A Choice-Based Conjoint Experiment with Genetically Engineered Cotton in the Mississippi Delta

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Abstract

Producers' preferences for cottonseed are examined using a willingness-to-pay (WTP) approach via mail surveys. Results indicate a positive WTP for yield, technology and fiber quality, and it increases with the level of technology and quality, respectively. WTP varies directly with farm size and inversely with farm labor.

Keywords: choice, conjoint, cottonseed, fiber quality, preferences, willingness to pay.

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Introduction

The United States produced a record 22.8 million bales of cotton in 2004, 25% more than the 2003 crop. Yield was a record 828 pounds, nearly 100 pounds above the previous record of 730 pounds established in 2002 (USDA, 2005). Record production set the stage for low prices. As a consequence, roughly two-thirds of the U.S. cotton is now marketed in the world export market. Thus, U.S. producers must strive to produce quality cotton that meets international fiber characteristic demands. Cotton importers desire cotton that is longer in fiber and more uniform than U.S. base grade cotton. (Anderson, 2005).

The trend in U.S. cotton production has been to lower costs, increase yield and expand acreage through the use of genetically engineered seeds (e.g., Bt and herbicide-tolerant varieties). Exports of U.S. cotton fiber are expected to reach 16 million bales for the 2005-06 marketing year. Lange (2005) estimates that at least this level of exports is necessary in order to keep U.S. cotton infrastructure in place and profitable. The need to export two-thirds of the U.S. crop may affect this trend by making fiber characteristics more important than insecticide-resistance or herbicide-tolerance and yield.

In a recent acreage survey, 47% of cotton growers surveyed reported fiber quality to be "very important" when selecting a variety to plant. About 25.5% indicated "fairly important," and another 25.5% thought it was a factor but not a deciding factor. Less than 2% said it was "not at all important," and none reported it to be "not very important" (*Cotton Grower*, 2005). Because of the relative importance of quality in domestic and international markets (Anderson, 2005; Cleveland, 2005; *Cotton Grower*, 2004; Kausik, 2005), producers must balance quality, yield, and cost of production considerations when making production decisions. Seed characteristics and their resulting production outcomes are a critical component in this decision process, and these decisions are likely to be influenced by factors such as farm size, labor availability, and their mechanization complement.

The overall objective of this study is to examine producers' preferences for cottonseed. Specifically, we examine the preferences for alternative cottonseed packages varied by different levels of the attributes of seed price, seed type/variety, lint yield, and fiber quality. Of particular interest is if the recent emphasis on fiber quality in world markets is translated into producer choices for seed characteristics. This study will allow a direct estimation of the relative importance of seed characteristics on producer seed choices. Additionally, the impact of farm characteristics such as size and labor availability on seed choice is also examined.

Willingness to pay (WTP) for seed characteristics is examined by utilizing a choice-based conjoint (CBC) experiment. The CBC is used because it enables the estimation of the marginal values (utilities) of different attributes through simple mail surveys. The CBC approach has been used in a number of contexts and settings to examine respondent WTP for characteristics of a good or service (Beggs, Cardell and Hausman, 1981; Hudson and Lusk, 2004; Lusk, Roosen and Fox, 2003;; Nalley *et al.*, 2004). The resulting marginal WTP values provide information about the relative importance of seed characteristics, which provides information to seed breeders and genetics companies about potential demand for these characteristics. Additionally, this approach also allows for a direct investigation of the impacts of farm characteristics on the marginal WTP for different seed characteristics/technologies.

Theoretical Framework and Methods

A random utility model is used to represent utility for seed characteristics, where utility is a function of the attributes consistent with Lancaster's (1966) hedonic theory. We assume that, income being given, a producer derives utility from the attributes of a seed bundle, which is denoted by:

$$U = U(Price, Variety, Yield, Quality), \qquad (1)$$

where *Price* is seed price per acre, *Variety* is seed type (conventional, herbicide-tolerant, stacked gene), *Yield* is lint yield in pounds, and *Quality* is the fiber quality (low, medium, high). We assume $\partial U / \partial Price < 0$, meaning that increases in price decrease utility. Additionally,
$\partial U / \partial Variety > 0$, or improvements in seed variety increase utility.[1] Similarly, $\partial U / \partial Yield > 0$, i.e., increases in yield increase producer utility. Finally, $\partial U / \partial Quality > 0$, meaning that improvements in fiber quality increase producer utility, generally through a higher output price.

Choice-Based Conjoint Analysis

The theoretical model was operationalized by using the choice-based conjoint (CBC) analysis or choice experiment (CE), to determine impacts of seed attributes on producer utility. A mail survey of cotton producers in

[1] Because the seed variety represents production technologies and therefore have no impact on output price, we are inherently assuming here that increasing technology levels are associated with lower costs of production.

Mississippi was conducted in February and March of 2005. To determine the relative importance placed by producers on the attributes of price, seed type, lint yield, and fiber quality of cottonseed, each producer was presented with discrete choices between two packages and a choice of none of those two packages. Each attribute was varied by three different levels (table 1). The decision to choose a certain package may be viewed as a choice of a bundle of attributes, each of which provides utility/disutility to the producer (Lancaster, 1966). This method is relatively easier to administer compared to the alternative of personal interview and does not limit sample size (Hudson and Lusk, 2004; McFarlane and Garland, 1994; Ayidiya and McClendon, 1990).[2]

The CBC method is often used in transportation, environmental, marketing, and other business literature to estimate the utility of product attributes ("product" being broadly defined) or predict consumer choice by determining the relative importance of various attributes in consumers' choice process (Adamowicz *et al.*, 1997, 1998; Beggs, Cardell and Hausman, 1981; Hudson and Lusk, 2004; Jayne *et al.*, 1996; Lusk, Roosen and Fox, 2003; Mark, Lusk and Daniel, 2004; Roe, Boyle and Tiesl, 1996; Unterschultz *et al.*, 1998; Wardman, 1988). The CBC analysis has been known to effectively predict the success of new products (Jayne *et al.*, 1996), genetically modified products (Lusk *et al.*, 2002; Lusk, Roosen and Fox, 2003), and quality differentiated products (Loureiro and Hine, 2002; Lusk and Schroeder, 2004; Nalley *et al.*, 2004). It has been shown to be consistent with consumers' revealed preferences (Adamowicz *et al.*, 1997; Adamowicz, Louviere and Williams, 1994), and robust to hypothetical bias (Carlsson and Martinsson, 2001; Hudson, Gallardo and Hanson, 2004). The CBC method is also appealing in that it is based on random utility theory (Louviere, Hensher and Swait, 2000) and allows for multi-attribute valuation (Hudson and Lusk, 2004) and permits the measurement of trade-offs among numerous attributes (Lusk, Roosen and Fox, 2003).

Experimental Survey Design

The CBC technique provides the inherent advantage of allowing deliberate manipulation of attributes across choice sets to test specific hypotheses. However, administering an experiment with the full factorial design of all possible combinations of attribute levels is cumbersome and expensive (Hudson and Lusk, 2004). Based on the number of attributes and attribute levels, a full factorial design would consist of $3^4 = 81$ possible scenarios. It was unrealistic to expect each individual would examine all 81 different choice sets.[3] To restrict this amount, a fractional

[2] It should be noted that the 117 participants in this survey generated 4,488 observations on choice.
[3] In designing an experiment, it is often necessary to make a trade-off between statistical efficiency and the number

factorial design was created that maximized design efficiency (minimized attribute correlation), while maintaining design orthogonality (Kuhfeld, Tobias and Garratt, 1994).[4] A total of 26 scenarios were created using this process. To minimize respondent fatigue and increase response rates, the scenarios were randomly divided into two blocks of 13 scenarios,[5] each scenario containing two alternative packages (A and B) of specified levels of each attribute, and the option of choosing none of the two packages (choice C, "Neither," meaning "Don't Buy Either Package A or Package B.").

A questionnaire consisting of 13 scenarios as well as demographic questions was sent to each of the 600 cotton producers (300 receiving each block) selected randomly by a simple MS-Excel random number generator from a possible list of 1,319 cotton producers in the Mississippi Delta region provided by the county extension offices. Following Dillman's (1978) general mail survey procedures, the questionnaire was sent along with a postage-paid return envelope, and a cover letter explaining the purpose of the survey. A follow-up mailing was sent to producers not responding to the initial mailing about three weeks later.

Out of the 600 questionnaires mailed, three were returned undeliverable. Of the 203 questionnaires that were returned, 86 were unusable with 83 indicating the respondents were no longer cotton producers, and three were returned blank. Therefore, a total of 117 cotton producers' responses (questionnaires) were usable. Assuming the non-respondents to the survey were active cotton producers, the overall response rate was approximately 34% (203/597), and the usable response rate was approximately 22.9% (117/511).

Producers who grew cotton in 2004 or planned to grow it in 2005 were presented with a set of attributes: seed price; seed type (variety); lint yield; fiber quality; and other considerations. Using a scale of 1 to 5 (1 being very important to 5 being very unimportant), producers were asked to evaluate how each of these attributes would influence their decision when purchasing cottonseed.

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of possible choice sets administered. While a larger design has better statistical efficiency and larger burden on the respondent or in administering, a smaller design has a clear advantage in that the choice sets can be visually inspected and investigated for poorly matched attribute options. Obviously, the latter is a task that becomes increasingly difficult with the growth in size of the design (Lusk and Norwood, 2005).

[4] Lusk (2002) showed that the approach on CBC experimental design followed by Kuhfeld, Tobias and Garratt (1994) performs as well at identifying the underlying utility function as any other experimental design.

[5] In experimental design, researchers must be concerned with the 'effects' that they are attempting to estimate (Louviere, Hensher and Swait, 2000). A simple model attempts to estimate the main effects, while more complex models incorporate two-way and higher order interactions between the attributes. The more interaction effects are incorporated, the more complex and sizable the experimental design becomes. An experimental design that only incorporates main effects are unusable to estimate two-way and higher order interaction effects. In the current analysis, we incorporated main effects only. Thus, the models presented are all without interaction effects.

The choice variables used in the survey were then briefly defined. Seed price (per acre) referred to the buying price of cottonseed, i.e., the cost producers incurred or were willing to incur to buy cottonseed. Three price levels presented were \$16, \$34, and \$75 per acre.[6] Seed type referred to the type (or variety) of cottonseed producers could buy. Three different types were included: conventional, herbicide-tolerant, and stacked gene (i.e., herbicide-tolerant as well as insect-resistant). Lint yield (pounds per acre) referred to the lint yield producers could expect from their seed presented in the scenario, which were representative of typical "low" (750 lbs.), "average" (1,000 lbs.), and "high" (1,500 lbs.) yields for the Delta region. Fiber quality referred to the quality of fiber producers could expect. Three different standards were assumed in this study: Low, Average, and High. For "Low," producers were assumed to receive a discount of 0 to 2 cents per pound of lint. They were assumed to receive a premium of 0 to 2 cents per pound of lint for "Average," and "High" a premium of 3 to 5 cents per pound of lint. The different attributes and attribute levels used in this study are shown in table 1.

Each of the 13 scenarios was presented in the form of a table with the names of the attributes (choice variables) on the first column, and a level each of price, seed type, lint yield and fiber quality stated on the two subsequent columns. Each column defined a package (A or B) – with a certain level each of seed price, seed type, lint yield and fiber quality. These levels were varied across scenarios and within the two blocks in accordance with the derived fractional factorial design. The fourth column had the heading "Neither," giving the respondent the option to choose neither Package A nor Package B. An example scenario is shown in figure 1.

Modeling Approaches and Estimation

Approach 1: Conditional Logit (CL) Model

Following Louviere, Hensher and Swait (2000), a random utility model is defined as:

$$U_{ij} = V_{ij} + \varepsilon_{ij}\,, \tag{2}$$

where U_{ij} is the i^{th} producer's utility of choosing seed bundle j, V_{ij} is the deterministic portion of utility (to be maximized) and ε_{ij} is the stochastic component. The probability of choosing any of these j seed bundles is:

$$\Pr\{j\ is\ chosen\} = \Pr\{V_{ij} + \varepsilon_{ij} \geq V_{ik} + \varepsilon_{ik};\ for\ all\ k \in C_i\}, \tag{3}$$

[6] These prices were derived using normal seeding rates for the Mississippi Delta. While some producers may seed at greater or lesser rates than commonly prescribed, these prices encompassed typical per acre seed charges in this area.

where C_i is the choice set for producer i (C_i = {A,B,C}), choice C = "Neither" in figure 1, and

$$V_{ij} = \beta_0 + \beta_1 Price_{ij} + \beta_2 Herbicide\text{-}Tolerant_{ij} + \beta_3 Stacked\ \ Gene_{ij} + \beta_4 Yield_{ij} + \beta_5 Medium\ Quality_{ij} + \beta_6 High\ Quality_{ij} + \varepsilon_{ij}' \qquad (3)'$$

is the indirect utility function of option j for respondent (producer) i to be estimated. The explanatory variables are described in table 1, β_0 through β_6 are the parameters to be estimated. In particular, β_0 is an alternative/product-specific constant (ASC), also known as "location parameter," associated with option j for respondent (producer) i.

Assuming the random errors in equation 1 are independently and identically distributed across the j alternatives and N individuals have a Type I extreme value distribution and scale parameter equal to 1, Ben-Akiva and Lerman (1985) have shown the probability of producer i choosing choice j is given by:

$$\Pr\{j\ is\ chosen\} = \frac{e^{\mu Vij}}{\sum_{k \in C} e^{\mu Vik}}, \qquad (4)$$

where μ is the scale parameter, assumed equal to one, because it is unidentifiable within any particular data set (Lusk, Roosen and Fox, 2003). A conditional logit model, constituting the attribute levels reported in table 1, was estimated with equation 4. Price and yield were entered into the equation as continuous variables. Variety entered the equation as two dummy variables – Herbicide-Tolerant and Stacked Gene, with Conventional serving as the base. Quality entered the equation as two dummy variables – Medium Quality and High Quality, with Low Quality serving as the base.

The estimated coefficients in equation 4 represent the marginal utilities of the different attributes, which can be used to estimate the "implicit" marginal WTP for each attribute in monetary terms. The values producers place on the different attributes represent the income increase (decrease) needed to offset the positive (negative) utility provided by a particular attribute. For example, assume that producers received positive marginal utility from both yield and fiber quality. These assumptions suggest that the producer is willing to forgo some yield to obtain better fiber quality. By examining the ratio of the parameter estimate for fiber quality relative to the parameter estimate of income (the ratio of marginal utilities), an estimate of the amount of money the producer is willing to forgo to obtain better fiber quality is obtained (Hudson and Lusk, 2004).

Approach 2: Random Parameters Logit (RPL) Model

There are two primary limitations to the CL model above. First, the CL model outlined assumes all respondents share the same coefficients for all relevant attributes, meaning they are assumed to have the same preferences for cotton attributes. Such homogeneity in preferences may, however, be unrealistic. In many cases, one might expect heterogeneity in preferences within the population. Second, because farm or other respondent characteristics are fixed across all choices for each respondent, they are perfectly collinear with the intercept and must be dropped. This result prevents analysis of the impacts of these characteristics on choice.

A "mixed" or "random parameters" logit (RPL) model is often used to investigate heterogeneity of preferences (Layton and Brown, 2000; Revelt and Train, 1998; Train, 1998). In the RPL model, the β's from equation 4 are allowed to vary across the population with an assumed (in this case, normal) distribution. In general, individual *i* will have a coefficient vector given by $\beta_i = \overline{\beta} + \sigma u_i$, where $\overline{\beta}$ is the population mean, σ is a diagonal matrix of coefficient standard deviations, and **u** is a vector of independent standard normal deviates. This specification assumes the coefficients vary randomly over individuals to capture the potential variation in tastes for specific cottonseed attributes and relaxes the restriction that every respondent exhibits constant marginal utilities for choice attributes. The advantage of the RPL method is that it is not subject to the independence from irrelevant alternatives (IIA) found in the conditional logit model and accounts for the repeated observations taken from each respondent (Layton and Brown, 2000; Revelt and Train, 1998; Train, 1998). The results of this model provide an indication of the variability of contract preferences within the sample. Additionally, individual specific (farm) characteristics can then be used to explain any observed heterogeneity in preferences, which affords a direct analysis of farm characteristics on preferences.

The price coefficient is assumed fixed in the population. The same data from modeling approach 1 were used to estimate the RPL in modeling approach 2. Louviere, Hensher and Swait (2002) contend that, if respondents are relatively homogeneous in their preferences (in our case, for cottonseed attributes), modeling approaches 1 and 2 should be equivalent (Lusk, Roosen and Fox, 2003).

Willingness-to-Pay (WTP) Estimates

Point estimates of willingness to pay (WTP) are obtained in both the above modeling approaches by the simple formula

$$WTP_j = \left| \frac{\alpha_j}{\beta_j} \right|, \tag{5}$$

where α_j is the alternative/product-specific coefficient (ASC) term associated with the j^{th} alternative choice, and β_j is the response coefficient for that choice. Equation (5) gives WTP estimate at each point but not variance. Krinsky and Robb (1986) proposed bootstrapping confidence intervals around the WTP estimates to facilitate statistical tests. The variance-covariance matrix produced during the estimation process was then utilized to generate a bivariate normal density on WTP_j using 1,000 simulated observations, and a 95% confidence interval on $\overline{WTP_j}$ was constructed from these simulated observations.

Results

Assuming a cotton producer's decision to purchase cottonseed depends on the attributes of seed price, seed type, lint yield, fiber quality, and other considerations, the survey asked the respondents to evaluate on a scale of 1 to 5 how each of these attributes would influence their decision when purchasing cottonseed. Based on the responses received, "other considerations" had the highest mean of 2.53. Seed price was close second, with a mean of 2.28. The means of fiber quality, seed type and lint yield were, respectively, 1.82, 1.68 and 1.60. These results along with their standard deviations are shown in table 2. The means and standard deviations of age, farm labor, education and income are presented in table 3. These demographic variables were similar to those in the 2002 Census of Agriculture for the Delta region of Mississippi (USDA, 2005).

From the regression results of the conditional logit model (table 4), both the constants (ASC1 and ASC2) associated with the package choices A and B, respectively, appear to have negative signs, indicating that, on average, respondents preferred "Neither" (choice C) to either of the two packages A and B. The coefficient on price is negative, as expected: increase in price of cottonseed lowers the probability purchase. The positive signs and statistical significance on technology coefficients (herbicide-tolerant and stacked gene varieties) and fiber quality (both medium and high) indicate the importance of these attributes to respondents. All coefficient, here, are positive implying that these attributes increase utility (have a positive marginal utility) to the producer. All the t-ratios are significant at the 1% level of significance.

Utilizing the variance-covariance matrix produced during the WTP estimation process, the Krinsky-Robb (1986) procedure was used to bootstrap 95% confidence intervals around the WTP estimates, as shown in table 5. The marginal WTP estimates from conditional logit also imply producer demand for the relevant attributes. The marginal WTP for the herbicide-tolerant seed versus the conventional variety is \$66.11 per acre. Even though herbicide-tolerant cotton in the study area was slightly less expensive in 2004 and 2005, this may indicate the true WTP when factors such as convenience, protection from herbicide-drift from the neighbors, and unwillingness to go back to the "conventional" ways of farming are considered. The marginal WTP for the stacked gene seed of cotton versus the conventional seed is $86.71. Because the stacked gene seed combines the properties of insecticide resistance along with herbicide tolerance, the marginal WTP for the stacked gene variety is expected to be higher than the herbicide-tolerant variety. Combining the results from these two varieties may provide more insight, because, in order to get the "package" (yield, insect resistance and herbicide tolerance), often the producers must buy the stacked gene seed. If we subtract the cost of the Bt seed ($32.00) from $86.71, it makes the herbicide-tolerance portion even less expensive than our WTP estimate ($54.71). Therefore, there is a positive marginal WTP for technology relative to conventional cottonseed, and this WTP increases with the level of technology.

The marginal WTP for lint yield is approximately $0.20 per pound. Given that cotton loan price is $0.52 per pound, this WTP value is surprisingly low! With this result, the production cost beyond the seed must be $0.32 per pound or less to get the producer to pay $0.20 for each pound of additional yield. The marginal WTP for medium and high fiber qualities are approximately $38.08 and $62.11 per acre, respectively.[7] Thus, there is a positive marginal WTP for yield and quality, and thus WTP increases with anticipated yield and quality.

To account for potential heterogeneity, a random parameters logit (RPL) model was estimated. The results obtained from this model are shown in table 6. The constant terms (ASCs) and variety dummies are allowed to vary randomly in the population. In the model, the heterogeneity of these parameters is a function of farm labor and farm acres. The choice of random parameters is arbitrary, and these were selected to observe changes in only technology with respect to the stated variables (farm labor and acres). Holding other parameters constant allows examination of heterogeneity with respect to biotechnology. Price is also held constant to allow calculation of WTP. The overall effects of the RPL model are similar to those observed in the CL model.

Each of the signs on the heterogeneity estimated parameters shows how the relevant estimated preference parameter changes as the variable (farm labor or acres) changes. For example, the parameter Herbicide-Tolerant:Farm Labor is negative (-0.0603). The estimated parameter (random) for Herbicide-Tolerant is positive (1.5515). Thus, this parameter adjusts the "mean" of the herbicide-tolerant parameter downward with increases in farm labor. The “mean” of the herbicide-tolerant marginal utility decreases as farm labor increases, implying a

[7] Interestingly, assuming a 1,000 lb/acre yield, these marginal WTP values are approximately $0.04 and $0.06/lb, respectively, which is close to the stated anticipated premiums for these qualities.

lower marginal WTP for herbicide-tolerant technology. Thus, farm labor and herbicide-tolerant biotechnology are substitute inputs. Similarly, the parameter Stacked Gene:Farm Labor is negative (-0.0558). However, the parameter (random) for Stacked Gene is positive (1.772). Thus, the mean WTP for stacked gene technology decreases as farm labor increases. This result further reinforces the conclusion that biotechnology and farm labor are substitute inputs in cotton in the Mississippi Delta.

The parameters Herbicide-Tolerant:Acres and Stacked Gene:Acres are positive (0.0002 and 0.0003, respectively), and so are the respective random parameters in the utility function (1.5515 for Herbicide-Tolerant and 1.772 for Stacked Gene, respectively). Thus, each of these heterogeneity parameters enhances the "mean" of the herbicide-tolerant and stacked gene parameters, respectively, and so enhances the WTP for biotechnology. From the producer's perspective, then, there are economies of size in biotechnology adoption so that biotechnology is not size neutral.

Conclusions

This analysis utilized the choice-based conjoint technique to examine preferences for four choice attributes of cottonseed: price, yield, variety, and fiber quality. Mail surveys of agricultural producers in Mississippi were conducted to gather choice information. Random utility models were estimated, and estimates of the monetary value of attributes were derived from these marginal utility estimates.

The marginal willingness-to-pay (WTP) approach using conditional logit revealed WTP for herbicide-tolerant variety of cottonseed relative to the conventional variety as $66.11 per acre, and WTP for stacked gene (also relative to the conventional variety) as $86.71 per acre. Thus, there was a positive WTP for technology relative to the conventional variety of cottonseed, and WTP increased with the level of technology. The WTP for yield was positive, and approximately $0.20 per pound. There was also a positive WTP for fiber quality, which increased as quality increased – $38.08 for medium and $62.11 for high – relative to the base (low) quality.

From the random parameters logit (RPL) model, the heterogeneity of farm characteristics was examined. Preferences for cotton attributes exhibited significant heterogeneity within the population. While not surprising, these results indicate that this heterogeneity could have profound impacts on the efficacy of agricultural policy design. Larger farms had a higher WTP for technology than smaller farms, and farms with more farm labor had a lower WTP for technology. Indirectly, these results provide evidence that, while on the one hand, economies of size are captured by genetic modification of cottonseed, i.e., technology, farm labor and genetic modification are substitute inputs in cotton production. Whether declines in farm labor availability are driving technology adoption or whether increases in technology adoption are leading to declines in farm labor demand is not determined here, but it is clear that these two inputs serve as direct substitutes, which has implications for policy in that programs that foster technology adoption will likely lead to decreases in labor demand.

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Table 1. Attributes and Attribute Levels Used in Choice-Based Conjoint Experiment.

Attribute	Attribute Levels		
	Level 1	Level 2	Level 3
Seed Price (per acre)[a]	$16	$34	$75
Seed Type/Variety[b]	Conventional	Herbicide-Tolerant[c]	Stacked Gene[d]
Lint Yield (pounds per acre)[e]	750	1,000	1,500
Fiber Quality[f]	Low[g]	Medium[h]	High[i]

[a] The buying price of cottonseed, i.e., the cost producers incurred or were willing to incur to buy cottonseed.
[b] The type of cottonseed producers had the choice to buy.
[c] The herbicide-tolerant type of cottonseed allows the farmer to use postemergent herbicides. For example, glyphosate is a herbicide effective on many species of grasses, broadleaf weeds, and sedges.
[d] The stacked gene type of cottonseed combines the properties of both insect resistance (e.g., Bt) and herbicide tolerance.
[e] The lint yield producers could expect from their cotton farming operation.
[f] The quality of cotton fiber producers could expect.
[g] Producers were assumed to receive a discount of 0 to 2 cents per pound of lint for this quality of cotton fiber.
[h] Producers were assumed to receive a premium of 0 to 2 cents per pound of lint for this quality of cotton fiber.
[i] Producers were assumed to receive a premium of 3 to 5 cents per pound of lint for this quality of cotton fiber.

Table 2. Summary statistics on factors (seed price, seed type, lint yield, fiber quality, other considerations) that may influence cotton producers' decision in purchasing cottonseed as per mail survey in the Mississippi Delta, 2005.[a]

Procedure	Seed Price	Seed Type	Lint Yield	Fiber Quality	Other
Mean	2.28	1.68	1.60	1.82	2.53
Std. Dev.	1.27	1.25	1.32	1.22	1.12

[a] Producers were asked to evaluate each factor from 1 being very important to 5 being very unimportant. Therefore, the numbers in the row for mean in the table indicate the relative importance of the respective factors.

Table 3. Summary statistics on age and education of cotton producers, and of farm labor and income of cotton producing households as per mail survey in the Mississippi Delta, 2005.

Procedure	Age	Farm Labor	Education	Income
Mean	52.86[a]	4.82[b]	2.58[c]	2.56[d]
Std. Dev.	12.19	4.39	0.80	0.62

[a] Average age of respondent (cotton producer) in years.
[b] Average number of laborers, including respondent, engaged in farming operation.
[c] Highest level of education attained by the respondent (cotton producer) on average: 1– High School, 2 – Some College, 3 – College Graduate, 4 – Graduate or Professional Degree.
[d] Average household income of respondent (cotton producer) from farming: 1– Under $50,000, 2 – $50,000 to $250,000, 3 – Above $250,000.

Table 4. Conditional Logit Regression Results.

Variable	Coefficient	Standard Error	t-ratio
ASC1	-5.5035	0.3255	-16.91
ASC2	-5.2403	0.3199	-16.38
Price	-0.0224	0.002	-11.02
Herbicide- Tolerant	1.4835	0.1341	11.06
Stacked Gene	1.9417	0.1338	14.52
Yield	0.0044	0.0002	20.45
Medium Quality	0.8538	0.1249	6.83
High Quality	1.3903	0.1339	10.38
Log-Likelihood	-1,068.49		
R-squared	0.3499		
Number of Observations	4,488		

Table 5. Marginal Willingness to Pay (WTP) (in $) from Conditional Logit.

Variable	WTP
Herbicide-Tolerant	66.11 [53.30, 81.76][a]
Stacked Gene	86.71 [76.28, 97.36]
Yield	0.20 [0.17, 0.23]
Medium Quality	38.08 [28.02, 49.83]
High Quality	62.11 [52.15, 72.16]

[a] The figures in brackets indicate confidence intervals for the relevant variables.
Note: Herbicide-tolerant and stacked gene figures are relative to conventional variety. Medium and high qualities are relative to "low" quality cotton. Yield is on a per-pound basis.

Table 6. Random Parameters Logit Model Regression Results.

Variable	Coefficient	Standard Error	*t*-Ratio
Random Parameters in Utility Function			
ASC1	-5.4459	0.385	-14.146***
ASC2	-5.212	0.385	-13.541***
Herbicide-Tolerant	1.5515	0.2244	6.913***
Stacked Gene	1.772	0.2054	8.627***
Nonrandom Parameters in Utility Function			
Price	-0.0227	0.0021	-10.638***
Yield	0.0045	0.0002	19.297***
Medium Quality	0.9204	0.1333	6.906***
High Quality	1.4326	0.1558	9.194***
Heterogeneity in the Mean, Parameter:Variable			
ASC1:Farm Labor	0.0181	0.0275	0.661
ASC1:Acres	-0.0002	0.0001	-2.717***
ASC2:Farm Labor	0.0316	0.0246	1.286*
ASC2:Acres	-0.0002	0.0001	-3.139***
Herbicide-Tolerant:Farm Labor	-0.0603	0.0316	-1.911**
Herbicide-Tolerant:Acres	0.0002	0.0001	2.104**
Stacked Gene:Farm Labor	-0.0558	0.028	-1.991**
Stacked Gene:Acres	0.0003	0.0001	3.456***
Log-Likelihood Chi-squared	1,116.564		
R-squared	0.3551		
Number of Observations	4,488		

Note: Heterogeneity of the mean refers to changes in the mean parameter value due to changes in the stated variable: manpower or acres. * Statistically significant at the 0.10 level. ** Statistically significant at the 0.05 level.
*** Statistically significant at the 0.01 level.

Scenario 1
Packages A and B represent two different descriptions for a purchasing arrangement.
Please check (✓) the package (A, B, or Neither) that you would be most likely to choose.

Attribute	Package A	Package B	Neither
Seed Price (per acre)	$16	$75	
Seed Type	Conventional	Stacked Gene	
Lint Yield (pounds per acre)	1,000	1,500	
Fiber Quality	High	High	
I would choose . . .	☐	☐	☐

Figure 1. Example Choice Set Used in Conjoint Experiment.