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

G. Palloni[1]; J. Aker[2]; D. Gilligan[1]; M. Hidrobo[1]; N. Ledlie[1]

1: International Food Policy Research Institute, Poverty, Health and Nutrition Division, United States of America, 2: Tufts University, , United States of America

Corresponding author email: g.palloni@cgiar.org

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. 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 the share of farmers willing-to-pay for VFC service is high at low prices and then 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. 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 that women have statistically lower WTP than men, but the framing has no impact on WTP.

Acknowledegment: We would like to thank all individuals in Upper West and Central Region who agreed to take part in this research. We are particularly grateful to Lucy Billing for managing the project in Ghana, and to the ISSER team in Ghana, led by Simon Bawakyillenuo and Felix Asante. We would also like to extend our gratitude to Groupe Spéciale Mobile Association (GSMA), Esoko, Vodafone Ghana, and Global Alliance for Improved Nutrition (GAIN) teams for their cooperation and support. We are also extremely grateful for the ongoing collaborative partnership with The Institute of Development Studies (IDS) and the GAMOS team.

JEL Codes: I12, O33

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

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, Ghosh, and Burrell 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; Hildebrandt and Romagnoli 2015; Nakasone, Torero, and Minten 2014; Mitra et al. 2013; Camacho and Conover 2011; Fafchamps and Minten 2012; Casaburi and Kremer 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 et al. 2014; Flax et al. 2014), a systematic review of interventions that use SMS to encourage drug adherence was more ambiguous about

their success (Nglazi et al. 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 et al. 2013; Rokicki et al. 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. Through an experiment we measure WTP from revealed preferences using the Becker-DeGroot-Marschak method (Berry et al 2015). 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. The share of farmers willing-to-pay for VFC service is at low prices and then 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.

In addition, 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 we randomly vary the targeting of VFC to investigate whether there are differences in WTP by gender. We find that in households with both an adult male and female, women have significantly lower WTP for VFC than men, however, we find no significant differences in WTP between individuals who receive the agriculture and nutrition framing and individuals who receive the agriculture framing.

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 VIII 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 3[1] nutrition tip per month) for the selected crop
- **Call centre:** Free access to a call centre with advice available from an agricultural expert

[1] The initial number of nutrition messages being sent to farmers was 1 per month. As of June 2017, this was increased to 3 messages per month.

- Free calls and SMS messaging to other VFC members
- Discounted SMS and Voice SMS to non VFC members

In total, 22 messages per month are sent to the subscriber. The content is 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 information service, develops and curates the message content and operates the platform to send SMS and recorded voice messages to registered farmers. Esoko also operates the Farmer call center.

Nutrition message content was developed by the Global Alliance for Improved Nutrition (GAIN) and Grameen. 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 general nutrition tips and messages for 13 crops that were not originally part of the Esoko profile. General nutrition tips were also developed by Grameen. Agri tips developed by Esoko cover information on best practices for planting, cultivation and harvest.

The VFC service offers 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 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 to which farmers can subscribe. The subscription fee for the mNutrition packages was initially GhC 2 (USD 0.45) per month. From October 2016 to May 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 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 using the Becker-DeGroot-Marschak (BDM) method (Berry, Fischer, and Guiteras 2015). 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 two-person (adult male and female) and female-only households (adult male-only households were excluded). Two-person households 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 the agriculture script or the agriculture plus nutrition script.

The WTP experiment was conducted at the end of the baseline household questionnaire which collected detailed demographic information and agriculture and nutrition knowledge and practices. Households in treatment EAs were asked if they had heard of the VFC service, 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+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]

After the scripts describing the VFC service were read, we measured WTP and registered users using a two-step variation on BDM (see Appendix A). In the first step we elicited the respondents' WTP for the VFC using BDM. Each participant was read basic instructions for the BDM game and asked if they had any questions. The participant was then asked how much they were willing to pay monthly for the VFC service, and reminded that once the bid was finalized they would not be able to change the amount, that they must be able to pay the bid amount today, and that if they draw a price that is greater than their bid they would not be able to purchase the good. To ensure that the bid represents the maximum monthly amount that the respondent is willing to pay, the enumerator 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 said 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 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.[2] 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, the enumerator asked the farmer to see the money. If the

[1] Respondents were informed that the monthly price would be between 0 and 3 GHC.
[2] This modification of classic BDM follows the method used in Berry et al. (2015) and Mazar, Koszegi, and Ariely (2014).

farmer did not have the funds, they were asked to go collect the funds.[3] Next, the farmer was instructed to draw a button from a cup (held above their head so that the buttons are not visible), with each button representing a different price from a distribution of prices [0.2-3 GHC].[4] If the respondent's bid was greater than or equal to the randomly drawn price, then they purchased the good at *the randomly drawn price*. If the respondent's bid was less than the randomly drawn price, then they were not allowed to purchase the good. Once the random price was revealed, the farmer was not allowed to change their bid. For expected utility maximizers, the optimal strategy is to bid their true valuation for the good.

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 with buttons labelled with the letters A through D. The enumerator entered the letter from the selected button into a tablet, and the final 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 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.

Before playing the game for the VFC service, farmers played a practice round for a bar of soap.[5] At the end of the practice round, enumerators were instructed to exchange the bar of soap for the farmer's bid amount if the respondent won the game[6] 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 random price.

III. Data

To measure households' demand for digital agricultural information services, we rely upon two primary datasets. The first is the household-level survey 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 is Vodafone administrative data that identifies whether the household activated their service and remained active as of June of 2017 (1-3 months after the WTP elicitation).

[3] In practice, bids were sufficiently low that respondents were always able to find
[4] 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}.
[5] The bars of soap were worth approximately 1 GHC.
[6] 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 want 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.

A. Baseline Data Collection

The household survey was conducted between March and May 2017 in 5 districts in the Upper West and 5 districts in the Central region of Ghana. The 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 households were randomly sampled, for a total of 3,936 households at baseline. The inclusion criteria were 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 15-60 years of age. To identify eligible households, a community listing exercise was conducted in selected EAs (see Billings et al. 2017).

Households were asked a series of questions on household demographics, agricultural production, farming and nutrition knowledge, food security, women's empowerment, and mobile phone usage. In two-person households, a primary male and a primary female were selected. If the household head was male, he was the primary male. If he was married, his first order wife was the primary female. If unmarried, an adult female member who participated in decision making around farming and household expenditure was selected as the primary female. If the household head was female, she was the primary female. If she was married, her husband was the primary male. If unmarried, an adult male who also participated in decision making around farming and housing expenditure was selected as the primary male. Modules on mobile phone usage and farming and nutrition knowledge were asked separately for the primary male and female.

In treatment villages, the randomly selected primary male or female was informed of the VFC service, read the agriculture or agriculture +nutrition script, asked to participate in the WTP game, offered the VFC service, and if they accepted, registered and profiled for VFC. Registration required a separate process, either migrating the existing Vodafone phone number of the respondent to VFC, or providing the respondent with a new VFC SIM card. When possible, enumerators competed the registration in the respondent's home. Respondents were instructed to check the registration status of their SIM regularly, and activate their SIM after it was registered by checking their balance, sending a text message, or making a call.

B. Vodafone Administrative Data

In addition to the baseline household data, we use administrative data from the Vodafone. Informed consent to access information on phone usage from mobile network was obtained during the data collection. Though the activation itself was free, it did create an additional time cost for households. We obtained administrative data the phone numbers that incurred this additional time cost, activated the VFC service, and were still active in June 2017 (1-3 months later). We use this as our primary measure of household use of the service.

The administrative data 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 explore whether baseline WTP and demographic characteristics help explain the variation in early VFC use.

C. Baseline Summary Statistics

Sample

Of the 1,979 households in the treatment arm surveyed at baseline, 122 households did not consent to receive additional information on VFC and therefore did not participate in the WTP exercise. An additional 14 households participated in the first stage of the WTP exercise but were unwilling to participate in the second stage, which meant that they did not receive a VFC SIM card. Of the remaining 1,843 households, 1,811 households agreed to be registered for the service. Overall, 91.5% of the treatment households agreed to be registered and receive the content on their mobile.

The sample used in the analysis are the 1843 households that completed the two-stage WTP exercise; of these, 1608 are two-person households.[7] Of the 1,843 households that participated in both stages of the WTP exercise, Vodafone's administrative data showed that 1,345 households were registered and activated for VFC service, 338 households were registered but had not activated their SIM cards, and the other 160 households either declined a SIM card after the WTP exercise, or their SIM cards were not registered. For the screening analysis our sample consists of the 1683 households with a SIM card that was registered and activated, or registered but not activated in June 2017.

Household summary statistics

[7] Two households do not have a knowledge score dropping the number of households to 1841 (for the full sample) and 1606 two-person households for our correlates of WTP analysis.

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 or agriculture+nutrition script; female 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), 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% chance of being below 150% of the national poverty line in Ghana. Approximately half of the respondents have some formal education, though just 42.8% of female respondents have some education compared to 58.7% of male respondents; on average, respondents answered correctly 57.68% of the nutrition knowledge and 56.33% of the farming knowledge questions that were included in the baseline survey. Households have a mean size of 5.30 members and 0.606 members under the age of five. Finally, a substantial fraction of respondents (31.02%) reported at baseline that their primary SIM card was a Vodafone SIM.

Table 1 also displays two different measures of balance between the agriculture and agriculture+nutrition arms, and the male and female targeted 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[8] (Imbens 2015) between the two groups. Normalized differences offer a metric that is sample size and scale free, and we therefore use them as our primary measure of balance. We follow the rule-of-thumb proposed in Imbens and Rubin (2007) and treat normalized differences below 0.25 in absolute value as indicative of balance. We note that while the differences in household characteristics should be 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 and female targeted treatment arms 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 the study context.

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

Overall, the randomization 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 education. On average, households in the agriculture script arm also have a slightly larger household size (5.4 members) relative to those in the agriculture+nutrition arm (5.2 members), which is significant at the 5% level. PPI scores and VFC SIM activation are nearly identical across arms.

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 0.08 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 are 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 42.8%), females answered more nutrition knowledge questions correctly in the baseline survey (60.82% to 54.28%), and males answered more farming knowledge questions correctly (58.04% compared to 55.32%). 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 that 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

A. Demand for VFC

The primary purpose of this paper is to assess farmers' demand for a digital nutrition-sensitive agriculture intervention. We therefore begin by describing farmers' 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 plot the inverse demand curve for all individuals that participated in the WTP exercise and then we disaggregate by sub-treatment status by plotting the 95 percent confidence interval along with the difference between the inverse demand curves.

B. Framing, targeting and other determinants of WTP

We explore the correlates of WTP for the VFC program 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 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:

$$\mathbf{(1)} \qquad \boldsymbol{WTP_{ihr} = \alpha + \beta X_{ihr} + \delta nutrition_{hr} + \gamma female_{hr} + \rho_t + \pi_r + u_{ihr}}$$

Where WTP_{ihr} is the willingness to pay of individual *i* from household *h* and region *r*. X_{ihr} is a vector of baseline characteristics, $nutrition_{hr}$ is an indicator for whether the respondent from household *h* received the agriculture+nutrition framing, and ρ_t and π_r are stratification indicators for two-person households and region respectively. 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, which we do not yet interpret causally because the indicator includes female only households. We also 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 additionally 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 (two person households), 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, γ, captures the differential valuation of the VFC service for females, relative to males.

(2) $$\boldsymbol{WTP_{ihr} = \alpha + \beta X_{ihr} + \delta nutrition_{hr} + \gamma female_{hr} + \pi_r + u_{ihr}}$$

Lastly, we 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, σ, captures whether female respondents differentially value the additional nutrition information included in the agriculture+nutrition treatment.

(3) $$\boldsymbol{WTP_{ihr} = \alpha + \beta X_{ihr} + \delta nutrition_{hr} + \gamma female_{hr} + \sigma nutrition_{hr} X female_{hr} + \pi_r + u_{ihr}}$$

C. Screening Effects: WTP and VFC Activation

After linking the WTP and baseline survey data to the Vodafone administrative data on activation of the VFC SIM cards in June of 2017, we 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 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. The coefficient on WTP captures any screening effect for the VFC service. The coefficients on the sub-treatment arms capture whether emphasizing nutrition in the agriculture+nutrition script or targeting females leads to greater use of the service.

All of the analysis is conducted with households in treatment EAs only, and randomization occurred at the household level, so we do not cluster standard errors at the EA level in our main specifications.

V. Results

A. Demand for VFC

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 the 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 at all monthly prices between 0 GhC and 3 GhC. 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[9]. After 3.0 GHC demand drops dramatically. 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.

We continue to explore whether there are differences in WTP along the dimensions set by the two sub-randomizations—agriculture or agriguture+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 (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 significantly more for the service than females.

B. Determinants of WTP

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 columns (2) and (3) restrict the sample to two-person households that were eligible for the gender targeting randomization.

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

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

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 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.

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 0.39 GhC (p-value<0.05); the point estimate is large 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. WTP for individuals from two-person households is significantly lower than WTP for individuals from female only households, with the point estimate indicating that relative to respondents in female only households, respondents from two person households bid 0.57 GhC less.

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 (column 1) or the two-person sample (column 2). However, column 2 reveals a large and significant negative impact of female targeting on WTP. Randomly selecting a female leads to a 0.30 GhC decrease in an individual's WTP. The interaction between the agriculture+nutrition treatment indicator and the female targeted treatment indicator (column 3) 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.

C. 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.[10] Although the

[10] 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.

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 therefore use VFC activation in June 2017 as a measure of whether farmers were using the VFC service.

Table 3 displays the estimates of the screening effect, for the full sample (column 1) and for two-person sample (column 2). 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 a two-person household. There is no evidence that respondents with higher WTP are more likely to be using the service. In fact, for the full sample, 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. In two person households, the association between WTP and activation is zero. In addition, the agriculture and nutrition script and the female targeting have no impact on the probability of activating. Activation in the central region is significantly lower than activation in the Upper West region which highlights regional differences in preferences, network coverage, and agriculture production.

VI. Robustness

VII. Discussion

VIII. Conclusion

In this paper we conduct a BDM experiment 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 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. Within households that had both an eligible female and an eligible male respondent, we find that female respondents have a statistically significant lower WTP for the VFC service by 0.30 GhC. This difference in valuation could be due to less access to mobile phones, less access to resources, or differences in preferences. Female respondents do not differentially value the VFC service when the agriculture+nutrition product description is used to market the program.

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 screening effects. The results suggest that respondents with higher WTP are no more likely to be using the VFC service; in fact, in the full sample, higher WTP is negatively correlated with the likelihood of VFC use, a relationship that is significant at the 5% level. 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.

References

Aker, Jenny C., Ishita Ghosh, and Jenna Burrell. 2016. "The Promise (and Pitfalls) of ICT for Agriculture Initiatives." *Agricultural Economics* 47 (S1):35–48. https://doi.org/10.1111/agec.12301.

Berry, James, Greg Fischer, and Raymond Guiteras. 2015. "Eliciting and Utilizing Willingness to Pay: Evidence from Field Trials in Northern Ghana." *CEPR Discussion Paper No. DP10703.*, no. July. https://ssrn.com/abstract=2630151.

Camacho, Adriana, and Emily Conover. 2011. "The Impact of Receiving Price and Climate Information in the Agricultural Sector." *SSRN Electronic Journal*, May. https://doi.org/10.2139/ssrn.1858036.

Casaburi, Lorenzo, and Michael Kremer. 2014. "Harnessing ICT to Increase Agricultural Production: Evidence From Kenya *," no. September 2013.

Chong, Alberto, Marco Gonzalez-Navarro, Dean S. Karlan, and Martin Valdivia. 2013. "Do Information Technologies Improve Teenagers' Sexual Education? Evidence from a Randomized Evaluation in

Colombia.” https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2217337.

Cole, Shawn A, and A Nilesh Fernando. 2016. “‘ Mobile ’ Izing Agricultural Advice : Technology Adoption , Diffusion and Sustainability.” http://www.hbs.edu/faculty/Publication Files/13-047_155cb6a2-afb5-4744-a62d-929b01fc9e7c.pdf.

Courtois, Pierre, and Julie Subervie. 2015. “Farmer Bargaining Power and Market Information Services.” *American Journal of Agricultural Economics* 97 (3). Oxford University Press:953–77. https://doi.org/10.1093/ajae/aau051.

Fafchamps, Marcel, and Bart Minten. 2012. “Impact of SMS-Based Agricultural Information on Indian Farmers.” *The World Bank Economic Review* 26 (3):383–414. https://doi.org/10.1093/wber/lhr056.

Flax, V. L., M. Negerie, A. U. Ibrahim, S. Leatherman, E. J. Daza, and M. E. Bentley. 2014. “Integrating Group Counseling, Cell Phone Messaging, and Participant-Generated Songs and Dramas into a Microcredit Program Increases Nigerian Women’s Adherence to International Breastfeeding Recommendations.” *Journal of Nutrition* 144 (7):1120–24. https://doi.org/10.3945/jn.113.190124.

Free, Caroline, Gemma Phillips, Leandro Galli, Louise Watson, Lambert Felix, Phil Edwards, Vikram Patel, and Andy Haines. 2013. “The Effectiveness of Mobile-Health Technology-Based Health Behaviour Change or Disease Management Interventions for Health Care Consumers: A Systematic Review.” Edited by Tony Cornford. *PLoS Medicine* 10 (1). Public Library of Science:e1001362. https://doi.org/10.1371/journal.pmed.1001362.

Hildebrandt, Nicole, and Giorgia Romagnoli. 2015. “Price Information, Inter-Village Networks, and ‘Bargaining Spillovers’: Experimental Evidence for Ghana,” 1–70.

Jiang, H, M Li, L M Wen, Q Hu, D Yang, G He, L A Baur, M J Dibley, and X Qian. 2014. “Effect of Short Message Service on Infant Feeding Practice: Findings from a Community-Based Study in Shanghai, China.” *JAMA Pediatr* 168 (5). Elsevier Ltd:471–78. https://doi.org/10.1001/jamapediatrics.2014.58.

Mitra, Sandip, Dilip Mookherjee, Maximo Torero, Sujata Visaria, Clarence Lee, Khushabu Kasabwala, Prathap Kasina, et al. 2013. “Asymmetric Information and Middleman Margins: An Experiment with West Bengal Potato Farmers *.” http://economics.mit.edu/files/8720.

Nakasone, Eduardo, Maximo Torero, and Bart Minten. 2014. “The Power of Information: The ICT Revolution in Agricultural Development.” *Annual Review of Resource Economics* 6 (1):533–50. https://doi.org/10.1146/annurev-resource-100913-012714.

Nglazi, Mweete D, Linda-Gail Bekker, Robin Wood, Gregory D Hussey, and Charles S Wiysonge. 2013. “Mobile Phone Text Messaging for Promoting Adherence to Anti-Tuberculosis Treatment: A Systematic Review.” *BMC Infectious Diseases* 13 (1):566. https://doi.org/10.1186/1471-2334-13-566.

Rokicki, Slawa, Jessica Cohen, Joshua A. Salomon, and Günther Fink. 2017. “Impact of a Text Messaging Program on Adolescent Reproductive Health: A Cluster–randomized Trial in Ghana.” *Working Papers*, January. Geary Institute, University College Dublin. https://ideas.repec.org/p/ucd/wpaper/201702.html.

Svensson, Jakob, and David Yanagizawa. 2009. “Getting Prices Right: The Impact of the Market Information Service in Uganda.” *Journal of the European Economic Association* 7 (2–3):435–45. https://doi.org/10.1162/JEEA.2009.7.2-3.435.

Figure 1: Inverse Demand Curve for Vodafone Farmers' Club

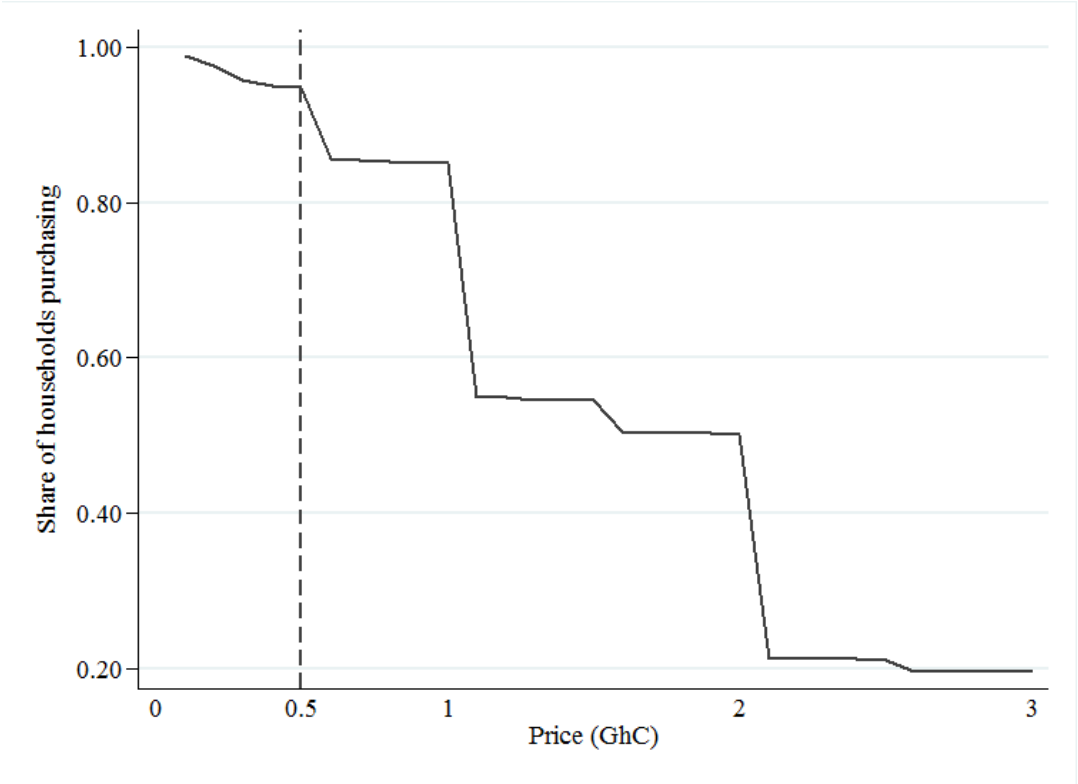

Figure 2a: Inverse Demand by VFC Framing, Agriculture and Nutrition or Agriculture

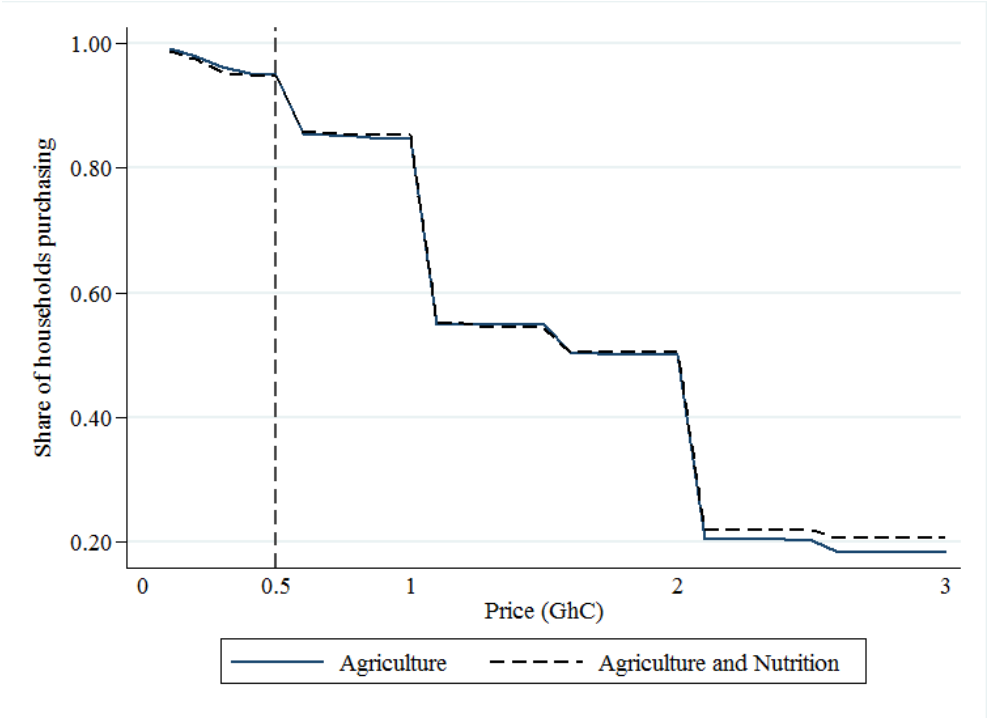

Figure 2b: Difference in share purchasing by framing, Agriculture and Nutrition vs. Agriculture

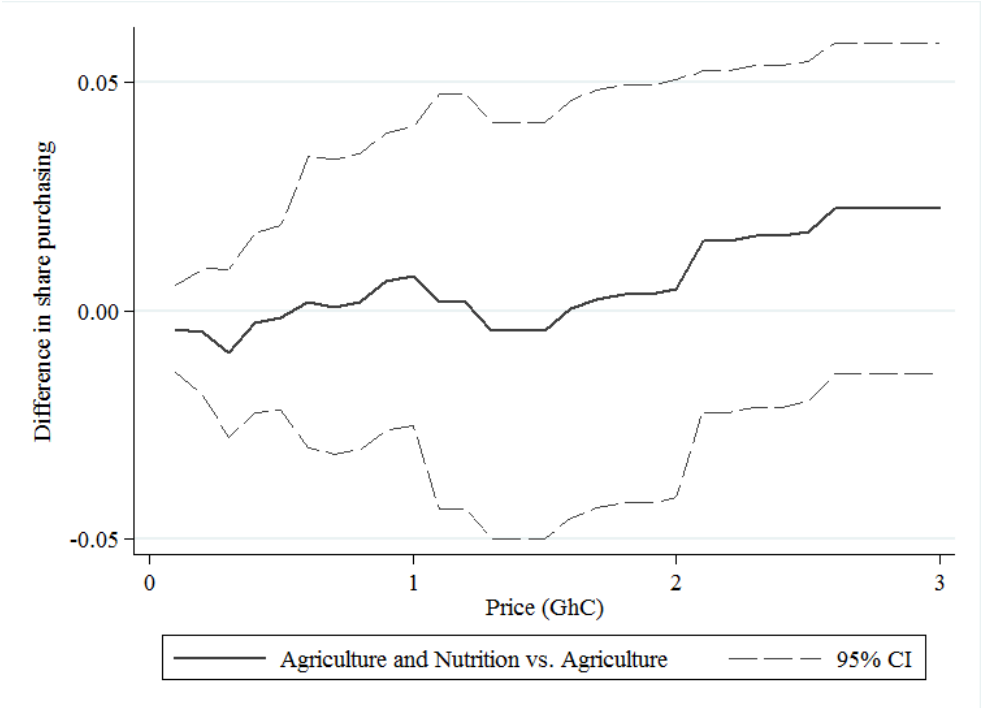

Figure 3a: Inverse Demand by Gender, Females and Males

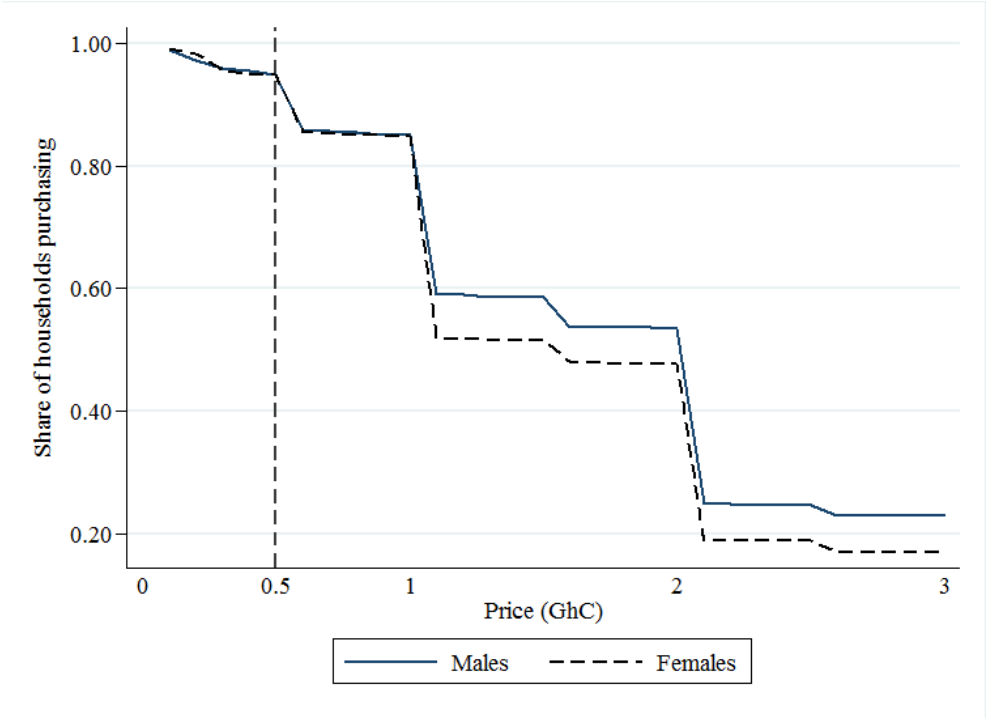

Figure 3b: Difference in share purchasing by gender, Females vs. Males

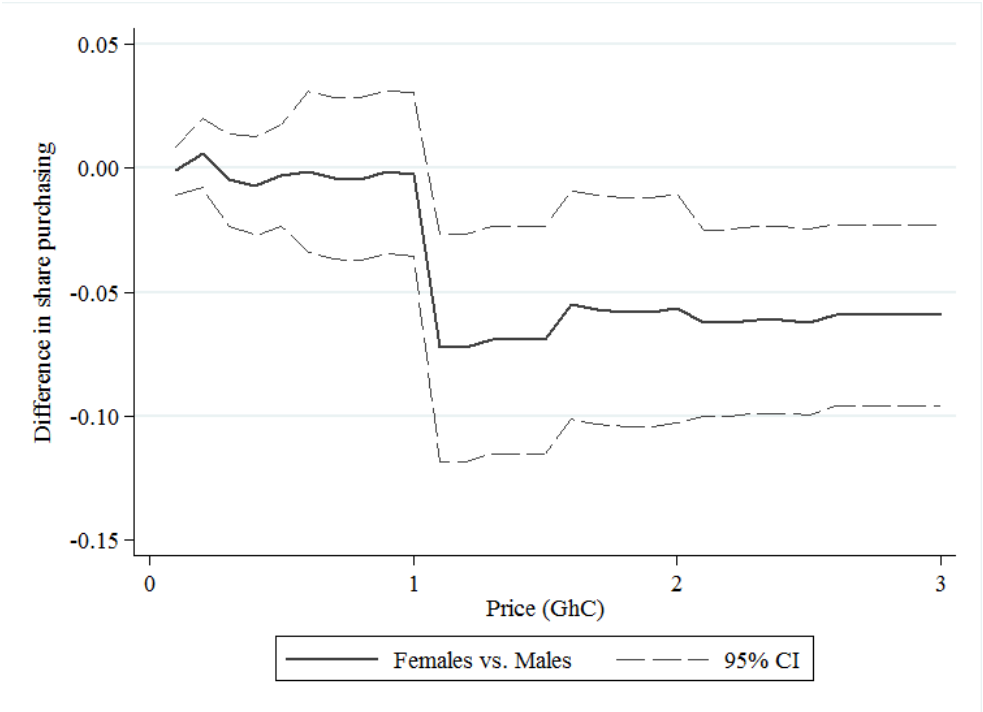

Table 1: Summary statistics, by mNutrition sub-treatment status

	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)	1.978 (2.804)	2.128 (3.984)	0.044	0.399	2.108 (2.515)	1.917 (2.699)	-0.073	0.161
Total PPI score	59.739 (13.802)	60.840 (14.090)	0.079	0.111	60.404 (14.457)	60.216 (14.278)	-0.013	0.807
Targeted member has some education	0.469 (0.499)	0.524 (0.500)	0.110	0.022	0.587 (0.493)	0.428 (0.495)	-0.321	0.000
Nutrition knowledge of targeted member	58.241 (16.210)	57.137 (16.013)	-0.069	0.148	54.284 (15.736)	60.824 (15.670)	0.416	0.000
Farming knowledge of targeted member	55.973 (17.743)	56.676 (17.288)	0.040	0.467	58.041 (17.162)	55.325 (17.431)	-0.157	0.001
Yield of maize (kg/acre)	271.571 (605.301)	266.356 (448.511)	-0.010	0.779	289.499 (461.099)	271.614 (604.167)	-0.033	0.510
Does not grow maize	0.282 (0.450)	0.280 (0.449)	-0.005	0.968	0.269 (0.443)	0.258 (0.438)	-0.023	0.675
Household size	5.390 (2.452)	5.221 (2.347)	-0.071	0.043	5.597 (2.301)	5.528 (2.363)	-0.030	0.588
Number of children under the age of 5	0.588 (0.778)	0.624 (0.758)	0.047	0.369	0.648 (0.781)	0.647 (0.777)	-0.002	0.969
First quartile - Distance to market	0.326 (0.469)	0.348 (0.477)	0.046	0.276	0.331 (0.471)	0.301 (0.459)	-0.065	0.146
Second quartile - Distance to market	0.232 (0.423)	0.239 (0.427)	0.016	0.669	0.243 (0.429)	0.229 (0.421)	-0.032	0.474
Third quartile - Distance to market	0.185 (0.388)	0.176 (0.381)	-0.022	0.628	0.173 (0.378)	0.204 (0.403)	0.080	0.088
Fourth quartile - Distance to market	0.257 (0.437)	0.237 (0.425)	-0.046	0.231	0.253 (0.435)	0.266 (0.442)	0.029	0.512
Vodafone is the provider of main SIM card	0.315 (0.465)	0.305 (0.461)	-0.022	0.590	0.345 (0.476)	0.318 (0.466)	-0.058	0.284
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	904	937			783	823		

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	Two Person Households
	(1)	(2)	(3)
Total PPI score	0.01	0.01	0.01
	(0.007)	(0.006)	(0.006)
Targeted member has some education	-0.39**	-0.26	-0.25
	(0.195)	(0.162)	(0.162)
Nutrition knowledge of targeted member	0.02***	0.01**	0.01**
	(0.006)	(0.005)	(0.005)
Farming knowledge of targeted member	-0.01	0.00	-0.00
	(0.006)	(0.005)	(0.005)
Yield of maize (kg/acre)	-0.00	0.00	0.00
	(0.000)	(0.000)	(0.000)
Does not grow maize	-0.11	0.08	0.09
	(0.191)	(0.158)	(0.158)
Household size	0.04	0.01	0.01
	(0.043)	(0.034)	(0.034)
Number of children under the age of 5 years	0.18	0.13	0.13
	(0.114)	(0.089)	(0.090)
First quartile - Distance to market	0.10	0.13	0.12
	(0.218)	(0.176)	(0.176)
Second quartile - Distance to market	0.22	0.18	0.18
	(0.234)	(0.187)	(0.187)
Third quartile - Distance to market	0.35	-0.04	-0.04
	(0.251)	(0.199)	(0.199)
Network provider of main SIM card is Vodafone	-0.23	-0.18	-0.18
	(0.193)	(0.153)	(0.153)
Female targeted	-0.40**	-0.30**	-0.13
	(0.182)	(0.139)	(0.192)
Agriculture and nutrition script	0.18	0.09	0.26
	(0.162)	(0.131)	(0.188)
Central region	0.21	0.08	0.08
	(0.211)	(0.172)	(0.172)
Two person HHs	-0.57**		
	(0.273)		
Female targeted*Nutrition script			-0.33
			(0.262)
Constant	1.03	0.83	0.72
	(0.694)	(0.536)	(0.542)
Observations	1,841	1,606	1,606
Prob > F	0.0645	0.2589	0.2366
R-squared	0.014	0.011	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	Full sample (1)	Two-person household (2)
Willingness to pay (GhC)	-0.01**	-0.00
	(0.003)	(0.004)
Female targeted	-0.02	-0.02
	(0.021)	(0.021)
Agriculture and nutrition script	-0.00	0.00
	(0.019)	(0.021)
Central region	-0.06***	-0.06***
	(0.020)	(0.021)
Two person HH	0.04	
	(0.031)	
Constant	0.82***	0.85***
	(0.039)	(0.022)
Observations	1,683	1,466
R-squared	0.011	0.006

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