Consumers' Willingness to Pay for Bioplastic Plant Containers: An Experimental Auction Approach

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Abstract: This study elicites consumers' willingness to pay for an environmentally sustainable good that might not typically be purchased on its own. We isolate the value of this perfectly-complementary, auxiliary good by endowing consumers with the complete good and giving them the opportunity to pay to upgrade the auxiliary component of the good. We employ a Becker-Degroot-Marschack auction design in a market setting to determine consumers' actual willingness to pay. We find consumers are willing to pay a \$0.67–\$1.12 premium for a bioplastic plant container over a traditional plastic one.

Horticultural specialty crop production is an \$11 billion industry in the U.S., and plastic plant containers (pots) are a major expense accounting for 5% of total expenditures and 15% of non-labor expenses (National Agricultural Statistics Service 2009). The container cropping industry uses over 4 billion plastic containers each year with ninety-eight percent ending up in landfills representing 1.6 billion pounds of discarded petroleum-based plastics (Mathers, Ramirez, and Case 2014). Plastic plant containers also contribute to carbon emissions, create disposal issues, and are a source of environmental pollution.

In this paper we report on the development of specialty crop containers made entirely from plant-based materials. Specifically, we report the results of experimental auctions designed to elicit consumers' willingness to pay for the bioplastic containers developed by our research team.

While stakeholders and consumers agree that alternatives to petroleum-plastics must be adopted, only a few non-plastic, sustainable alternatives exist. The reason for low adoption of non-plastic alternatives is associated with their lack of strength and functionality when compared to plastic containers. Together with a team of crop scientists, agricultural and biosystems engineers, and materials scientists, we have developed and market-tested crop container made from bioplastic materials that exhibit the durability of conventional petroleum-based plastic pots, yet are entirely derived from plant-based material and, in some cases, are biodegradable.

Eliciting Willingness to Pay for a Perfectly Complementary Auxiliary Good

Ultimately, adoption of these novel bioplastic pots by the horticulture industry will depend on the profitability of bioplastic pots to specialty crop producers. In this study, we focus on end consumers—individuals who shop at greenhouses and other plant retailers. Adoption of bioplastic pots by specialty crop producer will ultimately depend on the final consumers' willingness to pay. The demand for bioplastic pots among final consumers is also a major factor in the decision of molders to adapt their machinery to work with the bioplastic materials, which will determine the production of these laboratory prototypes at an industrial scale.

Estimating consumer demand for a new product is a difficult task because individuals tend to overstate the amount they are willing to pay. In practice, it is difficult to elicit consumer behavior by using surveys, focus groups, market test, and laboratory pre-test markets (Lusk, Alexander, and Rousu 2007). Stated preference arguments are hard to verify because people tend to overstate or understate their preference since there is no gain or loss to answering hypothetical questions. We address this by implementing an auction where participant's responses may be consequential.

Experimental auctions have advantages over stated preference methods because an exchange mechanism is used. The bids obtained from the experimental auction are the revealed preferences obtained in a real market with a real product and real money. This creates incentives for people to think about what they will actually pay for goods and services while accounting for the relevant budget constraints. An experimental auction mechanism employs the usefulness of both non-experimental data and induced-value experiments to create a middle ground between total-control, in-lab experiments and total-context surveys (Lusk and Shogren 2007).

Experimental auctions create an active market environment with feedback where subjects exchange money for goods (Lusk 2003). Although there are many different auction designs we could have used—first price, Nth price (second price), Becker-Degroot-Marschack (BDM) mechanism, and the random Nth price auction—we employ the Becker-DeGroot-Marschak (BDM) auction mechanism (Becker, DeGroot, and Marschak 1964). We use the BDM auction mechanism because it is designed to be incentive compatible—in other words, it encourages individuals to bid truthfully (Lusk, Feldkamp, and Schroeder 2004). The BDM mechanism can also be used with individual subjects in a market setting, and it allows the willingness to pay to be elicited quickly.

In a BDM auction, participants are asked to place a bid on a given product—in our case, two products—that reflects how much they are willing to pay for the product. Although participants place bids on multiple products, only one, randomly chosen product is actually sold. The price is also randomly chosen, and the participant pays the randomly chosen price if it is below their bid price. Because the binding price is drawn at random, participants are advised that it is in their best interest to submit a bid equal to the price they are willing to pay for the product.[1]

[1] Subjects in a BDM auction have no incentive to understate their true willingness to pay because the binding price is determined by a random draw, not the subject's bid. If a subject bids higher than her true value, she could end up paying a price higher than the true value. Conversely, if a subject bids lower than her true value, she could miss out on a profitable purchase. For more on the BDM auction mechanism, refer to (Becker, DeGroot, and Marschak 1964; Corrigan and Rousu 2008; Thrasher et al. 2011).

Bioplastic Plant Containers

The six bioplastic pots used in our analysis are as follows: PLA-SOY, PLA-BioRes, PLA-Lignin, Recycled PLA, PHA-DDGs and Polyurethene-coated paper fiber. PLA is the Polylactic Acid which is a plant based plastic. 3 of these pots are made up of blend of soy protein, other plant based protein and lignin- protein extracted from wood. Recycled PLA is made up of biodegradable and recycled containers used for yogurt. PHA-DDGs is made from Polyhydroxyalkanoate, which is produced in nature by bacterial fermentation of sugar or lipids, and Dried Distillers Grains with Solubles (DDGS), which are a cereal byproduct of the distillation process. The last pot is a polyurethene coating on paper fiber pots.

Experimental Design/Procedure

To determine end-consumers' preferences and willingness-to-pay for the six prototype bioplastic pots currently not available in the market, we implemented an experimental auction at a local farmers' market. The research team reserved a space at a Midwest farmers' market for three different Saturdays in the fall of 2014. The market provides a venue for local and regional growers, producers, and artisans to sell their products to the public. The market also provides a setting for direct interactions and conversations between producers and consumers to foster mutual understanding and to socialize, network, and connect. Hence, the consumers and producers that this market attracts come from various facets of the local community.

Upon consenting to participate in the study, participants were given a Maranta or Dracaena in a 4.5-inch traditional petroleum-plastic pot. Participants were informed that the plant was theirs to keep, regardless of the outcome of the study. They were then told they would have a chance to purchase one of the bioplastic-pot prototypes as part of an experimental auction. The participants were also told that if they won the auction, a member of the research team would transplant their free plant into the appropriate bioplastic pot to take home.

As described previously, there were six unique bioplastic pots to evaluate. However, due to the field setting, where many participants were time-constrained, we asked each participant to roll two dice to randomly select two of the six different bio-pots to evaluate. Once the two bio-pots were determined for the participant, the research team quickly set up the pots while the participant completed a brief questionnaire with basic socio-demographic information. For the assigned bio-pots, we provided information cards describing the pots, including information on the materials from which the pot was derived and any unique features or benefits of the specific pot, e.g., biodegradability, recyclability, and fertilizer effects.[2] The participant was given the opportunity to physically examine the randomly selected bio-pots and ask any clarification questions.

After they inspected the pots, participants were asked to bid their willingness to pay for each pot. Since this is a novel product to participants and because the cost to manufacture the pots is low (less than 20 cents), we bounded bids to be between $0 and $2. During the bidding process, the researchers clearly explained the Becker-Degroot-Marschack (BDM) auction mechanism and ensured that participants understood one of their bids would be binding. To determine which bid was binding, participants rolled a single die; an odd number would make the bid for the first pot binding and an even number would make the bid for the second pot binding. Following standard BDM auction procedures, the binding bid was compared to a randomly drawn price, and in the cases where the participants' bids were higher than the price drawn, the participants paid the price drawn and the research team transplanted their plants to the relevant bio-pot. After the auction procedure, participants were asked to fill out some general behavioral questions in an exit survey.[3]

Participant Characteristics

In table 1 and 2, we report the demographic characteristics, environmental attitudes and plant purchasing behavior of individuals in our sample. Table 1 reports that 65 percent of the sample are female, and 57 percent are under the age of 35. Sixty-eight percent have at least a bachelor's degree. About 55 percent have an annual income less than $50,000, while 16 percent have over $100,000 in annual income. Just under 50 percent of the sample own their home.

Table 2 reports the behavior of the sample along dimensions that are congruous with sustainability. The plant-purchasing behavior is fairly evenly distributed between never purchasing plants (14.29%) to purchasing plants more than 5 times per year (15.31%). The most common frequency of plant purchases is 3–5 times a year (25.51%).

Table 2 also reports the following environmentally conscious behaviors: recycling, reusable bag use, and composting. Eighty-four percent of the participates report recycling 'often' or 'always;' only 2.13 percent report never recycling. Thirty percent of the participants always use reusable bags, while 52 percent use reusable bags 'sometimes' or 'often.' Fifty-four percent of participants report 'never' or 'rarely' composting their waste. Almost 19 percent report 'always' composting their waste.

[2]The exact wording of the information card is available in the online appendix.
[3]The survey instruments are available in the online appendix.

Table 1: Summary of Consumer Characteristics—Demographics

Variable	Description	Sample Proportion (%)
Gender	Female	65.31
	Male	34.69
Age	18-24	30.61
	25-35	26.53
	35-44	12.24
	45-54	12.24
	55-64	10.2
	65 or above 8.16	
Highest Education	Some High School	1.02
	GED/High School diploma	2.04
	Some College	22.45
	Associates/Technical degree	6.12
	Bachelor's degree	27.55
	Post Bachelors	40.82
Annual Income in dollars	0-24,999	36.08
	25,000-49,999	17.53
	50,000-74,999	16.49
	75,000-99,999	13.4
	100,000-124,999	7.22
	125,000-149,999	5.15
	150,000+	4.12
Resident Status	Own House	46.94
	Rent House	16.33
	Rent Apartment	30.61
	Other	6.12

Overall these tables indicate the typical participant in this study is a young, well-educated woman who owns her own house and makes less than $50,000 per year. She purchases plants 3–5 times each year, always recycles and consistently uses reusable grocery bags. Although the typical participant does not compost waste, a large share of the participants compost all of their waste.

Table 2: Summary of Consumer Characteristics—Plant Purchase and Environmental

Variable	Description	Sample Proportion (%)
Purchase Plant	Never	14.29
	Once a year	23.47
	2 times a year	21.43
	3–5 times a year	25.51
	6 or more times a year	15.31
Recycle	Never	2.13
	Rarely	5.32
	Sometimes	9.57
	Often	35.11
	Always	47.87
Reusable Bags	Never	6.25
	Rarely	11.46
	Sometimes	23.96
	Often	28.13
	Always	30.21
Compost Waste	Never	33.33
	Rarely	20.83
	Sometimes	12.5
	Often	14.58
	Always	18.75

Results

The distribution of participants' willingness to pay for each pot type is illustrated by the box plots in figure 1. The median willingness to pay for four pot types—PLA/Soy, PLA/BioRes, recycled PLA, and PHA/DDGS—is $1, reflecting, perhaps, participants choosing the mid-point between the lowest ($0) and highest ($2) allowable bids. Despite this potential anchoring effect, however, PLA/Soy clearly has the highest inter-quarterly range. PLA/Lignin, the pot with the most traditional plastic-like characteristics, has both the lowest median bid and the lowest inter-quartile range.

Figure 1: Spread of consumers' willingness to pay for 6 different Bio-Plastic pots

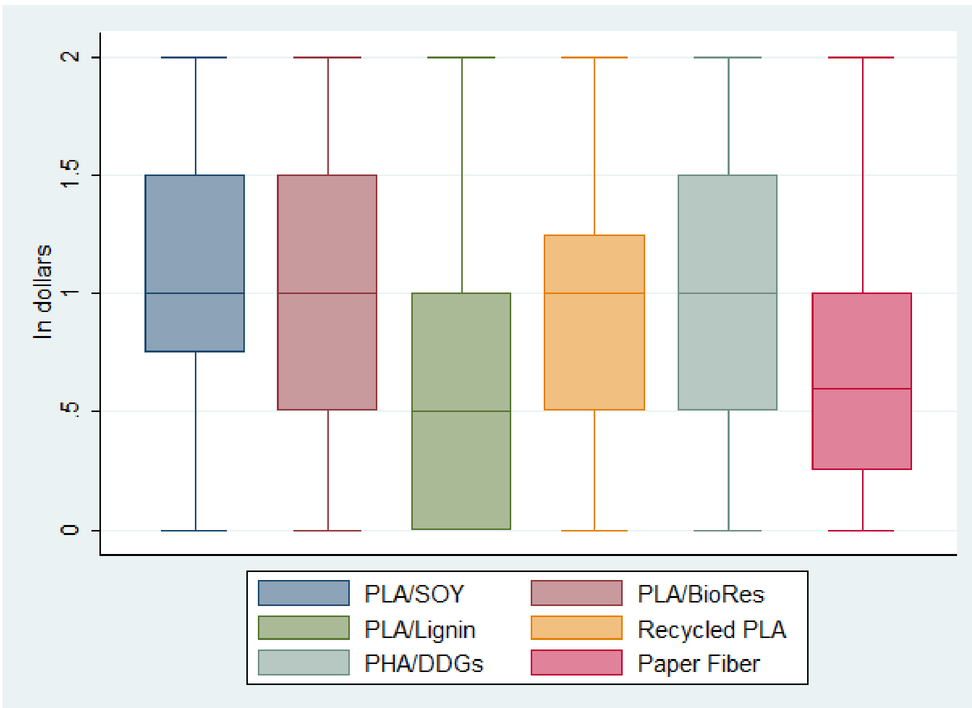

Table 3 reports the number of bids for each pot type, which was randomly determined by dice, and the average and standard deviation of the bids for each pot type. According to the law of large numbers, after nearly 200 die rolls each pot type should account for close to one-sixth of the bids. The last column of table 3 reports that the law of large numbers appears to hold after 200 rolls for just four pot types: PLA/Lignin, Recycled PLA, PHA/DDGS and Poly-coated Paper Fiber. PLA/Soy was randomly selected just one-eighth of the time, while PLA/BioRes was chose one-fifth of the time.

Despite being chosen just one-eighth of the time, PLA/Soy clearly received the highest average bid of $1.12 along with the lowest standard deviation (0.585). PLA/Lignin received the lowest average bid of 67 cents, followed by Poly-coated Paper Fiber at 76 cents and Recycled PLA at 86 cents. PLA/BioRes and PHA/DDGS both received an average bid of about $1.

According to the research design, participants bid to *replace* the traditional plastic pot they were given. So the average bids reported in table 3 are not the absolute price consumers would be willing to pay for each pot type. Instead they represent the *premium* consumers actually paid for a bioplastic pot relative to a traditional plastic pot.

Table 3: The premium consumers are willing to pay for bioplastic pots (in dollars)

Pot Type	Mean	Std. Dev.	N
PLA/Soy	1.123	0.585	26
PLA/BioRes	1.051	0.656	42
PLA/Lignin	0.669	0.626	31
Recycled PLA	0.862	0.624	33
PHA/DDGS	1.015	0.615	33
Paper Fiber (Polyurethene coated)	0.76	0.618	31

The Value of Pot Characteristics

To determine the value consumers place on the various pot characteristics, we isolated three characteristics that vary across all six pot types: improvement in plant health, biodegradability, and whether pot residue can be detected in the soil after two years. Each pot received a binary categorical value for each pot characteristic as reported in table 4.

Table 4: Pot Characteristics

Pot Type	Improves Plant Health	Biodegradable	Soil Residue in 2 Years
PLA/Soy	1	1	1
PLA/BioRes	1	1	0
PLA/Lignin	0	0	1
Recycled PLA	0	0	1
PHA/DDGS	0	1	0
Paper Fiber (Polyurethene coated)	0	1	1

To determine how much consumers value each characteristic, we conduct ordinary least squares (OLS) of bids on the three container characteristics. The first column of table 5 reports the results of the OLS regressions. The coefficients represent the marginal value consumers place on the pot characteristic. Column 1 reports that consumers will pay 17.8 cents more for a bioplastic pot that improves plant health. They will pay an extra 7.5 cents for a biodegradable bioplastic pot, but will pay 9.2 cents *less* if the pot does not completely degrade within two years.

Column 2 of table 5 reports the marginal willingness to pay associated with the various consumer characteristics and behavior. Focusing on the statistically significant coefficients, consumers in the $25,000–$49,999 income group will pay 27 cents more than those in the lowest income group. Consumers with annual income in $125,000–$149,999 will pay 44 cents more. Consumers who rent an apartment will pay 42 cents more than home owners, and those in the "Other" residence status group will pay 52 cents more. Interestingly, consumers who use reusable shopping bags will pay substantially *less* than those who never use such bags. The willingness to pay ranges from 86 cents less for "Sometimes" and "Often" reusable bag users to 67 cents less for consumers who always use reusable shopping bags. Perhaps consumers who typically use plastic shopping bags see a bioplastic pot as a way to counteract their environmentally unsustainable behavior. Finally, consumers who always compost their waste will pay 44 cents more than those who never compost their waste. Although one might assume that education and age would influence the willingness to pay, we do not find these variables to be statistically significant.

Discussion

This study contributes to the literature by eliciting consumers' willingness to pay for an environmentally sustainable good that might not typically be purchased on its own. We isolate the value of these perfectly-complementary, auxiliary goods by endowing consumers with the complete good and giving them the opportunity to pay to upgrade the auxiliary component of the good. We employ a Becker-Degroot-Marschack auction design in a market setting to determine consumers' actual willingness to pay for the auxiliary good.

Specifically, we have determined consumers' willingness to pay for a variety of bioplastic plant containers that are not yet available in the market. In a farmers' market setting we endowed consumers with plants in traditional plastic pots, and we used an experimental auction to determine the consumers' willingness to pay to have their plant transplanted into a bioplastic pot.

Consumers exhibited a willingness to pay a $0.67–$1.12 premium for a bioplastic pot over a traditional plastic pot. Consumers most value a bioplastic pot that improves plant health and biodegrades relatively quickly. The results from this study provide guidance to the container cropping industry on adopting bioplastic pots to replace the petroleum plastic pots

Table 5: Regression analysis of consumer and pot characteristics for bioplastic pots

Variables		(1) Bid	(2) Bid
Improves Plant Health		0.178	
		(0.110)	
Biodegradable		0.0754	
		(0.125)	
Soil Residue in 2 Years		-0.0917	
		(0.111)	
Male			-0.0904
			(0.110)
Annual Income ($)	25,000–49,999		0.270*
			(0.159)
	50,000–74,999		0.103
			(0.158)
	75,000–99,999		0.184
			(0.185)
	100,000–124,999		-0.125
			(0.205)
	125,000–149,999		0.439*
			(0.231)
	150,000+		0.220
			(0.317)
Resident Status	Rent House		0.195
			(0.160)
	Rent Apartment		0.418**
			(0.167)
	Other		0.521**
			(0.256)
Purchase Plant	Once a year		0.278*
			(0.151)
	2 times a year		0.166
			(0.176)
	3–5 times a year		0.247
			(0.163)
	6 or more times a year		-0.605***
			(0.191)
Reusable Bags	Rarely		-0.736***
			(0.253)
	Sometimes		-0.866***
			(0.234)
	Often		-0.861***
			(0.245)
	Always		-0.686***
			(0.245)
Compost Waste	Rarely		0.238*
			(0.143)
	Sometimes		0.215
			(0.167)
	Often		0.209
			(0.156)
	Always		0.441***
			(0.161)
Observations		196	186
R^2		0.044	0.449

Standard errors in parentheses. Age, Education and Recycle indicator variables not included in the table because they are not statistically significant. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

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