Paying for Digital Information: Assessing Farmers' Willingness to Pay for a Digital Agriculture and Nutrition Service in Ghana

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Abstract. With the widespread growth of mobile phone coverage and adoption over the past decade, there has been considerable enthusiasm over the use the ICTs in agricultural initiatives, primarily to disseminate information to farmers (Aker et al 2016). Over the past decade, the number of public and private sector initiatives in this space has increased substantially, with over 140 deployments worldwide in 2015. This paper assesses farmers' willingness to pay (WTP) for a newly introduced digital nutrition-sensitive agricultural information service in Ghana, called Vodafone Farmers' Club (VFC). Using both an experimental game and administrative data, we find that farmers are willing to pay just over 2 Ghanaian cedis monthly on average for the service. We experimentally vary both the framing around the introduction of VFC—to emphasize either the platform's nutrition and agriculture information or the agriculture information alone—and the gender of the household member invited to play the game and find no significant difference in stated WTP along either dimension.

I. Introduction

With the widespread growth of mobile phone coverage and adoption over the past decade, there has been considerable enthusiasm over the use the ICTs in agricultural and health initiatives, primarily to disseminate information to farmers (Aker et al 2016) or to provide general health information and appointment or medication-related reminders to individuals. Over the past decade, the number of public and private sector initiatives in the agriculture ICT space has increased substantially, with over 140 deployments worldwide in 2015. While there is substantial potential for such services to address farmers' and traders' information and credit market constraints, previous research finds mixed impacts on agricultural adoption, behavior and welfare. Similarly, though there are clear opportunities for health and nutrition ICTs to help overcome knowledge gaps and information asymmetries related to food or medication availability and use, past studies suggest existing ICT interventions have had varied effects on health behaviors and other outcomes (Free et al. 2013).

Digital technology in the agricultural sector has primarily been used in three ways: (1) to provide information to farmers about agricultural techniques, prices or weather; (2) to provide agricultural extension advice; and (3) to monitor agricultural extension agents (Aker, Ghosh and Burrell 2016). Overall, studies on digital agriculture initiatives suggest that such services increase farmers' knowledge in particular areas—such as prices and cropping systems—but have little to no impact on agricultural practices, production, or farm-gate prices. In Uganda, an RCT that assessed the impact of providing market prices through the radio finds that the intervention increased farmers' prices and maize sold (Svensson and Yanagizawa 2009, Aker, Ghosh and Burrell 2016, Cole and Fernando 2016). Yet other studies on the impact of digital agriculture offer mixed evidence: while three studies find that digital information and agricultural extension systems improved farmers' welfare, others find no effects (Aker, Ghosh and Burrell 2016, Courtois and Subervie 2015; Hildebrant and others 2014; Nakasone 2013; Mitra and others 2015; Camacho and Conover 2011; Fafchamps and Minten 2012, Casaburi and others 2014).

In the health and nutrition sectors, digital technology has been used in a variety of ways—for medical devices, recordkeeping, and providing information and reminders—however, the majority of studies in developing countries focus on the provision of information and reminders. Similar to digital agriculture interventions, these studies find that digital technology is associated with improvements in knowledge, with mixed evidence on behavioral change and other health outcomes. While some of these studies find that sending mothers SMS improves breastfeeding practices (Jiang and others 2014; Flax and others 2014), a systematic review of interventions that use SMS to encourage drug adherence was more

ambiguous about their success (Nglazi and others 2013). In sexual and reproductive health, several studies have found that the provision of reproductive health information in public schools leads to behavioral change, lower sexually transmitted disease prevalence and lower self-reported pregnancy rates (Chong and others 2013; Rokicki and others 2017).

There are numerous potential explanations for the variation in results, however, an oft-missing component in the design and evaluation of such services is an assessment of agents' willingness to pay for such services. To date, many of the agriculture services and all of the health and nutrition services have been heavily subsidized initially (e.g., Fafchamps and Minten 2012), with adoption and use of the agriculture programs dropping off when subsidies are removed. A common motivation for temporary initial price subsidies is that they allow users to gain experience with the product to strengthen demand. However, this justification requires that initial demand for the product be low in the absence of price subsidies..

Despite the proliferation of ICT interventions and studies on the topic, there has be little, if any, research on the demand for agriculture and health information. In this paper, we test the "product experience" justification for offering temporary price subsidies by measuring willingness to pay (WTP) for a nutrition-sensitive agriculture information platform, the Vodafone Farmers' Club (VFC) in Ghana, at the moment of its introduction to the user. Our results suggest that, at the monthly market price of 0.5 Ghanaian cedis (GHC), 95% of users would be willing to participate in the program even without any price subsidy. We randomly vary the framing of VFC to investigate whether emphasizing the platform's nutrition and agriculture information leads to higher stated WTP than highlighting just the program's agriculture information, and randomly vary the targeting of VFC to investigate whether there are differences in WTP by gender. We find no significant differences in WTP between individuals who receive the agriculture and nutrition framing and individuals who receive the agriculture framing; similarly, the gender of the targeted household member has no impact on WTP under either framing scenario.

Lastly, we link the WTP information to administrative data on program participation to investigate whether an individual's WTP for the VFC product predicts product use as measured by VFC activation. Likely reflecting the low activation costs—there were no financial costs and limited time costs to complete the VFC activation process—80% of participating individuals had completed the VFC activation one to three months after the completion of the household survey and WTP elicitation. Interestingly, we find evidence that individuals with higher WTP for the VFC program were less likely to have activated VFC: a one standard deviation increase in WTP is associated with a 2 percentage point

decrease in the likelihood of VFC activation. This suggests that screening effects may be unlikely to play a critical role in determining the effectiveness of agriculture and nutrition ICTs in this context.

The remainder of the paper proceeds as follows: Section II introduces the setting, context, and ICT intervention being studied; Section III discusses the data and presents baseline summary statistics; Section IV details the empirical strategy and Section V presents the empirical results. Finally, Section VI concludes.

II. Research Setting and Design

A. The Vodafone Farmers' Club service

The Vodafone Farmers' Club (VFC) service is a mobile agricultural extension service, offering agricultural and nutrition information in addition to voice and SMS services. The objective of Vodafone's mNutrition program is to create and scale commercially sustainable mobile services that enable smallholder farmers to improve the nutritional status of their household and increase their productivity. Vodafone began offering the VFC service in May 2015. Smallholder farmers with access to mobile telecommunications are the primary target for VFC enrolment. The service operates across 71 districts of Ghana, which were selected based on network access and crop cultivation patterns to ensure that farmers could receive messages and that content would be relevant to their location and crop choices.

The service package offered to VFC members includes the following components:

- **Weather information**: Three SMS messages in English with local weather information per week
- **Market price information**: One SMS message in English with local market price information per week for a selected crop and selected market
- **Agr and nutrition tips**: One weekly recorded voice message in the selected local language with seasonal agricultural or nutrition tips (3 agri tips and 1 nutrition tip per month) for the selected crop
- **Call centre:** Free access to a call centre with advice available from an agricultural expert
- Free calls and SMS messaging to other VFC members
- Discounted SMS and Voice SMS to non VFC members

In total, 20 messages per month are sent to the subscriber. The mode of content are SMS text messages for weather and price information and voice messages for agricultural tips and nutrition information.

While SMS are in English, voice messages are available in ten local languages. Esoko Ghana, a mobile phone-based rural information service, develops and curates the message content and operates the platform to send tailored SMS and recorded voice messages to registered farmers. Esoko also operates the Farmer Helpline call center.

Nutrition message content was developed by the Global Alliance for Improved Nutrition (GAIN). GAIN created a large library of nutrition-sensitive agriculture messages and nutrition-specific tips designed to complement the agriculture messages provided by Esoko. GAIN created 312 crop-specific messages (13 messages per crop for 24 Esoko-supported crops) with nutrition information on topics including food preparation, food hygiene, safety and storage, and processing. GAIN also developed many general nutrition-specific tips as well as messages for 13 crops that were not originally part of the Esoko profile. Agri tips developed by Esoko cover recommended planting time and information on best practices for cultivation and harvest.

The VFC service is designed to offer customized information to farmers based on their selected preferences. Each new member is profiled by calling the Farmer Helpline call center and indicating their preferred location for weather and market price information, their preferred language for receiving recorded voice messages, and their preferred crop for agricultural tips and price information. Until profiling is completed, new members are given default profile options based on their district of residence, receiving agriculture and nutrition tips on the crops most widely grown in that district.

The VFC service is available through a dedicated Farmers' Club SIM which is activated when farmers subscribe to the monthly service. The subscription fee for the mNutrition packages was initially GhC 2 (USD 0.45) per month. From October 2016 to June 2017, the monthly fee was eliminated to increase subscriptions. In June 2017, the monthly service fee was reinstated at GhC 0.5. Changes in subscription fees to increase take-up demonstrate the need to understand a user's WTP for the service in order to create a sustainable service.

B. The WTP Intervention

To assess potential demand for the digital agriculture platform, we designed a willingness to pay experiment. The WTP experiment was embedded within a larger study that estimates the impact of the VFC service on agriculture and nutrition outcomes through a randomized encouragement design. The encouragement design randomly assigned enumeration areas (EAs) to a treatment (marketing) or control (no marketing) group after stratifying by geographic region. Within the treatment group, households were

stratified by whether a primary male and female were available or whether only a primary female was available. Households with both primary female and male were assigned to one of the four groups: (1) agriculture script + male targeted; (2) agriculture script + female targeted; (3) agriculture + nutrition script + male targeted; (4) agriculture + nutrition script +female targeted. Households with only a primary female were randomly assigned to either the agriculture script or the agriculture plus nutrition script.

The WTP experiment was conducted at the end of the baseline household questionnaire to collect detailed information on demographic characteristics and agriculture and nutrition knowledge and practices. Households in treatment EAs were asked if they had heard of the VFC service and if they consented to receive information on the VFC and play a game. If consent was given, enumerators read either the agriculture script or the agriculture and nutrition script to the randomly assigned primary male or female. The agriculture script was Vodafone's default script for the VFC product that emphasized the value added of the agriculture information (weather, price, and agriculture tips). The agriculture+nutrition script used the same agriculture script and added two lines on the value added of the nutrition information. Respondents were informed that they may have the chance to register for the VFC program, but that the final monthly price for the service was not yet certain and it would be determined through the subsequent game.[1]

We measure farmer WTP for the VFC service through the Becker-DeGroot-Marschak (BDM) method (Berry et al. 2015). To begin, participants in BDM are read basic instructions for the BDM game and are asked if they have any questions. The participant is then asked how much they are willing to pay for a good—in our case how much they are willing to pay monthly for the VFC service—and reminded that once their bid is finalized they will not be able to change the amount, that they must be able to pay their bid amount today, and that if they draw a price that is greater than their bid they will not be able to purchase the good. After recording the WTP amount, the respondent draws a button from a cup (held above their head so that the buttons are not visible to them), with each button representing a different price. If the respondent's bid is greater than or equal to the randomly drawn price, then they purchase the good at *the randomly drawn price*. If the respondents bid is less than the randomly drawn price, then they are not allowed to purchase the good. For expected utility maximizers, the optimal strategy is to bid their true valuation of the good.

Before playing the game for the VFC service, farmers played a practice round for a bar of soap.[2] At the end of the practice round, enumerators were instructed to exchange the bar of soap for the farmer's bid

[1] Respondents were informed that the monthly price would be between 0 and 3 GHC.
[2] The bars of soap were worth approximately 1 GHC.

amount if the respondent won the game.[3] This was done to reinforce that the game was binding, and the farmer would only be able to register for the VFC service if their bid was greater than the randomly drawn price.

After the scripts describing the VFC service were read, we measured WTP and registered users using a two-step variation on BDM. In the first step we elicited the respondents' WTP for the VFC using BDM. The farmer was asked how much they were willing to pay monthly for the VFC service. To ensure that the bid represented the maximum monthly amount that the respondent was willing to pay, the enumerator then asked the farmer if they would still want to pay for the VFC if they drew a button with an amount equal to their bid plus 1 GHC. If the farmer reported that they would still want to purchase the VFC, they were asked if they would like to adjust their bid upwards. If yes, the original bid was revised upward to a new bid amount provided by the farmer. This process continued until the farmer reported that they would not want to register for the VFC for a monthly amount greater than their bid.[4] The final bid was recorded by the enumerator and the farmer was reminded that they must be able to pay the fee for the first month of service now. If—as was almost always the case—the farmer had the funds to pay their bid amount with them, the enumerator asked the farmer to see the money. If the farmer did not have the funds with them, they were asked to go collect the funds.[5] Next, the farmer was instructed to draw a button from a cup, with each button representing a different price from a distribution of prices [0.2-3 GHC].[6] If the farmer's bid was greater than or equal to the price drawn, he/she was offered the product at the randomly drawn price. If the farmer's bid was below the price drawn, he/she was not offered the product at that time. Once the random price was revealed, the farmer was not allowed to change his/her bid.

In the second stage, regardless of the outcome of the first stage, farmers were offered another opportunity to receive the VFC. They were informed that the new price would be lower than the price they drew in the first round if they won the BDM game, and lower than their bid if they lost the BDM game. Farmers again selected a button from the cup, but this time buttons were labelled with the letters A through D. The enumerator entered the letter from the selected button into a tablet, and the second stage price was revealed. Farmers were not informed about the second stage until after they had completed the first stage BDM procedure. In practice, the second stage price was drawn from a degenerate distribution where the

[3] The prices for the bar of soap were drawn from the distribution {0.05,0.05,0.1,0.1,0.15,0.15,0.2,0.2}. Prices were set low intentionally to ensure that respondents who wont the soap during the practice game would not be cash constrained from bidding up to their true monthly WTP in the BDM game for the VFC service.
[4] This modification of classic BDM follows the method used in Berry et al. (2015) and Mazar, Koszegi, and Ariely (2014).
[5] In practice, bids were sufficiently low that respondents were always able to find
[6] Distribution of prices was {0.2,0.4,0.6,0.8,1.0,1.2,1.4,1.6,1.8,2.0,2.2,2.4,2.6,2.8,3.0}.

only possible price was 0. The two stages were necessary to first elicit a farmer's WTP and then to offer the product for free to all farmers in the encouraged group.

III. Data

To measure households' demand for digital agricultural information services, we rely upon two primary datasets. The first is a household-level survey with the primary respondent, either male or female, which included the WTP game. These data are used to estimate farmers' WTP for the service, and to explore the relationship between WTP for the service, observable characteristics, and the different sub-treatments. The second dataset is administrative data from Vodafone, which records whether the household activated their VFC service and remained active in June of 2017, between one and three months after the WTP elicitation.

A. Baseline Data Collection

The baseline household survey was conducted between March and May 2017 in 5 districts in the Upper West region and 5 districts in the Central region of Ghana. The 10 districts were selected based on (1) availability of Esoko market price information for crops, and (2) low FC subscription rates. From each selected district, we randomly selected 20-21 EAs from a list of EAs within a 10-mile radius of a Vodafone cell phone tower. A total of 207 EAs (104 in the treatment arm and 103 in the control arm) are part of the study.

In each EA, 19 or 20 farmer households were randomly sampled, for a total sample of 3,936 households at baseline. Households that were not initially sampled were randomly ranked within each EA and each of the four strata. The resulting ordered list was used to select replacement households if one of the originally sampled households was not able to be interviewed. The inclusion criteria into the sample was that households must (1) be a farming household, (2) own a mobile phone, (3) not be a current member of VFC, and (4) have at least one female member age 15-60 years old. In order to identify households that met our sampling criteria, a community listing exercise was conducted in the selected EAs.

In the baseline survey, households were asked to complete a series of questions on household socio-demographic, agricultural and nutrition-related issues. In treatment villages, the randomly selected targeted respondent was informed of the VFC service through either the agriculture or agriculture +nutrition script, asked to participate in the WTP game, offered the VFC service, and if they accepted, an attempt was made to register and profile them for VFC.

Of the 3936 interviews conducted, 616 surveys (15.6%) were sampled from the list of replacement households and 411 (10.4%) did not have both the primary female and the primary male available. Of those 411, 304 did not have a primary male available, and 107 did not have a primary female available.

B. Vodafone Administrative Data

Following WTP game, enumerators attempted to register households for the VFC service. This required a separate process, either using the existing Vodafone phone number of the respondent, or by providing the respondent with a new Vodafone SIM card. Of the 1,979 households in the encouraged arm surveyed, 136 households did not consent to receive additional information on the Farmer Club service and therefore did not participate in the WTP exercise. Of the remaining households, 1,811 households agreed to be registered for the service. Overall, 91.5% of the treatment households agreed to be registered for the service and to receive the content on their mobile.

Enumerators were asked to try and register the new SIM cards while in the respondent's home. If they were unable to complete the registration immediately due to poor network service, information was recorded so that the enumeration team could complete the registration remotely during the following week. Respondents were instructed to check on the registration status of their SIM regularly, and to activate their SIM after it was registered.

After the SIM was successfully registered, households were required to activate their new SIM cards by using their mobile to check the balance or send a text message to start receiving VFC messages. Though the activation itself was free, it did create an additional time cost for interested households. We obtained administrative data from Vodafone on those phone numbers that had incurred this additional time cost, activated their VFC service. and that were still active as of June 2017. We use this as our primary measure of households' use of the service.

Approximately four months after the baseline survey—in August of 2017—a follow-up survey was conducted with households in treatment EAs. Enumerators asked a series of questions about experiences with the VFC, including whether they had activated and used the service. Any households that had not yet activated the service but were still interested in doing so were assisted in activating VFC on their mobile. Effectively, this follow-up visit enabled the research team to incur the time cost of VFC activation and greatly reduced the scope for household self-selection into participating in the VFC program.

C. Baseline Summary Statistics

Table 1 displays summary statistics for the sample of households in the treatment group of the main evaluation that consented to participate in the WTP exercise. Means and standard deviations are shown separately by sub-treatment status (agriculture script or agriculture+nutrition script; female targeted or male targeted), with standard deviations in parentheses.

Reported willingness to pay for the VFC service is substantially higher than the current monthly price for the program (0.5 GhC), at roughly 2 GhC in all four sub-treatment arms. Perhaps partially explaining this high average WTP, Progress out of Poverty Index (PPI) scores—which can be mapped to the likelihood that households fall below different national and international-level poverty lines—indicate that, on average, the sample households have just a 10.6% of being below 150% of the national poverty line in Ghana. Approximately half of the respondents have some formal education, though just 42.7% of female respondents have some education compared to 58.7% of male respondents; on average, respondents answered 57.6% of the nutrition knowledge questions and 56.28% of the farming knowledge that were included in the baseline survey correctly. Households have a mean size of 5.29 members and 0.603 members under the age of five. Finally, a substantial fraction of respondents (31.0%) reported at baseline that their primary SIM card was a Vodafone SIM.

The Vodafone administrative data, which capture VFC SIM card activation one to three months after the baseline survey, indicate that sample households were overwhelmingly willing to incur the activation costs to participate in the VFC service: 80% of respondents had an active VFC SIM in June of 2017. The remaining 20% of households had not yet activated the VFC service. Below, we use the fact that activation was not universal to explore whether baseline WTP and demographic characteristics can help to explain the observed variation for this early measure of VFC use.

Table 1 also displays two different measures of balance between the agriculture and agriculture+nutrition sub-treatment arms, and the male and female targeted sub-treatment arms: the p-value from a t-test of the null hypothesis that there is no difference in means between the two groups and the normalized difference[7] (Imbens 2015) between the two groups. Normalized differences offer a metric that is substantially less sensitive to sample size and scale free, and we therefore focus on them as our primary measure of balance across the two treatment arms. We follow the rule-of-thumb proposed in Imbens and Rubin (2007) and treat normalized differences below 0.25 in absolute value as being indicative of good balance for each characteristic. We note that while the differences in household characteristics should be

[7] The normalized difference for characteristic x is defined as $\Delta_x = \frac{\mu_T - \mu_C}{\sqrt{(\sigma_T^2 - \sigma_C^2)/2}}$

minimal across both sub-treatments, we should only expect individual-level characteristics to be balanced across the VFC framing sub-treatment arms (agriculture or agriculture+nutrition). This is because the comparison between individuals in the male targeted treatment arm and in the female targeted treatment arm necessarily compares observable characteristics across men and women. To the extent that there are gender differences in educational attainment, access to information, or any other observable dimension among households in our sample, the comparison in observable characteristics between these two sub-treatment arms will reflect these differences. Rather than suggesting that the sub-randomization was not successful, these imbalances simply indicate different opportunities and experiences for men and women in our study context.

Overall, the randomization within both sets of sub-treatment groups was successful at creating comparable groups along observable dimensions. For the framing sub-randomization (comparing the agriculture and agriculture+nutrition sub-groups), the normalized differences are extremely small in magnitude: none are above the 0.25 threshold and only one of the fifteen—whether the targeted member has some formal education—has a normalized difference above 0.10. Similarly, only one of the differences in means between the treatment arms is significant at the 5% level, also for the education measure. On average, households in the agriculture script sub-treatment arm also have a slightly larger household size (5.4 members) relative to those in the agriculture and nutrition script arm (5.2 members), though the difference is not significant at the 5% level. PPI scores and VFC SIM activation are nearly identical across treatment arms. The finding of one significant difference out of fifteen tests is what we should expect to find by chance for tests at the 5 per cent level.

The male and female targeted households are similarly balanced with respect to household-level characteristics: none of the eleven household-level measures have normalized differences above 0.082 in absolute value and none of the p-values are below 0.05. Household size is similar (5.5 members in female targeted and 5.6 in male targeted), and the average PPI score is nearly identical (60). Male targeted households were slightly more likely to activate their VFC SIM card, but the normalized difference is just -0.037 and the corresponding p-value is far above 0.05 (0.423). As expected, there is substantial imbalance in individual characteristics: men are significantly more likely to have some formal education (58.7% relative to 42.7%), females answered more nutrition knowledge questions correctly in the baseline survey (60.766% to 54.326%), and males answered more farming knowledge questions correctly (58.053% compared to 55.239%). Interestingly, WTP is not significantly different between males and females, though the male stated WTP is roughly 0.2 GhC higher, on average. Based on the demographic, wealth, agricultural yield, and knowledge characteristics we explore, both the VFC framing

randomization and the gender targeting randomization appear to have been successful at selecting observably similar households.

IV. Estimation Strategy

The primary purpose of this paper is to assess farmers' demand for a digital nutrition-sensitive agriculture intervention. We therefore begin by describing farmer WTP for the VFC service visually, by plotting the inverse demand for the VFC service for all prices between 0 GHC and 3 GHC. The inverse demand at price p, is calculated as the share of individuals with $WTP_{iv} \geq p$, or the share of individuals who would register for the VFC program at price p.

We are also able to explore the correlates of WTP for the VFC program. We do so by estimating ordinary least squares (OLS) regressions of individual WTP on a set of individual, household, and enumeration area-level baseline characteristics. Though the estimated parameters are not causal, they provide information about what characteristics predict demand for nutrition-sensitive agriculture information; the results are useful for helping organizations that fund and operate ICTs for agriculture and health to balance reaching a broad group of users against recovering costs through charging positive prices for the service.

As a part of the same exercise, we also test how WTP varies with the framing of the VFC program provided to the individual—either the agriculture only VFC description or the agriculture and nutrition VFC description—by including an indicator for whether the household was randomly assigned to the agriculture+nutrition treatment. More precisely, we estimate:

$$WTP_{iv} = \alpha + \beta X_{iv} + \delta nutrition_{iv} + u_{iv} \quad (1)$$

Where X_{iv} is a vector of baseline characteristics, $nutrition_{iv}$ is an indicator for whether the respondent received the agriculture+nutrition framing, and the sample is limited to just households in treatment enumeration arease. Because the households that received the agriculture+nutrition framing of the VFC product were randomly selected, we interpret δ as the causal effect of adding the nutrition description on WTP, relative to receiving the standard service description. Included in the vector of baseline characteristics are all the characteristics listed in Table 1 as well as an indicator for whether the farmer is female, an indicator for whether the household had both an eligible female and an eligible male respondent, and an indicator for whether the household is in the Central region. We include the indicator for whether the farmer's primary SIM card at baseline was a Vodafone SIM to test whether WTP for the

VFC service is driven by the respondent's demand for a new Vodafone SIM as opposed to the other features of the program; if demand for a Vodafone SIM is an important determinant of WTP for the service, we should estimate a negative relationship between having a Vodafone SIM at baseline and WTP.

We also test whether the sex of the targeted respondent in the household has any impact on WTP by restricting the sample households with both an eligible female and an eligible male respondent, for whom the gender of the targeted respondent was randomly selected. For this sample, the coefficient on the indicator for whether the respondent was female captures the differential valuation of the VFC service for females, relative to males. We additionally include an interaction between whether the targeted respondent was female and whether the household was randomly assigned to receive the agriculture+nutrition framing of VFC; the point estimate on this interaction captures whether female respondents differentially value the additional nutrition information included in the agriculture+nutrition treatment.

After linking the WTP and baseline survey data to the previously described Vodafone administrative data on activation of the VFC SIM cards in June of 2017, we can investigate whether there are any screening effects—correlations between WTP for the VFC and use of the VFC service, as measured by SIM activation. Testing for screening effects allows us to assess whether the individuals and households that would select into participating in the program at different positive prices, would also be differentially likely to use the service. This is helpful for understanding whether there is a tradeoff between providing the service to a broad set of households and ensuring that the service is actually used by those who are offered access to the program. We test for screening effects by estimating OLS regressions of the indicator for whether the VFC SIM card was activated by June of 2017 on WTP, the sub-treatment and strata indicators, and the Central region dummy. The coefficient on WTP will capture any screening effect for the VFC service.

As all of the analysis is conducted just with households in treatment villages, and hence randomization occurred at the individual level, we do not cluster standard errors at the EA level in our main specifications. However, we cluster at the EA level as a robustness check.

V. Results

A. Demand and the Determinants of WTP

1855 individuals in treatment EAs met the study's sampling requirements and were willing to participate in the WTP game. The mean monthly price farmers are willing to pay for the VFC service is 2.05 GHC and the median is 1.90 GHC; approximately $US 0.45. While the mean and median WTP are useful for understanding demand for the VFC service among the sample, the BDM exercise provides a precise measure of WTP that allows us to measure what exactly what demand for the VFC service would be at all positive prices for individuals in the sample. Figure 1 displays this relationship by plotting the inverse demand curve—the share of individuals that would be willing to register for the VFC at a given price—at all monthly prices between 0 GhC and 3 GhC. As expected, the share of households that state they are willing to pay at least as much as a price p for the service decreases as the price increases and there is considerable bunching at integers and intervals of 0.5 GHC. At 1.0 GHC, the share of households willing to pay for the service is 85 percent, whereas at 3.0 GHC the share who would register for VFC is just 19 per cent[8]. After 3.0 GHC demand drops dramatically. Critically, at the current monthly price of 0.5 GHC, 94.7% of individuals report that they would be willing to pay to participate in the VFC service. This suggests that a temporary price subsidy may not be necessary to ensure that interested farmers are able to gain experience with the VFC product; nearly all our sample would register for the service even without any subsidy. In contrast, at the previous non-zero monthly price charged by Vodafone (2 GhC), only 50 percent of respondents would be willing to participate.

To better understand what drives WTP, Table 2 presents OLS estimates of WTP for the VFC service on baseline characteristics and the sub-treatment indicators. Column (1) shows the estimates for the full sample of households, while column (2) restricts the sample to households with both a potential male and a potential female respondent that were eligible for the gender targeting randomization; we refer to this sample as "Two person households."

The estimates for both samples indicate that higher nutrition knowledge is associated with a higher WTP: a 10% increase in the number of nutrition knowledge questions that were answered correctly is associated with a 0.20 GhC increase in WTP in the full sample and a 0.10 GhC increase in WTP in the two-person household sample. Both relationships are significant at the 5% level. There is no observed relationship between farming knowledge and WTP for VFC for either sample. If we expect the information contained in the VFC messages to be more useful to individuals and households with low baseline nutrition and

[8] The inverse demand curve is plotted until a price of 3 GhC, the highest price that could be drawn by the farmer.

farming knowledge, these correlations suggest that offering the service at lower prices may help to ensure that those who would benefit the most are not denied access to the content.

Somewhat surprisingly, the relationship between PPI score, a measure of household poverty, and WTP is small in magnitude and not significantly different from zero in either sample (point estimate 0.01). In the full sample, respondents with some formal education have WTP that is lower by 0.37 GhC (p-value<0.10); the point estimate is of a similar magnitude in the two-person household sample, but no longer significant at conventional levels. There is no observed relationship between maize yield (kg/acre), household size, the number of children under the age of 5, distance to market, or region in either sample. Reassuringly, we also find no association between whether the respondent's main SIM card was a Vodafone SIM at baseline. This helps to dispel the potential concern that valuations for the VFC service was primarily driven by their desire for a Vodafone SIM card.

There is no significant relationship between WTP and being randomly assigned to receive the agriculture+nutrition framing of the VFC service in the full sample. Similarly, the interaction between the agriculture+nutrition treatment indicator and the female targeted treatment indicator is not significantly different from zero. Thus, respondents were not willing to pay any additional monthly fee for the nutrition information, and female respondents were similarly indifferent to the extra nutrition information in the content. The female treatment indicator in column 2 is negatively signed (-0.13), but not significantly different from zero. WTP for individuals from two-person households is significantly lower than WTP for individuals from one person households, with the point estimate indicating that relative to respondents in one person households, respondents from two person households bid 0.55 GhC less.

We continue to explore whether there are differences in WTP along the dimensions set by the two sub-randomizations—agriculture or agriculture+nutrition framing and male or female targeted—by plotting the inverse demand curves and confidence intervals for WTP throughout the 0 GhC to 3 GhC monthly price range in Figures 2 and 3. In both figures the solid lines represent the inverse demand curves for the sub-groups being compared, with the dashed lines depicting the 95% confidence intervals. It is clear from Figure 2 that there are no differences in WTP up until a price of 2 GhC. After 2.0 GHC, differences emerge, with farmers in the agriculture and nutrition arm willing-to-pay more than farmers in the agriculture arm, though the difference is not statistically significant at conventional levels. A slightly larger difference between male and female respondents is apparent in Figure 3 at all prices above 1 GhC, with male respondents willing to pay more for the service than females. However, the 95% confidence intervals for the two inverse demand curves overlap at all possible prices. We also remain agnostic about

what is driving the, admittedly statistically insignificant, gap in demand shares between male and female respondents, though different levels of access to resources would seem to be a plausible explanation.

B. Screening Effects: WTP and VFC Activation

To activate the VFC service, all farmers who participated in the WTP game during the baseline survey had to incur a small additional time and effort cost. Migrated and registered farmers were required to either send a SMS message or check their phone balance using their VFC registered SIM.[9] Although the implied cost is relatively small, it does impose some additional time and effort. And given the reported activation rates in Table 1 (roughly 80% of the sample had activated their VFC SIM in June of 2017), the activation costs did prevent part of our sample from starting the service. We can therefore use VFC activation in June 2017 as an early measure of whether farmers were using the VFC service.

All the farmers that agreed to participate in the BDM game eventually were offered the VFC service for free. As a result, there is no way to estimate the causal effect of price paid, as is typically possible when implementing BDM. However, we can use the VFC activation data to estimate whether there are any screening effects. To do so, we follow the strategy described at the end of Section IV, and estimate OLS regressions of VFC activation on WTP. We do not need to make any additional sample limitations[10] to estimate screening effects because the second stage price discount ensured all participants were registered for the VFC service.

Table 3 displays the estimates of the screening effect—whether stated WTP predicts SIM activation and VFC use in June of 2017. In addition to WTP, the specification also controls for the sub-treatment indicators, the Central region indicator, and the indicator for whether the respondent was in two-person household. There is no evidence that respondents with higher WTP are more likely to be using the service. In fact, the point estimate for WTP is negative and statistically significant at the 5% level, suggesting that respondents with higher WTP are *less* likely to use the VFC service; a one standard deviation increase in WTP is associated with a two percentage point decrease in the likelihood that the respondent is using the program. If anything, this indicates that higher prices for VFC would result in a sample of users that are less likely to use the service and therefore less likely to benefit from the content.

[9] For farmers who were given a new VFC SIM this was their new SIM. For farmers that migrated an existing Vodafone SIM, this was their old Vodafone SIM.

[10] Estimating screening effects typically requires limiting the sample to individuals who bid more than their random price draw and therefore won the good. All individuals in our sample win the good through the second-stage price randomization.

VI. Conclusion

In this paper we BDM to elicit a farmers' willingness-to-pay for a nutrition-sensitive agriculture information service—the Vodafone Farmers' Club (VFC)—among farming households in rural Ghana. We find that participating individuals are overwhelmingly willing to pay the current monthly price for the service: nearly 95% of respondents stated a WTP of at least 0.5 GhC. This suggests that temporary initial price subsidies may not be necessary to ensure that potential beneficiaries can experience the service in our context. The share of farmers willing-to-pay for VFC service decreases rapidly as the price increases. At 1.0 GHC, 85% would register for the service; at 2.0 GHC 50% would register; and at 3.0 GHC, just 19% would still be willing to participate. From the standpoint of identifying a price that enables the operating organization to recover some of their costs while still reaching as many interested farmers as possible, the results suggest that small positive monthly prices (between 0-1 GhC) for the VFC service are not likely to substantially decrease demand.

We find that farmers' demand for the VFC service does not depend importantly on whether it was described using an agriculture script or an agriculture and nutrition script that placed additional emphasis on the nutrition content contained in the program. That said, above a monthly price of 2 GhC a slightly higher share of farmers in the agriculture+nutrition group would be willing to participate in the program, though the difference is not statistically significant at any positive price in the 0-3 GhC range; female respondents also do not differentially value the VFC service when the agriculture+nutrition product description is used to market the program.

Within households that had both an eligible female and an eligible male respondent, we test whether the gender of the targeted household member matters for stated WTP. As with the VFC framing, we find no significant difference in mean WTP for the program between male and female respondents and we fail to reject the null of no difference in the share of respondents who would register for the VFC service at any monthly price in the 0-3 GhC range. However, while none of the differences are statistically significant, mean WTP is higher among male respondents and the share of male respondents that would participate in the VFC service is above the share of female respondents that would participate for all monthly prices greater that 1 GhC.

We link administrative data on which VFC SIM cards were activated and remained active one to three months after the BDM game to baseline characteristics and stated WTP to explore whether there are any

screening effects. The results suggest that respondents with higher WTP are no more likely to be using the VFC service; in fact, higher WTP is negatively correlated with a the likelihood of VFC use, a relationship that is significant at the 5% level. We estimate that a one standard deviation increase in WTP is associated with a two percentage point decrease in the likelihood that the respondent activated the service. The lack of any screening effect insinuates that there is no trade-off for policy makers with respect to making the service available at a lower price and ensuring that the individuals who are sent the content are likely to use the information they receive. Future work will explore whether WTP is associated with longer-term measures of VFC use as well as whether WTP predicts nutrition and agriculture related behaviour change.

Table 1: Summary statistics, by mNutrition sub-treatment status

	Full sample				Subsample of households with a primary male and female			
	Agriculture script (A)	Ag+Nutrition script (A+N)	Normalized difference between (A+N) and (A)	P-Value	Male targeted (M)	Female targeted (F)	Normalized difference between (F) and (M)	P-Value
Respondent's willingness to pay (GhC)	1.967 (2.791)	2.124 (3.976)	0.046	0.374	2.105 (2.510)	1.913 (2.692)	-0.074	0.154
Total PPI score	59.786 (13.819)	60.844 (14.078)	0.076	0.126	60.433 (14.492)	60.220 (14.280)	-0.015	0.783
Targeted member has some education	0.467 (0.499)	0.523 (0.500)	0.111	0.018	0.587 (0.493)	0.427 (0.495)	-0.323	0.000
Nutrition knowledge of targeted member	58.151 (16.236)	57.094 (16.030)	-0.066	0.164	54.326 (15.741)	60.766 (15.654)	0.410	0.000
Farming knowledge of targeted member	55.904 (17.762)	56.644 (17.276)	0.042	0.446	58.053 (17.168)	55.239 (17.461)	-0.163	0.001
Yield of maize (kg/acre)	270.579 (602.323)	266.652 (447.787)	-0.007	0.814	289.914 (460.110)	270.936 (602.518)	-0.035	0.483
Does not grow maize	0.281 (0.450)	0.279 (0.449)	-0.004	0.990	0.267 (0.443)	0.259 (0.439)	-0.018	0.742
Household size	5.371 (2.455)	5.216 (2.349)	-0.065	0.055	5.599 (2.299)	5.516 (2.362)	-0.036	0.511
Number of children under the age of 5	0.583 (0.776)	0.622 (0.757)	0.050	0.341	0.646 (0.780)	0.643 (0.776)	-0.004	0.930
First quartile - Distance to market	0.329 (0.470)	0.348 (0.476)	0.038	0.339	0.333 (0.472)	0.300 (0.459)	-0.071	0.113
Second quartile - Distance to market	0.233 (0.423)	0.240 (0.427)	0.017	0.654	0.242 (0.428)	0.232 (0.422)	-0.024	0.588
Third quartile - Distance to market	0.183 (0.387)	0.176 (0.381)	-0.016	0.706	0.172 (0.377)	0.204 (0.403)	0.082	0.071
Fourth quartile - Distance to market	0.255 (0.436)	0.236 (0.425)	-0.044	0.239	0.253 (0.435)	0.264 (0.441)	0.025	0.562
Vodafone is the provider of main SIM card	0.316 (0.465)	0.305 (0.461)	-0.024	0.543	0.346 (0.476)	0.317 (0.466)	-0.061	0.257
Activated on VFC system in June 2017	0.800 (0.400)	0.798 (0.402)	-0.007	0.855	0.814 (0.389)	0.800 (0.400)	-0.037	0.423
Number of Households	914	941			789	826		

Notes: Estimates from the mNutrition Ghana Baseline Survey sample. Standard deviations are in parentheses. The normalized difference is the difference in means between the two groups scaled by the average of the within group standard deviations. P-value is from the test of difference of means between the relevant treatment groups.

Table 2: Correlates of WTP

	Full Sample	Two Person Households
	(1)	(2)
Total PPI score	0.01	0.01
	(0.007)	(0.006)
Targeted member has some education	-0.37*	-0.24
	(0.194)	(0.161)
Nutrition knowledge of targeted member	0.02***	0.01**
	(0.006)	(0.005)
Farming knowledge of targeted member	-0.01	-0.00
	(0.005)	(0.004)
Yield of maize (kg/acre)	-0.00	0.00
	(0.000)	(0.000)
Does not grow maize	-0.11	0.09
	(0.190)	(0.157)
Household size	0.04	0.01
	(0.042)	(0.033)
Number of children under the age of 5 years	0.18	0.13
	(0.113)	(0.089)
First quartile - Distance to market	0.09	0.12
	(0.217)	(0.175)
Second quartile - Distance to market	0.21	0.17
	(0.233)	(0.186)
Third quartile - Distance to market	0.35	-0.04
	(0.250)	(0.199)
Network provider of main SIM card is Vodafone	-0.24	-0.18
	(0.191)	(0.152)
Female targeted	-0.40**	-0.13
	(0.181)	(0.191)
Agriculture and nutrition script	0.19	0.27
	(0.160)	(0.187)
Central region	0.21	0.07
	(0.210)	(0.171)
Two person HHs	-0.55**	
	(0.271)	
Female targeted*Nutrition script		-0.34
		(0.260)
Constant	0.97	0.70
	(0.688)	(0.539)
Observations	1,855	1,615
Prob > F	0.0538	0.2186
R-squared	0.014	0.012

Standard errors in parentheses

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

Table 3: Screening Effects, WTP, and VFC Activation

	Activated on VFC system in June 2017
	(1)
Willingness to pay (GhC)	-0.01**
	(0.003)
Female targeted	-0.02
	(0.021)
Agriculture and nutrition script	-0.00
	(0.019)
Central region	-0.06***
	(0.020)
Two person HH	0.04
	(0.031)
Constant	0.82***
	(0.039)
Observations	1,683
R-squared	0.011

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 1. Inverse Demand Curve for Vodafone Farmers' Club

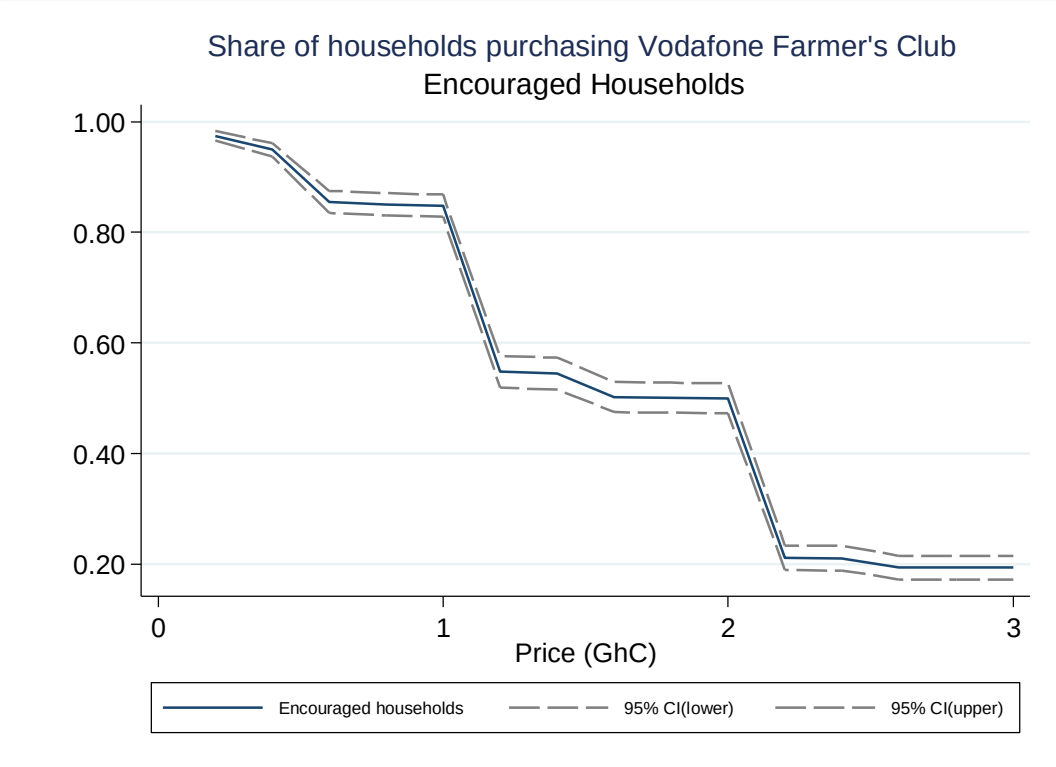

Figure 2. Inverse Demand by VFC Framing Treatment Status

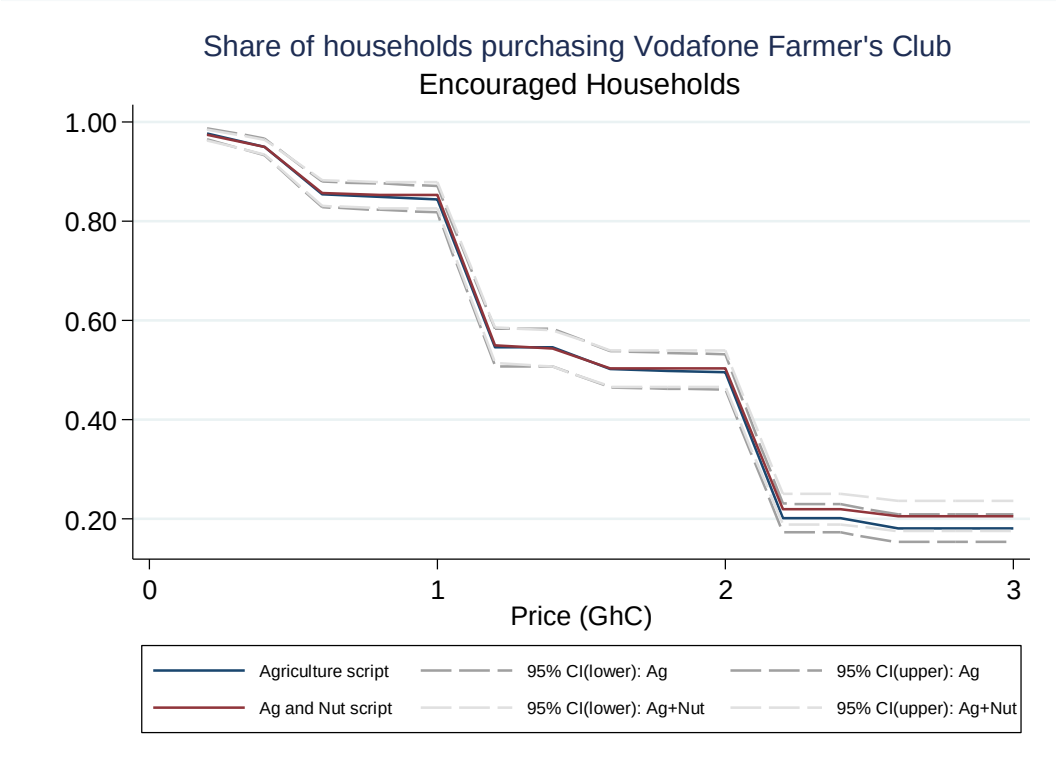

Figure 3. Inverse Demand by Gender