Do Different Extension Approaches Affect Smallholder Farmers' Willingness-to-Pay for New Agricultural Technologies? Experimental Auction Results from Tanzania

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1. Introduction

Promoting the adoption and sustained use of new agricultural technologies is a major challenge for policymakers seeking to raise agricultural productivity and advance agricultural transformation (Barrett et al. 2017). In the absence of strong agricultural extension services, governments often rely on donor-funded projects and non-governmental organizations (NGOs) to demonstrate and market new technologies in rural areas. While adoption and take-up of new technologies is often robust during the promotion and testing period of a new product, we frequently observe rapid disadoption and low takeup when technologies are sold through traditional market channels (Moser and Barrett 2003; Hoffmann, Barrett, and Just 2009; Bensch, Grimm, and Peters 2015). Given the potentially high welfare gains to the diffusion of new agricultural technologies, the goal of the current study is to better understand how the outreach efforts of NGO extension programs might influence farmers' perceptions and willingness to pay (WTP) for technological improvements. Focusing on improved bean seed varieties and a new chemical seed treatment, Apron Star, this research seeks to answer the question: how do NGO lead-farmer extension programs influence the WTP for new bean technologies among Tanzanian bean producers?

Combining a randomized controlled trial (RCT) with a real auction approach to gauge technology demand, we extend the existing literature in several important ways. First, we explicitly test whether lead-farmer technology demonstrations result in a higher producer WTP for improved bean seeds and Apron Star compared to villages without such demonstrations. Furthermore, we measure the effects of two extension approaches. One is a demonstration plot approach, where a lead-farmer maintains a plot in the village to educate other farmers about the use and benefits of a new technology. In the second approach, the lead-farmer maintains a demonstration plot but also distributes trial packs of inputs to village farmers to test the new bean technologies on their own land. As lead-farmer methods become more popular, this research speaks to the benefits of incorporating more learning-by-doing into private extension efforts (in this case, facilitated by the distribution of trial packs). Our second key contribution is to understand how farmers value key agrodealer services in their communities, specifically the chemical treatment of seeds. We leverage differences in WTP between seeds pre-treated and self-treated with Apron Star to measure the demand for basic agricultural services both with and without lead-farmer demonstration plots and technology trial packs.

Working in partnership with the International Center for Tropical Agriculture (CIAT), fieldwork was conducted in August-September 2017 in the southern highlands region of Tanzania. We focus on the efforts of lead-farmers selected by an NGO, Farm Input Promotions-Africa (FIPS-Africa), who are using demonstration plots and the distribution of small input trial packs to educate smallholders about improved bean and maize technologies. Drawing from an ongoing RCT (Snapp et al. 2015) ,we randomly selected 12 villages total in Mbeya Rural and Mbozi districts for inclusion in the study based on which lead-farmer extension approaches were employed in the village (6 demonstration plot only villages and 6 demonstration plot with trial packs villages). Additionally, we worked with FIPS-Africa to choose 6 control villages that met all the criteria for participation in the lead-farmer extension program but were excluded due to funding constraints. Within each village, 25 bean-growing households were randomly selected from village rosters to participate in a household survey covering bean production history, engagement with lead-farmer extension activities, knowledge of new agricultural technologies, and household demographics.

After completing the survey, households were invited to participate in a real Becker-DeGroot-Marschak (BDM) mechanism (Becker, DeGroot, and Marschak 1964) using two varieties of improved bean seeds (Njano Uyole and Uyole 96) and the Apron Star seed treatment. Farmers received an endowment of 5000 Tanzanian Shillings (Tsh), roughly US$2.25, to bid in the auction. Farmers placed bids on the following products for each variety of seed: (i) 1 kg of certified, untreated bean seed; (ii) 1 kg of certified, untreated bean seed with a sachet of Apron Star (for farmers to use to self-treat the seed); and (iii) 1 kg of certified bean seed pre-treated with Apron Star. After all bids were placed, dice were rolled to select a single bid to be binding and to determine the random price.

Our findings on farmer WTP for improved varieties of bean seed and Apron Star seed treatment suggest that, on average, there is no effect of VBAA demonstration plots or demonstration plots paired with trial packs when compared to the control group. A test for heterogeneous effects across the two districts suggests that in Mbozi district but not Mbeya Rural exposure to the demonstration plot only treatment decreases farmer WTP when compared to farmers in control villages or demonstration plots plus trial packs villages. We also find strong evidence that improved varieties of bean seed bundled with Apron Star are more valuable to smallholders in terms of WTP. Farmers are willing to pay a significantly larger premium for seeds pre-treated with Apron Star compared to untreated seed with a sachet of Apron Star for the farmer to apply him/herself.

The remainder of this paper is organized as follows. Section 2 reviews previous related research on agricultural extension and experimental auctions. Section 3 provides background on the agricultural technologies examined in this paper. In Section 4, we explain the conceptual framework for how exposure to different extension models may result in differences in farmer WTP for new technologies. Section 5 discusses the experimental design and sampling process. Section 6 presents our results. Section 7 explores the policy implications of this study and opportunities for further research.

2. Literature Review

2.1 Agricultural extension and delivery

Investment in agricultural extension systems is a key tool of policymakers to address the large gap in agricultural productivity observed in many developing regions. Beginning with the establishment of national agricultural advisory services in the 1950s, extension programs have been a key piece of government budgets dedicated to agricultural growth and poverty reduction (J. R. Anderson 2008; Benin et al. 2011).

Anderson and Feder (2007) highlight several key types of agricultural extension models: Training and Visit (T&V), Fee-for-service, and Farmer Field Schools. T&V is the most common extension program where a formalized structure of in-house agricultural specialists and extension agents provide information and training to targeted villages on a set schedule (e.g. biweekly visits). This model is heavy on human capital, both for training and fieldwork, and has been implemented by national and local governments (Anderson and Crowder 2000). To better leverage resources, the T&V model often involves working with lead-farmers who were successful early adopters of new agricultural technologies and management practices and would be able to share information with others (Aker 2011). Lead-farmers are then expected to train other farmers in their area about the use of new technologies or management practices. Fee-for-service models, often operated by private firms or public-private partnerships, focus on providing more specialized information or services to groups of farmers who pay. FFSs were originally designed to promote integrated pest management in Southeast Asia and are now a widely used approach that brings together groups of farmers for multiple days to facilitate general information about agriculture, agronomy, and management practices (Aker 2011). FFS programs often engage lead-farmers as facilitators within their community, to try to capture some benefits of social learning and peer identification (Davis et al. 2012).[1]

Previous work on the effects of agricultural extension programs largely focuses on how program design affects outcomes related to technology adoption and uptake. Results on different extension modalities are mixed. Pan, Smith, and Sulaiman (2018) use a regression-discontinuity design to evaluate an NGO's lead-farmer extension program on adoption and food security among smallholder women in Uganda. The program increases the probability that individuals adopt improved soil fertility management practices and improved seeds marketed through the NGO.[2] When looking at all improved varieties however, the authors find little evidence that the program increases the adoption. Smallholders in the treatment group experience a corresponding increase in food security measures, which the authors argue occurs through the adoption of improved production practices stimulated by the lead-farmer extension program.

Leveraging an existing national lead-farmer program in Mozambique, Kondylis, Mueller, and Zhu (2017) evaluate the adoption consequences of adding a direct training module on sustainable land management (SLM) for some lead-farmers. Their study finds that additional direct training significantly increases SLM adoption among lead-farmers, but not among end-user farmers in treatment villages. Unlike our study, there is no pure control group containing villages without lead-farmers so their findings do not speak to the overall impact of additional training. Alternatively, Emerick and Dar (2017) show that the addition of farmer-field days to a lead-farmer extension model in India increases end-user uptake of an improved variety of seed by 12 percentage points.

Nakano et al. (2018) evaluate the effects of a farmer-led training program on 3 distinct groups of rice producers in Tanzania: lead-farmers, farmers trained by lead-farmers, and peer farmers in the village. Covering the adoption of improved seed, chemical fertilizer, and better management practices, a difference-in-differences analysis reveals that there were immediate positive effects of training on adoption among trained farmers. However, within 3-4 years, new technologies diffused to untrained farmers in the village. These results are suggestive of the important time dimension of agricultural extension and training. For diffusion to take place broadly, it can take multiple production seasons for information about the new technologies to be collected and utilized by non-targeted farmers.

There is a significant and related group of studies that focuses on how the selection and incentive mechanisms behind lead-farmer extension programs can influence outcomes (Beaman et al. 2015; BenYishay and Mobarak 2015; Emerick and Dar 2017). For example, evidence from Malawi suggest that bypassing extension agents and choosing lead-farmers to demonstrate a new technology via social network theory increases the adoption of an improved planting technique by 3 percentage points on average (Beaman et al. 2015). Emerick and Dar (2017) find no effect of lead-farmer selection methods on adoption rates when comparing lead-farmers selected by local leaders to those selected by the community in India. Compensating lead-farmers can also increase effort exerted in communicating about new technologies across the village, further boosting adoption rates in Malawi (BenYishay and Mobarak 2015).

[1] FFS do not focus primarily on adoption and dissemination of new technologies.

[2] Improved soil fertility management practices with positive effects include the application of animal manure, intercropping, crop rotation, and irrigation (Pan et al. 2018).

2.2 WTP auctions in developing countries

Experimental auctions are widely used in the field as a tool to elicit individuals' valuations for goods and services. Real auctions, where bids are binding and money is exchanged for goods and services, can easily be conducted in the field to avoid the problem of hypothetical bias while capturing heterogeneity in valuations for a sample of interest (Lusk and Shogren 2007). Early applications of auction mechanisms focused on estimating consumer WTP for a myriad of products: e.g., certified baby food (Masters and Sanogo 2002), bed-nets (Hoffmann, Barrett, and Just 2009; Dupas 2014), and fortified maize meal (De Groote, Kimenju, and Morawetz 2011).

Most relevant to our work is when these studies are conducted in the context of agricultural extension or outreach programs. De Groote et al. (2014) estimate the WTP of rural consumers in Tanzania for biofortified maize flour. While they find that consumers are willing to pay a significant price premium for the improved product relative to unfortified maize flour, they find no evidence that the extension program designed to promote the biofortified crop had any impact on individual WTP.

Recent research has evolved to focus on producer WTP for improved inputs and agricultural services, rather than emphasizing goods for household consumption. Examples of auction studies include for laser land levelers (Lybbert et al. 2013), improved seed varieties (Waldman, Kerr, and Isaacs 2014), and safety equipment for chemical application (Goeb 2017). Similar to our study, Waldman, Kerr, and Isaacs (2014) estimate production and consumption preferences of Rwandan farmers for a common bean variety. In a similar vein to an extension program, some producers in their study are exposed to an on-farm trial where they grow all improved bean varieties in a demonstration plot prior to participating in experimental auctions. This is similar to the training that many lead-farmers are provided before being sent into the field. Farmers who participated in the on-farm trial were found to offer lower bids on average than farmers who only received yield information. This suggests that increased experience about a new technology may lower WTP as more information is obtained (e.g. days to maturity, weeding requirements) that is best observed in practice.

3. Background

In this section we describe the improved bean technologies introduced to farmers in this study. We also describe the lead-farm extension program being implemented in our treatment villages.

3.1 Improved varieties of beans in Tanzania

Uyole 96 is an improved variety of bean seed released by CIAT and the Agricultural Research Institute Uyole (ARI-Uyole) in 1996. Traditional breeding methods were used to produce this line of large, dark red kidney beans from local cultivars that are used for both household consumption and sale as a cash crop (Hillocks et al. 2006). Consistently cited for high yields, Uyole 96 is tolerant to several common bean diseases including bean rust, asochyta, and Bean Common Mosaic Virus (BCMV) (Muhamba et al. 2013). Njano Uyole is a more recent bean variety released in 2008 by ARI-Uyole. Njano Uyole is a medium size yellow bean that is tolerant to common bacterial blight (CBB), Alternaria leaf spot (ALS), halo blight, and root rot (Muhamba et al. 2013). Njano Uyole is also high yielding and farmers cite the relatively high market price and quality for cooking as postivie characteristics (Em et al. 2013). In addition to the color and size of the two improved bean varieties, there are also other significant differences between them. Uyole 96 (Njano Uyole) takes 84 days (88 days) to mature, requires 36-40 kg (26-28 kg) of seed per acre, and has an expected yield of 480-1000 kg (600-1200 kg) of dry beans per acre.

These technologies allow us to investigate potential heterogeneous effects of the extension treatments between the two bean varieties. Furthermore, having two improved varieties with distinct production and consumption characteristics will increase the likelihood that bean growers would be willing to purchase at least one of the products in an experimental auction. Both varieties share elements of improved yield and disease tolerance but vary on elements of color and taste, which may be important for households that consume some portion of their farm output. Another added benefit of these technologies is that they represent local or domestic innovation. Uyole 96 and Njano Uyole were both developed in consultation with domestic researchers at ARI-Uyole and require similar management practices to common varieties of beans. Thus the technologies may offer improved value without the adoption of complementary improved inputs or management practices, making both varieties a useful target for education by the lead-farmer extension program.

3.2 Apron Star seed treatment in Tanzania

Complementing the improved seed varieties, this article also looks at the introduction of a chemical seed treatment developed by Syngenta and marketed in Tanzania under the name Apron Star. Billed as a fungicide-insecticide treatment, Apron Star is a chemical mixture that can be applied to bean (and maize) seed to control mildew, protect against early season insects (e.g., control sucking pests for 30 days after planting), and to prevent soil borne diseases (Syngenta 2017). Farmers can choose from several application methods for using Apron Star including direct application as a dry dust, dry application to wet seed, or application to seeds as a water-based slurry. This means that the small-scale farmer at home can easily apply the treatment, using resources readily available on hand. Syngenta recommends using 5 g of Apron Star for every 2 kg of seed to achieve optimal results (Syngenta 2017).

While Apron Star is a novel technology in Tanzania, seed treatments and dressings have a long history of use in sub-Saharan Africa, promising increased yields through reduced risk of diseases and pests (Gibson 1953). An added benefit of these chemical treatments is that they do not incentivize the reduction of genetic diversity in cropped bean varieties as they can be applied to farmers' most preferred seed variety without requiring selection for particular genetic traits (Trutmann, Paul, and Cishabayo 1992).

In the southern highlands region of Tanzania, there is little evidence that seed treatments are a commonly used agricultural technology, especially in the production of legumes, despite the southern highlands being an important maize and bean-growing area in the country. In 2016, extension officers in the Mbeya region of Tanzania began recommending seed treatments similar to Apron Star for bean planting, but there has not been widespread adoption of these technologies. Additionally, some agribusiness firms test and pilot new technologies in the Mbeya region before releasing them to the rest of the country. This raises the possibility that some sample farmers may have been exposed to similar seed treatment technologies prior to this study.

3.3 Village-Based Agricultural Advisors

FIPS-Africa is an NGO focused on improving food security and farmer incomes by making improved agricultural inputs and practices accessible to small-scale farmers. Founded in Kenya in 1990, FIPS has expanded their portfolio from inorganic fertilizer to include improved seed varieties, pesticides, herbicides, and fungicides that are demonstrated to farmers (Blackie and Albright 2005). Using a network of Village-Based Agricultural Advisors (VBAAs), FIPS provides extension services through a series of technology demonstration plots and the distribution of small trial packs of improved inputs for farmers to test on their own plots.

VBAAs operating in Tanzania are selected by members of the rural community they will serve based on farming experience, record keeping, communication skills, willingness to follow up with FIPS, and interest in becoming an agricultural input supplier. Similar to other lead-farmer extension programs, we would expect this model to result in lead-farmers who have more experience with new technologies and are likely to be more educated than the average farmer in the village (Anderson and Feder 2007; Kondylis, Mueller, and Zhu 2017). VBAAs are all volunteers and are not paid employees of FIPS-Africa or other collaborating partners. Each VBAA serves as the primary point of contact between his/her village and the external public and private research institutes or firms who are interested in piloting or marketing new agricultural technologies. VBAAs' responsibilities may include providing information to other farmers in their community, establishing and maintaining one or more demonstration plots, and even distributing samples of agricultural technologies (e.g., small seed packs) to other farmers.

We focus on a sample of villages who have been randomly assigned to different VBAA outreach models as part of an RCT focusing on bidirectional learning and extension delivery (Snapp et al. 2015). In the first treatment, VBAAs are assigned to conduct a demonstration plot for improved bean technologies in their village. The VBAA is provided necessary inputs and training to maintain the plot where they can plant traditional local varieties next to the new technologies for comparison. In the second treatment, VBAAs also maintain the same demonstration plot but receive resources to deliver small input trial packs (100 g) to smallholder farmers in their village.[3] Prior to implementing the program in the village, all VBAAs in this study participated in an intensive direct training module on farmer participatory extension, learning by doing, and customizing extension advice for the local area (Snapp et al. 2015).

4. Conceptual framework and hypotheses

We first seek to determine if there is an effect of VBAA extension and demonstration activities on farmer WTP for new agricultural technologies. There are two primary mechanisms for the extension treatments to affect WTP: learning-by-doing and social learning or learning from others (Foster and Rosenzweig 1995; Munshi 2004; Bandiera and Rasul 2006; Conley and Udry 2010).[4] First, demonstration plots provide information to farmers who are unfamiliar with new technologies because the farmers are able to observe the production process and the new technologies in direct comparison with traditional production methods throughout the growing

[3] Trial packs distributed by FIPS-Africa VBAAs contained the following: an improved variety of bean seed both pre-treated with Apron Star and untreated, a local variety of bean seed both pre-treated with Apron Star and untreated. This allowed for the comparison of improved vs. local bean varieties as well as Apron Star vs. untreated seed.

[4] The literature on learning-by-doing and social learning broadly focuses on technology adoption as the key outcome of interest. This is different from our WTP measure because adoption occurs at a fixed market price. We would expect WTP to be highly correlated with technology adoption in the marketplace.

season. Additionally, a VBAA may involve other farmers in the village in the preparation or planting of the demonstration plot or other activities (e.g. weeding, harvesting) that provide hands-on experience with a new technology. Second, the distribution of small input trial packs would allow some producers in the village to gain information about the performance of a new technology on their own land. Similar to the field days tested in Emerick and Dar (2017), provision of trial packs to village farmers significantly increases the probability that a farmer unconnected with the VBAA has a member of their social network who can provide information about the technology. This would also allow individuals to aggregate the experiences of different producers facing different production conditions (e.g. input application, soil conditions, etc.) and gain a more complete view of the technology.

Conditional on a new technology being profitable, we would expect that the acquisition of more information would increase farmers' WTP for improved bean seed technologies when compared to farmers with no access to new information, *ceteris paribus*. Comparing the two VBAA treatments however, we might expect WTP among farmers in the village with a demonstration plot paired with trial pack distribution to be higher than for trial packs alone. Considering the same profitable technology, having more information about the performance across heterogeneous peer farmers (Munshi 2004; Magnan et al. 2015; Tjernström 2015; Emerick and Dar 2017) would increase WTP.

We also leverage the marketing of the Apron Star seed treatment technology to identify if farmers value self-treated and pre-treated seed differently. Once treated with Apron Star, seed can be stored for up to a year before being planted. Because treatment takes very little time/effort, we would expect there to be little to no differential in WTP between the two different products since pursuing self-treatment would potentially be a pathway to reducing input costs for the household.

5. Methods

In this research, we are interested in whether the type of lead-farmer extension program employed in a village affects small-scale farmers' WTP for improved bean seed technologies. We also want to understand how farmers might value the provision of local agricultural services – in this case pre-treatment of the bean seed with Apron Star. To address these issues, we conducted experimental auctions with small-scale bean farmers in Tanzania living in a set of villages targeted by the FIPS VBAA lead-farmer extension programs as well as with a set of control villages who did not have a VBAA in the village.

5.1 Village Selection

This study took place in 18 villages in August-September 2017 in the southern highlands of Tanzania. Villages were selected for the experimental auctions from an ongoing RCT training lead-farmers in bean agronomy and participatory extension approaches (Snapp et al. 2015). Snapp et al. (2015) focus on evaluating the effects of different extension approaches on VBAAs themselves and employ a pair-wise Mahalanobis matching algorithm based on observable VBAA characteristics to increase balance among two treatment groups: demonstration plots and demonstration plots combined with trial packs.

Using preliminary compliance data from Snapp et al. (2015) we randomly selected 12 villages - 6 matched VBAA treatment pairs - to conduct the experimental auctions. Treatment pairs were equally divided across two administrative districts - Mbeya Rural and Mbozi. Additionally, we worked with FIPS-Africa to choose 6 control villages that met all the criteria for participation in the lead-farmer extension program but were not yet covered by FIPS-Africa due to funding constraints. Control villages do not have a FIPS-Africa VBAA in the village and we are aware of no targeted information or training on improved bean technologies that have been distributed in these villages. Our final sample includes 18 auction villages equally divided into two treatment groups and a control group.[5]

5.2 Farmer Selection

Within each village, we randomly selected 25 farmers to participate in a bean production survey and experimental auction. Each village maintains a roster of current households and their members residing in the village and we used the following protocol to ensure random sampling. Upon arrival in the village, we met with the village chairperson, members of the village council, and, when available, the local agricultural extension agent and/or VBAA to ensure we had a complete and correct roster of current village households.[6] From the list of current households, we then worked with village leadership to identify all of the bean growing households in the village. For most villages this was a straightforward process as the village maintained agricultural records for each household by crop in addition to identifying information. We then rolled a six-sided die to determine the random start point for sampling of the bean growing households as well as the random sampling interval. In each village we selected 25 households for interview/auction participation with an additional 10 selected using the same process to serve as replacement households in the event that a selected household was not available or declined to participate in the study.

5.3 Survey and Experimental Auction Mechanism

In the experimental auctions, we used a Becker-DeGroot-Marschak (BDM) mechanism to collect participant bids for each bean seed product. Similar to a second-price auction, BDM auctions provide incentives such that the optimal strategy is for an individual to bid his/her true valuation of a given product. In the BDM mechanism, an individual wins the auction and receives the product when his/her bid is higher than a randomly drawn price, but the farmer only pays the amount of the drawn price.

Working with implementing partners at CIAT and ARI-Uyole, we prepared six distinct products for use in the experimental auctions (Table 1). For both improved varieties of seed, Uyole 96 and Njano Uyole, we offered 1 kg of certified untreated seed, 1 kg of certified untreated seed with a 5 g sachet of Apron Star, and 1kg of certified seed pre-treated with Apron Star. Seeds used in this experiment were purchased from certified growers affiliated with ARI-Uyole. Agronomists at ARI-Uyole treated the seeds with Apron Star following Syngenta recommendations using a wet slurry before packaging the seeds. All products were labeled and packaged in transparent bags to

[5] We also conducted an agronomic survey in an additional 20 villages where we collected information on household demographics, bean production during the past four seasons, and knowledge of improved bean technologies. Bean production in Tanzania occurs in two seasons each year. In the study region, the major bean season runs from March-July and the minor bean season from December-March.

[6] This process often involved removing households that was no longer in the village due to relocation or death in recent months.

allow farmers the opportunity to inspect the product and observe the color and/or quality of the seeds presented to them.

The following steps were followed for all auction households participating in this study. First, subjects were read a statement of informed consent before completing a basic survey covering household demographics, the past four seasons of bean production (the major and minor seasons of the previous two agricultural years 2015/16 and 2016/17), and knowledge of improved bean technologies.[7] The survey took around 45 minutes to complete for each household and enumerators recorded responses using tablets.

Second, enumerators read a statement of informed consent to each participant explaining confidentiality of bids and their rights as participants in the auction. Participants were informed that they could end the experiment at any point in time. Enumerators practiced with a standard auction script to ensure that all instructions and elements of the BDM were presented the same way.

Third, individuals participated in a practice BDM auction using a bar of soap. After walking through an example of how the BDM mechanism works and why bidding your true value is the optimal strategy, participants received 1200 Tsh (US$1 is roughly 2200 Tsh) with which to place bids on the soap. Individuals were instructed to place bids in 100 Tsh increments - this is commonly the smallest denomination of pricing, especially in rural areas. Once their bid was placed, the random price was determined by rolling a 12-sided die to generate a price from 0 to 1100 Tsh. If the soap was purchased, the farmer paid the random price and received the soap, keeping any change left over.

Fourth, farmers were introduced to the new improved bean seed technologies and were read and shown descriptions of the improved been varieties and the Apron Star seed treatment. Descriptions of the Apron Star product were taken from the Syngenta product packaging and descriptions of the improved varieties were provided by CIAT. Individuals were also provided a copy of the product descriptions to keep and reference throughout the bidding process.

Fifth, farmers rolled a six-sided die to determine the random order in which they would submit bids for the six bean seed technology products. After the order was selected, farmers were given 5000 Tsh to place bids in increments of 100 Tsh on the six different products.

Sixth, participants placed bids on all six products. Once all bids were submitted to the enumerator, the participant rolled a 6-sided die to determine which product bid would be binding.

Seventh, the random price was then determined for the binding product, using dice rolls to generate a random price from 0 to 4900 Tsh. If the seed was purchased, the farmer paid the random price and received the seed, keeping any change left over. If the farmer purchased a product with pre-treated seed or with a sachet of Apron Star, enumerators also provided them with safety information about the product and safe handling instructions. All auction participants received contact information of who to approach (VBAA, extension agent, ARI-Uyole staff) if they had any additional questions about the improved bean technologies used in the experiment.

5.4 Summary statistics

We present summary statistics for key demographic, bean technology, and 2017 bean production variables in Table 2. The sample is slightly more heavily weighted towards men (54%) with an average age of 44 years old and six years of formal education. Subjects were primarily small-scale

[7] All survey questions were identical for households located in the 20 villages where we did not conduct experimental auctions.

farmers who owned four acres of land on average, very little of which was titled (6%). To estimate a measure of the likelihood that a household would be classified as poor, we used a set of 10 questions to construct the Progress Out of Poverty Index and related likelihood score calibrated for Tanzania (Schreiner 2016). In the full sample, there is an average poverty likelihood of 21% across all of the households surveyed. Finally, we construct an asset index to approximate a wealth measure using the types and quantity of different assets owned by the household (e.g. livestock, mobile phones, computers, transportation, etc.).[8]

We test for balance across the experimental treatments, drawing on the demographic characteristics we collected for each household. This is important because the original treatment assignment for the extension program used the matched characteristics on the VBAAs serving the village and not local bean farmers for random treatment assignment. We exclude variables describing knowledge of improved bean technologies and 2017 bean production activities because these variables may have been influenced by the village's VBAA treatment assignment. The results of the balance test show that the demographic characteristics are jointly insignificant in predicting treatment assignment (F-test p-value > 0.1) and we fail to reject the null hypothesis of joint orthogonality (Table 3). A few statistically significant differences emerge between some of the treatments. For example, individuals in the demonstration plot are slightly more educated than those in control villages at 6.99 years compared to 6.22 (p<0.05). Individuals in the demonstration plot with trial pack treatment are 3.98 years older (p<0.10) and are 4.37% less likely to be in poverty (p<0.01) on average than those in the control group. We find no significant differences between individuals assigned to the demonstration plot and demonstration plot with trial pack treatments.

Summary results from the experimental auctions are presented in Table 4. We see that individual bids ranged from 200-5000 Tsh across the 6 products up for auction. No participants submitted a bid of zero, suggesting that all individuals had some valued or had some use for the bean production technologies being auctioned. This also increases our confidence in the sampling strategy for identifying bean growing households (assuming non-bean growing households are more likely to bid zero). The auction endowment was 5000 Tsh, and we find participants bidding the upper threshold for all 6 products. Turning to mean WTP for each product, we find that the control group consistently has the highest average WTP for each product. This suggests that the effect of either treatment on WTP is likely to be zero or negative, but we need to control for key sources of individual and geographic heterogeneity to better understand these differences.

6. Results

In the following section we present results for each of our main findings. First we analyze the effects of the different VBAA extension treatments on farmer WTP for improved bean technologies. We look at main effects as well as heterogenous treatment effects by technology and district.

6.1 Effects of treatment on farmer WTP for improved technologies

Farmer WTP for an improved bean technology is our main outcome of interest. To estimate the effect of our extension treatments on farmer WTP, we use the following linear specification:

[8] We use principal components analysis (PCA) to construct this index measure.

$$WTP_{ij} = \alpha + \beta_1 Demo_{ij} + \beta_2 Trial_{ij} + \boldsymbol{Z}_j\boldsymbol{\gamma} + \boldsymbol{X}_i\boldsymbol{\delta} + \varepsilon_{ij} \qquad (1)$$

where WTP_{ij} is the bid of farmer i for improved bean technology j in our real auction experiment. The parameter β_1 measures the treatment effect of having only demonstration plots in a village, relative to the control group with no VBAA involvement. β_2 measures the treatment effect of having demonstration plots combined with the distribution of seed trial packs in a village. $\boldsymbol{Z}_j$ is a vector of indicator variables for the different bean seed variety and Apron Star products used in the auctions with untreated Uyole 96 serving as the reference category. $\boldsymbol{X}_i$ is a vector of demographic characteristics and indicators for the auction bid order. Random treatment assignment was at the VBAA/village level, so we cluster all standard errors at the village level to allow for the correlation of treatment effects across households within a given village (Abadie et al. 2017). Because we have a relatively small number of clusters (18 villages) in our sample, it is necessary to present cluster adjusted standard errors so as to avoid over-rejection of the null hypothesis (Colin Cameron and Miller 2015; Cameron, Gelbach, and Miller 2008; Esarey and Menger 2018; Webb 2014). We implement a wild cluster bootstrap method (Wu 1986) to implement this correction.

We find little evidence that the implementation of either VBAA extension treatment had an effect on farmer WTP for the bean seed technologies included in the experimental auctions. The treatment effects presented in column 1 of Table 5 for both the demonstration plot and the demonstration plot with trial pack interventions are small in magnitude and not statistically different from zero. We do, however, find evidence of large, statistically significant increases in WTP for products that include some version of Apron Star seed treatment. For example, take the case of Uyole 96. We estimate in column 1 that farmers are WTP 2937.80 Tsh for 1kg of untreated seed. WTP increases by an estimated 571.84 Tsh for 1kg packet of Uyole 96 paired with an Apron Star sachet for a total valuation of 3509.64 Tsh or a 19.46% increase in price. Similarly, we estimate an increase in WTP of 768.14 Tsh for 1kg of pre-treated Uyole 96, which is a 26.15% increase over the untreated product. The same pattern holds for the Njano Uyole varieties.

Column 2 shows that these inferences are robust to the inclusion of controls for the education level of the respondent and the district in which the respondent resides.[9] Across all models specifications, we find that farmers with a higher level of education have a higher WTP for improved bean technologies as do farmers located in Mbozi district (relative to those located in Mbeya Rural district). An additional year of education is estimated to increase WTP for an improved bean technology by 46.94 Tsh ($p<0.01$), or 1.93% of the estimated WTP for 1kg of untreated Uyole 96. While small initially, for an individual who has completed through secondary school this magnitude of the expected increase is comparable to adding an Apron Star sachet to one of the products. Living in Mbozi increases average WTP by 377.18 Tsh or 15.53% over untreated Uyole 96. There are two possible reasons for this effect. First, it could be that the soil quality and production environment benefit more from these technologies and are valued by farmers. Second, households in Mbozi are a longer distance away from the ARI-Uyole research institute who produces and sells these improved lines of bean seed. The longer distance could reflect greater difficulty in acquiring the seed and thus a greater WTP for the product.

[9] With the exception of education level, all other demographic characteristics are jointly insignificant when included in the models (F-test p-value > 0.1). Based on testing we drop gender, age, council membership, land holdings, land tenure, poverty likelihood, and the asset index score from models in Table 5. This is largely consistent with the findings of Waldman, Kerr, and Isaacs (2014).

A test for heterogenous treatment effects between districts in column 3 reveals that the use of demonstration plots in Mbozi district (but not Mbeya Rural district) has a negative and statistically significant effect on farmers' WTP with no corresponding effect when demonstration plots are paired with trial packs. After adjusting for the small number of clusters via bootstrapping however, this result is only marginally significant (p=0.095). This finding suggests that farmers may perceive the value of a technology differently when they are only exposed to information from the demonstration plot as opposed to being exposed to information both from the demonstration plot and the trials of multiple other farmers in their village.

Bean variety performance is highly susceptible to variation in climate and soil conditions which can lead to different farmer preferences by their location (Waldman, Kerr, and Isaacs 2014). Given evidence of heterogenous treatment effects by location in the full sample, we next explore potential location-specific preferences using the same regression equation (equation 1) but restricting our sample to farmers residing in either Mbeya Rural or Mbozi district (Table 6). Consistent with Table 5, we find no effect of the extension method used in Mbeya Rural district (column 1) on farmers' WTP for the new technology; and in Mbozi district, we again find a significant negative effect of the demonstration plot treatment on WTP.

In columns 2 and 4 in Table 6, we check for heterogeneous treatment effects by product to determine if some products but not others are affected by the different extension activitites. In Mbeya Rural (column 2) we find that exposure to the demonstration plot with trial packs increases WTP by an average of 198 Tsh for 1 kg of Uyole 96 bean seed pre-treated with Apron Star. This suggests that having farmers experiment on their own plots with pre-treated Uyole 96 in addition to the demonstration plot set of by the VBAA increased the perceived value of the product by farmers in Mbeya Rural. In contrast, in Mbozi (column 4) we find that exposure to the demonstration plot treatment significantly decreases WTP by an average of 258 Tsh for 1 kg of Njano Uyole bean seed with 2.5 g of Apron Star for self-treatment. However, there is no evidence of heterogeneous treatment effects for the other eight treatment group-bean product pairs.

6.2 Are farmers willing to pay for value-added agricultural services?

We next explore how the various combinations of improved bean seed technologies, variety and chemical seed treatment influence farmer WTP. To do so, we use the following linear regression specification:

$$WTP_{ij} = \alpha + \boldsymbol{Treat}_{ij}\boldsymbol{\beta} + \gamma_1 Njano_j + \gamma_2 Sachet_j + \gamma_3 AST_j + \boldsymbol{X}_i\boldsymbol{\delta} + \varepsilon_{ij} \qquad (2)$$

where WTP_{ij} is the bid of farmer i for improved bean technology j in our real auction experiment. $\boldsymbol{Treat}_{ij}$ is the vector of extension treatment indicators with the control group serving as the reference category. We're now interested in the attributes of each product. The parameter γ_1 measures the effect of the Njano Uyole variety on WTP, compared to Uyole 96. The parameter γ_2 captures the effect of the item including a 2.5g sachet of Apron Star for self-treatment. Finally, parameter γ_3 measures the effect of a product being pre-treated with Apron Star. We also again include $\boldsymbol{X}_i$ a vector of demographic characteristics and indicators for the auction bid order .[10] Standard errors are clustered at the village level and adjusted for the small number of clusters.

[10] Again, based on an F-test (p>0.1) we drop gender, age, council membership, land holdings, land tenure, poverty likelihood, and the asset index score from models in Table 6.

Small-scale farmers are willing to pay more for products including Apron Star and for the Njano Uyole seed variety (Table 7). The results in column 1 suggest that farmers are willing to pay an average of 2942 Tsh for a 1 kg bag of untreated Uyole 96. There is a positive and significant premium associated with the Njano Uyole variety, however it is relatively small in magnitude at 42 Tsh or 1.4% of the mean WTP for the untreated Uyole 96 variety. Inclusion of the Apron Star sachet increases estimated WTP by an average of 574 Tsh or a 19.5% price increase relative to the base product (untreated Uyole 96). Finally, seed treated with Apron Star increases WTP by 753 Tsh, on average, which is a 25.6% increase over the base product.

We also leverage the nature of the Apron Star seed treatment to test if there is a significant difference in producer WTP for seed pre-treated with Apron Star compared to bundled seed where an individual would have to treat the seed on their own. Across all specifications in Table 7, we find that farmer WTP for pre-treated bean seed is higher than that of seed requiring self treatment. For example, in column 1 we see that a being paired with an Apron Star sachet increases average WTP by an estimated 574.25 Tsh while being pre-treated increases WTP by 752.92 Tsh. This difference is statistically significant at the 1% level (p=0.000) and at the 10% level (p=0.051) when we account for interaction effects between item and treatment.

Taken together, these results illustrate two key points. First, there is significant demand for improved bean seed technologies, even among small-scale producers. Taking the example of improved varieties of seed, the certified, untreated Uyole 96 and Njano Uyole can be purchased by any producer from ARI-Uyole for at 2500Tsh/kg. The results above estimate mean WTP for certified, untreated Uyole 96 and Njano Uyole at 2942.07 Tsh/kg and 2984.22 Tsh/kg respectively which are approximately 18% above the wholesale price. Figures 1 and 2 plot demand curves for the Uyole 96 and Njano Uyole products respectively. In Figure 1, we illustrate that at the wholesale price of 2500 Tsh/kg 50% of farmers would be willing to purchase untreated Uyole 96 at this price , 68% would purchase untreated seed with an Apron Star sachet, and 75% would purchase seed pre-treated with Apron Star. Second, farmers have a high WTP for new technologies that do not necessarily require learning or work on their part. Contrary to our initial expectation, farmers have a significantly higher valuation for pre-treated seed when compared to self-treated. This could reflect a desire to forego some of the risk associated with a new technology (e.g. incorrectly applying Apron Star) or the costs associated with learning about the application of the new technology.

7. Discussion and Policy Implications

Public and private sector extension programs often incorporate lead-farmer demonstration activities and trial packs in an effort to increase the number of opportunities farmers have to learn about technologies through both their own experience and the experiences of others. These mechanisms are expected to increase adoption and diffusion of the improved agricultural technologies they showcase, assuming there are profitability gains for the farmers they target. Building on an RCT focused on varied farmer-led NGO extension approaches (Snapp et al. 2015), this article leverages real auctions to test the effect of these extension approaches on farmers' WTP for improved bean technologies. We focus on improved seed varieties (Uyole 96 and Njano Uyole) as well as a chemical seed treatment called Apron Star. Leveraging the need to treat bean seeds with Apron Star, we are also able to investigate how producers value the provision of basic agricultural services by agricultural input suppliers – a potentially significant area of future demand and employment growth in rural areas. This research makes two main contributions to the literature. First, we evaluate the impacts on village farmers of adding trial packs, a significant source of learning-by-doing, to a farmer-led extension model. This complements recent work evaluating the impacts of different extension modalities on farmer outcomes (Kondylis, Mueller, and Zhu 2017; Emerick and Dar 2017). Second, we extend the application of WTP modules to an extension and supply-side framework, providing insight into the market viability of improved bean technologies in rural areas. Specifically, we focus on producer WTP for improved inputs into the bean production process rather than on goods predominately for immediate consumption.

We find little evidence to suggest that exposure to either extension treatment significantly impacts farmer WTP for improved bean technologies. In fact when we look at location-specific effects, farmers exposed to the demonstration plot treatment have a significantly lower WTP than farmers in the control group or demonstration plots plus trial packs treatment group. One explanation for this finding is that the new technologies may not represent a profitable improvement for producers, especially under specific agricultural and climate conditions. Because information from the demonstration plot does not translate perfectly to a farmers' own land, these imprecise signals could lead to a downward adjustment in WTP. The addition of trial packs and own experimentation on a farmer's own land dissipates. Another possible explanation has to do with access to new technologies in an auction context. We could be observing farmers who already have access to some improved technologies and are not willing to pay as much to procure new ones (e.g. a specific variety of bean seed). Similarly, producers in the control group – with no access to new technologies – might bid higher for improved technologies just for the opportunity to test them on their farms. Combined, these effects would make it more difficult to detect any treatment effects of extension services. We find no significant difference in WTP between the two extension treatment groups (demonstration plots vs. demonstration plots plus trial packs). We should also highlight that these WTP results are in the context of low power due to the small number of clusters where experimental auctions were conducted. To adjust for this, we report wild cluster bootstrap p-values for all WTP regressions.

There is evidence, however, that farmers are willing to pay for improved bean technologies. We find that producers in our sample are willing to pay a premium of 1.5% for Njano Uyole over Uyole 96, 19.5% for improved varieties with an Apron Star sachet, and 25.6% for improved varieties treated with Apron Star. Individual valuation for pre-treated seed is also 5.1% greater than for the same amount of seed plus Apron Star that would have to be applied by the farmer. Taken together, these results suggest there is significant demand for new technologies and even the provision of services among small-scale farmers.

Our experimental results point to the following policy implications First, if lead-farmer extension efforts paired with demonstration plots or with trial packs do not raise farmer valuations of ostensibly beneficial technologies, they may be diverting critical resources away from the provision of traditional government extension services. This would be true even when activities are funded by donors or NGOs, if the government views private extension services as a substitute for traditional outreach efforts. Despite the close proximity of lead farmers both socially and geographically to other farmers in the village they are serving and the relatively low cost of recruiting participants, the quality of lead-farmer extension activities is extremely difficult to monitor which could influence their effectiveness. Pursuing public-private partnerships focused on capacity building (e.g. Syngenta with Apron Star) and monitoring of lead farmers may represent a viable path forward. Second, this research calls into question the presumed profitability of the improved bean seed technologies being offered to rural communities. If the highest valuations come from farmers who have little to no experience with a new technology, this suggests that the technology may not be well suited to the region or area. Lead farmer extension services may instead represent a promising field laboratory to refine which technologies are provided to which regions. Third, we do find evidence that smallholder farmers demand improved bean technologies and even the provision of relatively simple agricultural services. Providing value-added support services like seed treatment, not demonstration and education, might be the most important role of VBAAs moving forward.

This article also highlights several areas ripe for future research. More work needs to be undertaken to understand the effects of extension programs on farmer WTP for new technologies for multiple types of goods to understand how producers might respond in the marketplace once promotional programs end. With the continued proliferation of actors in the extension space (Anderson and Feder 2007), introducing auctions might allow us to compare the effects of extension outreach across private and public extension models. Furthermore, more work needs to be done to understand which agricultural services smallholder farmers would be willing to purchase from local agro-dealers instead of performing themselves. Not only do these services potentially reduce required costs and expertise on the part of the household, but they represent a significant area for potential employment growth in the agricultural value chain serving smallholders.

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Table 1: Experimental Products for Auction

1kg certified, untreated Uyole 96
1kg certified, untreated Njano Uyole
1kg certified, untreated Uyole 96 with 2.5g sachet of Apron Star
1kg certified, untreated Njano Uyole with 2.5g sachet of Apron Star
1kg certified Uyole 96 treated with Apron Star
1kg certified, Njano Uyole treated with Apron Star

Notes: All seed purchased from the same certified supplier affiliated with ARI-Uyole's bean research department in August 2017. 2.5g of Apron Star is the Syngenta recommended application for 1kg of bean seed. All of the treated seed was treated using a slurry method where the treatment is applied to seeds wet and allowed to dry by ARI-Uyole staff.

Table 2: Summary Statistics by Treatment

VARIABLES	Auction Households (N=435)			Demonstration Plot (N=147)			Demonstration Plot + Trial Packs (N=144)			Control (N=144)		
	mean	min	max	mean	min	max	mean	min	max	mean	min	max
Demographics												
Gender (1 = Male)	0.543	0	1	0.578	0	1	0.507	0	1	0.542	0	1
Age	43.650	18	90	42.210	18	73	46.380	22	90	42.400	19	90
Education (Respondant)	6.400	0	21	6.993	0	18	5.972	0	21	6.222	0	17
Served on Village Council (1 = Yes)	0.267	0	1	0.259	0	1	0.271	0	1	0.271	0	1
Total land owned (acres)	4.050	0	30	4.099	0	20	3.804	0	23	4.244	0	30
Total titled land (acres)	0.464	0	28	0.374	0	20	0.312	0	11	0.708	0	28
Share of titled land (%)	6.150	0	100	5.101	0	100	5.800	0	100	7.569	0	100
PPI Poverty Likelihood (%)	21.150	1	62.1	21.860	1	62.1	18.610	1	62.1	22.980	1	62.1
Asset Index Score	0.033	-2.579	10.6	0.009	-2.579	9.269	-0.112	-2.546	7.776	0.202	-2.512	10.6
Extension/Technology Experience												
Heard of Uyole 96 (1 = Yes)	0.526	0	1	0.537	0	1	0.562	0	1	0.479	0	1
Heard of Njano Uyole (1 = Yes)	0.393	0	1	0.361	0	1	0.458	0	1	0.361	0	1
Heard of Apron Star (1 = Yes)	0.078	0	1	0.129	0	1	0.076	0	1	0.028	0	1
Used of Uyole 96 (1 = Yes)	0.285	0	1	0.306	0	1	0.271	0	1	0.278	0	1
Used of Njano Uyole (1 = Yes)	0.117	0	1	0.061	0	1	0.153	0	1	0.139	0	1
Used of Apron Star (1 = Yes)	0.007	0	1	0.000	0	0	0.014	0	1	0.007	0	1
Know of VBAA in Village (1 = Yes)	0.345	0	1	0.469	0	1	0.542	0	1	0.021	0	1
Correctly Indentify VBAA Status (1 = Yes)	0.662	0	1	0.469	0	1	0.542	0	1	0.979	0	1
HH member attended demo plot (1 = Yes)	0.044	0	1	0.068	0	1	0.063	0	1	0.000	0	0
HH received trial pack of seed (1 = Yes)	0.097	0	1	0.048	0	1	0.243	0	1	0.000	0	0
2017 Major Season Production	**Producing HH (N=327)**			**Producing HH (N=108)**			**Producing HH (N=108)**			**Producing HH (N=111)**		
Number of 2017 Major Season (MS) Plots	1.116	1	3	1.120	1	3	1.093	1	3	1.135	1	3
2017 MS Total Plot Area (acres)	0.961	0.25	6.178	1.007	0.25	4	0.938	0.25	6.178	0.938	0.25	4
2017 MS Total Bean Area (acres)	0.932	0.25	6.178	0.965	0.25	3	0.914	0.25	6.178	0.916	0.25	4
2017 MS Bean Harvest (KG)	177.3	0	1,440	185.6	7	980	151.2	0	1,440	194.7	12	1,440

VARIABLES	Auction Households (N=435) mean	min	max	Demonstration Plot (N=147) mean	min	max	Demonstration Plot + Trial Packs (N=144) mean	min	max	Control (N=144) mean	min	max
2017 MS Bean Sold (KG)	87.440	0	1,440	87.140	0	840	82.710	0	1,440	92.340	0	1,440
2017 MS Bean Price Received (Tsh/KG)	1149	300	2,200	1214	500	2,200	1191	500	2,200	1050	300	2,200
2017 MS Intercropped Beans (1 = Yes)	0.147	0	1	0.120	0	1	0.102	0	1	0.216	0	1
2017 MS Improved Variety (1 = Yes)	0.196	0	1	0.213	0	1	0.241	0	1	0.135	0	1
2017 MS Applied Apron Star (1 = Yes)	0.003	0	1	0.000	0	0	0.000	0	0	0.009	0	1
2017 MS Inorganic Fertilizer (1 = Yes)	0.419	0	1	0.472	0	1	0.361	0	1	0.423	0	1
2017 MS Herbicide (1 = Yes)	0.073	0	1	0.028	0	1	0.120	0	1	0.072	0	1
2017 MS Pesticide (1 = Yes)	0.495	0	1	0.389	0	1	0.454	0	1	0.640	0	1
2017 MS Fungicide (1 = Yes)	0.180	0	1	0.231	0	1	0.185	0	1	0.126	0	1
2017 MS Manure (1 = Yes)	0.018	0	1	0.009	0	1	0.009	0	1	0.036	0	1

Table 3: Balance Test

	(1) Demo vs. Trial	(2) Demo vs. Control	(3) Trial vs. Control
Age	-0.003	0.002	0.004*
	(0.002)	(0.002)	(0.002)
Education	0.017	0.026**	0.009
	(0.011)	(0.011)	(0.011)
Gender (1 = Male)	0.044	0.012	-0.025
	(0.064)	(0.065)	(0.066)
Council membership	-0.023	-0.039	-0.032
	(0.072)	(0.072)	(0.072)
Land Owned (acres)	0.005	0.013	0.006
	(0.012)	(0.014)	(0.012)
Land Titled (acres)	0.023	-0.018	-0.018
	(0.030)	(0.019)	(0.019)
Share of land titled (%)	-0.002	0.000	0.001
	(0.002)	(0.002)	(0.002)
PPI Poverty Likelihood (%)	0.003	-0.002	-0.005**
	(0.002)	(0.002)	(0.002)
Asset Index	-0.001	-0.026	-0.020
	(0.019)	(0.021)	(0.019)
Constant	0.426***	0.254	0.363**
	(0.155)	(0.161)	(0.157)
Observations	291	291	288
R-squared	0.048	0.032	0.048
F-Test			
H0: Joint Orthogonality	0.119	0.416	0.126

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

Table 4: Auction Summary Statistics by Product

	Demonstration Plot (N=147)			Demonstration Plot + Trial Packs (N=144)			Control (N=144)		
VARIABLES	mean	min	max	mean	min	max	mean	min	max
Auction Bids									
Untreated Uyole 96 Bid (Tsh)	2,498	500	5,000	2,317	200	5,000	2,529	400	5,000
Untreated Njano Uyole Bid (Tsh)	2,492	500	5,000	2,438	200	5,000	2,567	300	5,000
Untreated Uyole 96 Bid + Sachet (Tsh)	3,011	700	5,000	2,890	300	5,000	3,159	500	5,000
Untreated Njano Uyole Bid + Sachet (Tsh)	3,048	500	5,000	2,980	300	5,000	3,200	500	5,000
Treated Uyole 96 (Tsh)	3,205	600	5,000	3,157	500	5,000	3,288	600	5,000
Treated Njano Uyole (Tsh)	3,276	700	5,000	3,156	500	5,000	3,277	600	5,000

Table 5: Reduced Form OLS Regression Results

VARIABLES	(1) Model 1	(2) Model 2	(3) Model 3
Demonstration Plot	-65.91	-104.06	377.27
	(0.798)	(0.638)	(0.310)
	[0.820]	[0.682]	[0.420]
Demonstration Plot + Trial Packs	-161.58	-147.08	0.31
	(0.560)	(0.463)	(0.999)
	[0.576]	[0.549]	[0.998]
Njano Uyole + Sachet	627.36***	627.36***	670.49***
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.000]	[0.003]
Treated Njano Uyole	788.39***	788.39***	747.92
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.000]	[0.130]
Untreated Njano Uyole	50.69	50.69	38.19
	(0.129)	(0.129)	(0.431)
	[0.119]	[0.119]	[0.422]
Uyole 96 + Sachet	571.84***	571.84***	629.86**
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.000]	[0.017]
Treated Uyole 96	768.14***	768.14***	758.33**
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.000]	[0.011]
Mbozi district		377.18**	783.35*
		(0.025)	(0.030)
			[0.090]
Demonstration Plot x Mbozi			-839.53*
			(0.042)
			[0.095]
Demonstration + Trial x Mbozi			-357.15
			(0.336)
			[0.471]
Education level (Respondant)		46.94**	40.63**
		(0.008)	(0.024)
		[0.030]	[0.031]
Constant	2,937.80***	2,428.78***	2,256.53***
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.009]	[0.000]
Treatment x Item Interactions	No	No	Yes
Indicator variables for auction order	Yes	Yes	Yes
Observations	2,610	2,610	2,610
R-squared	0.099	0.137	0.155

Notes: OLS regressions. Dependent variable is the farmer bid for a given product in Tanzanian Shillings (Tsh). Standard errors are clustered at the village level (18 clusters). Robust p-values in parentheses. In square brackets we report wild cluster p-values (Wu 1986) generated using boottest command in Stata 14 (Roodman et al. 2016).
*** $p<0.01$, ** $p<0.05$, * $p<0.1$ for the wild cluster p-values respectively.

Table 6: Location Specific Reduced Form OLS Effects of Treatment on WTP

VARIABLES	(1) Mbeya Rural	(2) Mbeya Rural	(3) Mbozi	(4) Mbozi
Demonstration Plot	295.00	232.96	-513.59**	-350.98
	(0.428)	(0.580)	(0.016)	(0.125)
	[0.548]	[0.653]	[0.032]	[0.178]
Demonstration Plot + Trial Packs	11.65	-112.10	-322.59	-263.52
	(0.971)	(0.740)	(0.140)	(0.266)
	[0.946]	[0.714]	[0.205]	[0.311]
Njano Uyole + Sachet	606.91***	554.17	647.71***	786.81***
	(0.000)	(0.001)	(0.000)	(0.000)
	[0.000]	[0.112]	[0.000]	[0.006]
Pre-treated Njano Uyole	740.55***	644.44*	836.01***	851.39*
	(0.000)	(0.000)	(0.000)	(0.000)
	[0.000]	[0.069]	[0.000]	[0.068]
Untreated Njano Uyole	10.14	-55.56	91.06*	131.94
	(0.834)	(0.284)	(0.059)	(0.001)
	[0.838]	[0.371]	[0.069]	[0.101]
Uyole 96 + Sachet	499.54***	447.22*	643.81***	812.50*
	(0.000)	(0.000)	(0.000)	(0.000)
	[0.001]	[0.067]	[0.001]	[0.093]
Pre-treated Uyole 96	717.51***	611.11**	818.53***	905.56*
	(0.000)	(0.000)	(0.000)	(0.000)
	[0.000]	[0.021]	[0.000]	[0.056]
Demo. Plot x NJ Sachet		18.06		-258.14***
		(0.934)		(0.000)
		[0.937]		[0.003]
Demo Plot x NJ Treated		194.44		-132.06
		(0.387)		(0.231)
		[0.429]		[0.309]
Demo Plot x NJ Untreated		44.44		-132.61
		(0.654)		(0.210)
		[0.722]		[0.355]
Demo Plot x U96 Sachet		-4.17		-231.83
		(0.980)		(0.156)
		[0.979]		[0.205]
Demo Plot x U96 Treated		119.44		-221.02
		(0.288)		(0.155)
		[0.339]		[0.210]
Demo. Plot + Trial x NJ Sachet		138.98		-154.41
		(0.561)		(0.094)
		[0.598]		[0.139]
Demo Plot + Trial x NJ Treated		93.91		92.27
		(0.452)		(0.490)

VARIABLES	(1) Mbeya Rural	(2) Mbeya Rural	(3) Mbozi	(4) Mbozi
		[0.492]		[0.524]
Demo Plot + Trial x NJ Untreated		151.45		14.53
		(0.144)		(0.653)
		[0.194]		[0.715]
Demo Plot + Trial x U96 Sachet		159.63		-273.06
		(0.239)		(0.182)
		[0.277]		[0.247]
Demo Plot + Trial x U96 Treated		198.48**		-33.72
		(0.014)		(0.748)
		[0.030]		[0.758]
Education level (Respondent)	48.94**	48.94**	29.77	29.77
	(0.036)	(0.037)	(0.327)	(0.328)
	[0.027]	[0.027]	[0.326]	[0.326]
Constant	2,196.48***	2,258.69***	3,136.65***	3,061.47***
	(0.000)	(0.000)	(0.000)	(0.000)
	[0.002]	[0.005]	[0.000]	[0.002]
Indicator variable for bid order	Yes	Yes	Yes	Yes
Observations	1,302	1,302	1,308	1,308
R-squared	0.122	0.123	0.152	0.154

Notes: OLS regressions. Dependent variable is the farmer bid for a given product in Tanzanian Shillings (Tsh). Standard errors are clustered at the village level (9 clusters). Robust p-values in parentheses. In square brackets we report wild cluster p-values (Wu 1986) generated using boottest command in Stata 14 (Roodman et al. 2016) and implementing weights via Webb (2014) to avoid spurious precision (Cameron, Gelbach, and Miller 2008).
*** p<0.01, ** p<0.05, * p<0.1 for the wild cluster p-values respectively.

Table 7: OLS Regression Results for Seed Attributes on WTP

VARIABLES	(1)	(2)	(3)
Demonstration Plot	-65.91	-104.06	-81.21
	(0.798)	(0.637)	(0.712)
	[0.820]	[0.682]	[0.743]
Demonstration Plot + Trial Packs	-161.58	-147.08	-161.43
	(0.560)	(0.463)	(0.391)
	[0.576]	[0.549]	[0.447]
Seed variety (1=Njano Uyole)	42.15*	42.15*	22.80
	(0.091)	(0.092)	(0.465)
	[0.092]	[0.092]	[0.469]
Apron Star Sachet (1=Sachet)	574.25***	574.25***	631.08***
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.000]	[0.002]
Apron Star Treatment (1 = Treated)	752.92***	752.92***	734.03***
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.000]	[0.001]
Mbozi district		377.18**	377.18**
		(0.025)	(0.025)
		[0.030]	[0.030]
Education level (Respondent)		46.94***	46.94***
		(0.008)	(0.008)
		[0.009]	[0.009]
Constant	2,942.07***	2,433.05***	2,430.08***
	(0.000)	(0.000)	(0.000)
	[0.000]	[0.000]	[0.000]
Treatment x Item Attribute Interactions	No	No	Yes
Dummy variable for bid order	Yes	Yes	Yes
Observations	2,610	2,610	2,610
Hypothesis Test			
H0: Apron Star Sachet = Apron Star Treatment	[0.000]	[0.000]	[0.051]

Notes: OLS regressions. Dependent variable is the farmer bid for a given product in Tanzanian Shillings (Tsh). Standard errors are clustered at the village level (18 clusters). Robust p-values in parentheses. In square brackets we report wild cluster p-values (Wu 1986) generated using boottest command in Stata 14 (Roodman et al. 2016).
*** p<0.01, ** p<0.05, * p<0.1 for the wild cluster p-values respectively.

Figure 1: Demand Curves for Uyole 96

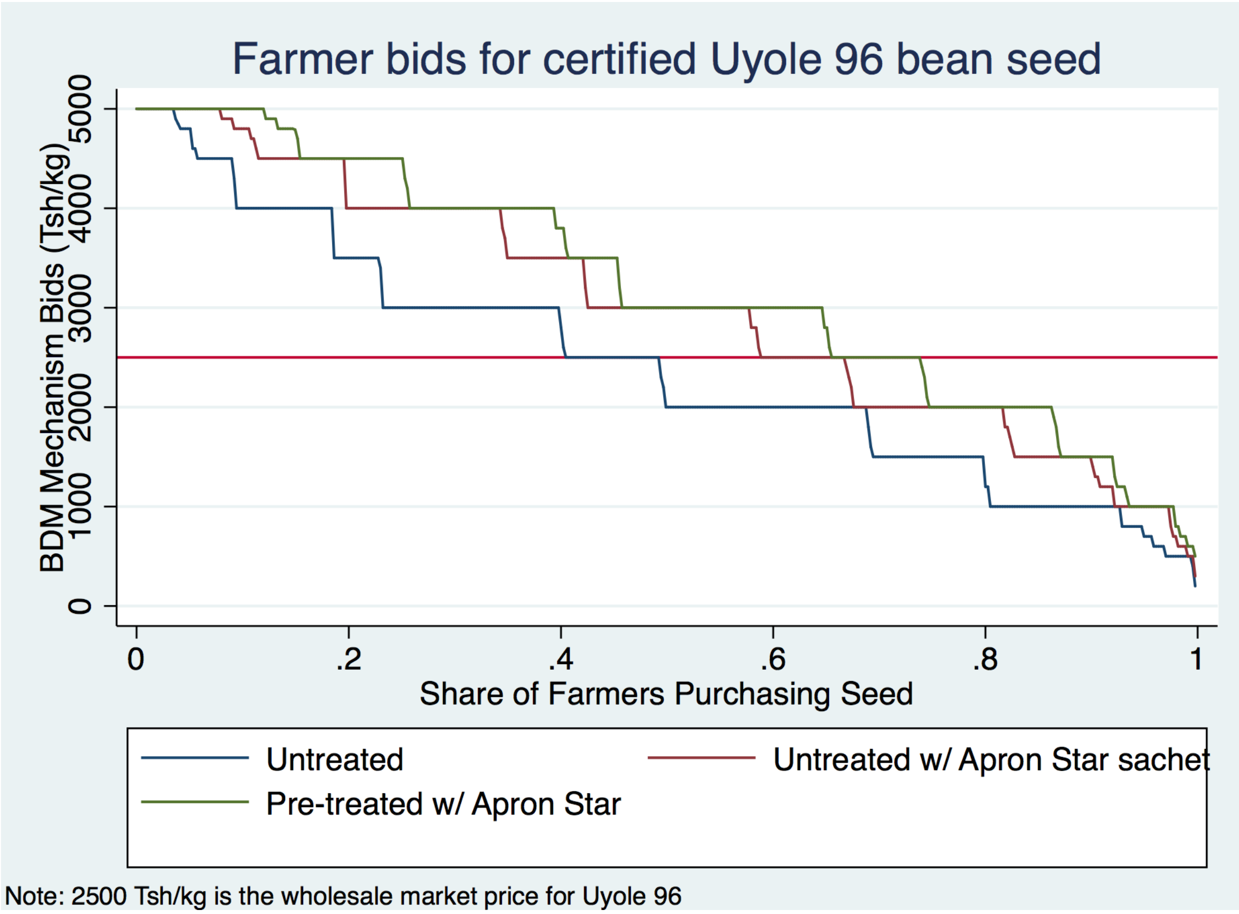
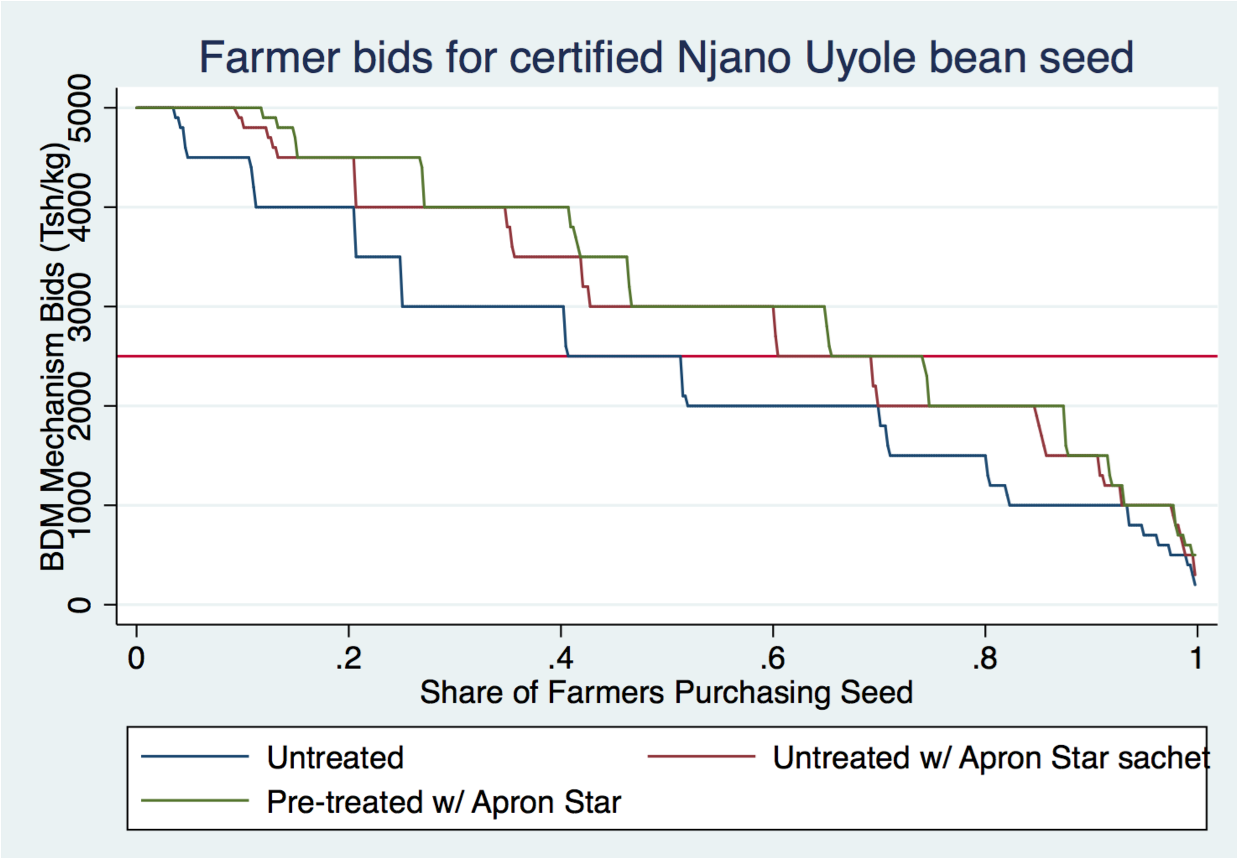


Figure 2: Demand curves for Njano Uyole



Note: 2500 Tsh/kg is the wholesale market price for Njano Uyole