structure, along with our separate measures of successful and failed usage attempts, allows us to separate the effects of peers on wanting to use the technology versus effects on ability to use.

4.1 Two Stage Process of Technology Adoption

We assume there are two stages in determining the adoption of a new technology. First, individuals decide whether or not they would like to use the technology; second, they may or may not be successful at using. We posit that technology value affects whether an individual *wants to use* (first stage) and knowledge about how to use affects *success in using* (second stage).

We denote the overall probability of usage as p_u, the probability that an individual wants to use as p_w and the probability of success at using as p_s. These are all functions of friendships and of observables. In particular, denote f_i as the number of treatment friend exposures to the cup (i.e. total months of exposure, as in Figure 5), and x_i as a vector of controls, which includes demographics, total numbers of friends and months since distribution.[22] In addition, denote v_i as the

[22] Apropos of the discussion in Section 3.3, if we were focused on friend usage, rather than friend ownership, the f in this analysis would measure friend months of usage, rather than friend months of ownership and we could instrument for usage with ownership.

value of the cup. Overall probability of usage can be written as:

$$p_u(f_i, x_i, v_i) = p_w(f_i, x_i, v_i)p_s(f_i, x_i, v_i) \quad (2)$$

Thus far, we have established (i.e. in Section 3) a positive relationship between friend exposure and overall use of the cup: $\frac{dp_u}{df_i} > 0$. This is consistent with either $\frac{dp_w}{df_i} > 0$ or $\frac{dp_s}{df_i} > 0$, or both. In this framework, we propose that $\frac{dp_s}{df_i} > 0$ indicates that friends matter because they help individuals learn about how to use the cup and that $\frac{dp_w}{df_i} > 0$ indicates that friends matter because they affect cup value (either through imitation or through learning about value of the cup).

In our data we observe whether or not someone attempts to use, and whether she is successful. These objects in the data map into the theory, but not directly. That is, we cannot directly interpret them reflecting p_w and p_s, but we can connect them to those parameters through theoretical framework.

Attempt to Use: We assume that attempting usage of the the cup has a cost, which we denote $\epsilon_i \sim H(.)$ and which is paid regardless of whether or not the attempt is successful. There is no additional costs of using successfully given the attempt.[23] An individual will attempt to use the cup if the benefits exceed the cost. The benefit of the cup is measured by how much the girl wants to use it, $p_w(f_i, x_i, v_i)$. However, these benefits are only experienced if the girl is able to successfully use the cup; in contrast, the costs are paid at the time of the attempt. This means that the girl will be more likely to try if she feels she is more likely to be successful, since her benefits are effectively adjusted by her probability of success. Denoting the expected probability of success as $E[p_s(f_i, x_i, v_i)]$ a girl will attempt to use the cup if the following holds:

$$p_w(f_i, x_i, v_i)E[p_s(f_i, x_i, v_i)] > \epsilon_i \quad (3)$$

Success at Usage: In the data we observe whether or not a girl is successful at using the cup conditional on having attempted. Formally, we observe $p_s(f_i, x_i, v_i)$ conditional on Equation (3) holding.

Because of these interdependencies – that we observe wanting to use only adjusted by

[23] We argue this is a reasonable assumption, since most of the difficult and uncomfortable aspects of using the cup involve trying to insert it. In this setting, the cup was free. In the case of other technologies or other settings there may be opportunity costs of adoption, or other costs that might be important in the decision to try to adopt.

probability of success, and success only conditional on Equation (3) holding – actually estimating $\frac{dp_s}{df_i}$ and $\frac{dp_w}{df_i}$ is empirically challenging. In the next sections, we outline how we use the data to identify these peer effects.

In moving from the theory to the data, we make one important and central assumption: once an individual decides to try the cup, there is no difference across individuals in the effort put into trying, and success is simply determined by factors fixed at that point (in particular, friend exposure and demographics). Formally, this amounts to assuming that $\frac{dp_s}{dv_i} = 0$. That is, we assume that the probability that an individual is able to successfully use the cup does not depend on cup value (either actual or perceived). Probability of success is a function only of the knowledge about how to use the cup (derived from friends) and, possibly, individual demographic characteristics. Given this assumption, moving forward we will refer to $p_s$as a function only of f_i and x_i: $p_s(f_i, x_i)$.

This is a crucial assumption because it is necessary for us to interpret the reports from participants about cup trial and usage as reflecting the elements of the model. Without this assumption, our two-stage process effectively collapses into a single decision about wanting to use, in which success at usage simply reflects how much the person wants to use, and how hard they are willing to try. In that case, "trial" and "usage" would simply reflect different intensities of desired usage and it would not make sense to think about a two-stage model. Ultimately, we feel that this assumption is reasonable, but it is important to keep in mind, given the role that it plays in our estimation of these mechanisms. If this assumption is not valid, we effectively lose our ability to interpret cup "trial" and "usage" as separate events, and our analysis of the data could not be informative about mechanisms.

4.2 Peer Effects on Successful Usage

Estimation Strategy

In Equation (3) above, in order to use observed cup trial to estimate the effect of friends on wanting to use the cup, we need a measure of the effect of friends on usage success. Given that we need this second stage estimate in order to estimate the first stage, and the converse is not the case, we work backward and begin by first analyzing the second stage of the adoption process: successful usage. We observe $p_s(f_i, x_i)$ directly in the data: it is successful usage conditional on attempting to use. However, we observe this only for individuals who attempt to use at all. We do not observe the probability of success among those who do not choose to try. This introduces a potential selection problem.

Based on Equation (3), girls who want to use more, or those with lower costs of attempting to use (lower ϵ_i), will be more likely to try the cup. We therefore are more likely to observe probability of success among those who really want to use or have lower costs. If the impact of peer exposure on success – $\frac{dp_s}{df}$ – is different among these girls, then estimates based on the selected set of girls who attempt usage will be biased. On the other hand, this is not a problem if wanting to use the cup is unrelated to the impact of peers on success.

We first estimate $\frac{dp_s}{df}$ with an OLS regression of cup usage on friend exposure, restricting the sample to girls who have tried the cup. These estimates are reasonable only if the selection issue outlined above is small or non-existent. As a strategy to address selection, we estimate the same regression using a Heckman selection model. This requires us to identify some variable which influences trial but does not influence knowledge of how to use; this selection model is only as good as the selection variable. In our case we use variations in individual menstrual frequency, since there a girl will not try the cup when she does not have her period. We believe that menstrual frequency at this age is unlikely to be otherwise correlated with ability to use the cup. In addition, as we discuss in Section 3.3, not having ones period is a perfect predictor of not using the cup. For both of these reasons, it provides an appropriate selection criteria.

Results

Figure 6 shows the regression coefficient on number of treatment friends, for each month, from the OLS and Heckman selection models. For most months, success is significantly higher among individuals with more treatment friends. In early months after distribution the effect on success at usage is as high as 25 percentage points per treatment friend. There appears to be some downward trend in these coefficients over time although the variation is noisy. Comparing the estimates for the OLS to the Heckman estimates we see very little difference in the coefficient magnitudes. This, along with the fact that the coefficient on not having ones period is large and very statistically significant, suggests limited selection bias. Intuitively, this means that girls who have a higher value of the cup, or a lower cost of trying, are not differently affected by their peers than those with a lower value or higher cost.

In addition to exploring variation over time visually, Table 7 estimates the effect of treatment friends on success. We use individual-month observations and estimate the effect of number of treatment friend months of exposure. Columns 1-3 present the OLS estimates and Columns 4-6 present corresponding Heckman Selection estimates (first stage regressions are shown in the Online Appendix). Consistent with Figure 6, both estimation strategies give similar results. Overall, having more exposure to treatment friend is strongly correlated with successful trial (usage). This is especially true during early months (Columns 2 and 5), although the effect remains significant in later months (Columns 3 and 6).

The evidence in Figure 6 and Table 7 suggest that peer exposure to this technology affects the probability of success at trial. This suggests that peers matter for adoption because people learn from others about how to use. The estimates are largest in early months after distribution consistent with the idea that there is some concavity in the $p_s(f_i, x_i)$: one additional friend exposure is more valuable when the initial level of exposure is lower.

We next move to the first stage of the adoption process, when individuals decide whether they want to use the cup.

4.3 Peer Effects on Trial (Wanting to Use)

Estimation Strategy

When making the decision to try the cup, the expected probability of success of trial is an important factor (Equation 3). As noted in Section 4.1, we cannot simply estimate the effect of friends on usage attempts and interpret them as an effect of wanting to use. This is especially true since we find in Section 4.2 that friends matter for success at usage. Given this, observing that friends matter for attempting to use might well reflect only their effect on expected usage success, not effects on wanting to use.

In order to identify the causal effects of peers on wanting to use the cup ($\frac{dp_w}{df_i}$), we would ideally like some exogenous variation that affects the expected probability of success, $E[p_s(f_i, x_i)]$. Unfortunately, in this case, we have no obvious candidate for this in our data limiting our ability to identify $\frac{dp_w}{df_i}$. However, we argue that we can use the structure of the model to estimate this parameter.

Recall Equation (2): $p_u(f_i, x_i, v_i) = p_w(f_i, x_i, v_i)p_s(f_i, x_i)$. Differentiating this equation with respect to f_i yields the following expression: $\frac{dp_u}{df_i} = p_w(f_i, x_i, v_i)\frac{dp_s}{df_i} + p_s(f_i, x_i)\frac{dp_w}{df_i}$. Rearranging to give an expression for our quantity of interest, $\frac{dp_w}{df}$, yields:

$$\frac{dp_w}{df_i} = \frac{\frac{dp_u}{df_i} - p_w(f_i, x_i, v_i)\frac{dp_s}{df_i}}{p_s(f_i, x_i)} \tag{4}$$

Several of these values have been estimated thus far in the analysis. We estimated $\frac{dp_u}{df_i}$, the effect of friend exposure on overall adoption, in Section 3 (Table 3). In Section 4.2 (Table 6) we estimated $\frac{dp_s}{df}$, the effect of friend exposure on the probability of a successful trial. The object $p_w(f_i, x_i, v_i)$ is the probability that an individual wants to use the cup overall; based on Equation (4) we note that this is the probability of attempting to use conditional on expecting to be successful for sure. We do not observe this directly in the data, since we only observe attempts at usage as determined by Equation (3). However, by the end of the study, most girls who try are successful; we can infer from this that expected success ($E[p_s(f_i, x_i)]$) should be close to 100%. Using this latter part of the sample, we predict the probability of attempting to use for each girl in the sample, and define this as her p_w. Put simply, this is the probability of wanting to use when $E[p_s(f_i, x_i)] \simeq 1$.

The object $p_s(f_i, x_i)$ is the probability of success, on average, for all individuals, including those who do not attempt to use. We can estimate this based on the results in Section 4.2 above. Specifically, we run the regressions from Table 7 and use them to predict $p_s$for each individual. Given these four parameter estimates, we can calculate $\frac{dp_w}{df_i}$ for each individual and take the average across individuals; we generate bootstrapped standard errors.[24]

Results

We begin, as a benchmark, estimating OLS regressions of the impact of friendships on cup trial. As we discussed above, these regressions reflect Equation (3). Consistent with this equation, finding an effect of friends on trial in these naive regressions could reflect friends impacting wanting to use (p_w) or could reflect friends impacting success at usage (p_s). We know from Section 4.2 that friends affect usage success, which means that we expect to see positive impacts of friends on

[24]We could also have taken the average p_w and average p_s and used these to calculate the average $\frac{dp_w}{df_i}$;this gives the same solution as calculating for each individual and averaging.

attempts to use, even if they do not actually affect wanting to use.

Columns 1-3 of Table 8 estimate the OLS regressions (regressions are estimated on observations stacked at the individual-month level, as in Table 7). The coefficient on number of treatment friend exposures in Column 1 is positive although not statistically significant. In early months, however, there is a relatively strong positive relationship between treatment friend exposures and attempts to use (Column 2).

Columns 4-6 of Table 8 show results from our structural estimation of $\frac{dp_w}{df_i}$.[25] The estimated effects of treatment friend exposure in this case are smaller in magnitude, and never significant. The fact that the difference between the naive estimates and the structural estimates is largest in early months may correspond to evidence in Table 7, where we find that friends matter most for success at usage during early months of the study. This is therefore also the period in which it is most misleading to run the naive estimates of attempts at usage on treatment friend exposure without accounting for differences in success probability.

Willingness to Pay

In addition to the structural approach of estimating how peers affect wanting to use the cup, we take advantage of a question in the follow-up survey asking each girl: "would you be willing to pay X for the menstrual cup?", with X ranging from 500 to 2500 Nepali Rupees ($7 and $33, respectively). We code girls as willing to pay 500Rs if they say yes when $X = 500$Rs; willing to pay 1000Rs if they say yes when $X = 1000$Rs, and so on up to 2500Rs. The average of this variable is 1380Rs, which is about $18. This quite a lot of money and the usual caveats about hypothetical willingness to pay questions apply here. Nevertheless, we feel that this variable indicates to some extent how much an individual may value the cup. We focus on girls who have ever used the cup, since we expect them to have $E[p_s(f_i, x_i)] \approxeq 1$ and estimate whether those with more friends have greater willingness to pay.

Column 7 of Table 8 presents the results. The coefficient is relatively small relative to the variable mean. One additional treatment friend increases willingness to pay by an insignificant 174Rs, or about $2 on a mean of $18. This suggests friends do not affect cup value and, by extension, do not affect wanting to use, consistent with the previous results.

[25] We do not report coefficients on controls here, since the estimates are generated based on running several regressions and calculating a non-linear combination of coefficients; standard errors are bootstrapped. In this sense there are no "controls" to report, even though they are included in the regressions that generate this estimate.

4.4 Summary: Peer Effects on Wanting to Use or Success at Usage

There are at least two important conclusions from our results on mechanisms. From a positive standpoint our analysis of peer effects supports the theory that peers matter in adoption because individuals learn about how to use the technology from them.

In contrast, we argue that peers *do not* affect whether individuals to want to use the new technology. We noted above that at this stage there are two possible mechanisms: friendships matter through desire for imitation, and friendships matter because friends increase learning about the benefits/value of the cup.[26] We cannot draw strong conclusions about separating these two mechanisms; we can conclude here is that friendships do not matter *overall* in this stage of the decision.

To the extent one can use these results to make statements about other types of technologies, they may have implications for policy. The influence of friends in usage success, but not so much in wanting to use, suggest that whether a product is difficult to use may matter for what we expect about peer effects. For a product like de-worming drugs, where there is likely to be almost no heterogeneity in success, we would not expect positive peer effects. In contrast, for a complicated technology – say, a computer – we might expect to observe larger positive peer effects. In this later case, peer-based targeting could be effective, at least for encouraging fast adoption. This analysis may also shed light on why we see such strong positive peer effects here, whereas existing evidence from randomization (for example, Miguel and Kremer, 2004) does not find such impacts.

5 Conclusion

This paper analyzes peer effects in the adoption of a new technology using data from a randomized evaluation of menstrual cup provision in Nepal. Although menstrual cups may not be important, per se, we argue that the data and setting have a number of advantages for this analysis. First, the menstrual cup is completely new and unfamiliar and it is somewhat difficult to use and requires

[26]It is possible that friends are a positive influence through imitation, but a negative influence through learning about benefits, and these balance out to zero. We think this is unlikely, since we have little evidence that friends would have a negative influence through learning. For example, among the individuals who use the cup, 100% of them, at the follow-up survey, report that they would recommend it to someone of their age (overall, including the girls who did not use, 95% said they would recommend the cup).

learning, a feature shared with a number of other important technologies (e.g. fertilizer or contraceptives). Second, because we randomize at the individual level, we have exogenous variation in peer exposure, which allows us to causally estimate peer effects on adoption. Third, our data contain rich information on both trial and usage of the cup allowing us to make progress on separating out mechanisms by which peers affect adoption.

We find strong evidence that peer exposure to the cup drives adoption. Girls with more treatment friends are more likely to adopt and do so more quickly. Our analysis of mechanisms suggests that peers successful usage attempts are more important than their failed attempts in influencing adoption. We also find that peers are most important for individuals to learning about how to use the product, rather than influencing individuals wanting to use the product.

The results here may have policy implications which go beyond the particular case of the menstrual cup. In many cases policymakers face choices about how best to distribute technologies in order to maximize adoption. The results here indicate that the appropriate targeting is likely to depend on specific characteristics of the product – in particular, how much variation there is in the likelihood of success – which could be a function of underlying abilities or in the difficulty of learning the technology.

We also believe the findings in this paper may also guide methodology. First, peer effects are more important in early months after product distribution. This likely reflects the concave nature of the value of information – some information is very helpful, moving from having a lot of information to even more is less helpful. This suggests there is value in observing adoption over time. Had we observed cup usage only at the follow-up survey we would have missed these effects. Second, the discussion of mechanisms here suggests that more data on patterns of adoption – in particular, collecting more information about the way that individuals are deciding whether or not to adopt – may be valuable in understanding the mechanisms through which these effects operate.

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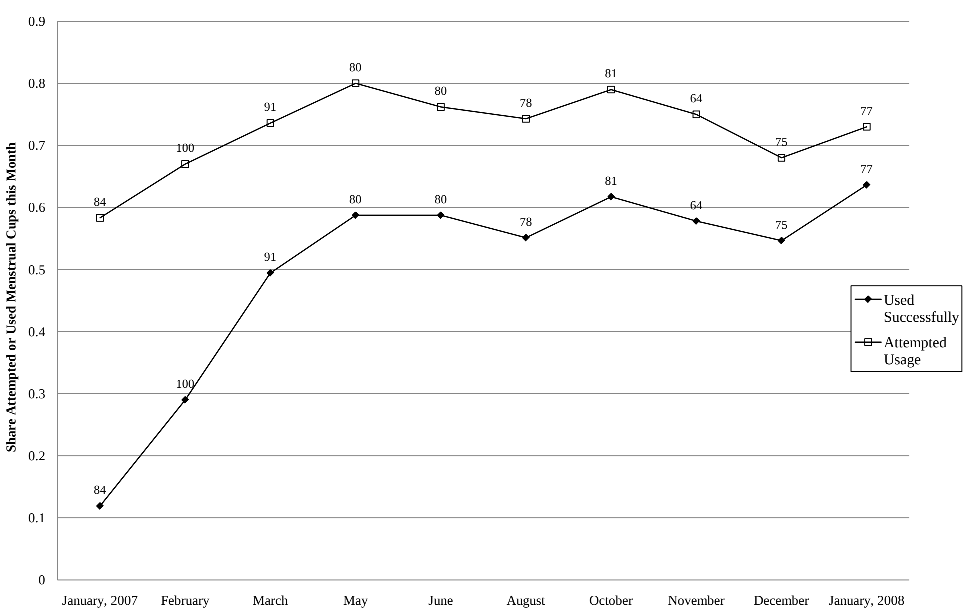
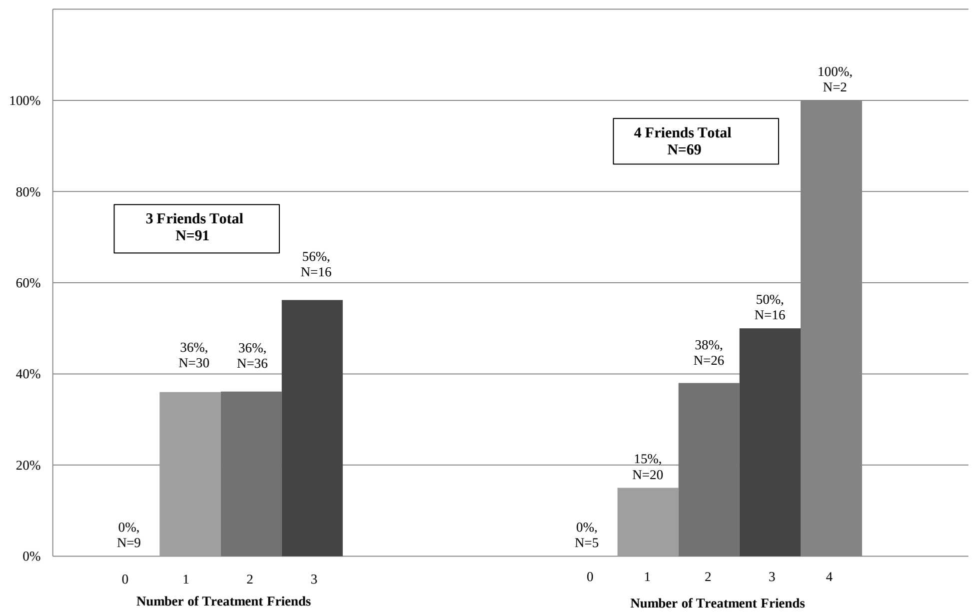
Figure 1: MoonCup Photo

Figure 2:
Menstrual Cup Attempted and Successful Usage Over Time



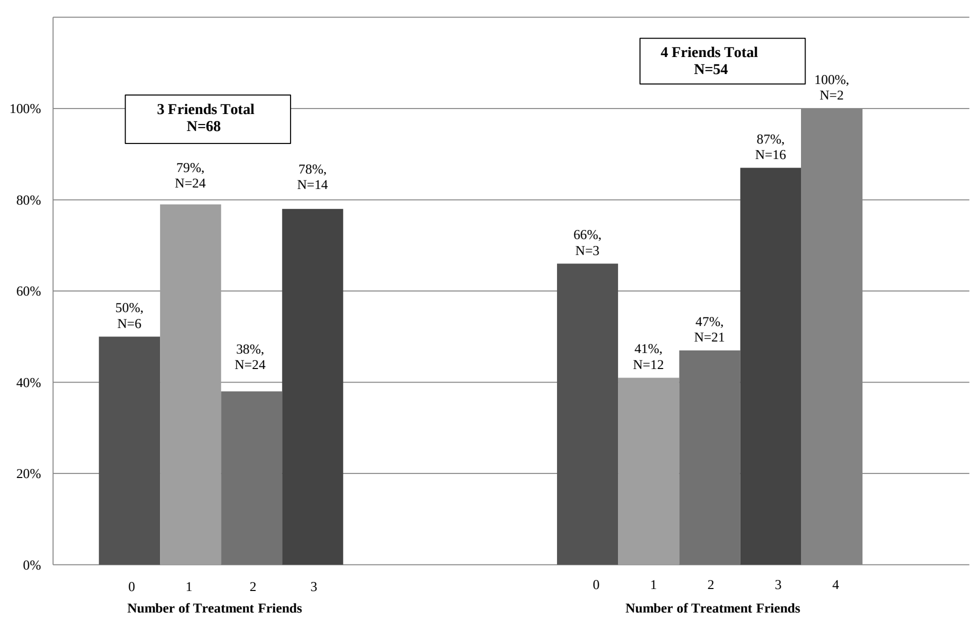
Notes: This figure shows evolution of usage of the menstrual cup, over time. Cups were distributed in November or December of 2006. The labels indicate the number of individuals observed in each month. There are a total of 101 treatment individuals.

Figure 3A:
Peer Effects in First 3 Months



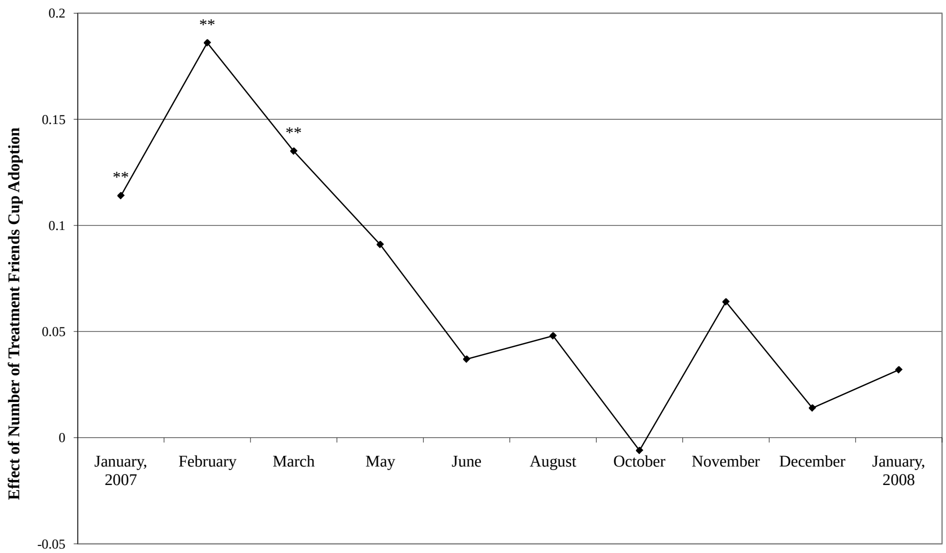
Notes: This figure shows usage by number of treamtent friends, grouped by number of *total* friends. This figure reports the average of usage in January, February and March, the first three months of the study.

Figure 3B:
Peer Effects in Last 3 Months



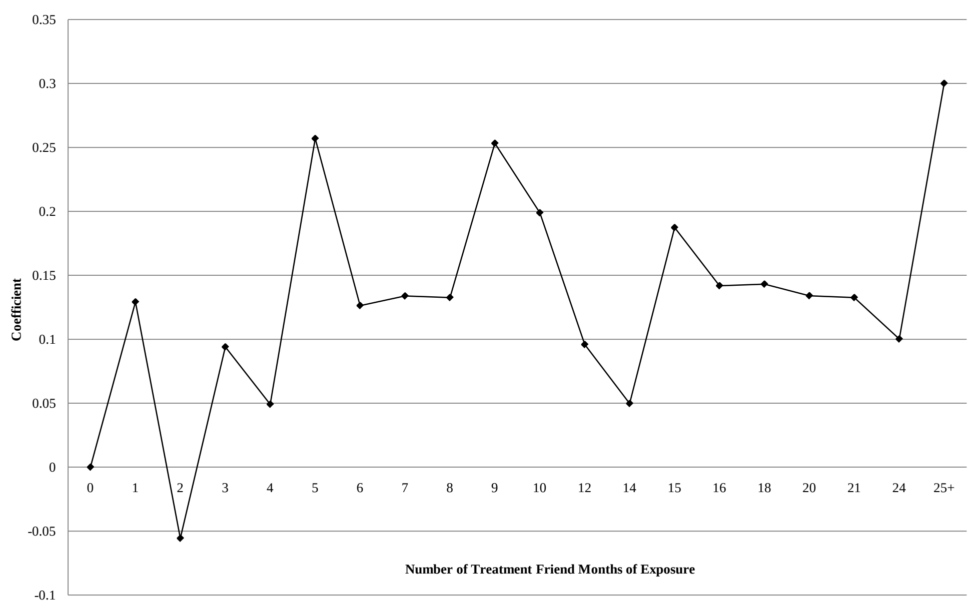
Notes: This figure shows usage by number of treamtent friends, grouped by number of *total* friends. This figure reports the average of usage in November, December and January 2008 (at the end of the study)

Figure 4:
Estimated Effect of Treatment Friends on Menstrual Cup Usage, by Month



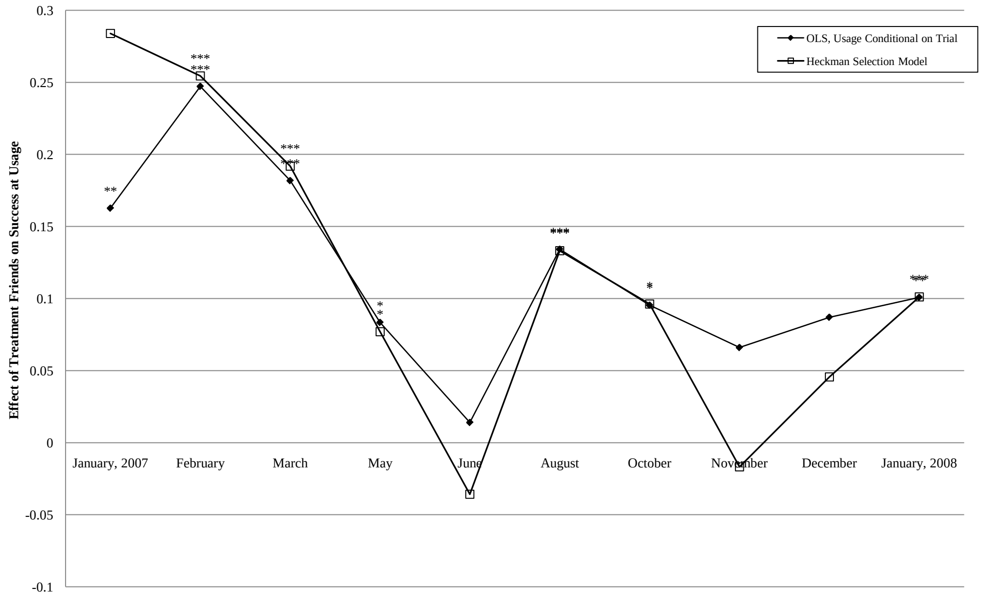
Notes: This figure shows coefficients on number of treatment friends interacted with month dummies from a regression where the dependent variable is menstrual cup usage. ** significant at 5% level; * significant at 10% level

Figure 5:
Effect of Number of Treatment-Friend Months of Exposure



Notes: This figure shows the coefficients on number of treatment friend months of exposure from a regression of usage on number of treatment friend months of exposure, number of friend months of exposure and controls.

Figure 6:
Estimated Effect of Treatment Friends on Success at Using Menstrual Cup, by Month



Notes: This figure shows coefficients on number of treatment friends from a regression estimating usage success (usage conditional on trial, either adjusted or not adjusted for selection). Regressions are run separately for each month. *** significant at 1% level;** significant at 5% level; * significant at 10% level

Table 1: **Summary Statistics**

Panel A: Number of Participants			
	Girls	*Mothers*	*Female Relative*
School 1	54	41	13
School 2	48	33	13
School 3	48	42	6
School 4	48	35	8

Panel B: Summary Statistics on Demographics and Cup Value Measures			
	Mean	*Standard Deviation*	*# of Observations*
Age	14.2	1.23	197
7th Grade (0/1)	.53	.50	198
Test Score Last Year	-.08	1.18	198
Father Hindu Ethnicity	.51	.50	198
Income Category	2.55	1.55	190
Mother's Yrs. Educ.	2.69	3.90	190
Father's Yrs. Educ.	5.61	4.70	190
Menses at baseline (0/1)	.87	.33	197
Work for Pay	.22	.41	198
Days/Week Worked (if >0)	2.51	1.93	43
Time to Wash Cloths	30.9	32.2	197

Panel C: Summary Statistics on Analysis Variables			
	Mean	*Standard Deviation*	*# of Observations*
Number of friends	3.78	1.35	198
Share of Friends Treatment	.51	.27	196
Mother Chats about MoonCup	.40	.49	95

Notes: This table shows simple summary statistics on sample sizes and basic demographics. All girls were in either 7th or 8th grade. Age at menses is reported only for girls who have their menses at baseline. Total number of friends includes all friends the individual lists, plus any people who list her as a friend. Income categories range from 1-6, and correspond to yearly incomes of: Less than 25,000 Rs, 25k-50k, 50k-75k, 75k-100k, 100-150k, 150k+. Mothers chatting about the MoonCup is asked only to treatment mothers at the follow-up survey.

***Table 2:* Balancing Tests**

	Coeff. on # of Treat. Friends (Std. Error)
Age	.090 (.091)
7th Grade (0/1)	.006 (.038)
Test Score Last Year	-.097 (.090)
Father Hindu	.053 (.038)
Income Category	-.132 (.121)
Mother's Yrs. Educ.	-.199 (.306)
Father's Yrs. Educ.	-.179 (.369)
Menses at baseline (0/1)	-.027 (.025)
Work for Pay	.099 (.031)***
Days Worked (if >0)	0.058 (.324)
Time to Wash Cloths	3.37 (2.47)
# Months Observed in Sample	.301(.237)

Notes: This table shows balancing tests for the demographics and friend variables by number of treatment friends. Total number of friends includes all friends the individual lists, plus any people who list her as a friend. Income categories range from 1-6, and correspond to yearly incomes of: Less than 25,000 Rs, 25k-50k, 50k-75k, 75k-100k, 100-150k, 150k+. Standard errors in parenthesis. * significant at 10%; ** significant at 5%; *** significant at 1%

***Table 3:* Determinants of Menstrual Cup Usage**

Dependent Variable:	*Used Menstrual Cup During:*			*Ever Used*	*First Month*	*Hazard Model*
	Feb, 2007	*Aug, 2007*	*Jan, 2008*	*Mooncup*	*Used (1-10)*	*for Usage*
	(1)	(2)	(3)	(4)	(5)	(6)
Explanatory Variables:						
#Treatment Friends	$.1864^{***}$	.0481	.0326	.0408	$-.6884^{***}$	1.221^{***}
	(.037)	(.049)	(.049)	(.042)	(.256)	(.073)
#Friends	$-.0841^{**}$	$-.071^{**}$	$-.0136$	$-.0489^{*}$	$-.0135$	$.9102^{**}$
	(.031)	(.033)	(.032)	(.028)	(.208)	(.044)
Work for Pay	$.3512^{**}$	$.4754^{**}$	$.472^{***}$	.2063	-1.5146^{*}	2.018^{***}
	(.154)	(.103)	(.071)	(.188)	(.894)	(.455)
Days Worked	$-.0755^{**}$	$-.1282^{**}$	$-.1519^{***}$	$-.0071$	.1431	$.879^{**}$
	(.032)	(.048)	(.047)	(.072)	(.201)	(.047)
Time to Wash Rags	$.0026^{*}$	$.0048^{*}$	$.0043^{*}$	.0033	$-.0077$	1.001
	(.001)	(.003)	(.002)	(.002)	(.008)	(.002)
Age	.0382	$.0679^{*}$	.0733	$.0598^{*}$	$-.2929$	1.094^{*}
	(.034)	(.04)	(.044)	(.032)	(.193)	(.057)
Grade	$.1529^{**}$	$-.1547$	$-.0528$	$-.0838$	$-.4358$	.856
	(.063)	(.099)	(.086)	(.077)	(.446)	(.094)
Ethnicity=Tebeto	$-.2341^{**}$	$-.1352$	$-.244^{**}$	$-.1315$	.0724	$.788^{*}$
	(.068)	(.107)	(.069)	(.09)	(.565)	(.111)
Ethnicity = Newar	.1335	.0018	$-.2375$	$-.1802$	$-.1599$	1.035
	(.183)	(.252)	(.23)	(.176)	(1.333)	(.316)
School #2	$-.2967^{***}$	$-.2854^{**}$	$-.2487^{**}$	$-.2523^{**}$	2.0892^{***}	$.5057^{***}$
	(.046)	(.085)	(.093)	(.089)	(.578)	(.074)
School #3	$-.3645^{***}$	$-.4992^{***}$	$-.4925^{***}$	$-.4373^{***}$	2.2847^{***}	$.303^{***}$
	(.055)	(.104)	(.111)	(.114)	(.749)	(.061)
School #4	$-.3922^{***}$	$-.5723^{***}$	$-.6261^{***}$	$-.5472^{***}$	2.965^{***}	$.214^{***}$
	(.042)	(.071)	(.061)	(.088)	(.813)	(.044)
Exam Score	.0291	.0598	$-.013$	.0155	$-.1519$	1.038
	(.027)	(.05)	(.029)	(.029)	(.195)	(.045)
Mom Educ.	.0151	.0311	.0018	$.0234^{**}$	$-.0409$	1.057^{***}
	(.013)	(.02)	(.013)	(.011)	(.074)	(.021)
Dad Educ.	$-.0126$	$-.0247$	$-.0293^{*}$	$-.0318^{**}$	$-.0206$	$.970^{*}$
	(.01)	(.016)	(.015)	(.012)	(.071)	(.017)
Family Income	.0208	.0458	$.0771^{**}$	.0403	$-.3755^{**}$	1.088^{**}
	(.025)	(.036)	(.034)	(.028)	(.151)	(.041)
Number of Obs	96	74	73	97	65	772

Notes: This table shows the effect of peers on cup usage. The first three columns use one month of data each. The fourth column estimates the effect of treatment friends on ever using the cup; the fifth column estimates peer effects on first month of usage, conditional on ever using. The sixth column shows estimates from a hazard model for usage; the coefficients reported are hazard ratios and the unit of observaion is a person-month. Columns 1-4 report marginal effects from a Probit model; Column 5 uses OLS and Column 6 is a Cox Proportional Hazard Model. Standard errors are in parentheses; *significant at 10%; **significant at 5%; ***significant at 1%.

Table 4: Influence of Mothers on Menstrual Cup Adoption

Dependent Variable:	*Used Menstrual Cup During:*			*Ever Used*	*First Month*	*Hazard Model*
	Feb, 2007	*Aug, 2007*	*Jan, 2008*	*Mooncup*	*Used (1-10)*	*for Usage*
	(1)	(2)	(3)	(4)	(5)	(6)
Explanatory Variables:						
#Treatment Friends	$.1988^{***}$	.0084	$-.011$	.0067	$-.6651^{***}$	1.158^{**}
	(.045)	(.051)	(.051)	(.040)	(.240)	(.071)
Mother Uses MoonCup	$-.1570^{**}$	.0378	$.2565^{***}$	$.1757^{*}$	1.045^{*}	1.247
	(.077)	(.139)	(.093)	(.099)	(.54)	(.183)
Mother Talks about Cup with Friends	.0948	.1643	$.1709^{**}$	$.1798^{**}$	$-.2403$	1.363^{**}
	(.087)	(.119)	(.082)	(.085)	(.446)	(.165)
Controls for # Fr.	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**
Number of Obs	91	65	66	92	63	733

Notes: This table shows the effect of peers on cup usage, controlling for maternal behavior. The first three columns use one month of data each. The fourth column estimates the effect of treatment friends on ever using the cup; the fifth column estimates peer effects on first month of usage, conditional on ever using. The sixth column shows estimates from a hazard model for usage; the coefficients reported are hazard ratios and the unit of observaion is a person-month. Mother MoonCup usage is measured at the follow-up survey. "Mother talks about cup" is an indicator for whether the mother reports talking to other mothers about the MoonCup. Regressions include the controls from Table 3, including controls for number of friends. Standard errors are in parentheses; *significant at 10%; **significant at 5%; ***significant at 1%.

Table 5: Influence of Friend Type on Menstrual Cup Adoption

Dependent Variable:	*Used Menstrual Cup During:*			*Ever Used*	*First Month*	*Hazard Model*
	Feb, 2007	*Aug, 2007*	*Jan, 2008*	*Mooncup*	*Used (1-10)*	*for Usage*
	(1)	(2)	(3)	(4)	(5)	(6)
Explanatory Variables:						
#Strong Treat Fr.	$.2655^{***}$	$.1497^{*}$	$.3099^{**}$	$.1481^{*}$	$-.8201^{**}$	1.288^{***}
	(.066)	(.092)	(.137)	(.088)	(.4040)	(.119)
#Weak Treat Fr.	$.1421^{***}$	$-.0004$	$-.001$	$-.0017$	$-.604^{**}$	1.190^{**}
	(.047)	(.058)	(.049)	(.048)	(.305)	(.083)
Contols for # Fr.	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**
Number of Obs	96	71	72	97	65	772

Notes: This table shows the effect of peers on cup usage separated by friend type. The first three columns use one month of data each. The fourth column estimates the effect of treatment friends on ever using the cup; the fifth column estimates peer effects on first month of usage, conditional on ever using. The sixth column shows estimates from a hazard model for usage; the coefficients reported are hazard ratios and the unit of observaion is a person-month. Strong friends are bidirectional – both individuals list the other – and weak friend are unidirectional. Regressions include the controls from Table 3, including controls for number of friends. Standard errors are in parentheses; *significant at 10%; **significant at 5%; ***significant at 1%.

Table 6: Peer Successful Usage versus Peer Failed Attempts

Dependent Variable:	*Used Menstrual Cup*		
	IV: Use Randomization Only		*IV: IncludeOther Instruments*
Explanatory Variables:			
#Treat Fr. Successful Uses	.0199** (.008)		.0210** (.010)
#Treat Fr. Failed Attempts		.0175 (.021)	−.002 (.024)
F-stat, Successful Attempts	7.63		9.12
F-stat, Failed Attempts		58.73	50.18
Instruments:	Treatment Friend Months of Exposure		Treatment Friend Months of Exposure, treatment friend months without period
Number of Obs	772	772	772

Notes: This table shows the effect of friend uses versus friend trials on adoption. The instruments in Columns 1 and 2 are dummies for number of treatment friend months of exposure; in Column 3 we add, in addition, quartiles of number of treatment friend months without period. First stage regressions are in Online Appendix. Controls include all controls from Table 3. Standard errors are in parentheses, clustered by individual; *significant at 10%; **significant at 5%; ***significant at 1%.

Table 7: Peer Effects on Menstrual Cup Usage Success

	Dependent Variable: Used Menstrual Cup					
	OLS: Used Condition on Trial			*Heckman Selection Selection: No Period*		
	(1)	(2)	(3)	(4)	(5)	(6)
	Entire Sample	*First 5 Months*	*Later 5 Months*	*Entire Sample*	*First 5 Months*	*Later 5 Months*
Explanatory Variables:						
#Treat. Fr. Months	.0138***	.0298**	.0120**	.0131***	.0306***	.0119***
	(.005)	(.011)	(.004)	(.004)	(.011)	(.004)
#Friend Months	−.0079*	−.0142	−.0075*	−.0073*	−.0147*	−.0072*
	(.004)	(.009)	(.004)	(.004)	(.008)	(.004)
CONTROLS	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**
Number of Obs.	562	297	265	772	416	356

Notes: This table shows the estimates of the effect of peers on success at menstrual cup usage. The first three columns estimate OLS regression of usage conditional on trial; Columns 4-6 estimate Heckman selection models, where the selection is on whether or not the individual tried, and the selector variable is "no period this month". Controls for demographics are included in all columns (the same controls as in Table 3, minus controls for benefits). Standard errors are in parentheses, clustered by individual; *significant at 10%; **significant at 5%; ***significant at 1%.

Table 8: **Peer Effects on Wanting to Use Menstrual Cup**

	OLS (Naive Regressions) Dependent Var: Tried Menstrual Cup			*Structural Estimates*			*Willingness to Pay Dep. Var: WTP, Rs.*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Entire Sample	*First 5 Months*	*Later 5 Months*	*Entire Sample*	*First 5 Months*	*Later 5 Months*	
Explanatory Variables:							
#Treat. Fr. Months	.0066	.0371***	.0038	.004	.0142	.0015	
	(.005)	(.014)	(.005)	(.005)	(.010)	(.005)	
#Treatment Friends							174.84
							(132.47)
CONTROLS	**YES**	**YES**	**YES**	**N/A**	**N/A**	**N/A**	**YES**
Number of Obs.	772	264	508	772	264	508	65

Notes: This table shows estimates of the effect of peers on wanting to use the cup. The first three columns show baseline effects of these variables on trial; the coefficient should not be interpreted as effects on wanting to use. Columns 4-6 provides estimates of friend effects on wanting to use based on structural assumptions in the model (standard errors are bootstrapped). Column 7 estimates effects on reported willingness to pay for the cup at follow-up. Controls for demographics are included in Columns 1-3 and 7 (the same controls as in Table 3). In the case of the structural estimates the controls are incorporated when we estimate the parameters that go into the structural estimation. Standard errors are in parentheses, clustered by individual when appropriate; *significant at 10%; **significant at 5%; ***significant at 1%.