# Does Bid Quantity Matter? Comparing Farmer Willingness-to-Pay for Pre-specified vs Actual Quantities of Biofortified Bean and Maize Seed in a Non-hypothetical Field Experiment

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## 1. Introduction

Experimental auctions and the Becker-DeGroot Marschak method are commonly used to elicit willingness-to-pay (WTP). In the past decade, many aspects of these methods have been studied to refine it such that the responses and analyses obtained are truly the best measures of demand for a specific product(s). In doing so, studies have examined auction methods, the number of rounds, the number of participants in a bidding group, and the endowment effect, among other factors (Lusk and Shogren, 2007; Canavari et al., 2019). Despite the impressive gains made in the literature, some issues regarding the method remain insufficiently addressed. This study contributes to the methods literature by addressing one area that has received little attention to date – the comparison of different experimental quantities when eliciting unit-level WTP bids.

Most often in experimental auction or auction-like mechanism studies, researchers pre-specify the quantity of a product that becomes the unit for which respondents state their bid and this quantity is held constant across product choices. The use of this pre-specified quantity has been justified under the assumption that individuals are rational and their preferences are stable (Maredia and Bartle, 2022); therefore, any quantity can be considered as an experimental quantity (Lin et al., 2022). Thus, WTP values can be scaled by any quantity from the results of a small-unit WTP, by simply multiplying the per-unit bid by the number of units of interest to achieve the desired larger quantity. However, several studies have shown that individuals' preferences are not fully rational and reversals sometimes occur as first noted in the economics literature by Grether and Plot (1979). This can occur because individuals' preferences are often constructed during the process of elicitation and can be dependent upon many issues including experimental settings, risk aversion, and inattention (Slovic, 1995; Camerer and Loewenstein, 2003; Harrison et al., 2003; Lusk and Shogren, 2007; Balcombe et al., 2018; O'Donnell and Evers, 2019). Consequently, marginal WTP from small quantities may not accurately reflect marginal WTP for larger quantities.

Typically, the pre-specified quantity used in experiments is the smallest unit of the good available at the market such as a pint of milk, a carton of eggs, a kilogram of rice grain, or a kilogram pack of seed. For consumer goods, using these smaller quantities may not be a serious issue as consumer goods are often purchased in small quantities due to perishability or cash constraints. Therefore, these small quantities used in WTP studies may be the modal quantities purchased in the market. However, farmers need and often purchase larger quantities of production inputs. Due to researchers' budget constraints and logistical reasons, experiments often use the smallest quantity units, which may not fully reflect their actual market purchase decisions.

The need for bid quantity research in non-market valuations was first noted by Corsi (2007) who proposed alternative theoretical and econometric approaches to incorporate choice-quantity via open-ended or closed-ended formats. Varying quantities have been incorporated into hypothetical discrete choice experiments, an alternative method to experimental auctions, largely by implementing open-ended choice experiments (OECE). In OECEs, participants are typically asked to state the quantity they demand for each of the goods included in the study at different price combinations. Results from this choice experiment format have been consistent with prior expectations and purchasing behavior when compared to traditionally designed experimental auctions (Corrigan et al., 2009) and choice experiments (COCE), (Dennis et al., 2021). Lin et al. (2022) incorporated quantity into CEs using a different approach and customized the experimental quantity based on consumers' self-reported actual purchase quantity history. Their study finds that consumers, on average, over-state WTP for small quantities compared to WTP when the question is framed with a larger quantity base, due to mental budgeting, a behavioral bias found in individual decision-making. This is explored further in Section 2. Evidence shows that respondent WTP decision-making can be dependent on the question's quantity context.

There is a lack of research on this topic in experimental auctions. A few non-hypothetical experimental auction studies focused on bid quantity have been conducted by examining the impact of quantity on bidding outcomes in multiunit scenarios, but they rely on pre-specified quantities. These studies have typically taken one of two paths: (1) bidding for multiple pre-specified quantities of the same product at the same time (e.g., Akaichi et al., 2012), or (2) via incremental pre-specified product quantity increases with each additional bidding round (e.g., Elbakidze et al., 2013). These studies' objectives have been to estimate the impact of demand reduction, diminishing marginal value of an additional unit of a good, and demand schedules; however, they only partially address the bid quantity question. What remains to be explored is the impact of respondent's actual purchase quantities on marginal WTP.

This study contributes to the literature in multiple ways. First, we test the question of marginal WTP when quantities reflect true market decisions in a non-hypothetical, real field experiment. To do this, we assess the difference in WTP for crop seed from maize and bean farmers randomly assigned to a Fixed Quantity Group (FQG) where the product quantity is pre-specified and farmers assigned to a Variable Quantity Group (VQG) that is open-ended to match each respondent's actual situation. In this context, we test whether the bias stemming from mental budgeting found by Lin et al. (2022) persists in a non-hypothetical setting.

Second, we focus on producers rather than consumers by following the theoretical framework of estimating producer WTP proposed by Lusk and Hudson (2004) and extended by

Zapata and Carpio (214) and Yue et al. (2017). In this context, we assume that the farmer derives utility when their profits are increased, whereby profit maximization is a function of expected revenues and costs (similar to what has been done in Rosch and Ortega, 2018; Maredia et al., 2019, Morgan et al., 2020, Mastenbroek et al., 2021, Maredia & Bartle, 2022, and Win et al., 2022). The quantity question is of special interest in this context, as many producer WTP studies elicit producers' WTP for small, pre-specified input quantities, even if they would typically purchase a larger quantity.

Finally, we examine varying bid quantity and producer WTP in a developing country context, Zimbabwe, which is a departure from previous studies on bid quantity differences that have largely occurred in developed or emerging countries (Dennis et al., 2021, Lin et al., 2022). In the context of developed countries, field experiments require a small percentage of disposable income be spent purchasing the product, but the same is not always true for the developing country context. Indeed, the amount submitted on bids for experiment products may be a large share of disposable income. Therefore, it is plausible developing country respondents in a non-hypothetical experimental auction think more critically about their bid formulation and may not exhibit the behavioral bias of mental budgeting.

In this study we assess the per-unit WTP for 2kgs of seed, the smallest seed pack size available at the market, when the quantities used in the experiment to obtain respondent bids differ (fixed quantity versus open-entry, variable quantity). We use the incentive-compatible Becker-DeGroot-Marschak (BDM) auction-like mechanism (Becker, DeGroot and Marschak, 1964) for eliciting farmer bids for maize and beans, two economically important but different crops grown in Zimbabwe. Both crop experiments follow a between-subjects design where farmers are randomly assigned to one of two groups, either the fixed quantity group (FQG) or the variable quantity group (VQG). In the FQG, farmers submit WTP bids for a 2-kg seed pack whereas in the VQG, farmers first state the desired quantity of seed they would like to purchase and then the total amount they are WTP for the stated quantity. In the first part of this study, we examine the difference in farmer WTP for bean seed between the FQG and those assigned to the VQG. In the second part of this study, we again follow a between-subjects design but with maize famers who are assigned to either the FQG or the VQG.

This paper is organized as follows: next we provide a review of how quantity has been incorporated into experimental auctions to date and a discussion of mental budgeting, the behavioral bias related to the underlying bid quantity, as highlighted by Lin et al. (2022). Section 3 outlines the experimental design, study design, hypotheses, empirical strategy, and an overview of the data. Descriptive and empirical regression analysis results are presented in Section 4. Section 5 includes the discussion and policy implications while Section 6 concludes.

## 2. A Review of Quantity Incorporation into Experimental Auctions and Behavioral Bias of Mental Budgeting

### 2.1 Quantity in Experimental Auctions

Most work incorporating quantity as a research question into experimental auctions has been around multi-unit homogeneous goods focused on testing the theories of demand reduction and diminishing marginal utility across different auction mechanisms to ensure they are incentive compatible (Lusk and Shogren, 2007; Canavari et al., 2019). List and Lucking-Reiley (2002) studied the effects of demand reduction of baseball cards comparing the outcomes of the uniform-price and Vickrey sealed-bid auctions. Ausubel (2004) tested a new method called ascending-bid auctions for multi-units of homogeneous goods, specifically communications licenses, where the auctioneer announced a price and bidders responded with their desired quantities, across multiple rounds with the price increasing in each. Engelbrecht-Wiggans et al. (2006) extended the research on demand reduction by studying the impact of the number of bidders, finding that demand reduction decreases with an increase in the number of bidders. Such studies gave way to informing experimental auction best practices, including that when multiple rounds and multiple product units (regardless of whether they are homogeneous or not) are included in the experimental design, a round and product unit are selected at random to be binding (Lusk and Shogren, 2007).

In addition to testing auction mechanisms, a few studies have been interested in developing a demand schedule as an applied research question to estimate market demand and elasticities for a specific product and its substitutes. For example, Elbakidze et al. (2013), utilized the second-price, random Nth-price, and incremental second-price auctions to test the impact of multiproduct, multi-quantity, and multi-round contexts of consumer WTP for cheese and ice cream. In the second-price and random Nth-price auctions, consumers bid for one, two, three, and additional units of the products in question. This was contrast to their incremental second-price auction procedure where consumers bid for a different quantity in each round, beginning with one unit in round one, two products in round two, and so forth. Across all study types they determined that consumers were WTP a premium for a unit of humane animal certified ice cream but not for multiple quantities.

Only recently, has there been an interest in researching the experimental quantity being valued. Instead of using the typical small quantity in their experimental design, Maredia and Bartle (2022), ask Kenyan farmers to bid on a 50-kg bag of potato seed as this is the typical unit size purchased by farmers in the market. They do this to obtain a more accurate valuation, as farmers are more familiar with thinking about potato seed prices at this quantity level. To capture the quantity of seed, farmers were asked at the end of the experiment to indicate the number of 50 kg bags they were willing to buy at their bid price; but the actual experimental quantity was fixed at 5 kg. Our approach extends this study by using an experimental quantity that is most relevant to farmers in their decision-making process. Unlike, Maredia and Bartle (2002), we do not restrict the quantity of the binding seed in the experiment, better reflecting an actual market environment.

### 2.2 Mental Budgeting

A possible mechanism related to the underlying effect of experimental quantity on WTP estimates is a behavioral bias known as mental budgeting (Lin et al. 2022). Thaler (1999) defines mental budgeting as the cognitive operations one uses to organize, evaluate, and keep track of financial activities. In practical terms, individuals group their expenditures or income into 'mental accounts' from which 'mental budgets' are adopted whereby spending is sometimes constrained (Thaler, 1999). As budgets are imperfect in anticipating all consumption opportunities in a given forecasted time period, individuals often earmark either too little or too much money for a particular good. However, evidence shows that budgeting effects are larger for purchases that are highly typical of their 'mental accounts' category (Heath and Soll, 1996). As such, individuals then tend to make a purchase if the costs fall within the 'mental budget' where total cost is reliant upon price and quantity (Thaler and Shefrin, 1981). Therefore, as outlined in Lin at al. (2022), when a respondent is bidding on a small quantity, it will likely fit into their 'mental budget' while the same may not be true for larger quantities. This can lead to over-stating per unit WTP for small quantities when compared to per unit WTP when the question is framed with a larger experimental quantity base. We further explore this concept by allowing respondents to specify the quantity they desire to purchase as the experimental quantity, which is likely in-line with past input purchases and falls within their mental accounting process and budgets.

### 2.3 Discount for large purchase quantities

In the study of WTP for large quantities, one may want to consider the potential impact of discounts on bulk purchases. Of course, this is context specific to the location and product. In the context of this study, no bulk discount is given in the market for the beans included in this study. Maize, on the other hand, has a small bulk discount of $0.30/kg in the largest seed pack size available. Therefore, for maize, we will compare any marginal difference in WTP found between the FQG and the VQG to the $0.30/kg bulk discount.

## 3. Methodology

### 3.1 Experimental Design

To assess the effects of a fixed experimental quantity on farmer's per unit WTP, this study follows a between-subjects design with two treatment groups. Study participants are randomly assigned to either a fixed quantity group (FQG) or a variable quantity group (VQG). In the experiment, the predetermined fixed quantity is restricted to 2 kilograms of seed as this is the smallest pack size available in the market for purchase (Gwaze, 2022). As described in the introduction, the VQG WTP is obtained by first asking farmers the quantity of seed they are interested in purchasing followed by the corresponding total amount they are willing to pay for the seed quantity specified. The total amount a farmer is willing to pay is divided by the total quantity and multiplied by 2 to get a WTP price for 2kg seed in VQG. This is compared with the WTP for 2kg seed in FQG.

To carry out our experiment, we utilize a Becker-DeGroot-Marschark (BDM) mechanism (Becker, DeGroot, & Marschak, 1964) which is an incentive-compatible, non-hypothetical procedure commonly used in experimental economics to measure WTP (Lusk and Shogren, 2007; Cole et al., 2020). In the BDM mechanism, respondents submit a bid that is compared against a randomly drawn price from an *ex-ante* established market price distribution. If the respondent's bid is greater than or equal to the randomly drawn market price, then they pay the randomly drawn price and receive the good; otherwise, no transaction occurs. In the case of individuals bidding on multiple goods, as is the case for this study, one of the goods is selected at random to be binding such that only one good's bid is compared against the randomly drawn market price. In this mechanism, the respondent's true WTP for a unit of the good being auctioned is defined as the price that induces a utility indifference between winning and not winning the unit of the good. Rational behavior under the BDM mechanism is for the respondent to place a bid equal to their WTP (Lusk and Shogren, 2007).

The main benefit of using the BDM mechanism is that it allows for a quasi-market scenario that can be carried out with only one respondent present because the price is determined exogenously. We elected to use this method for eliciting WTP as this experiment was part of a larger farmer survey which took place in or near each farmer's house where only the enumerator was present and no other farmers. Further, in the case for the VQG, conducting this study in a BDM setting ensured that each farmer was able to provide their specific desired purchase quantity; this would have been difficult in a group auction setting where the quantity across all bidders would need to be fixed. As with any method, BDM does have a few drawbacks. BDM can be difficult to explain and be understood by respondents compared to other experimental auctions (Cason and Plott, 2014; Ortega and Wolf, 2018; Asioli et al., 2020; Cole et al., 2020). Finally, BDM can be a budgetary and a logistical challenge for researchers as they do not know the total product needed for winners as the number of winners is determined individually in each interview, as the market is simulated and not created by a group (Lusk and Shogren, 2007).

## 3.2 Study Design

We conduct our preference elicitation experiments with maize and bean seeds for a variety of reasons. First, these are very important crops to the Zimbabwean agricultural system, but are different in several ways. While maize is a staple crop that constitutes a large portion of the diet, beans are a legume crop and viewed as a food security crop due the different nutrients provided. The maize used in this study is a hybrid crop, reflective of the fact that most of the maize cultivation in Zimbabwe is via hybrid varieties. Conversely, beans are self-pollinated crops which have different implications on yield potential and recycling of grain as seed. The experiments were conducted as part of a larger adoption study on biofortified maize and beans. Biofortification is the breeding of staple food crops to increase their micronutrient and mineral content. This intervention largely targets rural populations that lack access to or affordability to other mechanisms of increasing micronutrient intake such as diet diversity, supplementation, or food fortification (Bouis and Saltzman, 2017).

In the experiments, farmers submitted bids for three products in three rounds. We focus our attention on first round bids in this study. The bean seed products included Gloria, the most popular non-biofortified bean variety, NUA45, a biofortified bean variety, and NAU45 with an additional label on the bag which read, “Iron and Zinc Enriched”. Similarly, in the maize experiment, farmers also bid on three maize seed products. The maize seeds included were the benchmark maize seed variety, Mutsa, and two versions of ZS500A, the biofortified maize seed—one with only the standard information and one with an additional nutrition statement, "Vitamin A Enriched".

Table 1, below, outlines the experiment's sample size per group and crop. Treatment assignments (FQG vs. VQG) and crop were randomized down to the village level to limit any potential conflict that could arise if neighbors had the opportunity to bid on different quantities or crops.

**Table 1: Sample Size by Crop Experiment and Group Assignment**[1]

| | **Fixed Quantity Group** | **Variable Quantity Group** |
|---|---|---|
| **Crop** | Full Sample | Full Sample |
| Bean | 262 | 265 |
| Maize | 302 | 302 |

In each experimental group, respondents were asked to bid for three bean (maize) products based on information presented on the 2kg seed packs available for them to observe and handle. The specific information on the seed packs by crop is presented in Table 2 below; pictures of the seed packs are available in the Appendix.

**Table 2: Seed pack information provided by crop**

| Information type | **Beans (FQG and VQG)** | | | **Maize (FQG and VQG)** | | |
|---|---|---|---|---|---|---|
| | Product 1 | Product 2 | Product 3 | Product 1 | Product 2 | Product 3 |
| Variety name | Gloria | NUA45 | NUA45 | Mutsa/ MN521 | ZS500A | ZS500A |
| Company name | ARDA | ARDA | ARDA | Mukushi | Mukushi | Mukushi |

[1] Based on sample size calculations of allowing a Type I error of 5% and a Type II error of 20%, the sample size required is 251 individuals per group (Lusk and Shogren, 2007; Canavari et al., 2019)

| | | | | | | |
|---|---|---|---|---|---|---|
| Size | 2kg | 2kg | 2kg | 2kg | 2kg | 2kg |
| Seed treated with a chemical? | No | No | No | Yes | Yes | Yes |
| Color of the seed or treatment hue | Cream | Purple-Mottled | Purple-Mottled | Blue | Orange | Orange |
| Seed type | Certified | Certified | Certified | Certified, ungraded | Certified, ungraded | Certified, ungraded |
| Hybrid? | No | No | No | Yes | Yes | Yes |
| Additional label | No | No | Iron and Zinc Enriched | No | No | Vitamin A enriched |

As is standard in experimental auctions, prior to conducting the experiment, enumerators explained the BDM procedure to farmers and conducted a practice round with them. The practice round was comprised of 3 different matchboxes, a common non-focal product in rural Zimbabwe with known market prices. Farmers were encouraged to ask any clarifying questions necessary as the BDM procedure can be a bit confusing, as noted in Section 3.2.

Currently, Zimbabwe has a multiple currency system – the US dollar (USD) and the local Zimbabwean dollar, officially the Real Time Gross Settlement dollar (RTGS dollar), which was reintroduced in 2019. Due to inflation of the RTGS since its reintroduction, most individuals prefer to use USD. As such, we used USD as the currency in this study. The *ex-ante* established price distribution used in the FQG experiment for both beans and maize 2kg seed packs was $0 USD to $14 USD, in increments of $1 USD. Our price distribution for the FQG was based on the current average market price of bean and maize seed, both of which were $7.00 for a 2kg pack. For the VQG, the underlying price distribution was $0-$7 USD per 1kg of seed as we converted each respondent's bid to a 1kg-equivalent price for ease in selecting the 'market price'. This price was then scaled by the appropriate quantity to determine total WTP, if the respondents'

1kg-equivalent bid was greater than or equal to the 'market price' to carry out the transaction. Respondents were not told the price distribution but instructed to think of the typical bean (maize) seed price they would find in the market as past studies have found that BDM may not be incentive-compatible due to a respondent's potential dependence of their bid on the price distribution (Horowitz, 2006; Ortega and Wolf, 2018). As bean and maize planting would begin soon after the experiment, farmers were already beginning to assess current bean and maize seed prices offered in the market. Respondents' bids were not censored in either group, bids could include decimals (i.e., did not have to be in increments of $1), and the quantity stated by farmers in the VQG was uncensored but did have to be in increments of 1 kg (e.g., a respondent could not state they wanted to purchase 22.5 kgs). These decisions reflected actual market scenarios.

This experiment was carried out from 14 November to 05 December, 2022 throughout six provinces of Zimbabwe as shown in Figure 1 below.

**Figure 1: Provinces where crop experiments were conducted**


Source: paintmaps.com with author additions

Farmers did not receive an endowment for purchasing seed nor a participation gift. Therefore, farmers submitted bids based on the money they had with them that day. Farmers were informed by their village leaders to come prepared to purchase product the day of the experiment. A total of 41 enumerators participated in this study, the majority of which were from the Ministry of Agriculture.

In the bean (maize) experiment, to select the binding round and bean (maize) seed product both FQG and VQG respondents randomly drew slips of paper from 'round' and 'product' opaque bags. Similarly, a market price was determined for both groups.

### 3.3 Main Hypothesis

Our null hypothesis, for both beans and maize, is that the marginal WTP of the FQG is equal to the marginal WTP of the VQG. However, based on our review of the literature and the role that mental budgeting can play in respondents' bid for different WTP quantities (Lin et al., 2022), our alternative hypothesize is that the 2kg-equivlent bids submitted in the FQG and VQG, will be statistically different.

$$H_0\colon\ WTP_{FQG,2kg} =\ WTP_{VQG,2k-equivalent}$$

$$H_A\colon\ WTP_{FQG,2kg} \neq\ WTP_{VQG,2k-equivalent}$$

Specifically, we hold this alternative hypothesis due to individuals in the FQG potentially viewing the seed quantity and price as trivial since it is a much smaller monetary amount than what they may be used to paying/purchasing for seed for their field(s) drawing from their mental accounts. Consequently, they may overestimate their WTP for 2kg bag. Conversely, potentially respondents in the VQG are able to specify their experimental quantity based on their precise desired amount which likely falls in-line with their mental budgeting. If we reject our null hypothesis then it is necessary to consider the quantities included in experimental auctions when eliciting WTP bids as they are found to have an impact.

### 3.4 Empirical Strategy

Given the nature of the data, regression analysis of farmer WTP is estimated via the panel Tobit estimation method drawing on its ability to account for correlation within individuals submitting multiple bids from two different groups while also accounting for censoring at corner solutions (Wooldridge, 2010; Wooldridge, 2016). In the case of the panel Tobit, we censor data below at zero. In addition to the panel Tobit estimation method, panel Random Effects OLS estimation is used as a check, since the number of censored bids is trivial (0.8% for beans, 1.3% for maize), as resulting estimates between Tobit and OLS should not diverge in a meaningful way (Canavari et al., 2019). Finally, we also check the robustness of results by using the panel Fixed Effects OLS estimation method.

Equation 1, below, is the parsimonious specification where the independent variables in our equation are bean (maize) seed type and treatment group type. Our key coefficient of interest for the hypothesis in the study is $\gamma$, the average WTP for 2kg-quivalent bids from the VQG for the seed products compared to the base case, the average WTP for 2kg of seed submitted by the FQG. We estimate Equation 1 for both the bean and maize experiments. In Equation 2, we test the robustness of $\gamma$ by incorporating control variables ($\boldsymbol{X_i}$). Our model specifications are:

$$Bid_{ijt} = \alpha + \beta' S_j + \gamma' T_t + u_{it} \qquad (1)$$

$$Bid_{ijt} = \alpha + \beta' S_j + \gamma' T_t + \eta' \boldsymbol{X_i} + u_{it} \qquad (2)$$

where $Bid_{ijt}$ is the WTP bid for farmer *i* for the bean (maize) seed type *j* in treatment group *t.* Variable $T_t$ delineates the treatment groups where t=1 for the VQG while *t*=0 represents the FQG which serves as the base group. $S_j$ is a categorical variable for the bean seed type (=0 for Gloria, =1 for NUA45 with no nutrition label, and =2 for NUA45 with the nutrition label) or in the case of maize seed type (=0 for Mutsa, =1 for ZS500A with no nutrition label, and =2 for ZS500A with the nutrition label). The $\boldsymbol{X_i}$ represents a vector of respondent characteristics and experiment controls. Respondent control variables include respondent age, female (0/1), education above primary level (0/1), household size, if the respondent was in the 3rd or 4th quartile of the created wealth index (0/1), province, if the respondent had already purchased some bean (maize) seed (0/1), if the respondent had received or expected to receive free bean (maize) seed from the government (0/1), if the respondent grew NUA45 (ZS500A) last season (0/1), and if the respondent grew Gloria (Mutsa) last season (0/1). Finally, $u_{it}$ is the idiosyncratic error term.

## 3.5 Data

### *Bean Experiment*

Table 3, below, outlines demographics of our sample respondents for our bean experiment. Table 15 in the Appendix outlines the demographic characteristics and balance tests for our full bean sample. Overall, we have sufficient balance across our treatment groups. Only three variables are significantly different at the 5% level or smaller: the average number of males aged 15-49 in the household, the average number of females 15-49, and farming being the main source of employment. Approximately 70% of respondents were their household's head, approximately half were female, on average they were 47 years of age, and the majority had completed secondary school. On average, the household size was five individuals, respondents cultivated approximately 2.8 hectares in the last growing season across all crops, and approximately 10% had already purchased at least some bean seed for the coming growing season. Farmers on average cultivate 0.5 ha of bean in the last season, used 34kgs of bean seed in the last season, and approximately half of the sample farmers purchased bean seed.

**Table 3: Bean sample demographic characteristics and balance tests**

| | Fixed Quantity Group (n=262) | | Variable Quantity Group (n=265) | | Test of equal means: FQG=VQG |
|---|---|---|---|---|---|
| **Variable** | Mean | Std. Dev. | Mean | Std. Dev. | p-value |
| Household Head (HH) (%) | 72.900 | (44.53) | 71.320 | (45.31) | 0.6866 |
| Female (%) | 50.000 | (50.1) | 51.700 | (50.07) | 0.6973 |
| Age | 47.570 | (13.96) | 46.600 | (14.77) | 0.6866 |
| Highest level of education completed (%) | | | | | |
| None | 3.820 | (19.2) | 4.530 | (20.83) | 0.6837 |
| Primary School | 30.530 | (46.14) | 30.570 | (46.16) | 0.9937 |
| Secondary School | 64.120 | (48.06) | 62.260 | (48.56) | 0.6591 |
| Tertiary School (certificate, diploma, degree) | 1.530 | (12.28) | 2.640 | (16.07) | 0.3717 |
| Respondent's main source of employment: own farming (%) | 91.980 | (27.2) | 95.470 | (20.83) | 0.0989 |
| Household Size (Total) | 4.940 | (2.31) | 5.140 | (2.3) | 0.3281 |
| No. of children under 15 | 2.290 | (1.82) | 2.090 | (1.55) | 0.1755 |
| No. of males 15-49 years of age | 0.980 | (0.79) | 1.110 | (0.93) | 0.0878 |
| No. of females 15-49 years of age | 0.920 | (0.7) | 1.140 | (0.86) | 0.0013 |
| No. of HH members age 50 or older | 0.690 | (0.74) | 0.700 | (0.76) | 0.865 |
| **Experiment Controls** | | | | | |
| Total land area cultivated (ha) | 2.760 | (2.25) | 2.860 | (3.11) | 0.6703 |
| Total bean land area cultivated (ha) last season | 0.45 | (1.318) | 0.37 | (0.577) | 0.3701 |
| Quantity (kgs) bean seed planted last season | 34.89 | (126.113) | 33.80 | (57.945) | 0.8987 |
| Purchased bean seed last season (%) | 48.47 | (50.01) | 50.57 | (50.09) | 0.6317 |
| Average price/kg (USD) paid for bean seed purchased last season | 2.58 | (4.579) | 2.05 | (1.992) | 0.2183 |
| Bean listed among top two most important crops grown for HH consumption (%) | 70.610 | (45.64) | 64.150 | (48.05) | 0.1142 |
| Bean listed among top two most important crops grown for HH income source (%) | 59.160 | (49.25) | 52.830 | (50.01) | 0.1438 |
| Already purchased some bean seed at home for planting (%) | 10.310 | (30.46) | 9.430 | (29.29) | 0.7379 |

| | | | | | |
|---|---|---|---|---|---|
| Has received or expects to receive seed from the government? (%) | 19.470 | (39.67) | 18.490 | (38.9) | 0.7758 |

Test of equal means across group assignment is an F-test of equality across groups.

### *Maize Experiment*

Table 4, below, outlines the maize sample demographics. Only one demographic characteristics were not balanced across our two treatment groups: the average number of females aged 15-49 in the household. Otherwise, no significant difference between means was found across the FQG and the VQG respondents. Sample characteristics are quite similar to those outlined in Table 3. One characteristic worth noting is that 99% of respondents, across both groups, indicated that maize was among the top two most important crops grown for consumption purposes by the household. This result is not surprising as maize is the most cultivated crop throughout Zimbabwe. Further, approximately 75% of respondents have received or expect to receive some maize seed from the government for the coming planting season. The average seed quantity received or expected to receive from the government was 9kgs, on average. Regarding planting quantity of all maize varieties in the last season, on average, farmers planted 19kgs of maize seed, which was not statistically different across treatment groups. Also, between 47-53% of respondents purchased maize seed in the previous season.

**Table 4: Maize sample demographic characteristics and balance tests**

| | **Fixed Quantity Group (n=302)** | | **Variable Quantity Group (n=302)** | | **Test of equal means: FQG=VQG** |
|---|---|---|---|---|---|
| **Variable** | Mean | Std. Dev. | Mean | Std. Dev. | p-value |
| Household Head (HH) (%) | 74.50 | (43.66) | 70.86 | (45.52) | 0.316 |
| Female (%) | 51.66 | (50.06) | 50.66 | (50.08) | 0.8075 |

| | | | | | |
|---|---|---|---|---|---|
| Age | 50.24 | (15.34) | 48.19 | (15.81) | 0.1065 |
| Highest level of education completed (%) | | | | | |
| None | 4.30 | (20.33) | 5.30 | (22.44) | 0.5688 |
| Primary School | 37.09 | (48.38) | 34.11 | (47.49) | 0.4452 |
| Secondary School | 57.28 | (49.55) | 59.93 | (49.08) | 0.5095 |
| Tertiary School (certificate, diploma, degree) | 1.32 | (11.45) | 0.66 | (8.12) | 0.4127 |
| Respondent's main source of employment: own farming (%) | 94.37 | (23.09) | 91.72 | (27.6) | 0.2013 |
| Household Size (Total) | 4.84 | (2.06) | 4.96 | (1.94) | 0.4636 |
| No. of children under 15 | 2.20 | (1.74) | 2.20 | (1.52) | 1.000 |
| No. of males 15-49 years of age | 0.91 | (0.8) | 0.91 | (0.73) | 0.9577 |
| No. of females 15-49 years of age | 0.89 | (0.71) | 1.05 | (0.74) | 0.0074 |
| No. of HH members age 50 or older | 0.78 | (0.78) | 0.73 | (0.81) | 0.3552 |
| **Experiment Controls** | | | | | |
| Total land area cultivated (ha) last season | 1.44 | (1.07) | 1.48 | (1.08) | 0.6011 |
| Total maize land area cultivated (ha) last season | 0.78 | (0.66) | 0.86 | (0.67) | 0.1601 |
| Quantity (kgs) maize seed planted last season | 18.45 | (17.21) | 19.37 | (14.33) | 0.4771 |
| Purchased maize seed last season (%) | 46.69 | (49.97) | 52.98 | (50.00) | 0.1225 |
| Average price/kg (USD) paid for maize seed purchased last season | 4.01 | (5.58) | 4.70 | (8.40) | 0.4904 |
| maize listed among top two most important crops grown for HH consumption (%) | 50.99 | (50.07) | 45.70 | (49.9) | 1.000 |
| maize listed among top two most important crops grown for HH income source (%) | 44.70 | (49.8) | 42.05 | (49.45) | 0.5121 |
| Already purchased some maize seed at home for planting (%) | 27.15 | (44.55) | 28.81 | (45.36) | 0.651 |
| Has received or expects to receive seed from the government? (%) | 75.17 | (43.28) | 74.17 | (43.84) | 0.7794 |

Test of equal means across group assignment is an F-test of equality across groups.

# 4. Results and Discussion

## 4.1 Descriptive Analysis

### *Quantity Demanded*

In addition to comparing marginal WTP for the two treatment groups, we examine the average quantity demanded by the VQG. Table 7 below outlines the summary statistics of quantity demanded in the VQG by bean seed product. The mean quantity demanded is 9kgs for Gloria and NUA45 with no nutrition label and 11kgs for NUA45 with the nutrition label, so approximately 4.5 to 5.5 times the quantity the FQG bid on of 2kgs. On average, across all bean seed products, 74% of the bean respondents bid for a quantity greater than 2kgs.

**Table 5: VQG Quantity (kg) Demanded Summary Statistics by Bean Product[2]**

| | Mean | Std Dev. | Median | Minimum | Maximum | % farmers willing to buy >2kgs |
|---|---|---|---|---|---|---|
| Gloria | 9.220 | (14.221) | 5 | 0 | 200 | 70.94 |
| NUA45 no label | 9.061 | (8.843) | 5 | 0 | 50 | 74.34 |
| NUA45 with label | 10.807 | (12.480) | 6 | 0 | 100 | 76.23 |
| All products | 9.696 | (12.069) | 6 | 0 | 200 | 73.84 |

Average quantity demanded in the VQG for the maize seed products is outlined in Table 8 below. On average, the mean quantity demanded for Mutsa, the benchmark maize variety, is 6kgs, 6kgs for ZS500A with no nutrition label, and 7kgs for NUA45 with the nutrition label. These average quantities demanded are between 3 to 3.5 times the 2kg quantity on which FQG respondents bid. Across all maize types, on average, 68% of farmers stated a quantity greater than 2kgs that they were willing to purchase in the VQG.

**Table 6: VQG Quantity (kg) Demanded Summary Statistics by Maize Product**

| | Mean | Std Dev. | Median | Minimum | Maximum | % farmers willing to buy >2kgs |
|---|---|---|---|---|---|---|
| Mutsa | 6.132 | (7.819) | 5 | 0 | 100 | 63.91 |
| ZS500A no label | 6.017 | (5.367) | 5 | 0 | 50 | 66.22 |
| ZS500A with label | 7.311 | (8.460) | 5 | 0 | 100 | 72.52 |
| All products | 6.487 | (7.353) | 5 | 0 | 100 | 67.55 |

[2] We exclude three outlier bid quantities of 600kg in Table 7 such that our n=744 instead of n=747.

*WTP by Crop Product*

Total WTP and the test of equality across treatment groups, outlined in Tables 5 and 6, are conducted via parametric regression analysis (F-tests) and by non-parametric tests using the Kruskal-Wallis rank test (K-tests).

In Table 5, we compare the WTP across treatment groups. Depending on the bean product, the FQG WTP is between 12%-26% higher than the VQG 2kg-equivalent WTP. Parametric equality of mean F-tests are not statistically different for Gloria, while they are statistically difference at the 1% level for NUA45 without the nutrition label and NUA45 with the nutritional label. Non-parametric rank tests for the sample range from 5% significance to 1% significance. This finding is in line with previous literature, that the bid quantity does impact marginal WTP (Lin et al., 2022) and small, fixed quantity WTP is overstated.

**Table 7: Total WTP (USD) by Bean Seed Product and Treatment Group for 2kg pack**

| | **Fixed Quantity Group** | **Variable Quantity Group** | **P-values** | |
|---|---|---|---|---|
| **Bean Product** | (n=243) | (n=249) | F-Tests | K-Tests |
| Gloria | 3.98<br>(3.83) | 3.51<br>(2.85) | 0.1133 | 0.0259 |
| NUA45 without nutrition label | 4.38<br>(2.89) | 3.50<br>(2.39) | 0.0001 | 0.0001 |
| NUA45 with nutrition label | 5.15<br>(4.01) | 3.84<br>(3.07) | 0.0000 | 0.0001 |

Note: standard deviations are in parenthesis. F-tests comes from the parametric equality of means tests while K-tests come from the non-parametric Kruskal-Wallis rank test.

Similar to the findings above, descriptive analysis for the maize WTP experiment (see Table 6 below) also finds statistical difference in mean WTP bids across treatment groups. However, in the case of maize, all maize seed products have mean WTP differences between the

FQG and the VQG, significant at the 1% level in both the parametric and non-parametric equality of means tests. On average, the FQG bids are between 28% to 32% higher than the 2kg-equivalent VQG bids.

**Table 8: Total WTP (USD) by Maize Seed Product and Treatment Group for 2kg pack**

| Maize | **Fixed Quantity Group** (n=302) | **Variable Quantity Group** (n=302) | **P-values** F-Tests | K-Tests |
|---|---|---|---|---|
| Mutsa | 4.60 (3.22) | 3.33 (2.21) | 0.0000 | 0.0001 |
| ZS50A without nutrition label | 4.77 (3.65) | 3.41 (2.07) | 0.0000 | 0.0001 |
| ZS500A with nutrition label | 5.71 (3.56) | 3.91 (2.48) | 0.0000 | 0.0001 |

Note: standard deviations are in parenthesis. F-tests comes from the parametric equality of means tests while K-tests come from the non-parametric Kruskal-Wallis rank test.

As is evident from Tables 5 and 6, initial descriptive results indicate that statistically significant differences exist across the two different treatment groups regardless of the good being auctioned (beans or maize).

## 4.2 Estimation Results

Results from regression models 1 and 2 are outlined for each of the crop experiments in Tables 9 and 10. Overarching results suggests that there is a significant difference in the WTP for 2kg (2kg-equivalent) crop seed between the FQG and the VQG. The key takeaway from these results is that researchers cannot elicit WTP for small quantities and assume it will equal the WTP on a per-unit basis for large quantities.

*Bean Regression Results*

Table 9 outlines the results for the bean seed experiment. Results for the full sample are included in the Appendix. On average across all bean seed products, farmers in the VQG bid between \$0.83 - \$0.90 less for a 2kg-equivalent seed pack than those in the FQG, significant at the 1% level, robust across models and estimation method. This translates to a 17%-22% discount in WTP price, on average. This result is both statistically and economically meaningful. Therefore, we reject our null hypothesis and find that bid quantity does impact marginal WTP.

*Maize Regression Experiment*

Compared to the bean experiment, we see the largest average deviation between the FQG and VQG WTP bids in the maize experiment, as shown in Table 10. Across models and estimation methods, results are robust. On average, farmers assigned to the VQG, bid \$1.47-\$1.50 less than the FQG for 2kgs of maize seed, and is significant at 1% level. Again, we reject our null hypothesis and find that bid quantity does impact marginal WTP. This \$1.47 discount, equates to a 32% price discount for the VQG bids. Recall that there was a bulk discount of \$0.30/kg for the largest maize seed pack available in the market. This discount of \$1.47 is greater than the \$0.30/kg discount, meaning the difference in the FQG and VQG bids comes from a different source, which we hypothesize to be a mental budgeting bias.

**Table 9: Regression estimates for hypothesis 1: Total WTP (USD) by bean product and treatment group**

| | (1) Panel Tobit (Corr. Random Effects) | | | (2) Panel Tobit (Corr. Random Effects) | | | (3) Panel OLS (Random Effects) | | | (4) Panel OLS (Random Effects) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | Coef. | Std. Error | | Coef. | Std. Err. | | Coef. | Std. Err. | | Coef. | Std. Err. | |
| Constant | 4.182 | 0.191 | *** | 5.110 | 0.837 | *** | 4.190 | 0.216 | *** | 5.129 | 0.822 | *** |
| **Treatment (Base=FQG)** | -0.901 | 0.256 | *** | -0.854 | 0.255 | *** | -0.885 | 0.256 | *** | -0.839 | 0.263 | *** |
| **Bean Type (Base=Gloria)** | | | | | | | | | | | | |
| NUA45 no label (0/1) | 0.197 | 0.102 | * | 0.197 | 0.102 | * | 0.192 | 0.104 | * | 0.192 | 0.105 | * |
| NUA45 with label (0/1) | 0.759 | 0.102 | *** | 0.760 | 0.102 | *** | 0.747 | 0.101 | *** | 0.747 | 0.102 | *** |
| **Respondent Controls Included?** | | No | | | Yes | | | No | | | Yes | |
| *Sigma _u* | 2.800 | 0.101 | *** | 2.732 | 0.095 | *** | 2.775 | | | 2.777 | | |
| *Sigma _e* | 1.694 | 0.038 | *** | 1.657 | 0.036 | *** | 1.646 | | | 1.646 | | |
| *Rho* | 0.732 | 0.017 | | 0.731 | 0.017 | | 0.740 | | | 0.740 | | |
| *Number of Observations* | | 1581 | | | 1581 | | | 1581 | | | 1581 | |
| *Number of Respondents* | | 527 | | | 527 | | | 527 | | | 527 | |
| *Number of Censored Bids* | | 13 | | | 13 | | | 13 | | | 13 | |
| *Log Likelihood* | | -3619.5773 | | | -3611.3814 | | | -- | | | -- | |
| *R-squared (within)* | | -- | | | -- | | | 0.0528 | | | 0.0528 | |

**For the panel OLS estimations, robust-standard errors are cluster at the participant level. *=p<10%, **=p<5%, and ***=p<1%.*

**Table 10: Regression estimates for hypothesis 2: Total WTP (USD) by maize product and treatment group**

| | (1) Panel Tobit (Pooled Corr. Random Effects) | | | (2) Panel Tobit (Pooled Corr. Random Effects) | | | (3) Panel OLS (Pooled Random Effects) | | | (4) Panel OLS (Pooled Random Effects) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | Coef. | Std. Err. | | Coef. | Std. Err. | | Coef. | Std. Err. | | Coef. | Std. Err. | |
| Constant | 4.689 | 0.161 | *** | 7.383 | 1.202 | *** | 4.704 | 0.178 | *** | 7.364 | 1.341 | *** |
| **Treatment (Base=FQG)** | -1.498 | 0.215 | *** | -1.495 | 0.214 | *** | -1.477 | 0.214 | *** | -1.474 | 0.215 | *** |
| **Maize Type (Base=Mutsa)** | | | | | | | | | | | | |
| ZS500A no label (0/1) | 0.137 | 0.093 | | 0.137 | 0.093 | | 0.124 | 0.099 | | 0.124 | 0.010 | |
| ZS500A with label (0/1) | 0.867 | 0.093 | *** | 0.867 | 0.092 | *** | 0.846 | 0.075 | *** | 0.846 | 0.076 | *** |
| **Respondent Controls Included?** | No | | | Yes | | | No | | | Yes | | |
| *Sigma _u* | 2.477 | 0.082 | *** | 2.440 | 0.081 | *** | 2.469 | | | 2.461 | | |
| *Sigma _e* | 1.607 | 0.033 | *** | 1.607 | 0.033 | *** | 1.588 | | | 1.588 | | |
| *rho* | 0.704 | 0.017 | | 0.697 | 0.017 | | 0.707 | | | 0.706 | | |
| *Number of Observations* | 1812 | | | 1812 | | | 1812 | | | 1812 | | |
| *Number of Respondents* | 604 | | | 604 | | | 604 | | | 604 | | |
| *Number of Censored Bids* | 24 | | | 24 | | | -- | | | -- | | |
| *Log Likelihood* | -4040.6714 | | | -4032.8949 | | | -- | | | -- | | |
| *R-squared (within)* | -- | | | -- | | | 0.0767 | | | 0.0767 | | |

**For the panel OLS estimations, robust-standard errors are cluster at the participant level. *=p<10%, **=p<5%, and ***=p<1%.*

## 4.2 Heterogeneous Effects

We investigate several heterogeneous effects for the mean difference in FQG and VQG 2kg-equivalent WTP bid comparisons. We do so to determine the robustness of the treatment effect found in regression analysis across different sub-groups of interest. We compare the resulting mental budgeting bias across specific seed varieties and by conditioning on past seed quantity planting of maize and beans.

### *4.2.1. Total WTP estimations by Seed Product*

First, we compare the impact of the treatment group (FQG versus VQG) on farmer WTP for each individual bean variety to assess if there is heterogeneity in the potential for mental budgeting bias. We regress the treatment variable on each bean (maize) seed product's total WTP via the Tobit estimation method. Potentially, there is a larger mental budgeting bias for newer products (e.g., NUA45 and ZS500A), than the well-known benchmark seed products (e.g., Gloria and Mutsa).

#### *Bean Seed Products*

We find WTP heterogeneity does exist across the different bean seed products (Table 13). The discount given to Gloria, the benchmark bean, for those assigned to the VQG is $0.49 less (a 12% discount) than those in the FQG and the difference is significant at the 10% level. The average WTP for 2kgs of NUA45 with no nutrition label, is $0.91 less (a 21% discount) than the average bid by farmers in the FQG, significant at the 1% level. Finally, the bean with the largest discount received by treatment type is NUA45 with the nutrition label. On average, the WTP for 2kgs of NUA45 with the label is $1.31 less (a 26% discount) for farmers in the VQG than those in the FQG, significant at the 1% level. Therefore, it seems that mental budgeting bias does change according to product type. This result could be because farmers have more experience purchasing the variety Gloria, or varieties similar to it, so they find it is easier to draw from their mental accounting and budgeting when submitting bids. Contrast this to the new varieties of NUA45, especially the product with the additional nutrition label, where farmers likely have less experience purchasing the variety, or varieties like it, due to its novelty in the market. This novelty creates a larger gap in WTP due to the mental budgeting bias (i.e., the difference in FQG and VQG bids).

**Table 11: Total WTP (USD) by treatment group delineated by bean product**

| | **(1) Gloria** | | | **(2) NUA45 with no nutrition label** | | | **(3) NUA45 with nutrition label** | | |
|---|---|---|---|---|---|---|---|---|---|
| **Variables** | Coef. | Std. Error | | Coef. | Std. Error | | Coef. | Std. Error | |
| Constant | 3.967 | 0.211 | *** | 4.380 | 0.165 | *** | 5.150 | 0.220 | *** |
| **Treatment (Base=FQG)** | | | | | | | | | |
| VQG | -0.487 | 0.297 | | -0.905 | 0.232 | *** | -1.313 | 0.312 | *** |
| **Respondent Controls Included?** | No | | | No | | | No | | |
| *Number of Observations* | 527 | | | 527 | | | 527 | | |
| *Number of Censored Bids* | 7 | | | 5 | | | 1 | | |
| *Log Likelihood* | -1382.643 | | | -1258.2294 | | | -1416.3006 | | |

*Note: *=p<10%, **=p<5%, and ***=p<1%.*

*Maize Seed Products*

Similar to beans, we find heterogeneity in the discount in WTP for 2kg seed packs provided by the VQG compared to the FQG (Table 14). The smallest discount, of $1.05 (25%) exist for Mutsa while the largest discount of $1.38 (27%) exist for ZS500A with the nutrition label. Again, we suspect that this underlying difference in the bids submitted by the FQG and VQG between the maize seed products is due to the bias of mental budgeting. While the absolute discount from the VQG compared to the FQG is heterogeneous, the percentage decrease from the constant (the FQG) only ranges from 29-32%.

**Table 12: Total WTP (USD) by treatment group delineated by maize product**

| | **(1) Mutsa** | | | **(2) ZS500A with no label** | | | **(3) ZS500A with nutrition label** | | |
|---|---|---|---|---|---|---|---|---|---|
| **Variables** | Coef. | Std. Error | | Coef. | Std. Error | | Coef. | Std. Error | |
| Constant | 4.592 | 0.162 | *** | 4.767 | 0.172 | *** | 5.712 | 0.177 | *** |
| **Treatment (Base=FQG)** | | | | | | | | | |
| VQG | -1.319 | 0.229 | *** | -1.390 | 0.243 | *** | -1.810 | 0.250 | *** |
| **Respondent Controls Included?** | No | | | No | | | No | | |
| *Number of Observations* | 604 | | | 604 | | | 604 | | |
| *Number of Censored Bids* | 15 | | | 7 | | | 2 | | |
| *Log Likelihood* | -1461.8888 | | | -1508.453 | | | -1531.911 | | |

*Note: *=p<10%, **=p<5%, and ***=p<1%.*

*4.2.3. Conditioning WTP on past planting quantities*

Using respondent information for bean (maize) seed quantity planted last year, we categorize respondents by those that planted between 3-5kgs of seed, between 6-10kgs, between 11-20kgs, and above 20kgs of maize seed and approximately 2kgs of seed[3]. We then condition the mean WTP in both the FQG and VQGs by these groups to determine if there is a potential difference in mean WTP that can be attributed to past growing quantity which could influence farmers' mental accounting and budgeting. We use quantity planted last year and not purchases as only approximately half of our maize sample respondents and our bean sample purchased seed last year, as many recycle grain as seed or received seed aid.

*Beans*

Table 13 below shows the average WTP by bean type conditional on specific categories of bean seed quantity planted in the last season. Results are heterogeneous across bean seed product and quantity of past planting. For the Gloria seed, no statistical difference between the FQG and VQG is found conditional on any of the previous planting quantity categories. Three of the conditional quantity categories are significantly difference between the FQG and the VQG for NUA45 with no nutrition label. And again, the same is found for NUA45 with the nutrition label. In particular, statistical differences exist for the 'Less than 2kg' group, the '3-5kg' group, and the 'above 20kgs' group. Based on this result, the mental budgeting hypothesis explaining the reason for the statistical difference in the two treatment groups falls apart a bit, though we have no other potential reason to explain this difference at this time.

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[3] Note, we do not include a 2kgs or less category as only 2 respondents across the entire maize sample were in this category.

## Table 13: WTP (USD) for Bean Products Conditional on Last Season's Planting Quantity

| Conditional on Bean Seed Quantity Planted Last Season | Fixed Quantity Group (n=262) | Variable Quantity Group (n=265) | Equality of means FQG=VQG P-values |
|---|---|---|---|
| **Gloria** | | | |
| Less than 2kgs | 4.154<br>(2.304) | 2.847<br>(1.69) | 0.122 |
| Approximately 2kgs | 4.119<br>(2.761) | 2.973<br>(1.988) | 0.233 |
| 3-5kgs | 2.875<br>(0.629) | 2.4<br>(1.131) | 0.523 |
| 6-10kgs | 3.206<br>(1.533) | 3.713<br>(2.429) | 0.2895 |
| 11-20kgs | 3.516<br>(1.96) | 3.359<br>(2.234) | 0.7085 |
| Above 20kgs | 4.51<br>(5.383) | 3.707<br>(3.745) | 0.2213 |
| **NUA45 no label** | | | |
| Less than 2kgs | 5.308<br>(2.25) | 2.385<br>(1.345) | 0.001 |
| Approximately 2kgs | 5.238<br>(4.155) | 3.439<br>(1.795) | 0.183 |
| 3-5kgs | 4.25<br>(0.957) | 2.5<br>(0.707) | 0.0884 |
| 6-10kgs | 3.721<br>(1.951) | 3.99<br>(2.318) | 0.5860 |
| 11-20kgs | 3.533<br>(1.568) | 3.279<br>(2.563) | 0.5578 |
| Above 20kgs | 4.797<br>(3.466) | 3.602<br>(2.698) | 0.0068 |
| **NUA45 with nutrition label** | | | |
| Less than 2kgs | 6.154<br>(2.911) | 2.711<br>(1.785) | 0.002 |
| Approximately 2kgs | 6.119<br>(4.919) | 3.788<br>(2.151) | 0.147 |
| 3-5kgs | 4.5<br>(1) | 2.5<br>(0.707) | 0.0690 |
| 6-10kgs | 4.221<br>(2.294) | 4.152<br>(2.85) | 0.909 |
| 11-20kgs | 4.484<br>(2.746) | 3.685<br>(2.567) | 0.131 |
| Above 20kgs | 5.524<br>(4.851) | 4.007<br>(3.967) | 0.0158 |

Standard deviations are in parentheses.

*Maize*

Table 14 below shows average WTP by maize type conditional on specific categories of maize seed quantity planted in the last season. Across all quantity segments and maize seed type, statistical differences exist between the FQG and the VQG. The premiums for the FQG over the VQG range generally decrease as we move from the smaller quantity planted last season to larger quantities. This result though, does not necessarily support mental budgeting.

**Table 14: WTP (USD) for Maize Products Conditional on Last Season's Planting Quantity**

| **Conditional on Maize Seed Quantity Planted Last Season** | **Fixed Quantity Group** (n=302) | **Variable Quantity Group** (n=302) | **Equality of means FQG=VQG P-values** |
|---|---|---|---|
| **Mutsa** | | | |
| 3-5kgs | 5.623<br>(2.974) | 3.144<br>(2.039) | 0.001 |
| 6-10kgs | 4.833<br>(3.495) | 3.115<br>(2.395) | 0.000 |
| 11-20kgs | 4.038<br>(2.732) | 3.302<br>(1.865) | 0.0555 |
| Above 20kgs | 4.513<br>(3.153) | 3.651<br>(2.311) | 0.0381 |
| **ZS500A no label** | | | |
| 3-5kgs | 5.568<br>(2.205) | 3.641<br>(2.028) | 0.0026 |
| 6-10kgs | 5.141<br>(4.581) | 3.373<br>(2.221) | 0.0004 |
| 11-20kgs | 4.185<br>(2.553) | 3.169<br>(1.814) | 0.0057 |
| Above 20kgs | 4.539<br>(3.069) | 3.606<br>(2.112) | 0.0188 |
| **ZS500A with nutrition label** | | | |
| 3-5kgs | 6.773<br>(3.477) | 3.981<br>(1.808) | 0.0007 |
| 6-10kgs | 5.851<br>(3.568) | 3.789<br>(2.878) | 0.000 |
| 11-20kgs | 5.123<br>(3.058) | 3.662<br>(2.202) | 0.001 |
| Above 20kgs | 5.77<br>(3.853) | 4.256<br>(2.404) | 0.0019 |

Standard deviations are in parentheses.

## 5. Discussion of Results and Policy Implications

Results from this study across both maize and bean seed products indicate that statistical differences in WTP do exists between the FQG and the VQG, and are statistically significant. The largest discount in the VQG is for maize seed compared to bean seed. However, there are greater heterogeneous effects for bean seed according to the bean seed product being bid on by the respondent. While across all maize seed products, we see strong statistical differences, the same is not true for bean seed. For Gloria, the benchmark bean seed, no statistical difference is found in the WTP bids between the two treatment groups. However, we find large discounts, statistically significant at the 1% level for NUA45 with no nutrition and with the nutrition label. Therefore, as NUA45 bean seed is a newer product on the market which farmers are less aware of, maybe this explains some of the variation in bidding across the treatment groups. In conditioning WTP by treatment group by last season's seed quantity planted, we find statistical differences for all maize seed types across all quantity segments. However, quite the opposite is found in the bean analysis where no statistical difference is found for Gloria, which supports earlier findings, but only part of the conditional quantity WTP results in statistical differences across treatment groups for NUA45 with and without the nutrition label; namely the 'under 2kg' group, the '3-5kg' group, and the 'above 20kg' group.

Average quantity seed planted by farmers in the previous season are, on average, 34kgs for bean farmers and 19kgs for maize farmers, much greater than the 2kg pack size used in the FQG. In the VQG, 74% of the bean farmers assigned to the group, bid for a quantity greater than 2kgs while 68% of the maize farmers in our experiment bid for a quantity greater than 2kgs.

## 6. Conclusions

In this study, we conducted a between-subjects experiment on farmer WTP for bean and maize seed between a fixed quantity group (FQG) and a variable quantity group. In the FQG, respondents bid on 2kg seed packs, while in the VQG they first stated the quantity of seed they wanted to bid on and then stated their WTP for the quantity specified. To compare WTP, we obtain a 2kg-equivalent bid from the VQG. We survey 604 maize farmers and 527 bean farmers across six provinces of rural Zimbabwe. In this study we ask farmers their WTP for a benchmark seed along with two newer seed products.

Across the two crop experiments, we find that there is a statistical difference in WTP between the FQG and the VQG, with the FQG being greater than the VQG 2kg-equivalent bids. We find heterogeneous effects across the specific bean seed products, though not maize seed products. We also find heterogeneous effects when we condition WTP on the last season's seed quantity planted. Based on the strong statistical difference that is found in WTP between treatment groups, our findings suggest as researchers we must think critically about the experimental quantity used as it does have an impact in elicitation results.

While our initial hypothesis to explain this difference in the FQG and VQG bids was mental budgeting bias, our heterogeneous analysis results do not support this. Therefore, we continue to think critically about what could be the route cause of this difference, or potentially there can be several, of which, mental budgeting is only one part.

## References

Ausubel, L.M. (2004). An efficient ascending-bid auction for multiple objects. *American Economic Review*, 94 (5): 1452-1475. https://www.doi.org/10.1257/0002828043052330.

Akaichi, F., R. M. Nayga, Jr. and J. Gil. (2012). Assessing consumers' willingness to pay for different units of organic milk: Evidence from multi-unit auctions. *Canadian Journal of Agricultural Economics* 60 (4): 469–94.

Balcombe, K., Fraser, I., Williams, L., McSorley, E. (2018). Preference Reversals in Discrete Choice Experiments. Inattention or Preference Uncertainty? Some Evidence using eye tracking. Conference Paper, 2019 Australian Agricultural and Resource Economics Society. https://www.doi.org/10.22004/ag.econ.285050.

Becker, G.M., DeGroot, M.H., Marschak, J., 1964. Measuring utility by a single-response sequential method. *Syst. Res. Behav. Sci*. 9 (3), 226–232.

Bouis, H.E., Saltzman, A. (2017). Improving nutrition through biofortification: a review of evidence from HarvestPlus, 2003 through 2016. *Global Food Security* 12: 49–58.

Canavari, M., Drichoutis, A.C., Lusk, J., Nayga Jr, R.M. (2019). How to run an experimental auction: a review of recent advances. *European Review of Agricultural Economics* 46(5): 862-922.

Camerer, C. F. and Lowenstein, G. (2003). Behavioral economics: past, present and future. In: C. Camerer, G. Lowenstein and M. Rabin (eds), Advances in Behavioral Economics. Princeton, NJ: Princeton University Press, 3–51.

Cason, T.N., Plott, C.R. (2014). Misconceptions and game form recognition: Challenges to theories of revealed preference and framing. *Journal of Political Economy*, 122:6, 1235-1270. https://doi.org/10.1086/677254.

Cole, S., Fernando, A.N., Stein, D., Tobacman, J., Business, H., Wharton, I., (2020). Field comparisons of incentive-compatible preference elicitation techniques. *Journal of Economic Behavior & Organization*, 172: 33-56. https://doi.org/10.1016/j.jebo.2020.01.021.

Corrigan, J.R., Depositario, D.P.T., Nayga, R.M., Wu, X., Laude, T.P. (2009). Comparing open-ended choice experiments and experimental auctions: An application to golden rice. *American Journal of Agricultural Economics* 91 (3): 837–53.

Corsi, A. (2007). Ambiguity of measured WTP for quality improvements when quantity is unconstrained: a note. *European Review of Agricultural Economics*, 34(4):501-515.

Dennis, E.J., Tonsor G.T., Lusk, J.L. (2021). Choosing quantities impacts individuals' choice, rationality, and willingness to pay estimates. *Agricultural Economics,* 52:945–962. https://doi.org/10.1111/agec.12678

Elbakidze, L., Nayga, R. M., Jr and Li, H. (2013). Willingness to pay for multiple quantities of animal welfare dairy products: results from random Nth-, second-price, and incremental second-price auctions. C*anadian Journal of Agricultural Economics/Revue Canadienne D'agroeconomie* 61(3): 417–438. https://www.doi.org/10.1111/j.1744-7976.2012.01263.x.

Engelbrecht-Wiggans, R., J. A. List and D. H.Reiley. (2006). Demand reduction in multi-unit auctions with varying numbers of bidders: Theory and evidence from a field experiment. *International Economic Review* 47 (1): 203–31.

Grether, D., Plott, C. (1979). Economic theory of choice and the preference reversal phenomenon. American Economic Review, 69: 623-638.

Gwaze, Tinashe. (2022). Personal Communication regarding bean seed pack sizes in the market.

Harrison, G.W., Johnson, E., McInnes, M.M., Rustrom, E.E. (2003). Individual choice in the laboratory: Paradox reloaded. Working Paper, Dept. Economics, University of Central Florida, September.

Heath, C. and Soll, J. B. (1996). Mental budgeting and consumer decisions. *Journal of Consumer Research* 23(1): 40–52. https://www.doi.org/10.1086/209465.

Horowitz, J.K. (2006). The Becker-DeGroot-Marschak mechanism is not necessarily incentive compatible, even for non-random goods. *Economics Letters*, (93) 1: 6-11, https://doi.org/10.1016/j.econlet.2006.03.033.

Lin, W, Ortega, D., and Caputo, V. (2022). Experimental quantity, mental budgeting and food choice: a discrete choice experiment application. European Review of Agricultural Economics, jbac017, https://doi.org/10.1093/erae/jbac017.

List, J.A., Gallet, C.A. (2001). What experimental protocol influence disparities between actual and hypothetical stated values? Environ. Resource Econ. 20 (3), 241–254.

List, J.A., Lucking-Reiley, D. (2002). Bidding behavior and decision costs in field experiments. *Economic Inquiry*, 40: 611-619. https://doi.org/10.1093/ei/40.4.611.

Lusk, J., Hudson, D. (2004). Willingness-to-pay estimates and their relevance to agribusiness decision making. *Review of Agricultural Economics* 26(2): 152–169. https://www.doi.org/10.1111/j.1467-9353.2004.00168.x.

Lusk, J.L., Shogren, J.F. (2007). Experimental auctions: methods and applications in economic and marketing research. Cambridge University Press.

Maredia, MK, Bartle, B. (2022) Excess demand amid quality misperceptions: the case for low-cost seed quality signalling strategies, *European Review of Agricultural Economics*, 50(2): 360–394, https://doi.org/10.1093/erae/jbac019

Maredia, MK, Shupp, R, Opoku, E, Mishili, F., Reyes, B., Kusolwa, F.K., Kudra, A. (2019). Farmer perception and valuation of seed quality: Evidence from bean and cowpea seed auctions in Tanzania and Ghana. *Agricultural Economics*. 50(4): 495– 507. https://doi.org/10.1111/agec.12505

Mastenbroek, A., Sirutyte, I., Sparrow, R. (2021). Information barriers to adoption of agricultural technologies: willingness to pay for certified seed of an open pollinated maize variety in northern Uganda. *Journal of Agricultural Economics*, Vol. 72, No. 1, 2021, 180–201, https://www.doi.org/10.1111/1477-9552.12395

Morgan, S., Mason, N.M., Maredia, M.K. (2020). Lead-farmer extension and smallholder valuation of new agricultural technologies in Tanzania. *Food Policy* 97: 101955. https://doi.org/10.1016/j.foodpol.2020.101955.

O'Donnell, M., Evers, E.R.K. (2019). Preference reversals in willingness to pay and choice. *Journal of Consumer Research*, 45(6): 1315–1330, https://doi.org/10.1093/jcr/ucy052.

Ortega, D.L.., Wolf, C A., (2018). Demand for farm animal welfare and producer implications: Results from a field experiment in Michigan. *Food Policy*, 74: 74-81. https://doi.org/10.1016/j.foodpol.2017.11.006.

Rosh, S., Ortega, D. (2018). Willingness to contract versus opportunity to contract: a case study in Kenya's French bean export market. *Agricultural Economics*, 50:7-37.

Slovic, P. (1995). The construction of preference. American Psychologist 50(5): 364. 10.1037/0003-066X.50.5.364.

Thaler, R. H. (1999). Mental accounting matters. *Journal of Behavioral Decision Making* 12(3): 183–206.

Thaler, R. H., Shefrin, H. M. (1981). An economic theory of self-control. *Journal of Political Economy* 89(2): 392–406. https://www.doi.org/10.1086/260971.

Win, M.T., Maredia, M.K. & Boughton, D. (2023). Farmer demand for certified legume seeds and the viability of farmer seed enterprises: Evidence from Myanmar. *Food Security*. 15, 555–569. https://doi.org/10.1007/s12571-022-01338-0

Wooldridge, J. (2010). Econometric analysis of cross-section and panel data (2nd ed.). MIT Press.

Wooldridge, J. (2016). Introductory econometrics: a modern approach (6th ed.). Cengage Learning.

Yue, C., Zhao, S., Gallardo, K., McCracken, V., Luby, J. and McFerson, J. (2017). U.S. growers' willingness to pay for improvement in rosaceous fruit traits. *Agricultural and Resource Economics Review* 46(1): 103–122. https://www.doi.rog/10.1017/age.2016.31.

Zapata, S. D. and Carpio, C. E. (2014). The theoretical structure of producer willingness to pay estimates. *Agricultural Economics* 45(5): 613–623. https://www.doi.org/10.1111/agec.12110.

# Appendix

## A.1 Pictures of Bean and Maize Seed Samples

Figure 2 below shows the three bean seed packs that were used in the survey for respondents evaluate when giving their WTP.

**Figure 2: Bean Seed Packs used in Experiment**


Figure 3 below shows the three maize seed packs that were used in the survey for respondents evaluate when giving their WTP.

**Figure 3: Maize Seed Packs used in Experiment**

## A.2 Scripts

### Beans

**Round 1:** respondents observe the seed packs, as shown in A1.

**Round 2:** ***Enumerator read:*** Iron deficiency is a severe public health issue in Zimbabwe as approximately 7 out of 10 children and 6 out of 10 women of reproductive age suffer from iron deficiency. Iron deficiency can impair the mental development and learning capacity of children, increase weakness and fatigue, and increases the risk of childbirth complications for the baby and mother. Further, zinc deficiency is also a severe public health concern in Zimbabwe as 1 in 2 individuals are at risk of inadequate zinc intake. Zinc deficiency can impair proper physical growth which can lead to stunting, impair cognitive development, and can cause a weak immune system. Consuming iron and zinc enriched beans can contribute a higher amount of daily iron and zinc needs compared to consuming beans not enriched with these nutrients.

**Round 3:** ***Enumerator read:*** Researchers in Zimbabwe have evaluated the cooking quality of NUA45 beans, the same as the variety presented to you here today. They have found that NUA45 produces a thick soup and the seed swells almost twice their size when cooked. The cooking time for NUA45 grain to become tender, is a little over 1 hour. Compared to other bean varieties, more consumers rated the taste of NUA45 beans as excellent.

### Maize

**Round 1:** respondents observe the seed packs, as shown in A1.

**Round 2:** ***Enumerator read:*** Vitamin A is a severe public health issue in Zimbabwe as approximately 1 in 5 children and 1 in 4 women of reproductive age suffer from vitamin A deficiency. Vitamin A deficiency can lead to blindness, inflamed skin, infertility, delayed growth and development issues. Consuming vitamin A maize can contribute up to 50% of daily vitamin A needs when processed and cooked in typical Zimbabwean styles.

**Round 3:** ***Enumerator read:*** In a recent study conducted in Southern Africa, consumers evaluated the taste of VAM compared to white maize, similar to the varieties presented to you here today. Nine out of ten individuals liked the taste of vitamin A *sadza* just as much as they liked *sadza* prepared with white maize.