# Are consumers willing to pay more for biodegradable containers than for plastic ones? Evidence from hypothetical conjoint analysis and non-hypothetical experimental auctions

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## Abstract

This study utilized and compared hypothetical conjoint analysis and non-hypothetical experimental auctions to elicit floral customers' WTP for biodegradable plant containers. The results of the study show that participants were willing to pay a price premium for biodegradable containers but the premium is not the same for different types of containers. This paper also shows the mixed ordered probit model generates more accurate results when analyzing the conjoint analysis internet survey data than the ordered probit model.



**JEL Classifications:** D12, Q13

**Keywords**: biodegradable, willingness to pay, marketing, carbon footprint, waste composition, green industry, nursery crops, floriculture crops

**Introduction**

The environmental horticultural industry (often referred to as the Green Industry) contributed $147.8 billion (2004 dollars) to the nation's economy in 2002 and employed approximately two million people (Hall, Hodges, and Haydu, 2005). Participants engaged in producing Green Industry products include growers of floriculture crops, nursery crops, and turf grass sod. Floriculture crops include bedding plants, potted flowering plants, foliage plants, cut cultivated greens, and cut flowers. Nursery crops are woody perennial plants that are usually grown in containers or in-ground. The Census of Agriculture defines nursery crops as ornamental trees and shrubs, fruit and nut trees (for noncommercial use), vines, and ground covers.

Nearly every floral crop and many nursery crops are grown in plastic containers. Botts (2007) reported that making nursery pots, flats and cell packs uses approximately 320 million pounds of plastic annually. The floral industry adopted plastic containers during the 1950's to replace expensive and breakable clay terra cotta containers. Nursery production evolved from in-ground, field-grown growing of plants to above-ground container-growing systems about the same time. There is still a significant portion of in-ground production, but a majority of nursery plants are grown in plastic containers since they can be harvested during most times of the year and are much easier to handle and ship.

In 2003, the U.S. generated approximately 11 million tons of plastic in the municipal solid waste stream as containers and packaging (EPA, 2007) which comprised a third of all municipal solid waste (EPA, 2005). Nationwide, only 3.9 percent of the 26.7 million tons of plastic generated in the U.S. was recycled in 2003, according to the EPA (2007). Most of the recycled plastic was from beverage containers, including soda pop and milk. It is often challenging to recycle or reuse agricultural plastics because of contamination problems or UV degradation. In the case of plant production, recycling facilities are often unwilling to accept plastics with soil or rooting media residue. Additionally, some professional plant growers have concerns about reusing plastic containers for fear that plant disease outbreaks will increase, and worry that existing sanitation practices may not be enough to render them sanitary for production. Typically, these non-reusable or non-recyclable plastic containers are disposed by consumers and landscapers, thus presenting a significant disposal issue for the horticulture industry (Evans and Hensley, 2004). What alternatives do professional plant producers and consumers of nursery and floral products have? One alternative might be to purchase biodegradable containers.

In recent years, the floriculture industry has seen a rise in biodegradable, compostable or bioresin containers often called "green" or "sustainable" products (Lubick, 2007). These containers are derived with renewable raw materials (e.g. corn or wheat starch, rice hulls, etc.), cellulose, soy protein, and lactic acid (White, 2009). Therefore, they are often labeled as compostable as they are broken down by naturally occurring microorganisms into carbon dioxide, water, and biomass when composted or discarded (White, 2009). Biodegradable containers are those that can be planted directly into the soil or composted and will eventually be broken down by microorganisms (Evans and Hensley, 2004; White, 2009). Most biodegradable containers are made of peat, paper, or coir fiber, with peat containers being the most prevalent (Evans and Hensley, 2004). Other examples of biodegradable container materials include spruce fibers; sphagnum peat; wood fiber and lime; grain husks, predominately rice hulls; 100% recycled paper; non-woven, degradable paper; dairy cow manure; (GreenBeam Pro, 2008) corn; coconut; and straw (Van de Wetering, 2008; Biogro-pots, 2007). Containers are sold to consumers with plants. Consumers can recycle or trash the plastic containers; for biodegradable containers, consumers also have the opportunity and are advised to plant the plants together with containers in the soil.

Despite the introduction of "green" products as alternatives to already existing ordinary products, many customers still choose ordinary products with lower environmental quality because of price and performance considerations or ignorance and disbelief (Ottman, 1998). Like most innovation activities, green product development is a task characterized by high levels of risk and uncertainty and the introduction of biodegradable containers into the Green Industry marketplace is no exception.

Most research has found that consumers willing to pay a price premium share attitudes that are favorable to the environment (Laroche, Bergeron, and Barbaro-Forleo, 2001; Schegelmilch, Bohlen, and Diamantopoulos, 1996; Straughan and Roberts, 1999; Engel and Potschke, 1998; Guagnano, Dietz, and Stern, 1994). Yet not all consumer attitudes about the environment are the same (Gladwin, Kennelly, and Krause, 1995; Purser, Park, and Montuori, 1995). Consumers think and act differently in response to ideas and products; ornamental plant containers are no different. Some questions that arise naturally are: will consumers be willing to pay a premium for biodegradable containers in comparison to the traditional plastic containers? If they do, what are the premiums? Will the premium they are willing to pay be the same for biodegradable containers that are made of different materials such as wheat starch, straw, and rice hulls? If not, which types of biodegradable containers glean higher premiums?

The objective of this study was to investigate consumer preferences for and willingness to pay (WTP) for biodegradable containers in comparison to traditional plastic containers. In addition to container type, we also included other important attributes that are related to the environment such as carbon footprint and percentage of waste materials used in making the containers. We investigated how consumer WTP changes when the environmental attributes change in a container. The results from this study are not only important for the Green Industry but also provide important implications and insights about the market potential of alternative packaging materials for other industries such as shopping bags and food packages.

In this paper, we used a combination of a hypothetical conjoint analysis using pictures of products and a second-price sealed-bid auction using real products to elicit consumer WTP for biodegradable containers. The hypothetical conjoint analysis and non-hypothetical auction have their own advantages and disadvantages. The advantages of hypothetical conjoint analysis include: the hypothetical conjoint analysis can virtually be applied to any new product without actually having to develop or deliver the good, whereas non-hypothetical real auction can only be applied to existing product because subjects will buy the products if they win (Lusk, 2003); in the hypothetical conjoint analysis subjects can be asked how they would behave in a real store whereas values elicited in a non-hypothetical auction may change based on tastes and preferences at the time and location of the experiment (Lusk, 2003); the hypothetical conjoint analysis elicits responses in a manner that closely mimic actual shopping behavior by posting prices whereas non-hypothetical auction requires subjects to formulate bids in a manner that is unfamiliar to most subjects (Lusk, 2003); it’s less costly in terms of money and time to conduct enough hypothetical conjoint analysis that can be generalized to a larger population compared to the non-hypothetical auction (Lusk, 2003). The advantages of non-hypothetical auction include: non-hypothetical auction is incentive compatible and is conducted in a non-hypothetical context that involves the exchange of real money and good, whereas the hypothetical conjoint analysis can lead to hypothetical bias because no actual payment is required (Cummings, et al., 1995; Fox et al., 1998; List and Shogren, 1998); non-hypothetical auction can also put subjects in an active market environment where they can incorporate market feedback; non-hypothetical auction elicits WTP values for each individual, whereas WTP values must be indirectly inferred in hypothetical conjoint analysis from utility estimation (Lusk, 2003).

Additionally, the hypothetical conjoint analysis, which uses pictures, has its strength in the internal validity of the experiment. For example, using the same pictures for containers made from the same material but labeled with different levels of carbon footprint and waste material composition, we know that the differences in WTP that we find in this part of the study are due to the variation in these two attributes alone. The real auction using real products instead of pictures has its strength in its external validity. With real economic incentives, the participants face a real trade-off between money and goods and, as in real-world markets, thus it is in consumers' own interest to act so that they maximize their own utility. Through combining the data from the hypothetical conjoint analysis and non-hypothetical auctions, we utilize the strengths and alleviate the weaknesses of the two methods.

In the literature, there are several studies that elicit consumer WTP using both conjoint analysis and non-hypothetical auction. Lusk and Schroeder (2006) compared results from different experimental auction with those from a conjoint analysis and found bids from the experimental auction were significantly lower than those derived from conjoint analysis. Silva *et al*. (2007) investigated consumers' willingness to pay for novel products using the Becker-DeGroot-Marshak (BDM) auction mechanism and conjoint analysis. Grunert et al. (2009) studied consumer WTP for basic and improved soup products and compared experimental auction and conjoint analysis and the use of real vs. game money. In addition to the contribution to the empirical WTP literature by estimating consumer WTP for biodegradable containers for plants by combining the hypothetical conjoint analysis and non-hypothetical experimental auction we employed and compared different estimation methods such as mixed ordered probit model and ordered probit model to estimate the conjoint analysis data and investigate which estimation method generates the most accurate and efficient WTP estimates.

## Material and Methods

### *Experimental Methods*

Conjoint analysis is a survey-based approach that has been widely used to evaluate consumer preference and willingness to pay for various products. Conjoint analysis decomposes a product with multiple attributes, all of which have associated utility, into individual attributes and asks respondents for an overall evaluation of the product. Using conjoint analysis, a researcher can determine a part-worth utility for each product attribute and the sum of the attributes allows for determination of total utility for any combination of attributes. Conjoint analysis is commonly used to evaluate product acceptance among consumers and consumer WTP for different attributes of a product (see e.g. Yue and Tong, 2009; Fields and Gillespie, 2008; Bernard et al., 2007; Harrison et al., 2005; Manalo et al., 1997). Most conjoint analysis studies conducted by previous researchers have been hypothetical using pictures without the real exchange of money and goods, which might lead to bias in the estimation in consumer WTP. Yue et al. (2009) showed that because the participants did not need to buy the product when presented with pictures, they tended to overstate their WTP for product in pictures compared to the cases where they were presented with real products and faced the chance they would need to pay out-of-pocket for the real product.  There are numerous studies related to hypothetical bias in the literature (see e.g. Cummings et al., 1995; Fox, et al., 1998; List, 2003; List and Gallet, 2001; List and Shogren, 1998; McKenzie, 1993; Poe, et al., 2002).

One way to overcome the aforementioned bias is to use experimental auctions, which is an incentive compatible experimental method since it involves the real exchange of money and goods. In the last 15 years, experimental auctions have been used to elicit WTP for a wide variety of food quality attributes (see, e.g., Olesen et al., 2009; Alfnes, 2009; Yue, et al., 2009; Hobbs et al. 2005; Brown, Cranfield and Henson 2005; Lusk, Feldkamp and Schroeder 2004; Lusk et al. 2004; Rozan, Stenger and Willinger 2004; Umberger and Feuz 2004; Alfnes and Rickertsen 2003; Roosen et al. 1998; Melton et al. 1996).

A (real) second-price sealed-bid auction is an auction in which the bidders submit sealed bids and the price is set equal to the 2nd-highest bid; the winners are those who have bid more than the price. Vickrey (1961) showed that in such an auction in which the price equals the first-rejected bid and each consumer is allowed to buy only one unit, it is a weakly dominant strategy for people to bid so that if the price equals their bid and they are indifferent to whether they receive the product or not. As a consequence, people not knowing the values of other participants have an incentive to truthfully reveal their private preferences. If they bid lower than their true WTP, they risk forgoing a profitable purchase. If they bid higher, they risk buying a product at a price that is above what they perceive the product to be worth given the available alternatives.

***Product***

The products we used were mature, yellow blooming chrysanthemums in four-inch containers. The flowers in the containers were identical to each other in appearance, while the container attributes changed among the alternatives. The container attributes and the attribute levels tested are shown in Table 1. The attributes include material type, carbon footprint, and waste composition of a container (price was also an attribute for conjoint analysis).

Other attributes that could be considered as important to the consumer's purchase decision (such as container size and color and flower attributes such as flower type, color and size) were held constant. There were four types of containers: wheat starch, rice hull, straw and plastic. We choose these three types of biodegradable containers because they are currently available on the market. Participants were made aware about the biodegradable nature of the containers; that is, they can plant the flowers together with biodegradable containers in the soil. The plastic container was also included in our study since it is widely used by many producers and consumers and can thereby serve as control for the biodegradable containers.

The second attribute was carbon footprint. Carbon footprint was included given its increased importance both at the producer and consumer end of the marketing channel. This increased importance can be easily seen by the increasing amount of not only academic research, but also increased media coverage and marketing strategies of businesses attempting to capitalize on claims of carbon footprint savings (Philip, 2008; Pearson and Bailey, 2009). In order to determine consumer preference for and the value of "carbon labels" we compare several different labels, namely "carbon neutral," "carbon saving," and "carbon intensive."

The third attribute was percentage of waste composition (the amount of waste materials used in making the product), which was included to determine if the percentage of the pot made of waste products played any role in the consumer's purchasing decision. Waste composition levels included: "0% waste," "1-49% waste," and "> or = 50% waste."

For the conjoint analysis, we had three price levels. Price levels were determined by taking the 4-state (Indiana, Michigan, Minnesota, and Texas) average market price, $2.99, for a 4-inch potted chrysanthemum. The low and high prices were then set at $0.50 above ($3.49) and below ($2.49) the average retail price, which was determined by market observation of the price variation of a 4-inch potted chrysanthemum in the four studied states. The 4-state average price was used since the conjoint survey was administered in Indiana, Michigan, Minnesota, and Texas. Price was not an attribute for the experimental auction since participants were asked to name their own prices they were willing to pay for the containers.

All the combinations of the carbon footprint levels and product raw materials are feasible since carbon footprint is generated not only from the raw material of the product but also from the way the product is produced or how the product is transported or stored. Therefore, it's possible to have a container that uses 0% waste material while still is considered carbon saving.

Since it was not practical to ask each participant to evaluate all possible combinations of the attributes, a fractional factorial design was developed to minimize alternative number and maximize profile variation. The design was developed based on four principles: (1) level balance (levels of an attribute occurred with equal frequency), (2) orthogonality (the occurrences of any two levels of different attributes were uncorrelated), (3) minimal overlap (cases where attribute levels did not vary within a scenario were minimized), and (4) utility balance (the probabilities of choosing alternatives within a scenario were kept as similar as possible) (Louviere et al., 2000). The fractional factorial design generated by software SPSS yielded 16 alternatives to evaluate in the conjoint internet survey and 14 alternatives in the experimental auction. We did not manually eliminate any alternatives after the computer design. For a further discussion of factorial design, see Louviere et al. (2000). The alternatives used in the conjoint internet survey were product pictures and the alternatives used in the experimental auction were real products.

***Experimental procedure***

*Hypothetical conjoint internet survey*

The Internet survey was developed by researchers and approved by the university committees involved with research on human subjects. It was then implemented by Knowledge Networks during July 2009. Advantages of Web-based surveys according to McCullough (1998) are that they are potentially faster to conduct than telephone or face-to-face interviews, generate more accurate information with less human error. Even though 69.6% of the U.S. population has internet at work or home (Internet World Stats, 2006), Knowledge Networks provides Internet access to potential respondents without it, thereby, eliminating that potential bias.

The survey was made up of four parts: 1) types and amounts of plants purchased, 2) conjoint questions, 3) recycling behaviors of retailers where consumers purchase most plants, and 4) consumers' own personal and household recycling behaviors. The conjoint questions included the 16 alternatives in pictures with different product attribute combinations clearly labeled. Each survey question stated: "Please take a look at the following photographs and tell me how likely you would be to purchase the plant for your own home as shown. Keep in mind that all of the containers are four inches tall and the same size." Survey participants were then asked to indicate how likely they would be to purchase the plants on a 9-point Likert rating scale with 1 meaning "extremely unlikely" and 9 meaning "extremely likely." Conjoint analysis using ratings has its merits: it allows subjects to express order, indifference and intensity across product choice (Field and Gillespie, 2005); there is no information loss if subjects wish to express cardinal properties in their preference ordering (Harrison and Sambidi, 2004); and it's easier for subjects to use since they do not require a unique ordering (Harrison and Sambidi, 2004).

The biodegradable containers we examined in our study were meant to be planted directly in the flower bed so they were more relevant to outdoor plants. In order to eliminate respondents who did not purchase outdoor plants, we asked potential respondents if they had purchased any plants for any type of outdoor use during the last year (since July 2008). If the respondent did not purchase any plants, then the survey ended and the respondent did not proceed to subsequent questions. An answer of "yes" allowed the respondent to finish the rest of the survey. A total of 1,113 participated in the survey with 834 participants completing the survey. The remainder of the respondents did not finish the survey since they did not purchase any ornamental plants in the past year.

*Non-hypothetical Experimental auction*

The experimental auctions were conducted in Twin Cities, MN and College Station, TX during May 2009. We chose to conduct the experiment auction in May because April and May are the months when people buy most of their outdoor plants (Yue and Behe, 2009). The participants were recruited through multiple channels including advertisements in local newspapers, *www.craigslist.org*, and community newsletters in order to make the recruitment pool as broadly representative of the local area and state population as possible. To make sure participants were regular buyers of ornamental plants, we specified in the advertisement that "you have to have purchased ornamental plants in the past year and you are at least 18 years old." To avoid self-selection bias, the recruitment advertisement indicated that participants would be asked about their market decisions on plant purchases, but nothing was said about biodegradable containers.

We conducted eight sessions with a total of 113 participants (there were four sessions in MN and TX, respectively). In each of the auctions there was simultaneous bidding on 14 alternatives. At the beginning of each session, participants were given a consent document and a questionnaire. The questionnaire consisted of similar questions to the conjoint internet survey.

To familiarize participants with the auction procedure, we ran one round of practice auction in which participants bid on candy bars. Next, the 14 alternatives were put on a large table and beside each alternative there was a label indicating the container type, percentage of waste materials, and carbon footprint levels. The label for each product was a piece of laminated and printed paper and was placed at a prominent position in front of each plant. Participants walked around the table and placed their bids on their bidding forms as they studied each alternative. Participants were not allowed to communicate with each other during the bidding process. To reduce any systematic ordering effects, the participants could start at any of the 14 alternatives on the table.

After the real auction, each participant randomly drew his or her exclusive binding alternative. The price of an alternative was equal to the 2nd-highest bid for that alternative. If the participants had bid more than the price for their binding alternative they had to buy the alternative. Participants were given $30 to compensate for their time. At the end of the experiment, if a participant won an alternative, he/she would get the alternative he won and get $30 minus the price for the alternative; if a participant did not win, he/she received the entire $30.

***Econometric Models***

The experimental auction data is analyzed using the following model:

$$Bid=\boldsymbol{\gamma}\boldsymbol{A}+\mu+\varepsilon \qquad (1)$$

where ***Bid*** is respondents' bid for the alternatives in the experimental auction, $\boldsymbol{\gamma}$ is a row vector of coefficients, $\boldsymbol{A}$ is a column vector of container attributes, $\mu$ is a random individual effect that is designed to capture the correlation between the bids submitted by the same participants and is assumed to follow a normal distribution with mean zero and standard deviation $\sigma_{\mu}$, and $\boldsymbol{\varepsilon}$ is the random econometric error. Measures of the difference between the WTP for attribute ***i*** and attribute ***j*** are then

$$WTP_{i\text{-}j}=g_{ij}\,(\boldsymbol{A}_i-\boldsymbol{A}_j) \qquad (2)$$

where $g$ denotes estimated coefficients for $\boldsymbol{\gamma}$, and $i, j$ denote different levels of attributes. Instead of using a linear model, we used a linear mixed model in estimating the auction data. Since participants bid on 14 alternatives simultaneously, it is very possible that there is correlation between the bids submitted by the same participants. The linear mixed model is used to capture the possible correlation by including a random individual effect.

For the conjoint analysis data, similar to Boyle et al. (2001), we assume that respondents have linear preferences over the container attributes in the experimental design such that

$$V(.)=\boldsymbol{\beta A}+\alpha\$+\tau+\boldsymbol{e} \qquad (3)$$

where $V(.)$ is an indirect utility function, $\boldsymbol{\beta}$ is a row vector of coefficients, $\boldsymbol{A}$ is a column vector of container attributes, $\alpha$ is the marginal utility of money, $\$$ is price in the experimental design, $\tau$ is a random individual effect that is designed to capture the correlation between the ratings submitted by the same participants and is assumed to follow normal distribution with mean zero and standard deviation $\sigma_\tau$, and $\boldsymbol{e}$ is the random econometric error. Measures of the difference between the WTP for attribute ***i*** and attribute ***j*** are then

$$WTP_{i\text{-}j}=b_{ij}\,(\boldsymbol{A}_i-\boldsymbol{A}_j)/a_{ij}, \qquad (4)$$

where $a_{ij}$ and $b_{ij}$ denote estimated coefficients for $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$, respectively, and $i, j$ denote different levels of attributes. The confidence interval for $WTP_{i\text{-}j}$ can be calculated using Delta method (Greene, 2002).

We analyzed the ratings data using a mixed ordered probit model. Probit model assumes that there is a postulated continuous latent variable that is partially observed and there is an existing transformation from ratings space to utility space. In the ordered-probit model, the ratings have ordinal interpretation, i.e. a rating of five is not necessarily twice as far from rating of one as rating of three. Instead of using ordered probit model, we use mixed ordered probit model by introducing an individual random effect into the model. Since in the conjoint analysis each participant evaluated multiple items (16 alternatives in our experiment) it's very possible that the ratings from the same participant on the 16 alternatives are correlated. The random individual effect is designed to capture this correlation.

**Results and Discussion**

Table 2 shows the socio-demographic background information of experimental auction participants and conjoint analysis internet survey participants. The average age of participants was 40-59 years old for both the experimental auction and internet survey. This is consistent with earlier studies that gardening plants purchasers tend to be older (Yue and Behe, 2008). The average household size of both experimental auction participants and internet survey participants were 2 to 3 people per household. Auction participants had relatively higher average education and income levels than internet participants. In addition, more auction participants were female (70%) than internet participants (52%). To compare the socio-economic variables of the auction participants and conjoint analysis internet survey participants we ran two-sample Wilcoxon rank-sum tests for medians for variables *Age, Education, Household Size* and *Income* and Z test for variable *Gender*. The two samples did not differ significantly from each other on *Age* and *Household Size* (p-values were 0.21 and 0.24, respectively) but the two samples differed significantly on *Education, Gender*, and *Income* (p-values were less than 0.01). We ran the analysis by including and excluding the socio-demographic variables for both experimental auction data and internet survey data. We incorporated and controlled socio-demographic variables in the analysis to make sure that the possible difference (if any) in the estimated WTP from experimental auction data and conjoint analysis data are not due to the difference in socio-demographic backgrounds of participants from the two experiments.

Table 3 shows the estimation results of the experimental auction data using two linear mixed models. Model 1a only included the product attributes and Model 1b included both product attributes and participants' socio-demographics such as age, gender, education level, household size and income levels. In the estimation, plastic, 0% waste composition and carbon neutral were used as the reference levels for the estimation. By incorporating the socio-demographic variables, Model 1b did not yield statistically significantly different coefficients than Model 1a. The estimation results show that participants were willing to pay a higher premium for biodegradable containers and the average premiums were not the same for biodegradable containers that are made from different materials. The WTP estimates and corresponding confidence intervals from experimental auctions are shown in the second column of table 5. Compared with plastic containers, participants liked rice hull pots the best and they were willing to pay the highest premium which was around $0.58 per pot. Participants were willing to pay about $0.37 premium for straw pots, and $0.23 premium for wheat starch pots compared with the traditional plastic containers.

The composition of waste materials in a given container also affected consumer WTP based on the auction data estimation results. We found that the higher the percentage of waste materials in a pot, the higher the premium. For example, compared with 0% waste material, participants were willing to pay about $0.16 for a pot comprised of 1-49% waste materials and about $0.23 for a container comprised of 50-100% waste materials.

As expected, carbon footprint level also significantly influenced participant WTP for a container. Specifically, we found that compared with a neutral carbon footprint, participants were willing to pay about \$0.17 more for a container that was carbon saving and they discounted carbon intensive containers by around \$0.43. The significant estimate of gender shows that female participants' WTP for plants were higher than that of male participants. The estimate of the random individual effect is significant ($\sigma_\mu$), indicating that there is correlation between the multiple bids submitted by the same participants. Therefore, the linear mixed model rather than linear model should be used since the use of the linear model would lead to biased estimation.

Tables 4 shows the estimation results on the conjoint internet survey using a mixed probit model. The inclusion of socio-demographic variables does not change the coefficients of the product attributes significantly, but we found that the estimation results from the conjoint analysis internet survey are quite different from those from experimental auction. The negative coefficient of ***Price*** means that as price goes up consumers' likelihood of choosing the product is lower. The coefficients of ***Rice Hull*** and ***Straw*** are significant and positive and the coefficients of ***Carbon Intense*** are negative and significant. The positive coefficients of ***Rice Hull*** and ***Straw*** indicate that participants were more willing to buy biodegradable containers made from rice hull and straw and they were willing to pay positive premiums for them. The coefficient of ***Rice Hull*** is higher than that of Straw, which indicates participants liked containers made of rice hull better than the containers made of straw. The coefficients of the variables measuring the percentage of waste materials, *Wheat Starch*, and *Carbon Saving* are not significant.

If we divide the coefficient of a product attribute by the absolute value of the coefficient of price we get the estimated WTP for that specific product attribute compared with the baseline attribute (Boyle et al., 2001). The estimates of WTP for different product attributes and the corresponding 95% confidence intervals from the conjoint analysis internet survey based on models 2a and 2a' were listed in columns 3 and 4 of table 5. The results show that compared with plastic containers, participants were willing to pay about $0.82 more for rice hull containers and they are willing to pay around $0.61 more for straw containers. Compared with carbon neutral containers, participants discounted carbon intense containers by around $1.04 per container. Estimates of WTP for other product attributes such as wheat starch container, carbon saving container, and the percentage of waste materials are not significantly different from their baseline product attributes (plastic container for container type, carbon neutral for carbon level, 0% waste material for percentage of waste material composition).

Table 5 shows that the WTP estimates from auction data are quite different from the WTP estimates from conjoint analysis data. Compared with the auction results, the premiums for rice hull pots and straw pots are higher but are not significantly different. The discount for carbon intense containers is significantly higher than the conjoint analysis results. While the premiums for wheat starch pots, carbon saving, higher percentage of waste material (1-49% and 50-100%) are positive and significant from auction results, no premiums were found for these attributes from conjoint analysis internet survey results. These differences stem from four major sources with the first being the differences that can occur between a non-hypothetical study versus hypothetical study and the second stemming from the use of real products versus the use of pictures of products. The experimental auction involved real exchange of money and goods. Participants were asked to buy the products if they won and the procedure is incentive compatible. The conjoint analysis internet survey did not involve real exchange of money and goods. It was a hypothetical method and participants were not required to purchase anything. Extensive literature has shown that if there is no involvement of exchange of money and goods, it also leads to hypothetical bias. Hypothetical bias measures the difference between what people say they would pay and their real WTP (Alfnes and Rickertsen 2003; Lusk, Feldkamp and Schroeder 2004; Yue, et al., 2009). Another difference between the two studies is that the experimental auction used real products while the conjoint internet survey used pictures of products. Being presented with real products, participants get the chance to see, touch, and feel the products, which gives participants a better idea about the products' texture, color, size, sturdiness and other physical quality attributes. By seeing only a product's picture, participants' judgments about products' quality is purely based on the appearance of the products shown in pictures and they have to imagine other dimensions of the product quality based on their own experiences and knowledge.

For example, the premium for wheat starch from experimental auction results is significant and positive while there is no premium for wheat starch containers based on the conjoint analysis internet survey results. The wheat starch containers and plastic containers are very much alike in appearance shown in pictures. Consumers might assume that products made from wheat starch might not be as sturdy as plastic even though they are biodegradable, which results in no premium in WTP. Whereas in the experimental auction, participants got the chance to value the texture, sturdiness, and other aspects of the container and better assess the quality of containers made from wheat starch. The validation of the quality and biodegradable nature led to participants' premium value for the product. Similar results hold for waste material composition. Without the chance of seeing the real products, participants might assume that the containers made from waste materials might be of lower quality. Even though the product may be more environmentally friendly, they are reluctant to pay a premium for a product consisting of higher percentage of waste materials if they have no opportunity to assess its quality in person.

Additionally, the conjoint analysis and auctions elicited subjects' WTP in different ways (one posted price and the other one asked subjects to name their own prices), which can lead to different WTP estimates (Lusk and Schroeder, 2006) and we used different recruiting methods, which can also lead the differences in results. Due to the focus of the research project and cost considerations, we did not identify the exact effect of each of the four factors.

In the literature, conjoint analysis data are mainly estimated using linear, tobit, or probit models (Wittink, Vriens and Burhenne, 1994; Boyle et al., 2001; Manalo and Gempesaw, 1997; Anderson and Bettencourt 1993; Harrison, Stringer and Prinyawiwatkul, 2002; Sy et al., 1997) instead of using mixed probit model. However, the linear model has been shown to have limitations for estimating qualitative data in the literature (Doyle, 1977; Louviere, 1988; Sy et al., 1997). The ordered probit model shows that the random individual effect is significant ($\sigma_\tau$), which means a correlation exists between the ratings on multiple products from the same participants. The last two columns of table 4 show the estimation results ordered probit model without considering the random individual effects. From the results we can see that the estimation results of ordered probit model are different from the results of mixed ordered probit models. The log likelihood of the mixed ordered probit model is greater than that of the ordered probit model and the likelihood ratio test statistics are statistically significant (p-value<0.001), which indicates the mixed ordered probit model is a better fit for the conjoint analysis data. Ignoring the random individual effect would lead to biased estimation. Therefore, for our data, the mixed ordered probit model should be used instead of the ordered probit model to get accurate estimation. To compare the possible differences between the WTP estimation results, we also estimated the WTP using a probit model as shown in the last column of table 5. From table 5, we can see that compared with the mixed ordered probit model, the ordered probit model generates different WTP estimates even though some of the differences might not be statistically significant. Additionally, the confidence intervals of the estimates are much wider from the probit model than those from mixed probit model. Ignoring the significant random individual effects can not only lead to biased WTP estimates but also lose efficiency by generating wider confidence intervals. Therefore, panel models such as mixed ordered probit model should be used in the conjoint analysis data instead of ordered probit model to capture the random individual effects.

**Conclusions**

A widely discussed topic in the Green Industry is the greater degree of awareness being exhibited by consumers on the issue of environmental sustainability. This awareness has lead to an increased development of products that not only solve the needs of consumers, but are also produced and marketed using sustainable production, distribution, and marketing methods. A greater emphasis has also been placed on product packaging in the mainstream marketplace and this has carried over to the Green Industry in the form of biodegradable pots. While various forms of these eco-friendly pots have been available for several years, their marketing appeal was limited due to their less-than-satisfying appearance. With the recent availability of more attractive options of biodegradable plant containers, this has renewed interest in their suitability in the floriculture sector and their acceptance on the part of floral customers. However, these biodegradable (sustainable) pot alternatives may also require a price premium in the marketplace to be economically sustainable.

The presence of environmentally sensitive or “green” consumers has been acknowledged for some time and such consumers are more likely than the general population to take environmentalism into account when purchasing goods. The presence of such consumers has also been assumed to generate profits for companies with a track record of environmentally-friendly practices.

This objective of this study was to determine the characteristics of biodegradable pots that consumers deem most desirable when purchasing potted flowering plants and to solicit their willingness-to-pay (WTP) for this type of sustainable product. This study utilized both conjoint analysis and experimental auctions to elicit WTP on the part of floral customers for four types of biodegradable containers. While conjoint analysis allowed the research team to simultaneously investigate a number of product attributes and determine the relative importance of each attribute in the consumer’s preference, the experimental auctions enabled the team to distinguish what consumers “say they will do” against what they “actually did” in making purchasing decisions.

The results of the study show that participants were willing to pay a price premium for biodegradable containers and their revealed WTP is heterogeneous for biodegradable containers that are made from different materials. The composition of waste materials in a given container also affected consumer WTP based on the auction data estimation results. We found that the higher the percentage of waste material composition in a pot, the higher the premium. Lastly, as expected, the carbon footprint associated with a given container also significantly influenced WTP. Specifically, we found that compared with a neutral carbon footprint, participants were willing to pay more for a container that was carbon saving and they discounted containers that were labeled as carbon intensive.

In addition to the empirical contributions, this paper also makes theoretical contributions. We show mixed ordered probit model generates more accurate results when analyzing our conjoint analysis data than the widely used models in the literature such as the ordered probit model. We found significant individual random effects when estimating mixed ordered probit model for our data. Additionally, the confidence intervals of the WTP estimates are much wider from the probit model than those from the mixed probit model. Therefore, if the random individual effect is statistically significant, ignoring the significant random individual effects can not only lead to biased WTP estimates but a loss of efficiency by generating wider confidence intervals. Accordingly, panel models such as mixed ordered probit model should be used in the conjoint analysis data instead of ordered probit to capture the random individual effects.

Through intelligent packaging and system design, it is possible to "design out" many potential negative impacts of plant packaging on the environment and society – in this case, the prominent amount of virgin plastic produced as requisite to the green industry. *Cradle to cradle* principles offer strategies to improve the material health of packaging and close the loop on packaging materials including the creation of economically viable recovery systems that effectively eliminate waste. The use of biodegradable pots reflects these cradle to cradle principles. This research will greatly benefit floral consumers by ensuring that environmentally-friendly products marketed to them in the future truly meet their "sustainability" needs and/or expectations.

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**Table 1. Container attributes and the attribute levels tested in this study of WTP for biodegradable containers for potted flowering plants using conjoint analysis and experimental auction methodologies.**

| Attributes | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| Container Type | Plastic | Rice Hull | Wheat Starch | Straw |
| Waste Material Level | 0% | 1-49% | 50%+ | ------ |
| Carbon Footprint | Saving | Neutral | Intensive | ------ |
| Price[a] | $2.49 | $2.99 | $3.49 | ------ |

[a] Price was not an attribute in the experimental auction since participants bid the price they were willing to pay for each alternative.

**Table 2. Summary statistics of socio-demographic characteristics of the sample frame of Minnesota and Texas consumers participating in a 2009 WTP study of biodegradable containers for potted flowering plants.**

| Variable | Variable Definition | Experimental Auction (N=113) | | Conjoint Analysis (N=834) | |
|---|---|---|---|---|---|
| | | Mean | Standard Deviation | Mean | Standard Deviation |
| *Age* [a] | 1=Under 20 years old | 4.32 | 1.41 | 4.23 | 1.68 |
| | 2=20-29 years old | | | | |
| | 3=30-39 years old | | | | |
| | 4=40-49 years old | | | | |
| | 5=50-59 years old | | | | |
| | 6=60-69 years old | | | | |
| | 7=70 years old or over | | | | |
| *Education* [b] | 1=Some high school or less | 3.61 | 0.71 | 2.70 | 0.92 |
| | 2=High school diploma | | | | |
| | 3=Some college | | | | |
| | 4=College Diploma or higher | | | | |
| *Gender* [c] | 0=Male | 0.70 | 0.46 | 0.52 | 0.50 |
| | 1=Female | | | | |
| *Household Size* [d] | Number of people in a household | 2.64 | 1.31 | 2.70 | 1.39 |
| *Income* [e] | 1=$15,000 or under | 5.29 | 2.14 | 4.68 | 2.24 |
| | 2=$15,001 - $25,000 | | | | |
| | 3=$25,001 - $35,000 | | | | |
| | 4=$35,001 - $50,000 | | | | |
| | 5=$50,001 - $65,000 | | | | |
| | 6=$65,001 - $80,000 | | | | |
| | 7=$80,001 - $100,000 | | | | |
| | 8=over $100,000 | | | | |

[a] The p-value of Wilcoxon rank-sum test for the two samples is 0.22.
[b] The p-value of Wilcoxon rank-sum test for the two samples is <0.01.
[c] The p-value of Z-test of proportions for the two samples is <0.01.
[d] The p-value of Wilcoxon rank-sum test for the two samples is 0.24.
[e] The p-value of Wilcoxon rank-sum test for the two samples is <0.01.

**Table 3. Linear mixed model estimation results for experimental auction data (n=1,580) collected as part of a 2009 WTP study of biodegradable containers for potted flowering plants.**

| | Model 1a | | Model 1b | |
|---|---|---|---|---|
| Variables | Coefficient | Standard Error | Coefficient | Standard Error |
| *Constant* | 2.064***[a] | 0.178 | 2.214*** | 0.180 |
| *Rice Hull* | 0.583*** | 0.066 | 0.600*** | 0.067 |
| *Straw* | 0.366*** | 0.069 | 0.375*** | 0.071 |
| *Wheat Starch* | 0.226*** | 0.066 | 0.233*** | 0.067 |
| *Waste 1-49%* | 0.159*** | 0.056 | 0.163*** | 0.057 |
| *Waste 50-100%* | 0.231*** | 0.056 | 0.243*** | 0.057 |
| *Carbon Saving* | 0.166*** | 0.056 | 0.174*** | 0.057 |
| *Carbon Intense* | -0.432*** | 0.060 | -0.422*** | 0.057 |
| *Age*[b] | --- | --- | 0.111 | 0.314 |
| *Education*[b] | --- | --- | -0.238 | 0.281 |
| *Gender*[b] | --- | --- | 0.349** | 0.170 |
| *Household size*[b] | --- | --- | -0.032 | 0.189 |
| *Income*[b] | --- | --- | -0.132 | 0.177 |
| $\sigma_\mu$ | 1.757*** | 0.119 | 1.737*** | 0.119 |
| Log Likelihood | -2300.221 | | -2252.650 | |

[a] Double and triple asterisks (*) denote significance at the 0.05, and 0.01 levels, respectively.
[b] The variables are standardized in the estimations, which makes interpretation of the product attribute coefficients straightforward because the variables have zero means and unitary standard deviations (s.d.). After the variables are standardized, the coefficient (β) of an independent variable would be interpreted in this way: changing the independent variable by one standard deviation, holding other independent variables constant, would change the dependent variable by β standard deviations.

**Table 4. Mixed Ordered Probit model estimation results for conjoint analysis data (n=13,194) [a] collected as part of a 2009 WTP study of biodegradable containers for potted flowering plants.**

| | Model 2a | | Model 2b | | Model 2a' (Ordered Probit Model) | |
|---|---|---|---|---|---|---|
| Variables | Coefficient | Standard Error | Coefficient | Standard Error | Coefficient | Standard Error |
| *Price* | -0.354***ba | 0.026 | -0.355*** | 0.026 | -0.174*** | 0.024 |
| *Rice Hull* | 0.291*** | 0.029 | 0.292*** | 0.029 | 0.143*** | 0.027 |
| *Straw* | 0.217*** | 0.028 | 0.217*** | 0.029 | 0.110*** | 0.027 |
| *Wheat Starch* | -0.043 | 0.028 | -0.043 | 0.029 | -0.019 | 0.027 |
| *Waste 1-49%* | -0.040 | 0.023 | -0.040 | 0.023 | -0.022 | 0.021 |
| *Waste 50-100%* | -0.036 | 0.028 | -0.036 | 0.029 | -0.019 | 0.027 |
| *Carbon Saving* | -0.015 | 0.023 | -0.016 | 0.024 | -0.006 | 0.022 |
| *Carbon Intense* | -0.370*** | 0.028 | -0.371*** | 0.029 | -0.181*** | 0.027 |
| *Age* [c] | --- | --- | 0.048** | 0.023 | --- | --- |
| *Education* [c] | --- | --- | 0.180*** | 0.020 | --- | --- |
| *Gender* [c] | --- | --- | -0.095*** | 0.020 | --- | --- |
| *Household size* [c] | --- | --- | 0.155*** | 0.019 | --- | --- |
| *Income* [c] | --- | --- | 0.118*** | 0.020 | --- | --- |
| $\sigma_\tau$ | 1.457*** | 0.032 | 1.521*** | 0.036 | --- | --- |
| *Constant1* | -2.935*** | 0.082 | -2.782*** | 0.083 | -1.360*** | 0.073 |
| *Constant2* | -2.231*** | 0.081 | -2.082*** | 0.082 | -1.083*** | 0.072 |
| *Constant3* | -1.535*** | 0.080 | -1.407*** | 0.081 | -0.777*** | 0.072 |
| *Constant4* | -0.997*** | 0.079 | -0.879*** | 0.080 | -0.516*** | 0.072 |
| *Constant5* | -0.147* | 0.079 | -0.035 | 0.079 | -0.055 | 0.072 |
| *Constant6* | 0.346*** | 0.079 | 0.459*** | 0.079 | 0.230*** | 0.072 |
| *Constant7* | 0.962*** | 0.079 | 1.072*** | 0.080 | 0.589*** | 0.072 |
| *Constant8* | 1.604*** | 0.080 | 1.717*** | 0.081 | 0.966*** | 0.073 |
| Log Likelihood | -21171.876 | | -21125.123 | | -27996.452 | |

[a] We had 834 participants and each participant evaluated 24 alternatives, which leads to a total of 13,344 observations. After deleting outliers and observations with missing values (about 1%), we had 13,194 observations for our estimation.

[b] Double and triple asterisks (*) denote significance at the 0.05, and 0.01 levels, respectively.

[c] The variables are standardized in the estimations, which makes interpretation of the product attribute coefficients straightforward because the variables have zero means and unitary standard deviations (s.d.).

**Table 5. WTP estimates using different models to analyze data collected as part of a 2009 study of biodegradable containers for potted flowering plants.**

| Product Attributes | Experimental Auction | Conjoint analysis | |
|---|---|---|---|
| | Mixed Linear | Mixed Ordered Probit | Ordered Probit Model |
| *Rice Hull* | 0.583*** | 0.822*** | 0.821*** |
| | [0.454, 0.712][a] | [0.645, 1.000] | [0.484, 1.159] |
| *Straw* | 0.366*** | 0.612*** | 0.632*** |
| | [0.230, 0.501] | [0.440, 0.784] | [0.301, 0.962] |
| *Wheat Starch* | 0.226*** | -0.121 | -0.110 |
| | [0.097, 0.355] | [-0.281, 0.039] | [-0.414, 0.194] |
| *Waste 1-49%* | 0.159*** | -0.112 | -0.127 |
| | [0.049, 0.269] | [-0.240, 0.016] | [-0.371, 0.116] |
| *Waste 50-100%* | 0.231*** | -0.101 | -0.106 |
| | [0.121, 0.341] | [-0.257, 0.051] | [-0.400, 0.187] |
| *Carbon Saving* | 0.166*** | -0.042 | -0.032 |
| | [0.057, 0.276] | [-0.171, 0.089] | [-0.280, 0.215] |
| *Carbon Intense* | -0.432*** | -1.045*** | -1.042*** |
| | [-0.549, -0.314] | [-1.262, -0.827] | [-1.456,-0.628] |

[a] 95% confidence intervals.