FARMER VALUATION OF SEED QUALITY: A COMPARATIVE ANALYSIS OF TWO PREFERENCE ELICITATION METHODS IN NICARAGUA

By

Sean Posey

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ABSTRACT

FARMER VALUATION OF SEED QUALITY: A COMPARATIVE ANALYSIS OF TWO PREFERENCE ELICITATION METHODS IN NICARAGUA

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To understand farmers' access to and knowledge of quality seeds in Nicaragua, I surveyed 242 bean producing households in the northwestern region of Nicaragua. The majority of farmers stated that they had heard of or had knowledge of certified seed, which is considered the highest quality seed potentially available to farmers. Despite this knowledge of higher quality seeds, 56% of households stated they had never purchased seed. In this study, I evaluate two non-hypothetical preference elicitation methods to estimate farmers' willingness to pay for quality seeds: a Becker-DeGroot-Marschak (BDM) auction and a Real Choice Experiment (RCE). The BDM auction and RCE were conducted after farmers examined the experimental plots on which three types of quality bean seeds of the same variety were planted—certified seeds, quality declared seed, and recycled grain. These were blind experiments and farmers were unaware of the quality types beyond what they observed in the experimental plots. The results of the BDM auction show that farmers are willing to pay a premium of C$5/lb (US$0.16/lb) for the plot planted with their highest rated seed compared to the plot planted with lowest rated seed. In the RCE, the average premium farmers are willing to pay for the highest rated seed was C$30/lb (US$1 /lb). The average premium farmers were willing to pay for the lowest rated seed was C$-9.16/lb (US$-0.31/lb) and was statistically different from C$0, which is not consistent with the BDM results. Potential reasons for the discrepancies in the results of the two methods are discussed.

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KEY TO ABBREVIATIONS

BDM – Becker- DeGroot- Marschak

C$ - Nicaraguan Cordoba (C$30 = USD$1)

CIAT – International Center for Tropical Agriculture

CSB – Community Seed Banks

DGS – General Directorate of Seeds

HH - Household

INTA – Nicaraguan National Institute of Agriculture Technology

KM - Kilometers

MAGFOR – Ministry of Agriculture and Forestry

QDS – Quality Declared Seed

RCE – Real Choice Experiment

RPL – Random Parameter Logit

WTA – Willingness To Accept

WTP – Willingness To Pay

1. Introduction

1.1 Problem Statement and Research Focus

As populations in developing countries have increased, so has the need to intensify food production to meet the growing demand. Improving the quality of seeds and the frequency at which farmers purchase these seeds can help farmers intensify production without the need to learn a new technology. Farmers in developing countries obtain seeds from both the formal seed system and the informal seed system. The formal seed system is defined by a vertically organized production of different generation of seeds, and distribution of commercial seed using a strict level of quality control (Douglas, 1980). The informal seed system, which is the most common source of seed in developing countries, consists of farmer-produced grain exchanged between farmers and recycled as seed or purchased from grain traders and vendors in the market for the purpose of planting it as seed.

The formal seed system aims to produce high quality seeds of improved varieties. High quality seeds are characterized by higher germination rate, higher purity, and higher resistance to pest and diseases, which leads to higher yields. This is achieved by training seed producers in the proper agronomic practices, crop maintenance, and seed storing techniques to reduce diseases, and increase purity and germination rates. But this also increases the cost of seed produced by the formal system relative to the grain price. Thus, farmers mostly obtain seed from the informal seed system where the price differential between seed and grain is close to zero.

Reusing grain as seed leads to lower yields as the quality of the seed declines after each harvest. Crops may intermix with seed of other varieties leading to deterioration of the original varietal traits as well as loss of germination potential from improper storage practices. The purchase of new seed of a given variety from the formal system as a replacement of recycled grain of the same variety can be seen as a technology adoption behavior. The decision to purchase new seed is based on the expected utility of profits and the deterioration in the production potential of the recycled seed from the farmer's harvested grain (Heisey and Brennan 1991). Theoretically, farmers will purchase new seed when expected profits are higher than the recycled seed for a given time period. Quality seeds have a significantly lower adoption rate than similar technologies like improved variety due largely to the competition of grain being used as seed. Self-pollinated crops, such as legumes, are at lower risk of losing the genetic traits of improved varieties (Rubyogo 2007). This is because self-pollination does not allow for cross breeding from other varieties and thus has low risk of genetic deterioration. However, legume crops are still susceptible to reduced germination potential caused by improper post-harvest handling and storage, and are more prone to seed borne diseases. These deteriorations increase the need for replenishing the seed stock with new seeds to restore yield potential for smallholder farmers.

The informal seed sector is estimated to supply more than 90% of all the legume seeds planted by farmers in developing countries (Rubyogo 2007). With such high use of seeds from the informal seed sector, the need to increase the quality of seeds used by farmers is very high. A major factor in increasing the overall quality of seeds is increasing the volume and frequency of quality seed purchased by farmers through the formal seed sector. Two significant problems with formal seed systems in developing countries are unreliable and inconsistent quality seeds and high prices, making the risk of purchasing new seeds too high for many farmers. Individuals are unable to observe the quality of seeds before planting. Therefore, a third-party certification is needed to create standard practices across seed producers to ensure more consistent quality and create trust between producers. A trusted third-party certifier could reduce the risk of purchasing new seed. There is a large disconnect between the demand and supply of quality seeds in developing countries. This disconnect is caused by many factors, including farmers' lack of information on quality seeds, unknown demand for quality seeds making larger quantity production too risky, lack of trust in quality seeds, and other problems of asymmetric information. These disconnections and market failure lead to high prices and higher risk of adoption of quality seeds. Market studies to measure farmers' willingness to pay (WTP) for higher quality seeds can help better understand how consumers value different products and make decisions. Such information can in turn help producers make production decisions and in setting a product's price. However, the method used to elicit WTP can impact results, especially in a developing country context, and may lead to vastly different estimates of WTP.

This research was undertaken to highlight the potential issues of implementing WTP studies in a developing country context by comparing two methods of eliciting Nicaraguan farmers' WTP for three different qualities of seed of a red bean variety. Farmers in this study state their WTP for three different qualities of seed based on three experimental plots grown in each village. The plots were labeled with the shapes Square (QDS), Triangle (recycled grain), and Circle (certified). Therefore, Farmers are unaware of the names of the three qualities and the variety used. The two preference elicitation methods compared and evaluated are: the Becker-DeGroot-Marschak (BDM) auction and the Real Choice Experiment (RCE). Theoretically both methods will result in equal or statistically equivalent results. Many studies focus on between individual comparison of methods, however I conduct a within individual comparison to directly compare the impact of method on estimated WTP. I briefly discuss the bean seed system in Nicaragua and describe the three seed quality types evaluated in this study, before I outline the research objectives and research questions addressed by this study.

1.2 Bean Seed System in Nicaragua

Dry beans are the second most important crop after maize in Nicaragua. Dry bean was the primary crop on 24 % of the average 1 million hectares planted annually from 2000 to 2016 in Nicaragua. This makes dry bean the second largest crop in Nicaragua behind maize (34%) in terms of area planted (FAOSTAT, 2018). Increasing bean yields for farmers therefore has the potential to increase a substantial portion of smallholder farmers' incomes. Improving the quality of seeds that farmers plant can raise yields, reduce the impact of pests, and potentially increase profits. Yet many farmers do not have access or knowledge of the quality of seeds available due to incomplete or nonexistent seed markets. At the same time, many seed producers are not aware of farmers' willingness to pay for higher quality seeds leading to lower production of quality seeds and uncertainty in prices.

In this study, I estimate farmers' WTP for three types of seed quality products of the same variety (*INTA Ferroso*). The three seed quality types evaluated are recycled grain, Quality Declared Seed (QDS), and certified seed, and they represent the informal, semi-formal, and formal seed sector in Nicaragua, respectively. Recycled grain is produced by farmers with no technical supervision or quality assurance and is perceived to have the lowest quality and price. QDS and certified seeds are grown using agronomic and processing practices to ensure a higher quality seed. But only certified seed is certified by the government's seed certification agency (the Ministry of Agriculture and Forestry's General Directorate of Seeds (DGS)) and is perceived to have the highest quality and has the highest price. QDS seed (referred in Nicaragua as *Apta* seed) is mostly produced by village based farmer groups for use within the community.

To meet the quality standards, certified seed must be produced under the supervision of authorized experts to maintain high levels of seed health, vigor, and genetic purity (Bash, Bowman, Chapman, & Blandon, 2002). In Nicaragua all the seed that is imported or produced by seed companies is certified by the DGS. Certification is a guarantee by the Ministry of Agriculture of high germination, uniformity of genetics, and that seeds are free from seed-borne diseases. This is achieved through proper agronomics, inputs, and proper post-harvest processing and storage techniques. Farmers can purchase certified seeds from rural retailers. These rural retailers are small retail outlets in rural communities that sell production inputs such as fertilizer, pesticide, and seed. Their locations tend to be in close proximity to bus stations and markets. Rural retailers have a high marketing potential to small farmers through personal relationships, however they are often very small retailers with little or no access to credit. This greatly hinders the ability of small retailers to purchase and sell certified seeds. The lack of availability and access to certified seeds has resulted in many farmers not adopting this type of quality seed (MAGFOR 2009, Sain 2011, Carter el al. 2012).

To increase the use of higher quality seed, in recent years there has been increasing efforts by the government to promote Community Seed Banks (CSB) to produce *Apta* seed or QDS to meet the seed needs of the community. QDS are not certified by the Ministry of Agriculture and cannot be declared as such. The seeds are produced by farmers without the supervision from the Ministry of Agriculture, however the farmers have been given technical guidance and training from the National Institute of Agricultural Technology (INTA) to produce seeds of higher quality (DeYoung 2015). Since these seeds are produced within communities, the ability to reach many small farmers is significantly higher than certified seed. The use of CSBs allow communities to have access to higher quality seeds of varieties that grow best in their community.

Finally, most farmers in Nicaragua use their own saved seed, trade seed with other farmers, or purchase from the grain market. Trading of bean seed allows farmers more access to different quality and variety of seeds at price closer to grain price. Farmers often use their own harvest as seed for planting which causes the demand for fresh seed (which is produced as 'seed') to decrease. According to Wierema et. al (1993) 72% of bean farmers in Nicaragua used their own seed while in Costa Rica and Honduras 79% and 58% respectively of bean farmers used their own seed. There is also trade among other farmers to meet demand that farmers' own saved seed could not suffice (Tripp 1997, Bentley et al. 2011). This trading among farmers increases the use of different varieties, but often these seeds are of lower quality and the variety may be nonuniform or unknown. The use of low quality seed leads to lower yields and higher rates of fertilizer and other inputs to combat poor germination rates and to control for seed borne diseases.

Some of the constraints leading to low adoption of quality legume seeds in Nicaragua are: i.) low access, ii.) lack of knowledge on the benefits of higher quality seeds, and iii.) lower varietal deterioration of legume seeds because of self-pollination (Rubyogo 2007). On the supply side, the lack of availability of quality legume seed is the low perceived profitability of seed production. Public sector seed agencies are often characterized by large overhead costs and inefficiencies and lack the capacity to provide an oversight to the production of large quantity of quality seed. The informal seed system does not have the capacity to produce higher quality legume seeds.

As mentioned before, farmers base their seed input decisions based on perceived quality of the seed and the total price of obtaining that seed. Higher quality seeds are often indistinguishable from seeds of the same variety and lower quality. This creates an issue with asymmetric information that Nicaragua has attempted to reduce by certifying seeds that fit the requirements set by the Ministry of Agriculture. Farmers therefore must have experience with certified seed in order to assess its quality and production capabilities relative to their own saved seed. This introduces many constraints for farmers such as cash constraints and access constraints. Experimenting with certified seeds or QDS can be too risky for cash constraint farmers. Moreover, farmers may be unaware of the availability of these higher quality seeds. This lack of knowledge causes many farmers to never participate in the formal seed sector reducing the overall demand for quality seeds. These constraints on the demand side, in turn lead seed producers to be unaware of the potential demand for quality seeds. Thus, market research is needed to bridge this potential gap in demand and supply of quality seeds. Estimating the potential premium farmers are willing to pay for higher quality legume seeds (if available) is a first step in bridging this knowledge gap. The problem with asymmetric information in seed markets creates an opportunity for economists to conduct market research using preference elicitation methods to construct market demand curves. However, it is not certain that all preference elicitation methods are equivalent and provide same kind of information. This lack of certainty motivates this study which is designed to compare individual's stated WTP in the context of an experimental auction and a choice experiment.

This study took place in ten villages in four different departments located in the northwestern region of Nicaragua.[1] One farmer in each village was selected to grow three demonstration plots (one for each seed type) using their own crop management practices. The plots were established side by side to minimize any effects that soil quality would have on plant

[1] Originally, I had chosen 12 villages, however 2 villages were taken out due to late planting or destruction of fields by pests.

development. These were blind experiments, whereby the host farmer and the participating farmers were not told the quality type of the seed but only that the three seed types were of the same bean variety (the name of the variety was also not revealed). The seed and plots were labeled with symbols--□ (QDS), Δ (recycled grain), and ○ (certified seed) to prevent any ranking biases from preconceived perceptions that may influence the farmer's preference and WTP as well as the host farmer managing the three plots differently.

The research objective of this study is to show the impact a preference elicitation method can have on estimating an individual's WTP through a within individual comparison of a BDM mechanism and an RCE . Two methods compared are both non-hypothetical to reduce the impact of hypothetical bias that may not be consistent or have the same magnitude of impact on WTP estimate for both methods. By measuring within-individual differences in WTP I can reduce the impact that individual's personality traits (unobservable characteristics) have on choice and auction behavior and reduces selection bias. Furthermore, using the data from this study I can deduce whether farmers are willing to pay a premium for higher quality seed based on the actual performance of the seed giving seed producers vital market information for the demand of quality seed.

My thesis is organized as follow. In Chapter 2, I present a review of the literature followed by the conceptual framework in Chapter 3. In Chapter 4, I discuss the experimental design and the sources of the data. In Chapter 5, I discuss the sources and give descriptive statistics followed by the analysis of the experiment in Chapter 6. In Chapter 7, I discuss the experiment outcomes and possible shortcomings followed by my conclusions on major findings in Chapter 8.

2. Review of the Literature

2.1 Determinants of Willingness to Pay for Quality Seed

The push for agricultural development in many developing countries has come with the push for increasing technology adoption and intensifying production to raise productivity and profits. There are many studies on how farmers decide to adopt technology (Feder et al 1985; Munshi 2004; Conley and Udry, 2010),but only a few capture farmers WTP for new technology (Magnan et al., 2015).. Building on the agricultural technology adoption literature, I know that farmers experiment with new technology, and learn the optimum input bundles to maximize profits over time (Foster and Rosenzweig, 1995; Bardhan and Udry 1999). Therefore, farmers may "adopt" a technology before they know that it is more profitable. It is important to know how much a farmer is willing to pay for agricultural technology and what are the determinants of their willingness to pay to develop strategic policy for efficient technology adoption. Level and diversity of household's income has shown to have a positive impact on a household's willingness to pay (Fay and Deininger 2005, Holden and Shiferaw 2002). Specifically, nonfarm income has a positive effect on household's willingness to pay for agricultural technology as income from non-farm sources may reduce liquidity constraints to access inputs, labor and other materials needed to use a new technology (Pender and Kerr 1998; Hondel and Shiferaw 2002). Also, as farmer's income is diversified, it reduces the risk associated with adopting a new technology. Another factor that may influence farmers' adoption decision is their education level. A higher level of education is associated with improving farmer's ability to receive and process new information (Holden and Shiferaw 2002, Oladele 2008). Education may increase farmer's awareness of agricultural technology and the knowledge of the existence of new technology is paramount in a farmer's ability to adopt or their willingness to pay (Pender and

Kerr 1998). Other factors are age and family size. Age may have a mixed effect, as older farmers tend to have more experience, younger farmers have a longer planning horizon which may cause them to be more likely to adopt technology (Holden and Shiferaw 2002). Agricultural households have a labor endowment based on the size of their household meaning as more kids come to age there is more labor available within the household possibly increasing the likelihood of adopting labor intensive technologies. The expected determinant of farmers' willingness to pay for quality seeds would be education, age, knowledge of this technology, and income. Household size should not factor into the adoption of quality seed as the labor requirements are equivalent with recycled grain. However, in reality farmers may equate quality seed with a new variety (i.e., genetics), and turn from buying them because of additional labor and cash investments needed to realize the full benefits of new seed variety.

2.2 Comparison of Preference Elicitation Methods

There are many preference elicitation methods to measure individuals' willingness to pay for a product or service, such as experimental auctions, choice experiments, or contingent valuations. Seed market data in developing countries are often unavailable for the seed producers or economists to analyze. Preference elicitation methods are growing in popularity for estimating preferences for goods with unknown market value such as environmental quality or for market goods such as improved qualities of food. For both choice experiments and experimental auctions there is evidence supporting the validity of each method (Brookshire, Coursey, and Schulze, 1987; Louviere, Hensher, and Swait,2000). However, there are very few studies comparing the two types of methods (e.g., Lusk and Schroeder 2006, Ginon et al. 2011, Stuer et. al. 2017) and even fewer comparing them in a developing country setting (e.g, DeGroote et al. 2010). Determining whether there are differences in preference elicitation methods and understanding why there may be differences is important not only for methodological advancement and accurate interpretation of results; it is important to know what is causing the differences and understanding individual's behaviors when incentivizing accurate stated WTP. Each preference method estimates individual preferences in a different way. For example, in a BDM mechanism, individuals state their willingness to pay for a product. Then a random price is drawn, and the individual pays the random price if their willingness to pay is above that random price. However, in a choice experiment, individuals make choices through a number of different scenarios. In choice experiment, the experimenter must also put a functional form on the individual's unknown utility function and for the stochastic nature of random utility. Therefore, any differences in stated WTP between methods may be contributed in part to the functional form the researcher uses to estimate an individual's utility function. In theory, both choice experiments and experimental auctions should yield insightful results on individual's willingness to pay and lead to equivalent conclusions. However, in practice it has proven much more difficult to replicate those results (Lusk and Schroeder 2006, Ginon et al. 2011, Stuer et al. 2017) and understanding why that may be the case can lead to more precise designs of both experimental auctions and choice experiments.

There have been very few papers that measure the differences in estimation of individual willingness to pay gathered by different elicitation methods. Lusk and Schroeder (2006) were among the first to do so when they compared individual's willingness to pay for quality of beef steaks using an auction and a real choice experiment in the United States. They concluded that auction behavior was significantly different than choice behavior (willingness to pay in choice experiment were significantly higher than in auctions), and auction bids predicted a higher frequency of opt-out choices than what occurred. They state that there are two possible conclusions--either one or both mechanisms are not incentive compatible, and/or preferences are different *a priori* or constructed differently in the two mechanisms. Lusk and Schroeder suggest that in auctions, individuals may have a non-expected utility function (Horowitz 2005), or that in a BDM mechanism the risk of deviation from a utility maximizing bid is much too weak to reinforce the optimal strategy (Harrison 1989; Lusk, Alexander, and Rousu 2006.) They also argue that since individuals state WTP directly in dollar amounts for auctions (dollar-space) and in choice experiments individuals choose between a number of different options in a set of choice tasks (choice-space), which options they would prefer to purchase may drive the differences between elicited WTP.

Lusk and Schroeder used a between-individuals approach, however Ginon et. al (2014) used a within-individual willingness to pay for French baguettes allowing them to investigate individual-level behaviors using a real choice experiment and a BDM mechanism. They found that WTP were not equivalent between methods but were also not consistent with their reservation prices. They hypothesize that individuals do not have consistent preferences and may have a different preference structure in different settings.

2.3 Preference Elicitation Method Comparison in Developing Countries

The studies mentioned above (i.e., Lusk and Schroeder 2006, Ginon et. al 2014) were conducted in developed countries. As explained before, individuals in developing countries face different constraints than in developed countries. Therefore, these studies may not have external validity outside of developed countries. DeGroote et. al. (2010) compared a BDM mechanism, kth price auction, and a choice experiment to elicit farmers' WTP for different color maize-based food product *kenkey* with and without biofortification information in Ghana. They found that the WTP elicited from choice experiment were comparable to stated WTP from auctions. They found this by accounting for lexicographic preferences and censoring bids for both auctions. Villages had higher premiums for *kenkey* that was the same color that they also grew and had much lower WTP for other colors. Farmers that were told of the health benefits of beta carotene enriched maize increased their WTP in all methods. This shows that preference ranking may be similar across methods but may not be similar in magnitude.

Hans De Steur et al. (2017) did a meta-regression on the determinants of willingness to pay for biofortified crops and food. His independent variables were types of respondents (student or adult), method of data collection, whether the WTP was hypothetical or non-hypothetical, method of value elicitation, study environment, participation fee, and if information was given or not, and the type of information. This study found that the type of information, nature of method used (i.e., hypothetical or non-hypothetical), and the method of value elicitation had a statistically significant impact on individuals' reported WTP for biofortified products. However, WTP for stated value-elicitation methods were not significantly different from revealed methods. The study's conclusion was that the impact of the nature of the study (hypothetical or non-hypothetical) had a much larger impact on the estimated WTP than the method used.

This current research builds on the recent trend found in the literature of comparing preference elicitation methods by focusing on two mechanisms--BDM and real choice experiment. The research aims to contribute to our understanding of what factors could possibly explain any observed difference in individual's WTP when making that decision in an auction versus a choice experiment. Specifically, this study will examine differences in stated WTP for quality seeds from two commonly used methods--a non-hypothetical BDM mechanism and a non-hypothetical or real choice experiment. By comparing two non-hypothetical elicitation methods I can rule out the impact of hypothetical bias and focus on the behavior of the individual under two different methods. The perceived quality of seed will be determined individually by the farmer through double-blind experimental plots and therefore the WTP should not be influenced by a priori knowledge or personal experiences with the seeds used in the experimental plots. This also provides a unique opportunity to compare two methods of individual WTP for three non-branded attribute bundles, which is novel and a contribution to the literature.

3. Conceptual Framework

3.1 Technology Adoption Decision Framework

Smallholder farmers in developing countries face many constraints that are (just like the farmers) heterogenous. These constraints are not always observed by the researcher, but influence farmers' technology adoption decisions and production outcomes. The use of quality seed can be viewed as a technology adoption decision that farmers make each planting season. This means that farmers make the decision to use quality seeds each planting season based on whether it maximizes either utility or profitability depending on the characteristics of that farmer and the constraints that farmer faces.

Agricultural households are both producers and consumers and their consumption are dependent on their production (Singh, Squire, Strauss 1986). The production decisions can be made independent of consumption (referred as separable household model) or production and consumption decisions are made simultaneously (referred as non-separable household model). In sectors where two or more input markets (often labor and land) are incomplete or missing, farmers are suspected of making production and consumption decision simultaneously (i.e., non-separable household model assumption). Farmers in a non-separable household are utility maximizers and do not behave as profit maximizing producers. This can be seen by the decision of farmers to produce local varieties for personal consumption even though it may not be profitable to do so.

In the context of technology adoption decision-making, there are usually two types of farmers--risk averse and risk neutral. Risk averse individuals maximize expected utility of profit.

Therefore, farmers may not choose the bundle of inputs that maximize profits but maximize their utility of the expected profits (Cameron, 1999), which can be expressed as:

$$E(U(\pi|New\ Technology)) > E(U(\pi|Without\ Technology))$$

Risk neutral individuals maximize profit and choose the bundle of inputs that maximize their profit as expressed by,

$$E(\pi|New\ Technology) > E(\pi|Without\ Technology)$$

Farmers' understanding of expected profits is driven by farmers' experience or prior knowledge of a given technology (i.e., quality seed in the context of this study). The main factors influencing adoption decisions by farmers are profitability, access, and knowledge of the new technology. If the price of the new technology is such that farmers cannot make a profit, or the risk is too high than they do not experiment, and adoption and diffusion will suffer. Market studies help understand what price farmers are willing to pay for this added risk, and potential increase in yields. It is important to know how farmers behave in higher risk environments than in a relatively low risk environment such as a hypothetical experiment. This may influence their WTP estimates or may not capture their true behavior. This study focuses only on non-hypothetical experiments to reduce any hypothetical bias and create a more realistic purchasing scenario. I first discuss the theory underlying the WTP elicitation methodology, followed by the conceptual underpinning of the two elicitation mechanisms used in this study—choice experiments and BDM auctions.

3.2 Theory of Demand

The Lancaster theory of demand states that the intrinsic properties of a good define that good. This means that the utility an individual derives from a good is from the attributes contained within that good. Lancaster (1966) put forth an approach that suggested that consumers derive utility from the properties of the good and not the good itself. This allows for the demand of a good to be divided into many attributes of that good, and an individual's utility is a function of those attributes. Individuals will choose the attribute bundle that maximizes his or her utility function. For example, an individual may prefer the color black versus pink. Therefore, it would be assumed that, all else equal, this individual will derive more utility from a black car as opposed to a pink car. From this theory, I am able to base the design of our preference elicitation methods to establish WTP for three seed products that differ in two attributes—quality and price.

3.3 Choice Experiment

Choice Experiments are growing in popularity as a tool to estimate individual's willingness to pay for marginal changes in attributes, measuring unknown market values, or estimating individual preference. Choice experiments are designed to replicate a purchasing scenario where individuals most commonly make their purchases. In choice experiments the researcher relies on the repeated choices to distinguish preference ranking and measure marginal utility. Through repeated responses to presented choice situations and using Lancaster's theory of demand, economists can estimate individuals' preferences by marginally varying the attribute bundle. There are many models that are used to estimate individual preferences that account for the heterogeneity in individual taste. The mixed logit model assumes a continuous distribution of heterogeneity in taste. Mixed logit assumes that individuals are inherently heterogenous in nature, therefore their tastes and preferences are heterogeneous. Choice models allow the researcher to estimate marginal values for different attributes encompassed in several goods and services. Furthermore, choice modeling allows for estimations of welfare effects with marginal changes in attributes (Colombo, Hanley, & Louviere, 2009). Choice experiments have been used widely in the agricultural and environmental economics literature for studying consumer preferences for environmental amenities (List et al.,2006), food safety attributes and food certification (Olesen et al., 2010; Lusk et al., 2004), and measuring farmers WTP for new technology (Ward et al., 2014; Magnan et al., 2015).

In this study, a choice experiment is used to elicit farmers' willingness to pay (WTP) for three different qualities of a red bean seed, *Inta Ferosso*. Choice experiments are most often used in the context of consumer theory, but few studies have used choice experiments to analyze producer welfare effects and technology adoption (Ward et al. 2014). In this study I used the theory presented by Singh, Squire and Strauss (1986) in which producers that are risk adverse make input choices that maximize their utility. However, if farmers are not risk averse, then maximizing utility will be equivalent to maximizing profits. Therefore, a choice experiment should theoretically measure farmers' WTP for inputs based on utility maximization in both risk averse and risk neutral farmers. Also, as mentioned before agricultural households that face more than one missing market are non-separable meaning production decisions and consumption decisions are made simultaneously, I thus view the adoption of quality seeds as a utility maximizing decision. The reasoning for this is that non-separable agricultural households maximize utility of farm production by choosing a set of technology attributes or inputs among a set of obtainable attributes or inputs (Useche, Barhma, and Foltz,2012).

According to Random Utility Theory an individual i faces N alternatives within a choice set A during occasion *t.* Following the approach used in Ward et al. (2014), I then assume individuals have an attribute bundle that maximizes their utility based on Lancaster's theory of demand. This attribute bundle will be represented by V_{imt}^* that denotes the value function associated with individual *i* choosing option $m \in A$ during occasion *t.* An individual, *i*, facing a fixed budget constraint will choose alternative *m* so long as $\mathrm{V}_{imt}^* > V_{int}^* \; \forall n \neq m$. The researcher cannot directly observe V_{imt}^*, but instead observes V_{imt}, through the choices the individual makes such that:

$$V_{imt} = \begin{cases} 1 & if \; \mathrm{V}_{imt}^* = \max(\mathrm{V}_{i1t}^*, V_{i2t}^*, \mathrm{V}_{i3t}^* \ldots., \mathrm{V}_{int}^*) \\ 0 & Otherwise \end{cases} \tag{1}$$

Where V_{imt} is the option individual i is choosing with attribute bundle m from the choice task t. Using the assumption that indirect utility is linear, I can write individual *i*'s indirect utility function as:

$$\mathrm{V}_{imt}^* = X_{imt}'\beta + \delta_{imt} \tag{2}$$

where X_{imt}' is a vector of attributes for the *m*th alternative, β is a vector of taste parameters, and δ_{imt} is a stochastic component of utility that is independently and identically distributed across individuals and alternative choices, and follows a Gumbel (extreme value type I) distribution with a cumulative distribution function $F(\delta_{imt}) = \exp[-\,exp(-\delta_{imt})]$ and a probability density function $f(\delta_{imt}) = \exp[-\delta_{imt} - \exp(-\delta_{imt})]$.

The probability of observing $V_{imt} = 1$ (i.e the farmer chooses option *m* in choice task *t*) can be written as:

$$Prob(V_{imt} = 1) = Prob(X_{imt}'\beta + \delta_{imt} > X_{int}'\beta + \delta_{int}) \forall N \in A, \forall n \neq m \tag{3}$$

$Prob(V_{imt} = 1) = Prob(\delta_{int} < X'_{imt}\beta + \delta_{imt} > X'_{int}\beta)\forall N \in A, \forall n \neq m(4)$

Then with the assumption made previously that the δ_{imt} is identically and independently distributed, the expression for the probability of observing $V_{imt} = 1$ can be rewritten as:

$$Prob(V_{imt} = 1|X'_{i1t}, X'_{i2t}, \ldots, X'_{int}, \beta) = \frac{\exp[X'_{imt}]}{\sum_{n=1}^{N} \exp[X'_{int}\beta]} \quad (5)$$

Which is the basic conditional logit model which I can estimate using maximum likelihood.

Since farmers are heterogeneous, their preferences are heterogeneous in nature. A mixed logit model accounts for continuous heterogeneity among individuals and approximates any random utility model and relaxes the limitations of the traditional multinomial logit by allowing the taste parameters to vary by individual within a sample according to a pre-specified distribution (McFadden and Train, 2000) which is the random parameters logit (RPL). Train (2003) states that the probability that individual *i* chooses alternative *m* from the choice set A in time or task *t* is given by the RPL:

$$Prob(V_{imt} = 1|X'_{i1t}, X'_{i2t}, \ldots, X'_{int}, \Phi) = \int \frac{\exp[X'_{imt}\beta_i]}{\sum_{n=1}^{N} \exp[X'_{int}\beta_i]} f(\beta|\Phi) d\beta \quad (7)$$

Where the vector Φ defines the distribution of the random parameters as pre-specified by the researcher.

I used the RPL with an error component with utilities specified in WTP-space. The RPL is designed to account for continuous heterogeneity in the error component, which accounts for systematic differences between the experimentally designed alternatives and the status-quo option, beyond what is explained by the attributes (Scarpa et al. 2005). Therefore, the utility that individual i derives from choosing option m in t choice tasks can be specified as the following:

$$U_{imt} = \theta_i(-Price_{imt} + \beta_{ij}Attribute_j + ASC + \gamma_{imt}) + \delta_{imt} \quad (8)$$

Where θ_i is a random positive scalar representing the price/scale parameter. β_{ij} is a vector of random parameters that are normally distributed as defined by the researcher and measures individual WTP. ASC is the alternative specific constant "no purchase" or "opt-out" option in each choice task. γ_{imt} is the normally distributed error component.

3.4 Becker-DeGroot-Marschak (BDM) Auction Experiments

The BDM mechanism was first introduced by Becker, DeGroot, and Marschak (1964). This mechanism is designed to obtain individuals' reservation price or willingness to pay for an item. This is obtained by creating a utility optimizing strategy that incentivizes an individual to state their WTP. The theory states that individuals have a monetary equivalent for any good which is when U(M)=U(G) or utility of the monetary equivalent (M) is equal to the utility of that good (G). This can be interpreted as how much money they are willing to forego or accept to obtain or sell a good. Individuals bid against a random price, and if their bid is greater than or equal to the random price they receive the good at the random price. If their bid is less than the random price they do not purchase the good. This creates two outcomes:

Outcome 1: $R \leq B = U(Y - R + M)$ (9)

Outcome 2: $R > B = U(Y)$

Where R is the random price, B is the bid, M is the monetary equivalent of the good, and Y is the participation allowance. However, with these two outcomes the optimal strategy for a participant is to bid where $B = M$. This will ensure that no matter R, the individual will never receive a utility where $R > M$. If $R > M$ than $U(Y - R + M) < U(Y)$ and the individual is worse off from winning. This can also be seen by the expected utility

$$EU = \int_0^{\boldsymbol{B}} p(R)U(Y + M - B) + \int_B^{Max} p(R)U(Y) \tag{11}$$

Equation 11 shows the importance of the distribution of the random price R. if R is not uniformly distributed then the optimal strategy is no longer B=M, but instead it is to maximize utility based on the $p(R < M)$. However, if $p(R < M) = p(R \geq M)$ the utility maximizing strategy breaks down into $B = M$. The distribution of the random price is known in advance by the participant and they are asked to state their maximum WTP or willingness to accept (WTA) for each item. It is assumed that this procedure is incentive compatible (since deviating from optimal strategy can potentially lead to lower utility than a non-purchase). However, Horowitz (2005) shows that theoretically, since individuals face uncertainty of price, if they experience a non-expected utility function (such as disappointment aversion) individuals will not state their true WTP for that good, but instead it will be utility derived from attributes not associated with that good. Mazar et al. (2014) found that in within-individual study, when using two different random price distributions, the differences between the two bids were not significantly different, and that individuals may make mistakes when reporting true WTP when considering only one price distribution. Plott and Zeiler (2005) showed that under certain controls the WTP-WTA gap can be diminished or completely removed. This shows that the individuals' knowledge of the optimal strategy is needed to extract more accurate WTP and possibly negate Horowitz's non-expected utility function.

3.5 Comparison of Two Methods

Since choice models are discrete and auctions are continuous, one of the two methods must be transformed to compare stated WTP in both methods. I chose to follow Train's (2011, 259-281) formula to estimate individual level parameters in WTP space. This uses the nature of the repeated choice aspect of choice experiments to obtain WTP conditional on an individual's choices in the choice set. Theoretically the individual's conditional WTP parameters should be statistically similar to the stated WTP in the BDM mechanism. To test this, I will use an individual fixed effects model with bootstrapped standard errors clustered at the village to test whether the WTP stated in both methods are equivalent as suggested by theory. I assume that individual's underlying utility function does not change between methods and is constant across the two methods. This assumption is based on Lancaster's theory of demand which states that individuals purchase attribute bundles that maximize their utility.

4. Methods and Data

4.1 Study Site and Field Experiments

This study took place in four Departments--Jinotega, Esteli, Matagalpa, and Madriz located in the northwest region of Nicaragua, where beans are an important crop (Figure 4.1). A total of 12 villages were selected based on whether they were average bean producing villages for that region and were served by a technician from INTA.

Figure 4.1 Map of Nicaragua

*Red circle is the location of our experiment

Source: https://geology.com/world/nicaragua-satellite-image.shtml

As noted before, this study is designed to elicit individual farmers' WTP for quality seed based on the performance or perceived quality of three different seed types. To ensure that farmer's WTP for different seed types can be attributed to the performance of the seeds and not biased by his/her previous experiences with quality seeds, it was vital to not reveal the identity of seed types. Towards this goal, double-blind field experiments were set up in each village. One farmer from each selected village was chosen with the help of staff from INTA and CIAT to host the field experiments. The host farmers were selected mostly for their status as a village leader and their bean growing experience. Their relationship with the rest of the community helped increase farmers' awareness of and participation in the field day events.

The host farmers volunteered to grow the experimental plots during the *Primera* season (May-August 2017) using their own bean growing practices. Host farmers were asked to set aside a part of their field to grow three types of bean seeds of the same variety in adjacent plots. Farmers were able to keep the harvested grain after the end of the experiment, which incentivized the farmers to maintain the plots as he or she would maintain their own.

Fligner and Verducci (2012) show that in blind experiments individuals chose items labeled 'A' above other options more often. To avoid such bias in ordering, the seeds given to host farmers and the plots on which they were planted were identified by symbols of square (for QDS), triangle (for recycled seed), and circle (for certified seed) (see Figure 4.2).

Figure 4.2 Demonstration Plots

1. Triangle Plot	2. Square Plot.	3. Circle Plot.
		

Source: Pictures taken by Researcher

The field experiments were designed to observe the performance of each seed quality type (i.e., certified, QDS, and recycled) while controlling for genetics (all seeds were of the same variety), soil quality (all the plots were grown in adjacent plots to reduce the effect of soil quality and characteristics), and farmers' management practices of the plots (the blind nature of the experiment reduced the incentive for farmers to systematically favor one plot over another). Bean growing farmers from the community were invited to participate in two field days organized around flowering and close to harvesting stages. This allowed participating farmers to observe the performance of each quality seed in terms of plant characteristics during the flowering stage (field day 1) and potential yield at maturity (field day 2).

Research assistants from CIAT worked with the farmers to ensure that the plots were labeled correctly in each village and that farmers did not know the identity of the seed quality type. The experimental plots served as a direct comparison of performance of seed quality to conduct auction experiments and elicit individual farmer's WTP for each seed type planted on plots represented by symbols of square, triangle and circle. The preference elicitation methods used were an incentivized non-hypothetical BDM mechanism and an RCE (explained in later sections).

4.2 Source of the Three Seed Types Used in the Experiment

Certified Seed: This seed was purchased from a government organization that is licensed to sell certified seed. This seed is grown by certified seed producers under a contract with the government organization. These seeds are considered to be the highest quality of seed available to farmers and is the most expensive of the three seed types used in this experiment. Only government agencies can certify seeds after the seed is determined to meet the quality standards. Certified seed is grown from registered seed maintained by the research program to reduce deterioration of genetic traits and is stored in a way to reduce seed borne diseases and to maintain seed germination rates. The certified seed used in this study was produced in *Postrera* season (October-December 2016) and represents first generation seed after registered seed.

Apta seed (QDS): This type of seed was purchased from a CSB and is not regulated by any third-party agency. QDS is often grown by farmers who are associated with the CSB and trained by INTA seed producers. The quality of seeds may vary from CSB to CSB. They are not required to be grown from registered or certified seed, but are produced, processed and stored using similar practices as certified seed. This seed type is supposedly of higher quality than recycled grain. It is sold at a price higher than grain but lower than certified seed. The Apta seed used in this study was produced in Postrera season (October-December 2016) and represents first generation seed as it was also produced from registered seed.

Recycled seed: In principle, recycled seed is the farmer's saved seed that they replant from past harvests. This seed is not grown to any specifications and is often considered of low quality and of unknown genetic identity. However, recycled seed is the lowest cost seed as it is produced as grain rather than seed. To ensure that the variety was uniform across all three seed types, it was not possible to procure this seed type from farmers. The recycled seed used in this study was purchased from the same CSB that produced the QDS. It was also produced in Postrera season (October-December 2016), but represents second generation seed after registered seed (or one generation older than the QDS and certified seed used in this study).

The seeds used in this study are a small sample of the overall seed system and therefore it cannot be assumed that the performance of these seeds in our experimental plots are representative of the seeds available to farmers in Nicaragua. In particular, the recycled seed used in this study was produced by a seed producing organization and not a farmer, and represents just a second generation seed. Due to both these characteristics, the recycled seed may not be representative of the quality of 'recycled' seed that farmers usually plant. Since these seeds are not meant to represent the seed system, I refer to them as seed 1 (Certified seed), seed 2 (QDS), and seed 3 (recycled) in the remainder of this paper. Since all three of these seeds were of the same variety any differences in the performance of the seeds will be due to the quality of the seed and not the genetics. What I am interested in this study is how the observed performance of seeds of three different qualities planted in the field experiments is perceived by the farmers, and how that perception of quality is reflected in their WTP for each seed type.

4.3 Field Days and Farmer Ranking of Seed Plots

Two field days were organized in 10 out of the original 12 villages. Two villages were dropped either because farmers planted the plots too late or the crop was destroyed due to pest problem. During field day 1, farmers from the village met either at the experimental plots or at the farmer's house where they were informed about the purpose of the meeting. Each village chose three attributes to rank the performance of the three plots on an evaluation sheet given to each farmer with their ID number (Appendix 1). These attributes varied across villages, but most common attributes were plant growth, resistance to diseases, resistance to too much rain (as Nicaragua was experiencing a more than usual level of precipitation that year), and amount of foliage. After they chose the three attributes to judge the plots, they were asked to pick the plot that was the best in each category and then chose overall best and worst plot. The first field day was conducted on average 32 days after planting, which corresponded to just before the flowering stage. Farmers were able to see the differences in the germination rates, development of the plants, and the foliage. This ranking mechanism captures which field farmers perceived to be the best and worst, but not the magnitude of differences.

The second field day took place just before maturity when the bean pods had formed fully on the bean plants but had not fully dried out for harvest. Farmers could see the number of pods each plant produced and the relative density of pods between plots Farmers were asked to complete the evaluation sheet that asked them to rank the plots on different characteristics, and an overall best and worst plot (Appendix 2).

4.4 WTP Elicitation Experiments

Following the field observation and ranking of the three plots on the second field day, individual farmers then participated in two elicitation experiments--BDM mechanism and RCE. The experiments were facilitated by a research team member who was a native Spanish speaker. The script followed to explain the experiments and how the mechanisms work in included in Appendix 3. The BDM mechanism was always first to prevent price anchoring from the real choice experiment. The RCE was not a full orthogonal design so not all possible combinations of prices and seeds were present. This may create a bias that one seed is more preferred than another if that seed comes up more often under a higher price. Therefore, to not bias individual's bid levels and preference ranking in BDM the RCE was always implemented second. This may create a fatigue bias in the RCE results. However, this was considered to be less of a problem. By giving individuals both a choice experiment and a BDM mechanism I can compare within individual WTP estimated by both models.

BDM experiments: Farmers were given C$40 or an item of similar value to participate in both the BDM mechanism and the real choice experiment. This amount represented about 18% more than the market price of one pound of certified seed, which was the highest cost seed type among the three types used in the experiment. Farmers were told that at the end one of these exercises will be selected randomly, and one seed type (if BDM was selected) or choice set (if RCE was selected) will be chosen as binding to determine whether and which seed type the farmer would end up purchasing. Thus, for each bid (in BDM) or choice set (in RCE), they were reminded that they had C$40 available to purchase a one lb. bag of seed of a given type and that they didn't have to distribute the C$40 across all the bids or choice sets.

Before farmers bid on the seeds in the BDM mechanism, farmers participated in a practice round to get them familiar with the mechanism. Farmers were asked to bid on an item with a commonly known market price such as a bar of soap or a pen. Farmers were given an endowment of C$10 or an item of similar value to bid with the random price ranging from 0 to 9 by using a 10-sided die. The practice bid was carried out to help farmers understand the BDM mechanism, how the random price is drawn, and how the purchase/no purchase decision is determined.

Following the practice auction, farmers were given a bidding sheet (Appendix 4) and asked to bid on the three seed types that were planted in each experimental plot and reminded that each seed was of the same variety but different quality. The seed quality type was not revealed to the farmers and they were told to bid as if they were purchasing one lb. seed used in the experimental plots. The bids were between C$0 and C$39 (approximately US$0 - US$1.30) with a uniform probability of being C$0 or C$39 (1/40). This was to prevent farmers from choosing a utility maximizing strategy that is not consistent with the BDM mechanism that increases expected utility above and beyond the attributes of the goods farmers are bidding on.

Real Choice Experiments: The choice tasks were designed following the method used by Street, Burgess, and Louviere (2005). The product attributes and corresponding levels were first used to develop an orthogonal fractional factorial design (Appendix 5). Following that, the generators described by Street and Burgess (2007) were used to develop 12 choice tasks, each containing two product alternatives (price and seed quality) and a “no purchase” or “opt-out” option with a D-efficiency of 96%. The price attribute had four levels ranging from C$14/lb. to C$34/lb (Table 4.1). This is based on the market level prices for the highest cost certified seed (C$34/lb.) and lowest cost grain price ($14/lb.).

Table 4.1 Choice Experiment Attributes and Levels

Attributes	Levels	
Quality	3	Circle (Seed 1); Square (Seed 2); Triangle (Seed 3)
Price	4	C$14; C$21; C$28; C$34

The design of the RCE only allowed for the comparison of farmers' WTP based on premiums relative to another attribute. Therefore, we measured premiums relative to seed 3 in the RCE. The comparison of the farmers' WTP is based on the differences in premiums for seeds 1 and 2 in both methods and not farmers' WTP for each individual seed.

Following the BDM mechanism, farmers were shown an example choice task to familiarize them with how to answer choice tasks and how to understand the options. This choice example used two common sodas at different price and a "no purchase" option. This was only an example and not a binding choice experiment or RCE and used as a way to explain a choice task. Farmers were then put into four similar sized groups where they participated in the RCE. Each group saw a different ordering of the same choice tasks. This is to reduce the systematic impact of fatigue on overall choice, as not all individuals saw the choice tasks in the same order.

Farmers were told before beginning the choice experiment that there is an equal probability of any one of these choice sets to be selected as binding. This was to reconfirm that the utility maximizing strategy was to answer each question in the choice set truthfully. Farmers were told to treat each choice task as if they were purchasing a pound of seed in the local market. Each choice task had three options, two were seeds and one no purchase option. Farmers were encouraged to not discuss their answers among each other and were told to hide their answers once they finished selecting the choice task.

After the end of RCE, one method was selected by flipping a coin to determine a binding option. If the choice experiment was chosen than a 12-sided die was rolled to select the binding choice set. However, if the BDM was chosen, then the seed type was randomly selected by asking one of the farmers to pick up one of the three cards on which the seed type was written. Then, two dice were used to determine the random price. The first die was a 4-sided die with numbers 1-4, where 4 was treated as 0. The first die chose the first number in the price, and the second die was the 10-sided die used in the practice auction with the number 0-9. This gave the probabilities a uniform distribution with 0-39 having a 1/40 probability of being chosen. The differences in the three bids is interpreted as the premium (discount) a farmer is willing to pay (accept) to obtain a different quality attributes as observed or perceived by the individual farmer in the experimental plots.

Purchases only happened after both methods were completed to prevent influences of disappointment aversion. Having only one randomly binding method does not allow individual's utility curve to change between methods. For example, if an individual won seed 2, they may not want to win a second pound of seed 2, or if they won a seed type they were not excited about it may shift their preference to prevent such outcome from occurring again that may not be aligned with their true preferences.

4.5 Data

In addition to the plot ranking data and WTP elicitation data from BDM and RCE described in the previous section, this study also uses farmer survey data collected from households that had participated on field day 2 (Appendix 6). The survey was conducted using a structured questionnaire to obtain participating farmers' household characteristics, bean growing practices, and other information that can influence farmers' WTP, such as age, gender, income, knowledge of technology, and access to technology.

For each experimental plots, data was also collected on the harvested yields and inputs used by farmers. Plot size, soil quality, and weather variables (e.g., precipitation) during the season were also recorded by the INTA agronomist and CIAT researchers collaborating on the field experiments. Host farmers were told to record their input decisions and management practices in order to compare across all three plots and to help control for underlying farming practices within farm and across villages. The yield data is used to align farmers' WTP with objective data to understand farmers' ability to measure quality from observing the experimental plots.

Chapter 5. Data Description

5.1 Analytical Sample

A total of 222 farmers had participated in field day 1. However, the data for this paper comes from farmers who attended field day 2 when the preference elicitation experiments were conducted. .Across all 10 villages a total of 219 farmers had participated in the second field day. However, in the comparative analysis, farmers who chose one option for all 12 choice tasks (6 farmers) were dropped from the study. This is to prevent biases in reported WTP from individuals who may not have understood the mechanism or lacked interest in the experiment. In total, the sample size of farmers included in the analysis presented in this paper is 213, and its distribution by villages is shown in table 5.1.

Regrettably, 19 farmers who participated in the experiments did not complete a survey. I have survey data for 194 farmers who participated in the preference elicitation experiments. Therefore, all WTP data I present are from the 213 farmers who participated in the preference elicitation experiment and all the survey data consist of only 194 farmers. Since multiple members of the household could have participated in the field day 2 activities and in the preference elicitation experiments, the number of household level surveys (188) is less than the number of farmer sample (213). Table 5.1 also shows the distribution of household sample in each village.

Table 5.1 Sample Size by Villages

Village ID	Village Name	Department	Number of farmers	Number of households
A1	Santa Rosa	Esteli	49	42
A2	Bramadero	Esteli	10	9
A3	El Horno	Esteli	11	10
A4	Matapalo	Esteli	15	12
A5	Moropoto	Madriz	15	13
A6	El Porcal	Madriz	38	35
B2	Susuli	Matagalpa	22	19
B3	Las Mesas Sur	Matagalpa	21	20
B4	Ojo de Agua	Matagalpa	16	15
B6	La Chichigua	La Concordia	16	13
	Total		213	188

Out of 213 farmers included in my analysis, 125 farmers had participated in both the field days and 88 farmers had only participated in field day 2. During the preference elicitation experiments on field day 2, farmers were told to bid based on their evaluations of the experimental plots they had just observed. Therefore, any differences in bidding or choice behavior based on their observations should be attributed to individual taste and preference heterogeneity and not to lack of attendance on the first field day. Theoretically farmer's attendance to both field days should not impact individual's underlying utility curve. To test the hypothesis that individuals' WTP does not depend on whether they went to both field days, I used an unpaired t-test to do a mean comparison between farmers who went to both field days and farmers who only went to the second. I am assuming for this study that the differences in

WTP from two methods is not affected by whether individuals participated on both field days or only the second. The hypothesis being tested is

$$Ho: (WTP_{RCE} - WTP_{BDM})_{both\ field\ days} - (WTP_{RCE} - WTP_{BDM})_{second\ field\ day\ only} = 0$$

Table 5.2 T-test for Attrition

Seed Quality	Mean Differences	P-Value (Mean Diff ≠ 0)
Seed 1	-2.74	0.30
Seed 2	2.45	0.47

Source: Primary Data Collected by Researcher 2017

Table 5.2 shows that there is no statistically significant difference between farmers' stated WTP that attended both field days or just the second field day. Therefore, I assume that the level of attrition should not be a factor driving my results.

5.2 Sample Characteristics

Table 5.3 provides descriptive statistics of the household and farmer characteristics of my analytical sample. The survey was designed to collect household demographic and other socio-economic characteristics, and farmers' knowledge and experience with quality legume seeds. As reported in Table 5.3 92% of participant farmers belonged to male headed households. On average, the age of the head of the household was approximately 46 years, and the average years of education for the head of household was 5 years. Five percent of farmers stated that they regularly purchase bean seed for grain production. This is consistent with the low level of involvement in the formal sector reported by previous studies. For example, Wierma et al, (1993) reported that 72% of bean farmers in Nicaragua used saved seed.

The average reported highest price paid for seed in our sample was C$ 21.23 per pound (approximated US$0.70/lb.). About 75 % of farmers claimed to know or have heard of CSBs, however only 54% reported knowledge or awareness of quality declared seed (or *Apta* seed), which is the type of seed produced by CSBs. A reason for this low awareness or recognition of *Apta* seed could be that CSBs are not labelling their seeds or promoting it as *Apta* 'seed', as legally only certified seed is recognized and can be sold as 'seed.' This can be seen from farmers response to the question -- what was the seed type they last purchased. Twenty eight percent of farmers reported certified seed, 41% stated they were unlabeled seed, and only 5% claimed they purchased *Apta* (QDS) seed, and the rest of the farmers unsure of the seed type.

About 31% of farmers have no knowledge or have not heard of either QDS or certified seed, the other 69% were aware of these higher quality seed types. This shows that most farmers are aware of the quality seed technology but either choose to not purchase these seeds or they are not available for them to purchase.

On average farmers in our sample sold approximately half of their bean harvest annually, and about half of their total income came from bean sales. A major share of bean production (close to 50%) is retained for home consumption. This could be a factor for why 72% of farmers do not purchase new seeds from the formal system, which are improved varieties, and may not meet farmers' preferences for taste and cooking characteristics.

Table 5.3 Descriptive Statistics

VARIABLES	N	Mean	SD
Gender of Individual Surveyed (Male=1)	194.00	0.84	
Age of Individual Surveyed	194.00	43.46	15.09
Years of Education of Individual Surveyed	193.00	5.12	4.38
Head of Household (HH) Gender (Male=1)	194.00	0.91	
Head of HH Age	194.00	45.78	14.68
Head of HH Years of Education	192.00	5.11	6.82
Total Members in HH	194.00	4.66	1.95
Males in HH	194.00	2.49	1.27
Females in HH	193.00	2.20	1.19
Have you ever produced bean seed (1=Yes)	193.00	0.29	
Heard of CSB (1=Yes)	194.00	0.76	
Heard of QDS (1=Yes)	194.00	0.56	
Heard of Certified Seed (1=Yes)	194.00	0.70	
Heard of INTA (1=Yes)	194.00	0.94	
Do you belong to a farmer group/ organization? (1=Yes)	194.00	0.30	
Are you a leader of these groups? (1=Yes)	60.00	0.30	
Does this organization produce/distribute seeds of any crops? (1=Yes)	60.00	0.82	
Distance to paved road from house (in km)	194.00	6.61	16.20
Distance to nearest road marker from house (in km)	194.00	15.70	17.13
Do you regularly purchase or have you ever purchased bean seed (1=Yes)	192.00	0.28	
Highest price per pound you have ever paid for bean seed for grain (C$)	76.00	22.41	55.87
Last time you purchased bean seed for grain production (year)	76.00	2,013	4.45
Price per pound you paid for acquiring this seed last time? (C$)	76.00	20.83	55.96
Total quantity of seed purchased last time? (lbs.)	76.00	77.39	72.36
In a normal year, what percent (%) of your bean harvest do you sell?	194.00	50.94	22.63
Annual percent of income from beans	193.00	50.73	28.78
Total amount of land area owned by your HH? (in Manzanas)	193.00	5.35	9.29
What was the total land area in all plots cultivated (in Manzanas)	193.00	3.99	6.14
Number of fields cultivated by the household	193.00	1.98	0.97
Number of fields planted with beans in the last agricultural year	193.00	1.93	6.28
Did you plant bean validation fields the last agricultural year? (1=Yes)	194.00	0.06	
Likelihood of being poor at 100% Nicaraguan National Poverty Line	194.00	47.60	30.25
Likelihood of being poor at 150% Nicaraguan National Poverty Line	194.00	76.16	25.53
1 if Farmer states they are an early adopter	194.00	0.67	

Source: Primary Data Collected by Researcher

Chapter 6. Results

6.1 Field Day Rankings

Table 6.1 shows overall ranking of the experimental plots across all 10 villages. Farmers were unaware of the quality type of the seed as the plots were labeled with symbols ○ (seed 1), □ (seed 2), and Δ (seed 3). In all the data in the following tables we refer to these seed types as seed 1, seed 2, and seed 3 as their identities (certified, QDS, and recycled) were unknown to the farmer and instead they bid (BDM), choose (RCE), and ranked the symbols (or seed types 1, 2, and 3) and not the seed quality names (certified, QDS and recycled). In the first field day 58% of farmers ranked the plot planted with seed 2 as the best plot, 29% ranked the plot with seed 3 as the best, and 13% ranked the plot planted with seed 1 as the best. Approximately 72.5% of farmers chose seed 1 as the worst plot with seed 3 and seed 2 being chosen by 14% and 11% farmers, respectively. In the second field day the rankings changed in favor of seed 2. About 79% of farmers chose seed 2 as the preferred plot, 12% chose seed 1, and 9% chose seed 3 as the best plot. Relative to first field day, seed 1 was rated as the worst plot by fewer farmers in the second field day. However, 56% still chose seed 1as the worst plot on the second field day, significantly more than for seed 3 (38%) or seed 1plot (7%).

Table 6.1 Blind Experimental Plot Rankings

Seed Type	First Field Day		Second Field Day	
	% That Chose Best Plot (N=222)	% That Chose Worst Plot (N=222)	% That Chose Best Plot (N=213)	% That Chose Worst Plot (N=213)
Seed 1(○)	13%	72%	12%	56%
Seed 2 (□)	58%	11%	79%	7%
Seed 3 (∆)	29%	14%	9%	38%

Source: Primary Data Collected by Researcher

Given the large variation in participation by village the average numbers reported in Table 6.1 may be biased towards villages where there was large participation. Table 6.2 shows which plot was ranked the best and the worst in each village.

Table 6.2 Best and Worst Ranked Plots by Village

Village ID	First Field Day		Second Field Day	
	Best	Worst	Best	Worst
A1	Seed 2	Seed 1	Seed 2	Seed 3
A2	Seed 2	Seed 1	Seed 2	Seed 3
A3	Seed 1	Seed 2 & Seed 3	Seed 2	Seed 3
A4	Seed 2	Seed 1	Seed 2	Seed 1
A5	Seed 2	Seed 1	Seed 2	Seed 3
A6	Seed 2	Seed 1	Seed 2	Seed 1
B2	Seed 3	Seed 1	Seed 2	Seed 1
B3	Seed 3	Seed 1	Seed 2	Seed 1
B4	Seed 1	Seed 2	Seed 1	Seed 2 & Seed 3
B6	Seed 3	Seed 1	Seed 2	Seed 3

Source: Primary Data Collected by Researcher

As shown here in the first field day seed 2 and seed 3 were the two best liked, and seed 1 was overwhelmingly disliked. In the second field day seed 2 is ranked best in every village but one, however seed 3 is now ranked worst in every village but four.

Researchers had also collected agronomic performance data from the experimental plots such as yield, number of pods per plant, and number of seeds in pod. This data gives us objective data on the quality of seeds planted as reflected in these plant performance indicators and how this aligns with individuals' perception of quality and WTP.

Table 6.3 Plot Performance Data

Seed Type	**Pods per Plant**		**Seeds per Pod**		**Average Yield in kg/ha**	
	Average	**S.D**	Average	**S.D**	**Average**	**S.D**
Seed 1	9.85 a	2.63	5.53 a	0.37	1336.5 a	798.09
Seed 2	10.40 ab	2.99	5.71 ab	0.51	1542 a	696.44
Seed 3	10.51 b	2.67	5.38 b	0.30	1431 b	727.15

a = not significantly different than seed 3 at 10% level
b = not significantly different than seed 1 at 10% level
Source: CIAT Yield data Nicaragua 2017

Based on Table 6.3 seed 2 plots had more pods per plant, more seeds per pod and higher average yield than both seed 1 and seed 3. On average, across all 10 experimental plots, a bean plants from seed 1 produced 53.6 seeds per plant, plants from seed 2 produced 61.3 seeds per plant, and plants from seed 3 produced 52.2 seeds per plant. Similar relative pattern is observed for bean yields across the three seed type plots. The relative difference in these objective measures of plant performance by seed type are well-aligned with the farmers' plot rankings based on subjective measures of performance of the three plots. This gives insight on how farmers perceive quality of bean plants, and how their perceptions match objective measures of seed quality in demonstration plots.

6.2 Farmers' WTP for different quality seed based on BDM mechanism

The benefits of using an experimental auction such as the BDM mechanism is that farmers' bids represent their WTP for each quality of seed. This means that there is no estimation needed or parameterization by the researcher that may misinterpret individual WTP. In this mechanism the individual explicitly states their WTP for different seed projects that reveals their preference ranking. I would expect the relative difference in individual's WTP for different seed types to match the best and worst plots. In other words, the highest bid would be for the perceived highest performing plot and the lowest bid would be for the perceived lowest performing plot. Table 6.4 shows results of stated WTP for different seed plots by villages based on the BDM mechanism.

Table 6.4 Farmers' Stated WTP: Results from BDM Experiments

Village ID	Seed 1 (○)	Seed 2 (□)	Seed 3(Δ)
A1	C$18.57	C$22.33	C$14.67
A2	C$21.50	C$23.20	C$18.70
A3	C$10.09	C$18.36	C$9.64
A4	C$21.00	C$27.13	C$23.07
A5	C$14.73	C$18.80	C$18.53
A6	C$13.05	C$19.53	C$12.66
B2	C$17.32	C$25.09	C$19.82
B3	C$14.81	C$19.38	C$16.33
B4	C$18.19	C$16.13	C$15.13
B6	C$25.38	C$27.31	C$25.38
Total	C$17.17	C$21.66	C$16.64

Source: Primary Data Collected by Researcher

In every village except B4, farmers' stated WTP was highest for seed 2, which was also the highest ranked plot. This shows that individuals are willing to pay a premium for the perceived quality of seed, irrespective of what is the market signal in terms of what it is called and the underlying belief system (i.e., seed 1 are considered the highest quality and seed 3 the lowest quality seed). In all villages except A4, A5, B2, and B3 farmers had lowest WTP for seed 3. However, when all the villages are aggregated, the average WTP is C$21.66 for seed 2, C$17.17 for seed 1, and C$16.64 for seed 3. This shows a preference ranking on average for seed 2 and possibly seed 1 over seed 3. However, as seen in Table 6.5 when testing for statistical significance using a fixed effect regression with clustered standard errors at the village level I find that farmers' WTP for seed 2 is statistically significantly different from seed 3 (first column), also from seed 2 (column 2).

Table 6.5 Testing the Mean Difference in Farmers' Bids for Different Seed Types: Results of Fixed Effects Regression

VARIABLES	Mean WTP relative to seed 3 (C$/lb.)	Mean WTP relative to seed 1 (C$/lb.)
Seed 1	0.53	--
	(0.94)	
Seed 2	5.02***	4.48***
	(0.92)	(0.82)
Seed 3	--	-0.53
		(0.94)
Mean of excluded seed type	16.64	17.17
Observations	639	639
Number of farmers	213	213
R-squared	0.255	0.255

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

Source: Primary Data Collected by Researcher

Based on the results presented in Table 6.5, I conclude that in the BDM mechanism individual farmers on average are willing to pay a statistically significant premium for highest ranked seed 2 relative to lowest ranked seed 3 and second lowest ranked seed 1. But there is no statistically significant premium/discount between the second (seed 1) and third (seed 3) ranked seed types.

6.3 Farmers' WTP for different quality seed based on Real Choice Experiments

The stated WTP in the BDM mechanism does not have to be parameterized and is exactly the number that the individual states on their bids. However, for the RCE, I use an RPL with an error component to estimate WTP using random utility theory and derive individual level (conditional) parameters (Appendix 7).

Table 6.6 Mean WTP for Different Seed Types Based on RCE: RPL Model Results

	Mean WTP relative to seed 3 (C$/lb.)	
Variables	RPL	RPL with error component
Seed 2	29.99*** (5.10)	29.86*** (4.31)
Seed 1	-9.79** (4.01)	-9.07*** (2.81)
Log-Likelihood	-2354.87	-2238.67
AIC	4723.7	4497.3
N	213	

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

Source: Primary Data Collected by Researcher

I chose the RPL with error component to account for systematic differences between the experimentally designed alternatives and the status-quo option. I believe this model gives me more accurate estimates of WTP as indicated by the log-likelihood and AIC. I used seed 3 as the base and these estimated WTP are the premiums (discount) individuals are willing to pay (accept) for these two types of seed. On average farmers are willing to pay approximately C$30 more for seed 2 relative to seed 3. Meaning that stated WTP in the RCE shows that on average individuals stated that they would pay a premium of C$30 for seed 2. On the other hand, on average farmers showed a willingness to accept a discount of C$9.07 for seed 1 relative to seed 3. The premiums stated in the RCE show a clear preference ranking unlike the BDM mechanism, where farmers are willing to pay a statistically significant premium for seed 2 and are willing to accept a statistically significant discount for seed 1.

Using the methods explained in Chapter 11 of Train (2011), I estimated individual WTP parameters conditional on individual choices they made. The individual WTP parameters were estimated relative to seed 3. Using these individual estimated parameters, I can look at how premiums stated in the RCE changes in each village. The stated premiums for seed 1 and seed 2 relative to seed 3 by farmers in different villages are shown in Table 6.7:

Table 6.7 Stated WTP Relative to Seed 3 Based on RCE: Results Disaggregated by Villages

Village ID	Seed 1	S.D	Seed 2	S.D
A1	C$-8.6	18.20	C$27.88	21.24
A2	C$-5.97	17.54	C$23.20	19.54
A3	C$-8.36	22.94	C$27.41	26.69
A4	C$-12.02	17.73	C$37.70	21.91
A5	C$1.90	9.34	C$18.00	13.54
A6	C$-20.37	20.98	C$40.61	27.67
B2	C$-17.23	17.99	C$42.08	25.40
B3	C$-8.79	16.46	C$31.88	20.05
B4	C$9.89	18.42	C$5.55	22.06
B6	C$-2.90	15.57	C$25.59	20.13
All	C$-9.16		C$30.01	

Source: Primary Data Collected by Researcher

The RPL estimates in Table 6.7 show that farmers' WTP in the RCE for seed 2 and seed 1 are significantly different than seed 3 across several villages. To test whether farmers' premiums for seed 1 and seed 2 are statistically significantly different I used a fixed effects regression model to estimate the mean premiums (Table 6.8)

Table 6.8 Comparison of Mean Premiums Relative to Seed 3 Derived from RCE: Fixed Effects Model Results

VARIABLES	Premium
Mean premium for Seed 2	39.173***
	(6.178)
Mean premium for Seed 1	-9.16***
	(2.913)
Observations	426
Number of id	213
R-squared	0.449

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Primary Data Collected by Researcher

Tables 6.7 and Table 6.8 show that in RCE method, individuals are willing to pay significantly different amounts for all three qualities of seed they observed in the blind experiments. Farmers are willing to pay a significant premium for seed 2 and willing to accept a significant discount for seed 1, both relative to seed 3.

6.4 Comparing Elicitation Methods for WTP

When comparing premiums (discounts) that individuals are willing to pay (accept) between methods, the BDM mechanism does not yield statistically significant difference in WTP for seed 1 relative to seed 3, however the RCE shows that there is a statistically significant difference and that the willingness to accept for seed 1 is a discount of approximately C$9.

Table 6.9 shows the comparison of WTP or WTA for seed 2 and seed 1 by method and village. This table highlights the vast difference between individual WTPs by village. On average the premium estimates using the RCE method are approximately five times more than the stated WTP premiums in the BDM mechanism for seed 2, which was the highest rated seed type. As shown in Table 6.9 the difference in WTP for seed 1 in RCE is on average 18 times smaller than the stated WTP in BDM. These differences between the two methods is significantly higher than what was found in Lusk & Schroeder (2006) where stated WTP in a real choice experiment was only twice the magnitude as found in experimental auctions.

Table 6.9 WTP for Seed 1 and Seed 2 Relative to Seed 3: Comparison of Results of RCE and BDM

Village	RCE Seed 1	BDM Seed 1	RCE Seed 2	BDM Seed 2
A1	C$-8.6	C$3.90	C$27.88	C$7.65
A2	C$-5.97	C$2.80	C$23.20	C$4.50
A3	C$-8.36	C$.45	C$27.41	C$8.73
A4	C$-12.02	C$-2.07	C$37.70	C$4.07
A5	C$1.90	C$-3.80	C$18.00	C$0.27
A6	C$-20.37	C$0.39	C$40.61	C$6.87
B2	C$-17.23	C$-2.50	C$42.08	C$5.27
B3	C$-8.79	C$-1.52	C$31.88	C$3.05
B4	C$9.89	C$3.06	C$5.55	C$1.00
B6	C$-2.90	C$0.00	C$25.59	C$1.94
All	C$-9.16	C$0.53	C$30.01	C$5.02

Source: Primary Data Collected by Researcher

6.5 WTP and Plot Rankings

Individuals preference rankings should not differ depending on the type of preference elicitation method used. Therefore, within an individual both methods should conclude that an individual prefers a certain good or service. Using individual level premiums, we can see whether an individual's preference ranking is exactly the same in both methods. We can test this by comparing directionality of the individual's premiums. This means that if a farmer prefers seed 1 over seed 2 it should be that both methods would show that this farmer is willing to pay a premium to obtain seed 1 over seed 2. However, in our study we see that in 36% of individuals the preference elicitation method concluded different preference rankings. Table 6.10 breaks down preference elicitation by seed 1 and seed 2. Of the individuals that have different preference ranking, 32 of them have different preference rankings for both seeds.

Table 6.10 Differences in Preference Rankings by Seed Type Based on BDM and RCE Experiments

Seed Type	Same Preference Ranking in both BDM and RCE	Different Preference Ranking
Seed 1	172	41
Seed 2	146	67

Source: Primary Data Collected by Researcher

Farmers were asked to rank the demonstration plots and rank one plot as the best and one plot as the worst. Using farmers stated preferred plot, we can look at which preference elicitation method align with farmers' stated preference in these ranking sheets. Due to the structure of the question farmers could not state that two plots had an equivalent ranking. If there is a stated premium of 0 than it was assumed that the plot rankings matched unless the seed type was ranked the best and seed 3 (baseline seed) was labeled the worst plot. Table 6.11 compares the percent of times farmer's premiums estimated in the RCE and BDM match individuals' stated plot preference in field day 2.

Table 6.11 Preference Ranking Compared with Plot Ranking

Seed Type	Percent premiums in the BDM matched Plot Ranking Sheet	Percent premiums in the RCE matched Plot Ranking Sheet
Seed1	61%	53%
Seed2	74%	73%

Source: Primary Data Collected by Researcher

Neither BDM nor RCE, are consistently matching the field ranking sheets, I expected the BDM to be more consistent as farmers state their WTP directly and there is no parameterization of their WTP. There are a few possibilities that can explain the disconnect between the two methods in ranking individual preferences, since farmers always took the choice experiment second there could be a fatigue effect that made them less price sensitive. Since there was no incentive for farmers to accurately state the best and worst plot, farmers may not have taken the exercise seriously leading to conflicting answers. However, there is no way to test these hypotheses in this study. It would be assumed that individuals would bid higher (or equal to the next preferred plot) for plots they preferred over others. This comparison of preference rankings may instead back up Lusk & Schroder's (2006) claim that individuals construct utility preference within each preference elicitation method separately. This hypothesis would account for the differences in preferred seed type in plots across methods within the same individual.

6.6 Comparison of Methods

As mentioned in the conceptual model, both methods theoretically claim to be incentive compatible and elicit individual's true WTP. Theoretically, this assumes that the stated WTP within individuals should be identical. I test this by comparing the stated/estimated WTP measures of two methods using a fixed-effects regression. I assume that individual's underlying utility function does not change between methods and is constant. This assumption is based on Lancaster's theory of demand and the notion that individuals purchase attribute bundles that maximize their utility. Therefore, I compare across the two methods (RCE and BDM) the WTP for seed 1 and seed 2 relative to seed 3 (i.e., the premium/discount) holding individual preferences constant. By measuring within individual differences by methods I can control for heterogeneity of unobserved characteristics of farmer participants. I assume these unobserved characteristics are constant in this experiment, and therefore the differences in WTP is associated with methodology and not with unobserved characteristics that may influence individual's WTP. Finally, I compare how determinants of WTP differ between the two methods. This can help us understand observable characteristics that impact farmers' WTP for seed quality. Table 6.12 presents the results of the fixed effect model comparing the estimated premiums for seed 1 and 2 across two methods – RCE and BDM. Seed 1 and seed 2 are the dependent variables which are the individuals' stated WTP for seed quality relative to seed 3. As shown in Table 6.12, the RCE method has a negative and significant effect on the estimated premium individuals are willing to pay for seed 1; while the method has a very large positive effect for the premium individuals are willing to pay for seed 2. Therefore, I conclude that preference elicitation method used in this study has a large and significant impact on estimated WTP premiums for different seed types.

Table 6.12 Comparison of Estimated Premiums for Seed 1 and 2 between RCE and BDM (base method): FE Regression Results

VARIABLES	Premium relative to seed 3
Estimate for Seed 1: RCE method	-9.69***
	(2.866)
Estimate for Seed 2: RCE method	25.00***
	(2.922)
Base Mean seed 1 (BDM method)	0.53
Base Mean seed 2 (BDM method)	5.02
Observations	852
Number of farmers	213
R-squared	0.426

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

Source: Primary Data Collected by Researcher

6.7 Determinants of WTP Premium for Quality Seed

As mentioned in Chapter 2, many factors can determine farmer's decision to adopt a technology. This includes demographic characteristics such as gender, household size, and household composition (Fay and Deininger 2005, Holden and Shiferaw 2002), economic factors such as the income potential of a technology (i.e., how risky is the adoption), household income and source of income (i.e., off-farm income) (Pender and Kerr 1998; Hondel and Shiferaw 2002), awareness and knowledge of the new technology, and access to that technology (Pender and Kerr 1998). One of the most important variables, in the context of this study that can influence farmer's WTP for seed is the perceived quality. I expect positive relationship between perception of quality and WTP.

To test how these theoretical predictions compare with the WTP premium for different seed types observed in my sample, I regress these attributes on the differences in farmers' premiums predicted by the BDM and the RCE for the overall highest rated seed and the overall lowest rated seed, seed 2 and seed 1 respectively. In both the models the standard errors are clustered at the village level. Results are reported in Table 6.13.

The model used is:

$$Premium_{i,RCE} - Premium_{i,BDM} = \beta X_{ij} + \theta Z_i + \varepsilon_{ijm}$$

Where, WTP_{ijm} is individual i's bid for seed type j in method m. X_{ijm} is farmer i's perceived quality of seed type j , and Z_i vector of household characteristics for individual i. Table 6.13 shows that the individual characteristics that may help explain the differences in premiums in preference elicitation methods for seed 1 and 2 (relative to seed 3) are plot ranking of the other seed type, individual's likelihood of being poor, and the gender of the head of household. If individuals purchase bean seeds more often, they are much more likely to have a much larger and statistically significant difference between the two methods. This may be due to their understanding of the advantages of quality seed. The seed type's own plot ranking had no significant effect, but the plot ranking for the other seed type had a negative effect for both seed 1 and seed 2. This means that if the farmer liked the other seed type more they were more likely to have a smaller difference in premiums between methods. Finally, the likelihood that an individual is poor has a small but significant effect. This coefficient states that poor farmers are more likely to have a higher premium in the RCE compared to the BDM mechanism for seed 1, but a smaller difference in premiums for seed 2.

Table 6.13 Determinants of Differences in Premiums Estimated from Two Methods (BDM and RCE)

VARIABLES	Seed 1	Seed 2
Males in HH	-2.55**	1.74
	(1.151)	(1.942)
Females in HH	-2.87**	2.67
	(1.346)	(1.851)
Head of HH Years of Education	-0.73	0.52
	(0.558)	(0.524)
Head of HH Age	0.08	-0.11
	(0.178)	(0.180)
Head of HH Gender	-9.34*	15.52**
	(5.675)	(7.489)
Poverty Likelihood at Nicaragua's Poverty Line	0.14***	-0.12*
	(0.047)	(0.073)
Ranking of Plot Planted with Seed 1	3.90	-8.31***
	(3.116)	(3.134)
Ranking of Plot Planted with Seed 2	-7.01***	3.83
	(2.534)	(3.508)
Have you ever produced bean seed	0.65	-2.40
	(4.367)	(6.020)
distance to paved road from house	0.18	-0.09
	(0.151)	(0.263)
distance to nearest marker from house	0.13	-0.03
	(0.156)	(0.239)
1= likely to adopt	-0.55	-0.01
	(2.771)	(3.386)
1= They have or Regularly Purchased Seeds	-5.00	7.59**
	(3.365)	(3.778)
Annual percent of income from beans	0.00	-0.04
	(0.063)	(0.073)
Primary Total area planted?	0.35	-2.77
	(1.185)	(2.493)
Total amount of land area owned by your HH?	0.11	0.06
	(0.159)	(0.223)
Constant	14.54	17.45
	(10.988)	(15.481)
Observations	185	185
R-squared	0.225	0.186

7. Discussion

7.1 Farmers' WTP for Quality

The objective of this study was to evaluate two WTP elicitation methodologies through a within individual comparison. The significance of a within individual comparative study of WTP elicitation methods is that it directly compares the outcomes of both methods for the same individual. This gets rid of the need to match individuals that can have numerous unobserved characteristics that can be a potential source for differences in the estimated WTP using the two methods. By keeping these unobserved characteristics constant between methods, I was able to show that preference elicitation methods do impact WTP estimates. It would be expected that the WTP estimates from two different methods may differ in magnitude, but in preference elicitation methods should conclude preference rankings due to a similarity in underlying utility curves. However, in this study I find that RCE stated WTP and the BDM mechanism's do not reach similar preference rankings within an individual. This may indicate that individuals construct preferences differently between the two mechanisms as suggested by Lusk and Schroeder (2006) or experimental auctions may be biased due to individuals exhibiting a type of non-expected utility preference function as suggested in Horowitz (2005).

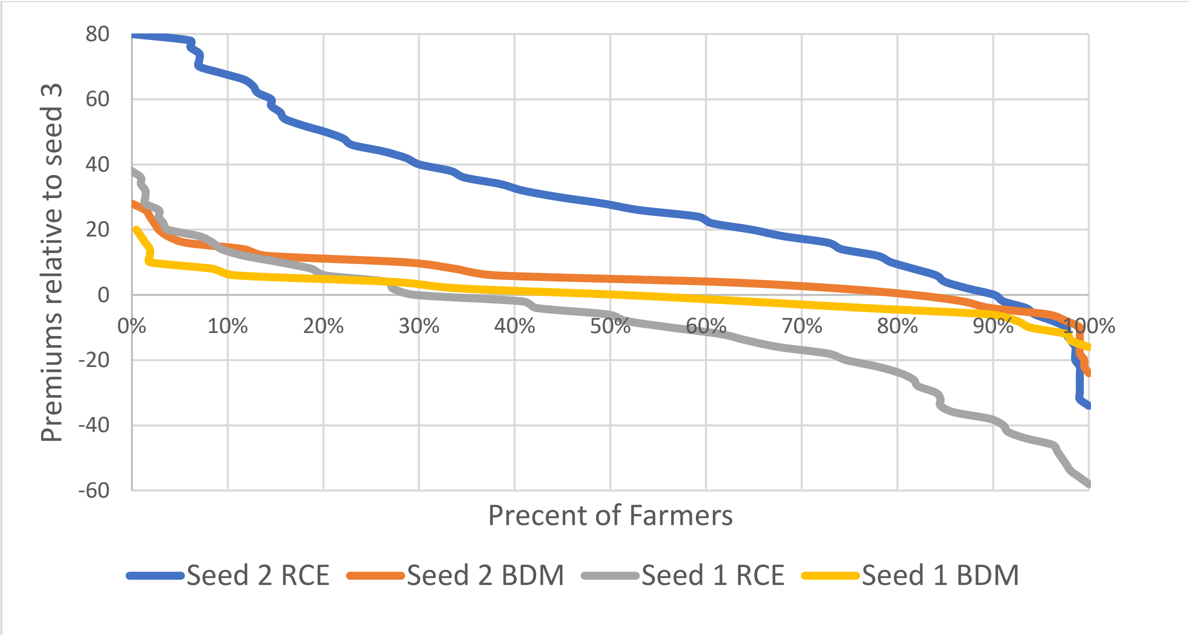
The differences in WTP estimates of the two methods could be due to several factors. One of the factors that apply directly to this study is price. It is possible that the prices used in both the RCE and the BDM mechanism did not reach a choke price and were more on a price inelastic point of the demand curve. The range of random prices in the BDM mechanism could have put a bias on the relative prices and lead to a large discount in individual WTP. Another factor is one or both methods are not truly incentive compatible and do not elicit true WTP as suggested in Lusk and Schroeder (2006).

Some studies have put forth theoretical reasons why the BDM mechanism may not be incentive compatible (Horowitz 2005). The differences in the marginal effects on WTP by the determinants of WTP put further constraint on the idea that both methods measure equivalent preference ranking or WTP. It follows that the method used to elicit preference ranking and overall magnitude of WTP has a significant impact on the estimated WTP.

The difference between the estimated WTP for different seed types relative to market price of the best quality seed available in the market is surprisingly large in the RCE. The premium was C$24 while the price premium in the market is approximately C$7 per pound. The BDM mechanism was designed in a way that it would be closer to the market prices which explains the closeness to market price premiums in the BDM mechanism for highest rated seed 2 with certified seed, which is considered to be highest market quality. Both methods showed very low premium farmers were willing to pay for lower rated seeds (seed 1 and seed 3) (BDM) or even a discount that farmers were willing to accept (RCE).

Our results indicate that on average bean farmers in our study area are willing to pay a premium for higher performing seeds based on individual's perception of seed quality. On average individuals in our study were WTP more for seed 2, which received best plot ranking by more farmers, and which also had highest yields. Compared to seed 2, seed 3 and seed 1 had lower yields and also received lower preference rankings, but the difference in the rankings and yield was not significant. This explains the close estimated WTP for these two seed types in the BDM auctions. However, in the RCE, results show a significant difference between the estimated WTP for seed 1 compared to seed 3. Figure 7.1 shows farmers WTP premiums (discounts) by method and seed quality.

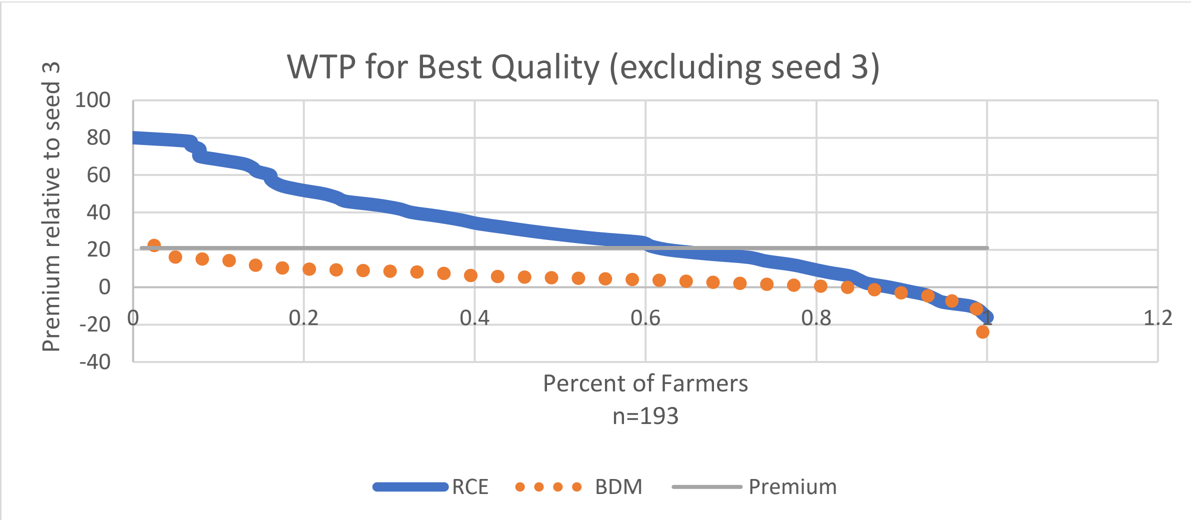
Figure 7.1 Premiums for Seed Type by Method



Source: Primary Data Collected by Researcher

This study shows that there is demand in Nicaragua for higher quality seed. However, as indicated earlier, the three seed types procured for our study are not a representative sample of the seed qualities of each type. Therefore, it is difficult to extrapolate these results to farmers' WTP for the three seed market classes--certified, QDS, and recycled. However, this study shows that in both preference elicitation methods, the farmers WTP for their perceived highest quality seed was significantly more than the second-best seed and worst rated seed. In our study, the average premium farmers were willing to pay for highest rated seed was C$5.02 (C$30.01) in the BDM (RCE). Currently, in the market the highest priced seed is C$34/lb. and represents a premium of approximately C$21/lb. over the grain price. Figure 7.2 compares farmers WTP for their highest ranked plot (perceived highest quality plot) compared to current market premium of most expensive seed (i.e., certified seed). The estimates of premiums are relative to seed 3.

Figure 7.2 WTP for Best Quality Seed



Source: Primary Data Collected by Researcher

To compare the premiums for the individually highest rated seed estimated in these two elicitation methods, I omitted observations of farmers who had rated the plot with seed 3 as the highest (n=20) since the premiums are relative to seed 3.The graph in Figure 7.2 continues to highlight the differences in premiums by method. In the RCE, for approximately 60% of farmers their WTP premium for their perceived highest quality seed is more than C$21. However, in the BDM this number is only 3%. the RCE is not bounded by a range of prices and predicts premiums above the highest possible bid in the BDM. The premiums in the RCE could be explained by experimental fatigue (as it always came after BDM), or participants may not have understood the concept and mechanism of the choice experiment, or the marginal price range in the RCE may not have been large enough to dissuade individuals from choosing their preferred seed, or a combination of all these factors.

7.2 Limitations of the Study

The main limitation of this study is the small sample size. A larger sample size would have allowed us to change the range of the random prices in the BDM or the prices in the RCE and test whether the price range had a significant effect on biasing individual bids. Theoretically if the upper range of the random price distribution is too low, then a large number of farmers would be censored at the top bid. However, in our study this was not the case, as only 9 out of 639 bids in the BDM method were C$39, which was the top price. However, Karna and Sarfi (1987) showed that this theory may not be accurate as individuals bid in relation to the distribution of random prices meaning that farmers may not bid C$39 as they may not understand the optimal strategy, or they may be taking a strategic bet. Horowitz (2005) showed that under uncertainty of price the individual's optimal bid may not be the same as their WTP. Horowitz states that the nature of the uncertainty is based on the distribution of random prices therefore the bid is dependent on this same distribution of random prices. In Morkbak et al., 2010 shows that increasing only the last price in the price vector of a choice design increases individuals WTP. This may explain the much larger premiums estimated in the RCE. Lazo et al. (1992) and Bohm et al. (1997) show the effects of increasing the upper bound of the random price in a BDM mechanism. Lazo et al. found out that increasing the upper bound of the random price above the value of a redeemable ticket led to 25% of individuals stating their WTA above the redeemable value of the ticket. This study shows that the distribution of the random prices impacts individuals bidding strategy. This can be explained by individuals not following the utility maximizing strategy of the BDM mechanism, but deviating to either maximize their own utility from winning or not understanding the BDM mechanism and bidding in a different strategical matter. The impact of price ranges may also impact WTP in each method differently leading to much larger differences in WTP estimates combined with fatigue effects.

8. Conclusion

8. Implications for Future WTP Studies

In this study I evaluated two incentivized WTP elicitation methodologies that are widely used in the literature, namely the Becker-DeGroote-Marschak auction experiment and the Real Choice Experiment. Through blind field experiments, I first assessed the farmers' perceived quality differences among three types of bean seeds produced under different quality assurance systems, and then related this perceived quality with farmers' WTP of these seed types. The main finding of this study is that preference elicitation methods do impact WTP estimates. I find that the premiums for higher rated seeds relative to the lowest rated seed are not consistent between RCE and BDM, both in magnitude and direction.

Since individual's true WTP is unobservable, there is no benchmark against which to compare the estimated WTP from the two methods. It is thus impossible to tell which of the two methods evaluated in this study—BDM or RCE is more accurate in estimating the true WTP for seed quality. Instead I show that preference elicitation methods are not interchangeable.

This study is similar to other studies (i.e., Lusk and Schroeder; 2006), where they find that WTP price premiums estimated using choice experiments are sometimes double the estimates derived using experimental auctions (in our study it was approximately five times more). As explained before, there are many studies that try to explain why this gap may occur. Grebitus, Lusk, and Nayga jr. (2013) showed how personality traits impact individual's WTP in both hypothetical and real experimental auctions and choice experiments. When comparing methodology and accounting for personality traits they see that different personalities contribute to how individuals behave across different mechanisms. Therefore, individuals may state their WTP in a BDM mechanism, and a RCE differently based on certain personality traits that may be difficult to control for in design. This could have also been the case in these experiments I conducted in Nicaragua. However, lack of data on personality traits does not allow me to confirm or reject this as a potential explanation of the observed differences in the estimated WTP from the two methods I studied.

Many policy decisions and marketing decisions are decided based on the finding of market demand elicitation using methods similar to those used in this study. This study has shown that WTP may be dependent on the method used and therefore may not be accurately capturing the underlying unobserved true WTP of individuals. As further studies are done to understand this phenomenon, it would be important to understand how the design of a preference elicitation method leads to changes in differences in WTP elicited by different methods and how individual behavior can be incentivized to report true WTP.

APPENDICES

APPENDIX A: Field Day 1: Farmer Ranking Sheet

Field Day 1 – Ranking Worksheet (one per farmer)

Y1a. Village Name: ____________________ **Y1b. Village ID:** ____________________ Y2. **Farmer ID:** [ ]

Z1. Name (last, first)		**Z2.** Gender	☐ 1-Male ☐ 2-Female

X. Farmer opinion about the plots

Farmer: *please choose plot section that best meets the first, second and third criteria of seed quality performance at flowering stage (based on YOUR opinion)*

Make sure the criteria listed in X2 are as agreed by the group and same for all the farmers attending this field day in this village

X1. Group Ranked Criteria	**X2. List/describe the criteria**	**X3.** Varietal plot section that best meets this criteria (Select only one for each criteria)
a. First		☐ □ ☐ ○ ☐ Δ
b. Second		☐ □ ☐ ○ ☐ Δ
c. Third		☐ □ ☐ ○ ☐ Δ

X4. Overall BEST Plot section	☐ □ ☐ ○ ☐ Δ
X5. Overall WORST Plot section	☐ □ ☐ ○ ☐ Δ

APPENDIX B: Field Day 2: Farmer Evaluation Sheet

Field Day 2 (pre-Harvest): Farmer evaluation sheet (one per farmer)

Y1a. Village Name: ____________________ **Y1b. Village ID:** ___________________________ **Y2. Farmer ID:** [ ]

Z1. Name (last, first)		**Z2.** Gender	☐ 1-Male ☐ 2-Female	**Z3.** Number of years of formal education	

Z4. In your opinion, which is the overall Best Plot section (mark one)

☐ □ ☐ ○ ☐ Δ

Z5. What is the MAIN reason for rating this plot the BEST? (mark one)

☐ ***1-plants look healthy***

☐ ***2-pods have filled nicely***

☐ ***3-higher yield***

☐ ***4-good seed quality***

☐ ***5-Other (specify)***___________________________________

Z6. How do the bean plants on this BEST plot compare with the bean plants on your own farm at this stage? (mark one)

☐ *1. Better than plants on my farm*

☐ *2. Same as plants on my farm*

☐ *3. Worse than plants on my farm*

Z7. In your opinion, which is the Worst Plot section (mark one)

☐ □ ☐ ○ ☐ Δ

Z8. What is the MAIN reason for rating this plot the WORST? (mark one)

☐ ***1-plants look unhealthy***

☐ ***2-pods have not filled nicely***

☐ ***3-lower yield***

☐ ***4-poor seed quality***

☐ ***5-Other (specify)***________________________________

Z9. How do the bean plants on this WORST plot compare with the bean plants on your own farm at this stage? (mark one)

☐ *1. Better than plants on my farm*

☐ *2. Same as plants on my farm*

☐ *3. Worse than plants on my farm*

APPENDIX C: Script for Seed WTP Experiments – Nicaragua 2017

NOTE: *All text in italics are instructions for the enumerator*. All **text not in italics** must be read to the farmer.

This experiment/survey will be performed at field days in 12 villages in Nicaragua. Each village has 1 field experiment (FE) and the field days will be run in all 12 villages. During each field day, farmers (who attended the first field day and were surveyed) will participate in a willingness-to-pay (WTP) auction experiment and a real choice experiment. A FE consists of one field split into 3 plots. All the plots contain the same variety of beans, but were planted using different qualities of seed – Semilla Certificada(CS), Semilla Apta (SA) or Grano Comercial (GC). The plots are labeled □, ○, and Δ and farmers and extension agents do not know (and should not be told) which quality of seed was used for which plot.

After a brief welcome to the field day and running through the criteria and plot ranking exercise – including a question regarding WTP per lb for each seed type. The script below is for the enumerator and helpers running the WTP auctions and RCE.

Step 1:Introduction/consent

The enumerator will introduce his or herself and read the consent script to the farmers and record their verbal consents to participate.

Step 2: Overall description of Exercise

ENUMERATOR:

Ok, thank you for being willing to participate. To begin with, let me give you an overall description about what we will be doing. We are interested in getting an idea about how much you would be willing to pay for the three types of seed that was used to grow each of the 3 plots that you looked at earlier. To make your decisions more realistic, we are going to give you C$40 that you can use towards the purchase of one lb bag of one of the seed types used to grow these plots. We will be performing two types of exercises today. The first involves you providing the maximum price you are willing to pay for each of these three seed types, and the second involves you selecting one of the seed type to purchase under different scenarios that we will present. In both these exercises, please determine your willingness to pay for one lb of seed based on your observations of the performance of these three types of seed qualities in the field you just visited.

[how we will decide which exercise becomes binding]

At the end of both these exercises, one of these two types of exercises will be chosen to give you a chance to actually purchase the seed. . This will be decided by flipping a coin so that either exercise will be chosen at random and will have equal probability of being chosen. We will flip a coin to decide whether the first exercise or second exercise will be chosen to be carried out through to purchase. We will let you all decide which Exercise is heads and which will be tails. This will be explained further on.

Before we begin with the two primary exercises, we would like to do a practice of the first exercise. For this practice exercise, we will give each of you C$10 to bid on purchasing a bar of soap like this one.

Hold up bar of soap

Let's do the practice auction first, and then we will explain more about the seed auction, ok?

Do you have any questions? (answer questions)

Should we begin?

Step 3: Practice Auction

The enumerator will begin explaining the practice auction.

ENUMERATOR:

Ok, so one of the exercises you will participate in today is a seed auction. We want you to understand how the seed auction will work, so we want to run a practice auction first.

For this practice auction each of you will be given C$10 to bid on one bar of soap. Unlike in most auctions, or in auctions you may have participated in the past, in this type of auction, it is possible for **everyone** to win and thus everyone might purchase a bar of soap using part or all of their C$10.

Let me explain how you bid and how we determine who wins and buys a bar of this soap.

First, we will hand out a bidding sheet like this one.

Hold up bidding sheet.

On this bidding sheet you will write down the maximum amount you would be willing to pay for this bar of soap, which could range from C$0 to C$9. Please note down this amount in increments of C$1. For example, the amount you are willing to pay for this bar of soap could be C$0, 1, 2, 3, 4, 5, 6, 7, 8, or 9. The maximum bid you can make is C$9. Once everyone has done this, we will collect the bidding sheets and move on to determine how many of you win and will buy a bar of soap.

To determine who wins we will simply choose a random price between 0 and C$9 – we will explain how this will be done in a moment.

If the price you bid is **greater than or equal to** this random price, then you win, ***BUT*** you pay the random price – not what you bid. This means that if you win, you pay a lower price for the soap than your bid (unless the random price is the same as your bid).

On the other hand, if the price you bid is **less than** this random price, then you do not purchase the soap and you can keep the money (C$10).

If you win, we will give you a bar of soap **and** the balance amount of your C$10; that is, C$10 minus the random price.

For example, if you bid C$5 and the random price is C$4, then you would pay C$4 for the soap and get it, along with the remaining C$6.

If you do not end up buying the soap, you do not spend any of your C$10 buying soap and we will give you C$10.

So, for example, suppose that "*name an enumerator1 in the room*" bids 6, I bid 4 and "*name an enumerator2 in the room*" bids 1. Now suppose that the random price is 3…in this case, *enumerator1* would buy the soap, but would pay C$3, not his/her bid of C$6. He/she would get a bar of soap and 10-3=C$7. I would also buy the soap and pay C$3 (my bid was C$4) so I would also get a bar of soap and 10-3=C$7. *Enumerator2* would not buy the soap since his/her bid of 1 is less than 3 so he/she would just get C$10.

[Best strategy explanation]

Before we hand out the practice round bidding sheets, let me explain the best strategy in this type of auction. The BEST thing to do is to bid the MAXIMUM amount you are willing to pay. This is because it is very likely you will actually pay LESS if you win.

However, bidding <u>less</u> than what you would be willing to pay might mean that you miss out on buying the soap at a price lower than what you would be willing to pay. For example if you are willing to pay C$7 and you only bid C$3 and the random price is C$4 then you will not purchase the soap at C$4.

Similarly, bidding <u>more</u> than what you would be willing to pay might mean that you end up having to pay more for the soap than you really want to. For example, if you are willing to pay a maximum of C$3, but you bid C$5 and the random price ends up being C$4, then you would pay C$1 – more than you were willing to!

Overall, your best strategy is to bid the MAXIMUM amount you are willing to pay.

Ok, let's go ahead and hand out the bidding sheets.

Are there any questions?

We will determine the random price as follows:

There are 10 possible options for the random price of this soap to be. The random price can be either a 0, 1, 2, 3, 4, 5, 6, 7, 8, or 9. We will thus roll this 10-sided die to determine which it is…if the die comes up 1, 2, 3, 4, 5, 6, 7, 8, 9 that will be the price of the soap, if we roll a 10 than that will be C$0

Overall, we will end up with one of the following numbers: 0, 1, 2, 3, 4, 5, 6, 7, 8, or 9; and that number will determine the random price. If your bid on the sheet is higher or equal to that random price, you will purchase the soap at the random price, if it is lower, then you will not purchase the soap and can keep the C$10. .

Are there any questions so far?

Ok, let's go ahead and hand out the bidding sheets.

[Hand out bidding sheets]

Ok, go ahead and write down your ID number from your name tag – this helps us keep track of who to pay how much) and your bid for a bar of soap. Please do not talk with others until we have collected the bids.

[Collect bidding sheets, making sure that bids and numbers are entered and legible and that the bid is in C$1 increments (i.e., 1.35 is not a valid bid).]

Ok, now let's go ahead and determine the random price.

[Determine random price as outlined above while writing it down on board. A helper should record this number on one of the bidding sheets so we have this information. We can allow farmers to flip coin/role die as long as it is tossed sufficiently to make it random.]

Ok, so this is the price (*say the random price*) – if you bid more than or equal to this price, you buy a bar of soap at this price (*say the random price*). If your bid was less than (*say the random price*) you will not buy a bar of soap, but will receive the C$10.

[It might be a good idea to briefly say "if you feel comfortable sharing, raise your hand if you bought a bar of soap. "If they are willing to reveal, they can even say how much they bid.]

Ok, so we will pay you and give you the soap, if you bought one, after the other exercises have completed.

Step 4: Seed Auction

The enumerator will begin explaining the seed auction.

ENUMERATOR:

Ok, so hopefully you have a better idea about how this seed auction will operate. It will be very similar to the practice auction you just did, except for a few things:

First, you will be bidding to purchase a one lb bag of the seed that was used to plant the plots in the field Exercise you just looked at. Specifically, you will be making 3 bids – one for each plot (labeled □, ○, and Δ). HOWEVER, even though you are bidding for each type, ONLY ONE type will actually have a random price determined and will be bought/sold. You will not know which type is available until after you bid, so you should bid as if each one might be the one chosen.

Second, instead of C$10, we are now giving you C$40 to use to bid. Just as before, your bid should be in increment of C$1. And as before, any amount you do not use to purchase seed, will be given to you after we are done.

Third, the random price can be between 0 and C$39 and will be determined as follows:

Enumerator: Write on a board two spaces

_____ ______

the first digit can be a 0, 1, 2, or 3. We will roll a 4 sided die to determine this first digit. If the die lands on 1, 2, 3 the first digit will be that number, but if it comes up 4, it will be a 0. Then a second 10 sided die will be rolled, the second digit can be 0, 1, 2, 3, 4, 5, 6, 7, 8, or 9. If the die rolls a 10 than the second digit will be 0.

Overall, we will end up with a number between 0 and C$39 in C$1 increments. As before, each number between 0 and 39 is equally likely.

Are there any questions?

[remind them of the strategy]

Ok, before we hand out the bidding sheets, let me just remind you that your best strategy is to bid the MAXIMUM amount you are willing to pay for each seed type represented by a symbol that was used in the field plots your just saw. Remember, since we are only going to determine a random price for ONE of the seed type, you do NOT need to try and spread your C$40 across the three seed types – in fact you can bid C$40 for each quality and not have to worry about spending more than C$40.

Any final questions?

As before, please do not talk with others until we have collected the bids.

[Hand out seed bidding sheets.]

Ok, go ahead and write down your ID number (from the card) and bids for all three seed qualities. Remember that this is for a 1 lb bag of the seed type used to plant the indicated plot (□, ○, and Δ). Also, please keep bids to C$1 increments ranging from 0 to 39.

[Collect bidding sheets, making sure that bids and numbers are entered and legible and that all bids are in C$1 increments.(i.e., C$10.48 is not a valid bid)

This ends our first Exercise. We will now begin the second Exercise.

Step 5: RCE

In this second exercise we will split into four groups. Your group leader will show you 12 different ellecions with different types of seed available in the market at different prices. Based on this information, you will be asked to select one option in each scenario. You will record your selection on a the sheet we will hand out to each one of you. Please fill out the information required as per the instruction of your group leader (e.g., Id code, Village code, name and choice set letter)

(Example RCE)

Each option will look like this one (show example sheet of RCE), but with seeds and different prices. As you can see, there are two different products with two different prices as well as a ninguna option.

(Explain Strategy)

When you are shown each set, we want you to choose which of the two seeds you would purchase if you were at the market to buy seed. If you wouldn't buy either then choose ninguna. It is in your best interest to choose the option you would choose in a market setting. If you are not willing to pay for either but you choose one of them, you may have to pay that price for that seed later. If you choose ninguna, then you will keep the C$40 but purchase neither seed.

Again, your best strategy is to choose the seed you are willing to pay for. For example, if you choose Seed □ for C$34, but you were only willing to pay C$27 than you would spend C$7 more than you would be willing to pay. So therefore your best option would be to choose the seed and the price as if you were purchasing between these seeds at a market.

Are there any questions?

Before we begin, it is important to note that if this second exercise is chosen to count, only one of the 12 set of options will be chosen for payment and purchase. We will decide by rolling a 12-sided die like this one (hold it up). Since only one set of options will be chosen, there is no need to spread your C$40 over all your choices – in fact, you could choose the highest price seed in every choice and not worry about spending more than your C$40.

We would like you to not talk to others about what choice you are making while we go through this task. Ok, so let's go ahead and split up into 4 groups.

[Separate participants into 4 groups and]

Group Leaders:

Ok, please go ahead and fill out the Id code, Village code, your name and the choice set letter.

[group leaders should provide the codes and the choice set letter]

Ok, so here is the first choice

[group leaders show the first choice and make sure everyone fills in their choice. Continue for all 12 choices.]

[Collect all the choice sheets]

Step 6: Choosing the binding choice

Ok, now we will flip a coin to decide whether the first or second exercise will be chosen to be carried out through to purchase. We will let you decide which one will be heads and which one will be tails.

[flip coin]

(if BDM)

Ok, since the first exercise was selecedwe will now reveal which seed quality was selected for today's auction. For this group, the seed type is [□, ○, and Δ as previously determined.]

Ok, so now that we know which quality, let's go ahead and determine the random price.

[Determine random price as outlined above while writing it down on board. A helper should record this number on one of the bidding sheets so we have this information. We can allow farmers to flip coin/role die as long as it is tossed sufficiently to make it random.]

Ok, so this is the price – if you bid more than or equal to this price, you won and will buy a 1 lb bag of this quality seed at this price. If your bid was less than this price you will not buy seed, but will receive the C$40.

(If RCE)

Ok, since the second Exercise was selected, we will now roll a 12-sided die to decide which Ellecion will be chosen. For example, if 5 is rolled than Ellecion 5 will be selected, and you will purchase the seed as per the choice you made in Ellecion# 5 . If you chose a seed then you will purchase that seed type at the price stated under that seed. If you had selected ninguna, then you will keep C$40. The choice will be random and each Ellecion has equal chance to be selected

[Roll the die]

This is the choice that is chosen you will now purchase the seed type you chose in that Elleccion number at that given price. If you chose niguna for this choice you will not purchase anything and you will keep the C$40.

[Closing Statements]

Ok, so we will call you up one or two at a time to give you the seed/soap if you bought them and however much we owe you in Cordobas.

Thank you and please do not discuss this with the other group of farmers until they have completed the exercises.

Thank you!

APPENDIX D: Survey

X1. Village ID:______________ X2.Farmer Name (who participated in Field Day 1):________________________________ X3. Producer Code (see card):____________

FAMER WILLINGNESS TO PAY FOR QUALITY BEAN SEEDS—NICARAGUA 2017 SURVEY

INSTRUCTIONS: *Please ask to speak to the person primarily responsible for BEAN production decisions AND had participated in the first field day. Ask him/her to show the acknowledgement card with a CODE and copy this code on X3 at the top. If the main decision maker is not available, find out when s/he will be available for interview. If this person is available, read the CONSENT STATEMENT and if he/she agrees to be interviewed, begin the interview s tarting on question X6.).*

CONSENT STATEMENT

cs1. Enumerator: ¿did you read and gave a copy of the consent statement to the farmer?	☐ 1-Yes ☐ 2-No
cs2. Enumerator: ¿the farmer is willing to be interviewed?	☐ 1-Yes ☐ 2-No

NOTES FOR ENUMERATORS

** Sentences in "italics" are instructions for the enumerator* *ID = Identification *esp. = Specify details *CSB=Community Seed Bank

X4a. Name of the **enumerator:** __________________________________ **X4b. Supervisor** Initials: __________ **X5. Date:** _____dd _____mm 2017

X6. *Enumerator: is this the* ***main (or one of the main) decision makers*** *in your household for* ***bean cultivation and production?***	☐ 1-Yes ☐ 2-No

SECTION X. Respondent Identification and information

X7. Gender	☐ 1-Male ☐ 2-Female	**X8.** Age		**X9.** Number of **years of formal education** completed?	

X10. Mobile phone number __[77] Prefers not to share it [88] Does not have a mobile phone)................	
X11. Who else from this family **had participated in the first Field Day** that was done in this village in June/July? *(Please* ***ask for the card with the assigned code*** *and note down the name and code.* ***If none, note down 88 in all spaces and continue in A1)***	a. Name Adult 1: b. Code Adult 1: c. Name Adult 2: d. Code Adult 2: e. Name Adult 3: f. Code Adult 3:

SECTION A. INFORMATION ABOUT THE HOUSEHOLD AND FARMING PRACTICES

A1. Your **relationship** to head of HH? [1] HH head =>*A5* [2] Spouse [3] Son/daughter (>18) [4] Other relative [5] Other non-relative	**A2.** What is the **gender** of the Head of this HH? [1] Male [2] Female [88] Does not apply (both consider themselves the head)	**A3. Age** of the Head of this HH?	**A4.** Number of **years of formal education** completed by the Head of the HH?	**A5.** # household **members**			**A6.** Are all household members ages 7 to 18 enrolled this school year in the formal educational system? [1] Yes [2] No [88] No children 7-18 years of age	**A7.** Have any household members, in their main occupation in the last seven days, were wage or salary workers?	**A8. What is the farthest anyone in this household has ever travelled?** [0] Never left this village [1] A village/town in this municipality [2] A place in other parts of country [3] Another country in Latin America [4] US/Canada/Australia/Europe [99] Other (specify)
				a. Total	**b.** Males	**c.** Females			

A9. Have you ever produced bean seeds for sale to other? [1] Yes [2] No=>*A12*	**A10.** If yes to A9 when was the last time you produced bean seeds? YYYY	**A11.** What type of bean seeds did you produce? [1] certified seeds [2] Apta seeds [3] Both types (1,2) [99] Other (specify)	**A12.** Have you heard about or know about the following organizations/ products/ services? [1] Yes [2] No						
			a. Community seed bank	b. Apta seed	c. Certified seed	d. Internet	e. Facebook	f. INTA	g. Climate change

A13. Do you belong to a **farmer group/ organization?** [1] Yes [2] No=>*A16*	**A14. Are you a leader of any of these groups?** [1] Yes [2] No	**A15.** Does this organization produce/distribute seeds of any crops? [1] Yes [2] No	**A16. Does the household own (and is in use)...** [1] Yes [2] No								**A17.** How many cellular phones does your household own? (0=>*A19*)	**A18.** How many of these are 'smart phones'? (77=No sé)
			a. bicycle	b. Boat	c. motorcycle	d. automobile	e. horse	f. donkey or mule	g. Iron	h. Blender		

A19. What is the distance from your house to the nearest paved road (if the house is next to the paved road, write zero)	*km*	
A20. What is the distance from your house to the nearest market where you obtain agricultural inputs (e.g., fertilizer, pesticides, seeds, etc.)	*km*	

A21. How many rooms does the household have for its use (excluding kitchen, bathrooms, hallways, and garages)?	**A22.** What is the main material of the floor of the residence? [1] Dirt, or other [2] Wood planks, mud bricks, or tiles and concrete [3] Cement bricks or tile	**A23.** What fuel does the household usually use for cooking? [1] Non-purchased firewood [2] Purchased firewood, charcoal, or does not cook [3] Butane or propane gas, kerosene, electricity, or other	**A24.** When it comes to **adopting new technology, inputs or farming practices, which** of the following **best describes your behavior?** *(Read each one and let farmer select one option)* [1] I am one of the **first ones** to adopt NEW technologies [2] I usually **wait until a few farmers** I know have used those inputs/technologies/practices, and then based on their experiences I make the decision [3] I usually **wait until most farmers** in this village are already using those inputs/technologies/practices, and I am 100% sure that those technologies work [4] I **rarely change my farming practices** as I am not comfortable doing new things

A25. Do you **regularly purchase** or have you **ever purchased** bean **seed** (not grain) for grain production? [1] Yes, regularly purchase [2] Yes, purchase occasionally [3] Yes, purchased once but not anymore [4] No, I have never purchased 'seed' => *A33* [5] I don't know the difference between seed and grain=> *A33* [77] Don't know/cannot answer	**A26.** What is the highest price per pound you have ever paid for bean seed for grain production? **Cordobas/Lb**	**A27.** When was the last time you purchased bean seed for grain production? **YYYY**	**A28.** What was the price per pound you paid for acquiring this seed last time? **Cordobas/Lb**	**A29.** Total quantity of seed purchased that time? **Lb**	**A30. Source** of the last purchased seed for grain production 1-farmer from this village 2-Community seed bank 3-other farmer organization 4- seed vendor in the market 5-Input dealer 99-Other source (specify)	**A31.** What type of seed was it? 1-Certified 2-Non-certified but came in a package with labeling (Apta) 3-Apta seed in bulk 4-Packaged but without label 77-Don't know 99-Other (specify)	**A32.** Name of the seed variety purchased 77-don't know / remember 99-More than one variety	**A33.** In a normal year, what **percent** (%) of your bean **harvest** do you **sell?**	**A34.** In a normal year, what **percent** (%) of your **HH income** comes from **bean sales?**
								Record the response on a scale of 0 to 100 (approx. value is fine)	

In the last **agricultural year (2016/2017)**: which were the **two most important crops** for your household in terms of… [1] Maize [2] Beans [3] Rice [4] Vegetables [5] Coffee [6] Fruit trees [7] Citrus [8] Banana or Plantain [9] African oil palm [10] Pastures [77] Don't know/cannot answer [88] No more crops *(only for 2 option)* [99] Other crop or activity (specify)						**A38.** Total amount of **land area owned by your HH?**	**A39. Units** for land area [1] Manzanas [2] Tareas [99] Other (sp.)	**A40.** *Using the same units reported in **A39**:* What was the **total land** area in **all plots** (own, rented, borrowed, etc.) cultivated with **all crops** during the **last agricultural year (2016/2017)?**	**A41. How many fields** (spatially separated pieces of land) cultivated in this household in the **last agricultural year (2016/2017)?**	**A42.** From these fields, **in how many were beans planted** the last agricultural year (2016/2017)?	**A43.** Did you plant **bean validation fields** the last agricultural year? [1] Yes [2] No [77] Don't know what that is
A35. Total **area** planted?		**A36. Purchased inputs** for production?		**A37.** As a source of **income**?							
a. 1ro	b. 2do	a. 1ro	b. 2do	a. 1ro	b. 2do						

SECTION B. INFORMATION ON BEAN FIELDS CULTIVATED DURING THE LAST AGRICULTURAL YEAR (may 2016/april 2017)

Enumerator, read to the farmer: *For each of the bean FIELDS planted in the last agricultural year, please tell me…*

B0a	B0b	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11
Field ID	**Planting season** [1] Primera [2] Postrera [3] Apante [4] Summer/ irrigated	**Total bean area** in this field?	**Units** of area [1] Manzanas [2] Tareas [99] Other (specify)	Was bean **inter-cropped**? [1] Yes [2] No=>B5	What percentage of this field was planted to beans? 0 to 100 values (approx. value is fine)	Total quantity of bean seed planted on this field? **Lbs**	Total quantity of bean grain harvested	Units for harvest [1] Lbs [2] Quintals (100 lb-sacks) [99] Other (specify units & weight)	Did you apply any **fertilizer (chemical or organic)** on this field? [1] Yes [2] No	Did you apply any **chemical pesticides** on this field? [1] Yes [2] No	Did you apply any **bio-pesticides** on this field? [1] Yes [2] No	Did you apply any other types of pest or disease control products on this field? [1] Yes [2] No
P1												

B0a	B0b	B12	B13	B14a	B14b	B15	B16	B17	B18	B19
Field ID in the same order as above, star-ting on P1 (field 1))	Write the season follo-wing the same order as above and with the same codes	**Name** of the bean **variety planted on this field** 77=don't know	**Source of seed** planted in this season [1] Saved from own **grain** harvest [2] saved from own **seed** production [3] Purchased **as grain** from others/market=>*B15* [4] Purchased **as seed** from a seed producer in the village=>*B15* [5] Purchased **as seed** from an input dealer=>*B15* [6] Given by NGO/Govt. program=>*B15* [99] Other (specify) =>*B15*	When was the last time you obtained fresh seed of this variety from outside your own farm production? *(Never? Write 777 and go to B15)* YYYY	Source of fresh seeds used for grain production that you mentioned in B14a [1] Grain from family/friends [2] Grain from the market [3] Purchased as Apta seed [4] Purchased as Certified seed [5] Given by NGO/Govt. program [99] Other (specify)	Type of seed planted [1] Commercial grain [2] APTA seed [3] Certified seed [77] Don't know	How would you rate this seed quality? [1] Excellent=>*B18* [2] Good=>*B18* [3] Bad [77] Don't know	If rated bad, ask the reason for 'bad' rating: [1] Low germination [2] Disease and pest problem [3] Plant growth not uniform [4] Low yield [99] other (specify)	Was this a **traditional or an improved** variety? [1] Traditional/local [2] Improved [77] don't know	How many years have you planted this variety on your farm? *(Always? Write 777)*
P1										

SECTION C. FARMER'S KNOWLEDGE, PERCEPTIONS, OPINIONS ON SEED TYPES AND SEED QUALITY

C1. Do you consider you have easy access to **good quality seeds** of bean, If you wanted to purchase it? [1] Yes [2] No=>*C3*	**C2.** Where is the nearest source of such good quality seed of bean? [1] From a seed producing farmer within or nearby village [2] From an input dealer [3] Farmer organization (e.g. CSB) [99] Other, specify	**C3.** Do you have easy access to **certified seeds** of any crops? [1] Yes [2] No [88] don't know what is certified seed =>*C7*	**C4.** Have you ever purchased certified seed of any crops? [1] Yes [2] No=>*C7*	**C5.** For which crops you have purchased *certified seed*? *List up to 3 crops* *See crop codes below*			**C6.** In your opinion what are the two main **advantages** of using certified seed *See codes to the right*	
				a. Crop 1	b. Crop 2	c. Crop 3	a. Most important	b. 2nd important

Codes for C6 and C10:

1=high germination rate
2=Uniformity in plant growth
3=less pest problems
4=less diseas problems
5=high quality grain at harvest
6=high yield
7=Easy and timely access
88=no other advantage
99=other (specify)

Codes for C5 and C9: [1] Maize [2] Beans [3] Rice [4] Pastures [5] Vegetables [99] Other (sp.) ____________

C7. Do you have easy access to **Apta seeds** of any crops? [1] Yes [2] No [88] don't know what is Apta seed > C11	**C8.** Have you ever used or purchased **Apta seed** of any crops? [1] Yes [2] No >C11	**C9.** For which crops you have used or purchased *Apta seed?* *List up to 3 crops* *See crop codes above*	**C10.** In your opinion what are the two main **advantages** of using Apta seed *See codes above*	**C11.** Based on your own experience or of other farmers you know, what is your opinion about the quality of following types of **bean seeds** [1] Bad [2] Regular [3] Good/excellent [77] Don't know		
				a. Certified seed	b. Apta seed	c. Grain harvested from own farm

C12. What are the **two main constraints** you face **in bean farming?** [1] Access to land [2] Labor [3] Cash constraint [4] Grain Price too low [5] Insects and diseases [6] Weather [7] No technical assistance [88] No more constraints [99] Other (sp.)		**C13.** What is the current price of bean grain if you were to sell it? **Cordobas/lb** [7777] Don't know	**C14.** Have you ever stopped using a bean variety you liked because of lack of access /availability of seed? [1] Yes [2] No	**C15.** What would be the **main reasons** you **DON'T replace** bean seed **often?** [1] Too expensive [2] Don't trust seed from outside [3] Seed not available [4] Don't see advantages of doing this [5] Seed packages too large [88] No more reasons [99] Other (sp.)		**C16.** What would be the **main reasons** you **would replace/change** your bean seed **instead of using recycled grain?** [1] When my yields are too low [2] I run out of seed [3] To test a new variety [4] My seed has too many diseases [5] When I get it for free [6] When market demands it [88] No other reasons [99] Other (sp.)	
a. First	b. Second			a. First	b. Second	a. First	b. Second

C17. In total, how much did you **spend on all the bean planting material** (seed or grain) you used for planting in 2016/2017 season? (write 0 if none) C$________

NOW WE WILL TRANSITION TO THE NEXT PART OF THIS INTERVIEW…

SECTION Z: Registration sheet for answers on the Hypothetical Choice Experiment

Enumerator: Please follow the script and record the responses of the hypothetical choice experiment for this farmer in the following table

Z1. Group ID (Circle one option)			
S	T	U	V

Please mark the producer answer for each selection number, with an **X**

#	Option A	Option B	None
1	|____|	|____|	|____|
2	|____|	|____|	|____|
3	|____|	|____|	|____|
4	|____|	|____|	|____|
5	|____|	|____|	|____|
6	|____|	|____|	|____|
7	|____|	|____|	|____|
8	|____|	|____|	|____|
9	|____|	|____|	|____|
10	|____|	|____|	|____|
11	|____|	|____|	|____|
12	|____|	|____|	|____|

ID del grupo (Encierre una opción)			
S	T	U	V
1	12	3	11
2	11	1	7
3	10	11	8
4	9	2	1
5	8	9	12
6	7	5	9
7	6	8	3
8	5	6	4
9	4	12	2
10	3	4	6
11	2	10	5
12	1	7	10

THANKS A LOT FOR YOUR COLLABORATION WITH THIS INTERVIEW!

APPENDIX E: BDM Bidding Sheet (Spanish)

Hoja de licitación de la subasta de semillas

Numero de Participante	
Nombre de Participante	

Tu oferta por Semilla □	**Ingrese lo más que esté dispuesto a pagar** **C$**
Tu oferta por Semilla ○	**Ingrese lo más que esté dispuesto a pagar** **C$**
Tu oferta por Semilla Δ	**Ingrese lo más que esté dispuesto a pagar** **C$**

Tipo de Semilla Seleccionado: ☐ □ ☐ ○ ☐ Δ

Precio al azar: ______________________

Nombre de communidad		
ID de communidad		
Name of the farmer hosting this FE *Nombre del agricultor anfitrión*		
Participant purchased the seed *¿Participante compra de semilla?*	*Yes* ☐	*No* ☐
Total Cash Owed *Total Cordobas Debe*	*40 – Precio al azar = C$*	*C$40*
Quantity of seeds willing to buy (kg) at this price *Cantidad de semillas dispuestas a comprar a este precio*		

APPENDIX F: Choice Tasks in RCE

Table F.1 Choice Tasks in RCE

Choice Task	Seed1	Seed 2	Seed3
1	-	C$21/lb.	C$14/lb.
2	C$34/lb.	C$28/lb.	-
3	C$28/lb.	-	C$34/lb.
4	C$21/lb.	-	C$28/lb.
5	-	C$28/lb.	C$21/lb.
6	C$14/lb.	C$34/lb.	-
7	C$21/lb.	C$14/lb.	-
8	C$14/lb.	-	C$21/lb.
9	-	C$34/lb.	C$28/lb.
10	C$28/lb.	C$21/lb.	-
11	C$34/lb.	-	C$14/lb.
12	C$14/lb.	-	C$34/lb.

APPENDIX G: RPL with Error Component Results

Table G.1 RPL with Error Component Results				
Random Parameter	Coefficient	S.E	P-Value	S.D
Price	1.0			
Seed2	29.86	4.31	<.01	29.92
Seed1	9.07	2.81	<.01	24.08
Error Component	0			78.42
Log-Likelihood	-2238.67			
AIC	4497.3			

WORKS CITED

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Bardhan, P., & Udry, C. (1999). *Development Economics.* New York: Oxfrord University Press Inc.

Bash, K., Bowman, J., Chapman, J., & Blandon, J. A. (2002). *Assessment of Nicaragua's Seed Sector.* Maryland: Development Alternatives, Inc.

Becker, G. M., DeGroot, M. H., & Marschak, J. (1964). Measuring utility by a single-response sequential method. *Systems Research and Behavioral Science,* 226-232.

Benzing, A. (1989). Andean potato farmers are 'seed bankers'. *ILEIA*, 1-3.

Brennan, P. W. (1991). An Analytical Model of Farmers' Demand for Replacement Seed. *American Journal of Agricultural Economics*, 1044-1052.

Brookshire, D. S., Coursey, D. L., & Schulze, W. D. (1987). The external validity of experimental economics techniques: analysis of demand behavior. *Economic Inquiry 25.2*, 239-250.

Brush, S. (1991). A farmer-based approach to conserving crop germplasm. *Economic Botany,* 153-165.

Cameron, L. A. (1999). The Importance of Learning in the Adoption of High-Yielding variety seeds. *American Journal of Agricultural Economics*, 83-94.

Carter, M. R., Toledo, P., & Tjernstrom, E. (2010). Investing in Small-Fram Productivity: Impact Dynamics and Hetergeneity in Nicaragua. *Working Paper*.

Colombo, S., & Louviere, N. H. (2003). Modeling preference hetergeneity in stated choice data: an analysis for public good generated by agriculture. *Agricultural Economics,* 307-322.

Colombo, S., Hanley, N., & Louviere, J. (2009). Modeling preference heterogeneity in stated choice data: an analysis for public goods generated by agriculture. *Agricultural Economics,* 307-322.

Conley, T. G., & Udry, C. R. (2010). Learning about a New Technology: Pineapple in Ghana. *American Economic Review*, 35-69.

Dennis, J. V. (1987). *Farmer management of rice variety diversity in Northern Thailand.* Ann Arbor, MI: Cornell University, Univ. Microfilms.

DeYoung, D. J. (2015). *Determinants of Sustainability of Community Seed Banks in Nicaragua: A Duration Analysis Approach, Master Thesis.* East Lansing, MI: Michigan State University.

Douglas, J. (1980). *Successful seed programs. A planning and management guide.* Boulder: Westview Press.

FAOSTAT. (2018, January 9). *Country*.

Faye, I., & Deininger, K. W. (2005, July 24-27). Do New Delivery Systems Improve Extension Access? Evidence From Rural Uganda. *Paper presented at the American Agricultural Economics Association Annual Meeting*. Providence, RI, US.

Feder, G., Just, R. E., & Zilberman, D. (1985). Adoption of Agricultural Innovations in Developing Countries: A survey. *Economic Development and Cultural Change*, 255-298.

Fligner, M. A., & Verducci, J. S. (1993). *Probability Models and Statistical Analyses for Ranking Data.* New York: Springer-Verlag.

Foster, A. D., & Rosenzweig, M. R. (1995). Learning by Doing and Learning from Others: Human Capital and Technical Change in Agriculture. *Journal of Political Economy*, 1176-1209.

Ginon, E., Chabanet, C., Cobris, P., & Issanchou, S. (2014). Are decisions in a real choice experiment consistent with reservation prices elicited with BDM 'auction'? The case of French baguettes. *Food Quality and Preference*, 173-180.

Grebitus, C., Lusk, J. L., & Jr., R. M. (2013). Effect of distance of transportation on willingness to pay for food. *Ecological Economics*, 67-75.

Groote, H. D., Tomlins, K., Haleegoah, J., Awool, M., Frimpong, B., Banerji, A., . . . Meenakshi, J. (2010). *Assessing rural consumers' WTP for orange, biofortified maize in Ghana with experimental auctions and a simulated radio message.* Cape Town: CYMMIT.

Harrison, G. (1989). Theory and Misbehavior of First-Price Auctions. *American Economic Review*, 749-762.

Holden, S. T., & Shiferaw, B. (2002). Poverty and Land Degredation: Peasants' Willingness to Py to Sustain Land Productivity. *Natural Resource in African Agriculture: Understanding and Improving Current Practices*.

Horowitz, J. K. (2005). *The Becker–DeGroot–Marshak Mechanism is Not Always Incentive Compatible, Even for Non-Random Goods.* Department of Agricultural and Resource Economics, University of Maryland.

Ingrid Olesen, e. a. (2010). Eliciting consumers' willingness to pay for organic and welfare-labelled salmon in a non-hypothetical choice experiment. *Livestock Science* .

Jayson Lusk, T. F. (2004). Experimental auction procedure: impact on valuation of quality differentiated goods. *American Journal of Agricultural Economics,* 389-405.

Jean Claude Rubyogo, L. S. (2007). A new approach for facilitating farmers' access to bean seed. *LIESA-LEUSDEN*.

Jeffrey K. Lazo, G. H. (1992). What is the Future Worth: An Experimental Examination of Rates of Time Preference. *Unpublished Manuscript*.

John A List, P. S. (2006). Using choice experiments to value non-market goods and services: evidence from field experiments. *Advances in economic analysis & policy*.

Karni, E., & Safra, Z. (1987). "Preference Reversal" and the Observability of Preferences by Experimental Methods. *Economtrica: Journal of the Econometric Society*, 675-685.

Kender, J. L., & Kerr, J. M. (1998). Determinants of Farmers' Indigenous Soil and Water Conservation Investments in Semi-arid India. *Agricultural Economics*, 113-125.

Lancaster, K. J. (1966). A new approach to consumer theory. *Journal of Political Economy*, 132-157.

Loviere, J. J., Hnsher, D. A., & Swait, J. D. (2000). *Stated choice methods: analysis and applications.* Cambridge university press.

Lusk, J. L., & Schroeder, T. C. (2006). Auction bids and shopping choices. *Advances in Economic Analysis & Policy*.

Lusk, J. L., Alexander, C., & Rousu, M. (2006). *Disgning Experimental Auctions for Marking Research: Effect of Values, Distributions, and Mechanisms on Incentives for Truthful Bidding.* Department of Agricultural Economics, Oklahoma State University.

MAGFOR. (2009). *Fortalecimiento al Sistema Nacional de Semilla, Evaluacion Social de Territorios, Ampliacion Proyecto de Tecnologia Agropecuaria II.* Retrieved June 2, 2015, from Ministerio Agropecuario y Forestal: http://www.magfor.gob.ni/programas/pea/salva/Evaluacion%20Social%20de%20Territorios%20Ampliacion%20PTA%20II.pdf

Maredia, M., Reyes, B., & DeYoung, D. (2014). Farmer perspective on the use of and demand for seeds of improved bean varieties: Results of beneficiary survey in Guatemala, Honduras, and Nicaragua. *Department of Agricultural, Food, and Resource Economics, Michigan State University*, Staff Paper No. 2014-04.

Mazar, N., Koszegi, B., & Ariely, D. (2014). True context-dependent preferences? The causes of market-dependent valuations. *Journal of Behavioral Decision Making*, 200-208.

McFadden, D., & Train, K. (2000). Mixed MNL Models for discrete response. *Journal of Applied Econometrics*, 447-470.

Munshi, K. (2004). Social learning in a heterogeneous population: technology diffusion in the Indian Green Revolution. *Journal of Development Economics*, 185 213.

Nicholas Magnan, D. J. (2015). Leveling with Friends: Social Networks and Indian Farmers' Demand for a Technology with Heterogeneous Benefits. *Journal of Development Economics*.

Oladele, O. I. (2008). Factors determining farmers’ willingness to pay for extension services in Oyo State, Nigeria. *Agricultura tropica et subtropica*, 165-170.

Opoku, E. (2017). *Willingness to pay for quality cowpea seeds: Experimental evidence from northern Ghana; Master's Thesis.* East Lansing Michigan: Michigan State University.

Peter Bohm, J. L. (1997). Eliciting reservation prices: Becker–DeGroot–Marschak mechanisms vs. markets. *The Economic Journal* .

Plott, C. R., & Zeiler, K. (2005). The willingness to pay- willingness to accept gap, the "endowment effect," subject misconceptions, and experimental procedures for eliciting valuations. *American Economic Review*, 530-545.

R. Tripp, N. L. (1997). Seed regulation: choices on the road to reform. *Food Policy*, 433-446.

Sain, G. (2011). *Un análisis de la evaluación campesina (aceptabilidad y satisfacción) de algunas innovaciones promovidas por el Proyecto Red SICTA.* Retrieved March 29, 2018, from http://repiica.iica.int/DOCS/B3425E/B3425E.PDF

Scarpa, R., & Willis, S. F. (2005). Perfomance of error component models for status-quo effects in choice experiments. *Applications of simulation methods in environmental and resource economics*, 247-273.

Seeds of peasant subsistence: agrarian structure, crop ecology and Quechua agriculture in reference to the loss of biological diversity in the souther Peruvian Andes. Ph.D. Thesis. (1989). Berkeley: University of California.

Singh, I., Squire, L., & Strauss, J. (1986). *Agricultural household models: Extensions, applications, and policy.* The World Bank.

Steur, H. D., Wesana, J., Blancquaert, D., Straeten, D. V., & Gellynck, X. (2017). Methods matter: a mete-regression on the determinants of willingness-to-pay studies on biofortified foods. *Annals of the New York Academy of Sciences*, pp. 34-46.

Street, D. J., Burgess, L., & Louviere, J. J. (2005). Quick and easy choice sets: constructing optimal and nearly optimal stated choice experriments. *International Journal of Research in Marketing*, 459-470.

Streets, D. J., & Burgess, L. (2007). *The construction of optimal stated choice experiments: Theory and methods.* John Wiley & Sons.

Train, K. (2003). *Discrete choice modles with simulation.* Cambridge: Cambride University Press.

Useche, P., Barham, B. L., & Foltz, J. D. (2012). Trait-based adoption models using ex-ante and ex-post approaches. *American Journal of Agricultural Economics,* 332-338.

Ward, P. S., Ortega, D. L., & Singh, D. J. (2014). Heterogenous demand for drought-tolerant rice: Evidence from Bihar, India. *World Development 64*, 125-139.

Wierema, H., Almekinders, C., Keune, L., & Vermeer, R. (1993). *La Produccion campesina en Centroamerica: los sistemas locales de semilla.* Tilburg, Netherlands: IVO P.O. Box 90153.