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Consumer Preferences for Labels Disclosing the Use of Neonicotinoid Pesticides: Evidence from Experimental Auctions

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Neonicotinoid pesticide use in the U.S. ornamental horticulture industry continues to capture attention due to the potential health risks to pollinator insects. While several retailers have announced mandatory labeling policies for plants treated with neonicotinoids, little is known about how individual consumers react to a firm's disclosure of neonicotinoid use in production and the extent to which this additional information is valued. Here, we use a laboratory experiment to assess consumers' preferences for environmentally friendly production practices, focusing on neonicotinoid labeling. Despite broad consumer unfamiliarity with neonicotinoids, results show that consumers have differentiated preferences for neonicotinoid-related labels and information disclosure.

Key words: information disclosure, labeling, ornamental plants, random effects Tobit model, second-price auction, text framing

Introduction

Pollination is an economically important global ecosystem service: Nearly 90% of flowering plants and 75% of the world's leading food crops benefit from plant–pollinator relationships (Hanley et al., 2015; Lundin et al., 2015). In 2019, the annual worldwide economic value of pollination services in agricultural production was US$195 billion (Gallai et al., 2009). Recent evidence indicates a decline in pollinator populations and diversity, which has generated widespread concern about the sustainability of agro-ecosystems and agricultural production systems (Potts et al., 2010; Garibaldi et al., 2013; Gemmill-Herren, 2016; Potts, Imperatriz-Fonseca, and Ngo, 2016; Hill et al., 2019).

Labeling of neonicotinoid (neonic) pesticide use in ornamental plant production is of interest because neonics may negatively impact pollinator health (Fairbrother et al., 2014; Goulson et al., 2015). Providing this information to consumers may impact their purchasing behavior (Wollaeger, Getter, and Behe, 2015; Rihn and Khachatryan, 2016). For instance, large retail stores in the United States have proactively engaged in mandatory labeling of plants treated with neonics in response to potential negative environmental consequences. Their actions have been highlighted by several environmental groups, such as Friends of the Earth (Radford et al., 2015). Additionally, consumer demand for green products and sustainable production practices (e.g., pollinator-friendly) has led to new research efforts on consumer preferences for pollinator-related eco-labels. Wollaeger, Getter, and Behe (2015) and Rihn and Khachatryan (2016) reported that consumers are interested in

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neonic-free plants; however, how consumers' preferences for products varies by the disclosure of the presence or absence of neonic labels is still unknown. In addition, both studies showed that consumers are not knowledgeable about neonics, meaning their preferences for products displaying different types of information may vary.

This study addresses this research gap by measuring participant knowledge of neonics and plants that benefit pollinators as well as how that knowledge interacts with neonic-related messages and consumers' willingness to pay (WTP). The results show that consumers prefer labels disclosing the absence of neonicotinoids over labels indicating the presence of neonicotinoids. Participants with higher levels of knowledge of neonicotinoids are willing to pay a higher price premium for plants with labels disclosing the absence of neonicotinoids. The objectives are to investigate consumers' WTP for (i) labels indicating the presence or absence of neonics; (ii) different forms of disclosure (i.e., text, logo) on labels that indicate absence of neonics; and (iii) differently framed text for labels that indicate presence of neonics. To the authors' knowledge, this is the first paper to provide a comprehensive analysis of WTP for labels disclosing the presence or absence of neonics. Another important objective was to elicit heterogeneous consumer preferences due to knowledge differences related to neonics and pollinator attractiveness.

This manuscript's contributions to the existing literature are twofold. First, this work contributes to the sizable body of eco-labeling literature by extending the dimensions of analyses to the labeling category (absence vs. presence) and framing, which address the effectiveness of different labeling strategies and policies (e.g., mandatory vs. voluntary). The most common approach is demonstrated in relevant genetically modified organism (GMO) labeling literature, in which a category analysis identifies consumer preferences and WTP for labels communicating the presence of a production method (e.g., "contains" label) relative to labels communicating the absence of a production method (e.g., "free of" label) (Liaukonyte et al., 2013; Costanigro and Lusk, 2014; McFadden and Lusk, 2018). This manuscript builds on this concept by incorporating both graphic and text formats as well as different delivery messages. Second, this study contributes to the large body of WTP estimation literature by exploring the impact of individual knowledge heterogeneity on consumer preferences. An emphasis of this experiment is to elicit individual choices in terms of characteristics of the product alternatives. Individual attributes and knowledge heterogeneity in this study are secondary to the examined product attributes. However, unlike eco-labeling related to food products (e.g., organic labeling with high consumer familiarity), the public exposure to neonics is limited. Thus, it is important to control for the knowledge heterogeneity effects when evaluating consumer WTP for labels communicating the absence or presence of neonics.

Literature Review

A possible linkage exists between declines in pollinator populations and their exposure to neonics due to the nature and mode of action of the pesticide. Neonics are the most widely used pesticide class in the world and provide effective control of a broad range of insect pests (Jeschke et al., 2011). However, some studies have argued that neonics are strongly associated with the decline of managed and wild bees (van der Sluijs et al., 2013; Goulson et al., 2015; Pisa et al., 2015). Being systemic, neonics are distributed into nectar and pollen, which could increase pollinator exposure. Pollinators may also be unintentionally exposed to neonics through soil accumulation (Goulson, 2013) and treated seed dust from agricultural planters (Goulson, 2013; Fairbrother et al., 2014). Due to these concerns, EU regulators banned the use of three major neonics in 2013 (Fairbrother et al., 2014). The U.S. EPA was more cautious about restricting the use of neonics and now requires products containing neonics to have a warning label indicating proper usage to minimize harm to pollinators.

Protecting pollinators is of interest because pollinator services are important to agricultural production, ecosystem conservation, and biodiversity. A large body of research has focused on quantifying and evaluating the economic benefits of pollinator services (Breeze et al., 2016; Melhim, Daly, and Alfons, 2016). Yet little has been done to explore the nonmarket value of pollination services from the end-consumer standpoint. A few recent studies (e.g., Diffendorfer et al., 2014; Breeze et al., 2015; Khachatryan et al., 2017) have demonstrated consumer interest in aiding pollinator insects but failed to investigate how this relates to neonic use and how the presence or absence of neonics is communicated to consumers. This is of particular interest given the increased demand for products that minimally impact the environment (Royne, Levy, and Martinez, 2011; Yue et al., 2016).

Due to rising consumer demand for green products, investigating consumer preferences for eco-labeling or sustainable production methods is not a new research topic (Michaud, Llerena, and Joly, 2013; Sörqvist et al., 2015; Van Loo et al., 2015). In fact, the majority of literature addressing this topic has focused on food labeling (e.g., organic) with information framing (i.e., on labels) as one of the most examined aspects. For instance, McFadden and Lusk (2018) compared consumer preferences for the presence and absence of genetically modified (GM) materials among different disclosure methods (i.e, text, logo, and QR code) and showed that consumers are more sensitive to text relative to a QR code disclosure. Liaukonyte et al. (2013) found that the positive impact of labels communicating attribute absence ("free of X") on WTP only exists when secondary information is provided. However, no studies have investigated the use of different disclosure formats (e.g., text, logo) for neonics in plant production. Our study could provide valuable insights to firms that discontinue or are considering discontinuing the use of neonics and to policy makers if or when a policy intervention is necessary.

Experimental Design

This study uses data collected from 141 participants during experimental auctions conducted in central Florida. The experiment was incentivized (details follow), and two forms of auctions (live product, product image) were used. The live product auction simulated a real purchasing environment and participants were able to move randomly among different alternatives and closely examine the actual plants. In contrast, the product image auction was conducted in a laboratory and images of the plants were displayed on a computer monitor in a predetermined order. The images were photos of the actual plants used in the live product auction. As a result, both auctions evaluated the same products but used different experimental stimuli. This method is similar to Bushong et al. (2010), who showed that real products were preferred and valued more than text descriptors or product pictures.

A four-section questionnaire accompanied the auctions. The sections included (i) purchasing behavior, (ii) knowledge and perceptions about pollinator-attractive plants, (iii) knowledge and perceptions about neonics and relevant regulations, and (iv) sociodemographics. Participants answered purchasing behavior related questions before the auctions. Each participant completed two auction rounds, one for annual plants and one for perennial plants (discussed shortly). In the live product auction, participants answered questions regarding pollinator-attractive plants between the annual and perennial plant auctions. Only general questions (e.g., "Do you agree that native plants require little water and save time and money because they are adapted to local environmental conditions?") were included to avoid any potential unintentional priming of participants toward or against neonic labeling strategies. Separating the auction rounds with questions served as a break to aid in minimizing participant fatigue. Product image auction participants answered questions about pollinator-attractive plants after both auctions. Regardless of the auction type, after completing the auctions, participants answered knowledge and perception questions about neonics, pollinator insects, and demographics.

Products and Attributes

Three annual bedding plants (impatiens, marigolds, and pentas) and three perennial plants (dianthus, chrysanthemums, and salvia) were used as representative bidding items based on being pollinator attractive and sales values.[1] Additionally, the plants were selected due to availability in local retailers and having similar price points at local retail stores ($1.15 per annual plant, $9.48 per perennial plant). To accurately reflect actual products available in retail outlets, annual bedding plants were in 4-inch containers and perennial plants were in 1-gallon containers.

The main attributes of differentiation were the production practices. The same types of plants (e.g., impatiens) were almost identical in appearance (e.g., similar size, flower/bud composition). Conversely, the production practice attributes (i.e., neonic-related labeling) and container attributes (e.g., biodegradable or conventional) changed among the alternatives. Numerous studies have found that disclosing additional production practice information on the label is effective in increasing or decreasing consumers' valuations depending on how the information was provided and framed (Lusk, Feldkamp, and Schroeder, 2004; Gifford and Bernard, 2006; Costanigro and Lusk, 2014; Wu et al., 2015; Costanigro, Deselnicu, and Kroll, 2015; Messer, Costanigro, and Kaiser, 2017). Accordingly, two distinct label categories were used to communicate the absence and presence of neonics in different forms (text and logo) and different text framings (treated with neonicotinoids vs. protected from problematic pests by neonicotinoids). A "no label" option was not included in the experiment given the mutually exclusive nature of the presence and absence of neonic label options.[2]

Neonicotinoid free (text) and Bee Better Certified$^{\mathrm{TM}}$ (logo) were used to communicate the absence of neonics. The Bee Better Certified$^{\mathrm{TM}}$ logo was developed by the Xerces Society for Invertebrate Conservation, an international nonprofit organization, to promote pollinator conservation in agriculture.[3] The logo was adopted to avoid introducing a new, hypothetical logo into this experiment. In contrast, the phrases "treated with neonicotinoids" and "protected from problematic pests by neonicotinoids" were used to communicate the presence of neonics. For practical reasons, the two phrases were adopted from plant tags used by Home Depot® garden centers.[4] Additional information regarding containers (biodegradable vs. conventional) was used as another indicator of sustainable production practices. This information was displayed next to each of the plants.

A fractional factorial design was developed to minimize the number of alternatives and maximize variation across alternatives based on the following principles: (i) equal frequency of attribute levels, (ii) uncorrelated occurrences of any two levels of different attributes, and (iii) minimal overlap of attribute levels (Louviere, Hensher, and Swait, 2000). JMP Pro 11 (SAS Institute Inc.) was used to construct 14 scenarios for annual bedding plants (D-efficiency of 93.42%) and 14 scenarios for perennial plants (D-efficiency of 92.25%). Plant types were intermixed, and each plant displayed one of the four types of neonicotinoid labels. χ^2 test results indicated that all of the experimental attribute levels were balanced in the experimental auctions. The study followed a within-subject design, as each participant viewed and provided WTP values for plants with different types of labels. The between-subject comparison was reflected by considering individual knowledge differences.[5]

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[1] According to the U.S. Department of Agriculture (2015) *Census of Horticultural Specialties*, impatiens, marigold, and pentas were ranked 5th, 7th, and 25th by sales value among all annual bedding plants, while chrysanthemum, salvia, and dianthus were ranked 1st, 5th, and 6th by sales values among all perennial plants. Impatiens were categorized in the NASS survey as impatiens (New Guinea) and impatiens (other). The annual plant experimental auctions used impatiens (other); we refer to these as simply "impatiens" in this article.

[2] It is common in organic labeling literature to adopt this distinct "organic" versus "not organic/conventional" attribute level structure without a "no label" option (e.g., Hu, Woods, and Bastin, 2009; Denver and Jensen, 2014).

[3] Detailed information about Bee Better Certified$^{\mathrm{TM}}$ production standards is available at https://beebettercertified.org/docs.

[4] One of the purposes of this study is to examine the effect of participants' existing knowledge on their purchasing decisions. Therefore, participants were not provided any additional facts about neonics except that they are a type of pesticide.

[5] The between-subject comparison (between the live product auction and the product image auction) was controlled for in the regression analysis by including a dummy variable (1 = live product; 0 = product image). Since the between-subject comparison is not the primary focus of this study, it is not emphasized in the results.

Second-Price Auction

Second-price auctions have been widely used to elicit consumer WTP for market goods (Lusk et al., 2001; Alfnes and Rickertsen, 2003; Rozan, 2004; Brown, Cranfield, and Henson, 2005; Hustvedt and Bernard, 2008; Napolitano et al., 2010; Demont et al., 2012). Advantages to the second-price auction include being relatively easy to implement and explain to subjects (Lusk and Shogren, 2007). On the other hand, drawbacks include potentially generating higher values in later bidding rounds (Lusk, Feldkamp, and Schroeder, 2004), bid affiliation (List and Shogren, 1999; Corrigan and Rousu, 2006), and overbidding (Rutström, 1998; Cooper and Fang, 2008; Delgado et al., 2008; Kassas, Palma, and Anderson, 2018). In this study, problems associated with the learning process were less of an issue since there were only two rounds with no repeat trials. According to Lusk, Feldkamp, and Schroeder (2004), the second-price, random nth price, English, and Becker–DeGroot–Marschak (BDM) methods all generate similar mean bids in the initial rounds. Noussair, Robin, and Ruffieux (2004) and Shogren et al. (2001) showed that the second-price auction outperforms BDM auctions and produces more accurate estimates of the WTP curve. To avoid bid affiliation, the winning bids were announced after both auctions were completed. Therefore, when participants bid for perennial plants, they had no price feedback from the previous auction. To further mitigate concerns of overbidding, the second-price auction was nonhypothetical. In each session, the winning participant of a randomly selected plant was obligated to pay the second highest price in exchange for that plant. In the product image auction, none of the products were within sight of the participants during the bidding process; prior to the experiment, participants were informed that the winners would be taking home live plants after the experiment. Both live product and product image auction winners received their products immediately after their sessions.

Prior to the experiment, participants signed an informed consent form (approved by university's Institutional Review Board) and agreed to participate in the study. Participants were then briefed on the nature of the experiment, their tasks, and the rules and procedures for a second-price auction. They then completed a brief quiz and two practice rounds with candy bars to ensure the second-price auction concept was clearly understood and to emphasize that bidding one's actual WTP was the best strategy. Participants were informed that the auctions were binding which ensured incentive compatibility. Specifically, in each session, there would be one annual and one perennial product randomly selected as the winning items for the auction winner to purchase at the second-highest price. Hence, if participants bid lower than their true WTP, they risked forgoing a desirable purchase; if they bid higher, they risked paying more for the product than their value. Participants could only win one item. If the same participant won in both auctions, one product was randomly selected. This procedure was followed for the live plant and product image auction sessions. Participants received \$25 (or equivalent) as compensation for participating in the study.[6]

Each participant bid on 14 annual bedding plants in the first round and 14 perennial plants in the second round. Regardless of the auction type, participants were reminded to match the displayed plant with the corresponding item listed on the bidding sheet and then move to the next product. Participants could not move backward to adjust their bids during the experiment. Participants submitted their bid sheets at the end of each round. Ordering effects of the two auctions could be a concern (Day and Pinto Prades, 2010; Carlsson, Morkbak, and Olsen, 2012), but ordering effects could be reduced in the live product auction since a short break (to reduce fatigue) occurred between auctions. Additionally, participants in the live product auction could walk around the plants and start at different locations (i.e., products). The product image auction was more susceptible to ordering effects because the two auctions were presented consecutively in a predetermined order. The possible impact of an ordering effect on participants' bid value is discussed in a later section.

In total, 21 experimental auction sessions occurred, with six live product auction sessions and 15 product image auction sessions. In each session, participants bid together and submitted bids

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[6] A winning participant would receive an equivalent of \$25, which is the amount of \$25 minus the market price (i.e., the 2nd highest bid) and the winning product.

simultaneously. The predetermined maximum number for each live auction was 14 participants, while each product image auction had the maximum capacity of seven participants. Each participant could only sign up to participate once regardless of auction type. Due to participants cancelling or missing appointments, the number of participants in each session varied. On average, there were 11 participants in each live product auction session and five participants in each product image auction session.

Data Description

Sample Sociodemographics

Participants randomly participated in either the live product auction (n = 66) or product image auction (n = 75). Participants' average age was 56 years, and 25.7% of the sample were males. Recruited locally, the sample deviated slightly from the Florida population, including having more females and older people with higher educations and higher incomes (Table S1 in the Online Supplement [www.jareonline.org]). However, this is consistent with core horticultural consumers' sociodemographic characteristics (e.g., female, 45 years old and older, college graduates, and two-person households with annual incomes of $50,000 or more, according to Rihn and Khachatryan, 2016). In terms of plant purchasing activities, participants typically visited the stores seven to eight times per year to purchase landscape plants and spent around $30 per visit.

Knowledge and Perceptions

In this survey, 38 participants (27% of the sample) indicated awareness of neonics by answering yes, they had heard about neonics. Only 20 participants (14%) reported themselves to be very knowledgeable about neonics.[7] Based on this information, participants were divided into knowledgeable (29 participants) and not knowledgeable (112 participants) groups.[8] Despite the relatively small sample size, the division of participants' knowledge statistics are close to the national level for public knowledge about neonics (Rihn and Khachatryan, 2016).

Next, participants indicated their agreement or disagreement with neonic and pollinator statements (Table 1, Panel A). Although 42% of the participants agreed with the first statement ("Neonicotinoid pesticides are effective tools to protect plants from major and unwanted pests"), almost half of the participants opted out by selecting the "neither agree nor disagree" option. This may be largely due to their unfamiliarity with neonics. Conversely, clear opinions (i.e., not selecting the "neither agree nor disagree" option) were observed when neonics were explained in a pollinator-containing context in statements 2–4.

Due to concerns regarding participants' limited knowledge about neonics, questions related to knowledge about pollinator-attractive plants were included. Participants rated their knowledge on a scale from 1 to 7 and then answered four quiz questions to measure real knowledge about pollinator-attractive plants. In each quiz question, participants were provided two plant names supplemented with plant images and were asked to select one that was pollinator attractive. Significantly more participants (55%) reported themselves as knowledgeable about pollinator-attractive plants by selecting 5 or more on the rating scale. However, only 4% of the participants correctly answered all of the follow-up quiz questions and only 30% correctly answered three of the four quiz questions. The correlation between self-perceived and real knowledge variables was 0.24. Previous studies have observed knowledge gaps where consumers overstated their knowledge (Fernbach et al., 2019). The difference in knowledge was also reflected in participants' agreement with statements regarding features of pollinator-attractive plants (Table 1, Panel B). Most annual flowering plants have been bred for showy flowers or vigorous growth and do not produce enough pollen or nectar to be good

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[7] The knowledge question used a 7-point Likert scale, with 1 indicating not at all knowledgeable, 4 neither knowledgeable nor not knowledgeable, and 7 extremely knowledgeable about neonics.

[8] Nine participants indicated that they had heard about neonics but were not knowledgeable.

Table 1. Participants' Perceptions about Neonicotinoid Pesticides and Pollinator-Attractive Characteristics

	Percentage Disagree (≤ 3)	**Percentage Neither Agree nor Disagree (4)**	**Percentage Agree (≥ 5)**
Panel A. Statements Pertaining to Neonicotinoid Pesticides and Pollinators			
Neonicotinoid pesticides are effective tools to protect plants from major and unwanted pests.	11	48	42
I am concerned about the effect of neonicotinoid pesticides on pollinators.	11	34	55
Use of neonicotinoid pesticides might be a cause of Colony Collapse Disorder (CCD), but I am not worried much about the extinction of bees and other pollinators.	68	18	14
We may face a pollination crisis in which crop yields begin to fall because of fewer pollinator insects.	7	16	76
Panel B. Statements Pertaining to Pollinator-Attractive Plant Features			
Ability to produce flowers	33	17	50
Low fragrance	31	14	55
Short flowering season	43	40	17
Colorful flowers	6	13	71
Flowering during the evening/night	50	35	15
Native plants	11	40	49

Notes: The three broad groups are regrouped based on the original 7-point Likert scale in the survey from 1 (strongly disagree) to 7 (strongly agree).

food sources for pollinators (Smitley et al., 2016), but 71% of participants thought colorful flowers were more pollinator attractive

Summary of Bid Distribution

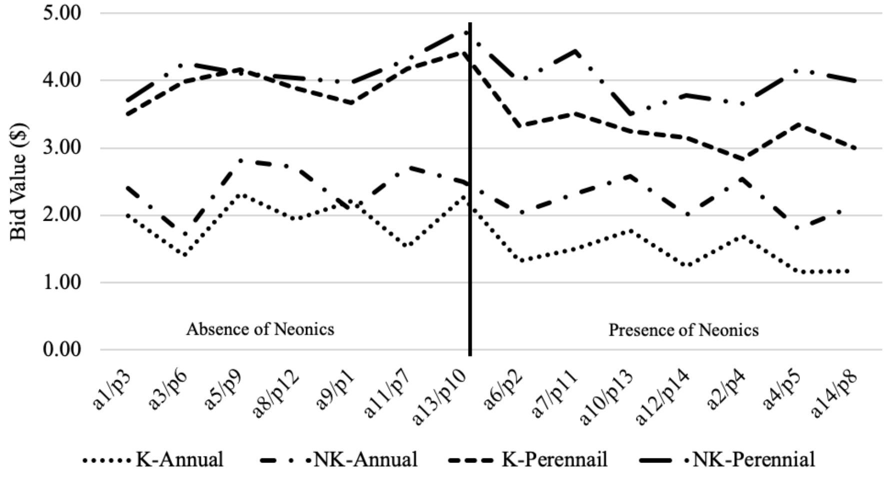
After excluding 369 0 bids (accounting for less than 10% of the total 3,948 bids), the average bid was \$2.18 for the annual bedding plants and \$3.96 for the perennial plants (Table 2), details in Table S2 in the Online Supplement). Bids for the perennial plants from the product image auction were \$1 lower than those of the live product auction, while bids for annual bedding plants from the product image auction were \$0.28 higher. The differences in bids between the live product and product image auctions were further explored by comparing the bids across individual annual and perennial items. Interestingly, the *p*-values showed that the differences in the bid values were not statistically different from 0 for the annual bedding plants but statistically different from 0 for the perennial plants (except for item p1). The insignificant differences in the bid values for the annual bedding plants suggest that the (within-round) ordering effect has little impact on the bids for the annual plants in the product image auctions. Participants in the live product auctions were able to freely move among the items (which is arguably equivalent to a randomized order) while the product image auctions had a fixed order. Bids across all annual plants were consistent between the two auctions despite the differences in auction formats and the number of bidders in the auctions. Recall that the live product auctions had a relatively large group size. One concern could be that the increased number of bidders in the auction could prompt more aggressive bidding. Here, there was no evidence that the number of bidders influenced bid value. Conversely, consistently lower bids for the perennial plants in the product image auctions could be driven by one of the following factors: the differences in auction format, the slightly different procedure between the live product and product image auctions (short break in live product auctions), or potential ordering effects (mainly fatigue, the starting point effect, or the learning effect). Given that participants in the product image auctions were bidding on annual

Table 2. Comparison of Bid Value by Product Item and Experimental Auction Types

	Bid Value				**Bid Value**		
Annual	**Live ($)**	**Product Image ($)**	**Difference ($)**	**Perennial**	**Live ($)**	**Product Image ($)**	**Difference ($)**
a1	2.18	2.44	0.27	p1	4.20	3.66	−0.53
			(0.41)				(0.21)
a2	2.18	2.52	0.35	p2	4.46	3.32	−1.14
			(0.37)				(0.03)
a3	1.49	1.77	0.28	p3	4.05	3.32	−1.78
			(0.26)				(0.07)
a4	1.45	1.87	0.42	p4	4.10	2.94	−1.16
			(0.13)				(0.01)
a5	2.68	2.74	0.05	p5	4.64	3.43	−1.21
			(0.88)				(0.02)
a6	1.7	2.05	0.35	p6	4.67	3.78	−0.89
			(0.26)				(0.07)
a7	2.03	2.26	0.23	p7	4.90	3.76	−1.15
			(0.46)				(0.03)
a8	2.49	2.72	0.23	p8	4.38	3.27	−1.11
			(0.53)				(0.02)
a9	1.57	2.31	0.75	p9	4.68	3.64	−1.04
			(0.01)				(0.04)
a10	2.39	2.43	0.04	p10	5.25	4.19	−1.06
			(0.90)				(0.05)
a11	2.62	2.62	0.00	p11	5.03	3.55	−1.48
			(1.00)				(0.01)
a12	1.65	2.01	0.36	p12	4.51	3.57	−0.93
			(0.21)				(0.03)
a13	2.36	2.4	0.04	p13	4.12	2.89	−1.22
			(0.89)				(0.01)
a14	1.69	2.17	0.48	p14	4.33	3.07	−1.25
			(0.12)				(0.01)
Mean	2.03	2.31	0.28	Mean	4.52	3.45	−1.07
			(0.00)				(0.00)
Mean combined	2.18			Mean combined	3.86		
No. of obs.	922	1,050		No. of obs.	922	1,050	

Notes: Annual bedding plants are in 4-inch containers; perennial plants are in 1-gallon containers. Numbers in parentheses are p-values.

(a) Bid Values by Knowledge of Neonicotinoids



(b) Bid Values by Knowledge of Pollinator Attractive Plants

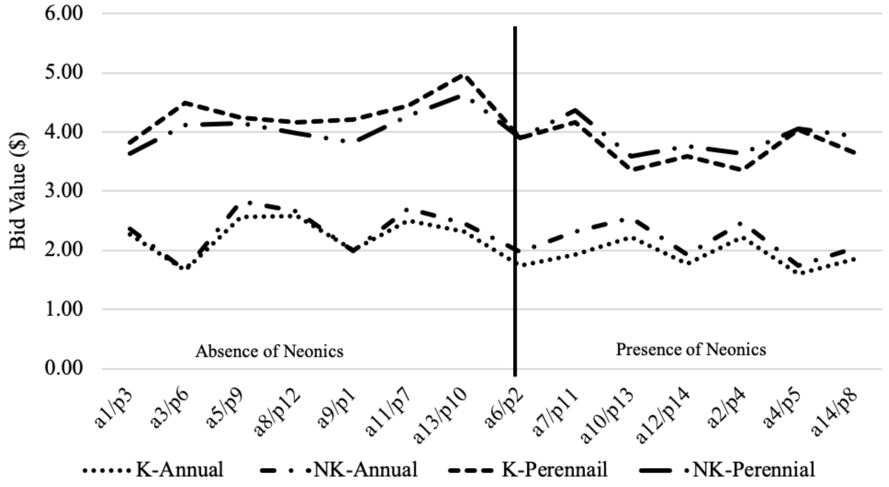


Figure 1. Distribution of Bids by Different Knowledge Groups

Notes: K represents the knowledgeable group and NK represents the not knowledgeable group. Participants were defined as knowledgeable about neonicotinoids if they selected 4 or higher on the knowledge rating scale (Figure 1(a)). Similarly, participants were defined as knowledgeable about pollinator-attractive plants if they selected 5 or higher on the knowledge rating scale (Figure 1(b)). The "absence of neonics" category consisted of Neonicotinoid Free (text) and Bee Better Certified$^{\text{TM}}$(logo). The presence of neonics category consisted of "Treated with Neonicotinoids" and "Protected from Problematic Pests." Annual plants a1, a3, a5, a8, a11, a13, and a6 and perennial plants p3, p6, p9, p12, p1, p10, and p2 had labels communicating the absence of neonics. Annual plants a6, a7, a10, a12, a2, a4, and a14 and perennial plants p2, p11, p13, p14, p4, p5, and p8 had labels communicating the presence of neonics. .

and perennial plants consecutively without a break, the first round of annual plant auctions may have influenced them more than their counterparts in the live product auctions.

To give an overall perspective of consumers' preferences and WTP for labels disclosing the presence or absence of neonics, we directly compared participants' bids for plants with labels disclosing the absence or presence of neonics. Participants valued plants labeled as neonic-free over plants with labels indicating the presence of neonics for both plant types (Tables 3a and 3b). The paired-t-test statistic between "presence of neonics" and "absence of neonics" was -3.26 (p-value = 0.00) for annual bedding plants and -2.62 (p-value = 0.00) for perennial plants, indicating statistical differences between participants' bid values. This is consistent with McFadden and Lusk (2018), who also found significant WTP differences for food with and without GMOs.

To further explore heterogeneous preferences for different label formats (text, logo) and framings (different phrases), bids were tabulated and grouped based on individual knowledge about neonics and pollinator-attractive plants (see Tables 3a and 3b). Using the self-reported knowledge question about neonics (subjective), participants were divided into knowledgeable ($\geq$4 on the knowledge scale), and not knowledgeable ($\leq$3 on the knowledge scale). With *t*-test statistics of 5.92 (*p*-value = 0.00) for annual bedding plants and 2.86 (*p*-value = 0.00) for perennial plants, bids from the knowledgeable group were on average consistently lower than those from the not knowledgeable group, regardless of plant type. While participants in the not knowledgeable group were less impacted by whether the plant was free of neonics, it is clear that the knowledgeable group bid significantly lower for plants labeled as grown with neonics (Figure 1(a)).

When participants were grouped by revealed knowledge of pollinator-attractive plants based on the quiz questions (objective), a consistent pattern was observed (Figure 1(b)). Participants who correctly answered at least three quiz questions were defined as knowledgeable about pollinator-attractive plants, while participants who correctly answered two or fewer quiz questions were defined as not knowledgeable. For annual bedding plants, participants who were knowledgeable about pollinator-attractive plants had slightly lower WTP values when compared to those who were not. WTP values for the knowledgeable group further decreased for plants labeled as grown with neonics, which is indicated by a wider space between the value lines in Figure 1(b) (*p*-value = 0.06, Tables 3a and 3b). On the other hand, participants who were knowledgeable about pollinator-attractive plants had higher valuations for perennial plants labeled as neonic-free but decreased their valuation for perennial plants labeled as treated with neonics. The two bid value lines for the knowledgeable about pollinator-attractive plants group (dashed line) and not knowledgeable group (dash-dotted line) were reversed for the perennial plants labeled with neonics. Nonetheless, the difference in bids between the knowledgeable and not knowledgeable groups for perennial plants was not statistically significant (*p*-value = 0.78, Tables 3a and 3b).

Model and Estimation

Random Effects Tobit Model

In second-price auctions, it is common to observe bids with 0 values along with bids that have strictly positive values. The Tobit model is a straightforward method to analyze data with such a pattern when there is a corner at 0 and has been widely used in auction data analysis (Yue et al., 2010, 2016). To capture the panel nature of the auction data (i.e., multiple bids submitted by each individual for different plants), the random effects Tobit model is formalized as follows:

$$bid_{ij} = \max\left[bid^*_{ij}, 0\right], \tag{1a}$$

$$bid^*_{ij} = \boldsymbol{x}_{ij}\boldsymbol{\beta} + c_i + u_{ij} > 0, \tag{1b}$$

$$u \sim N\left(0, \sigma^2_u\right), \tag{1c}$$

where bid_{ij} is the auction bid of consumer i for plant j; bid^*_{ij} is a latent variable, representing the individual consumer's true WTP, which is assumed to follow a linear unobserved effects model (equation 1b); $\boldsymbol{x}_{ij}$ is a vector of plant attributes and individual characteristics that influence the consumer's bidding price; and c_i is the unobserved, individual-specific random effects varying across each individual i but not plant j.[9] The random error term, u_{ij}, has a normal distribution with a 0 mean

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[9] Individual characteristic variables included age, gender, ethnicity, household size, education level, household income, whether allergic to pollen or insect stings, and purchasing behaviors. Estimated results related to individual characteristics were suppressed from Tables 4 and 5 due to statistical insignificance. The complete set of estimation results is available from the authors upon requests.

Table 3a. Distribution of Bid Values by Neonicotinoid Labeling Types and Different Knowledge Groups, Annual Bedding Plants

		Knowledge about Neonicotinoids			Knowledge about Pollinator-Attractive Plants		
		Mean Bid Value ($)		Paired-*t* Test (NK-K)	Mean Bid Value ($)		Paired-*t* Test (NK-K)
Labeling	**Item**	**K**	**NK**	***t*-Statistic**	**K**	**NK**	***t*-Statistic**
Absence of neonicotinoids (1)	a1	2.00	2.40	1.01	2.27	2.37	0.27
Neonic-free text				(0.32)			(0.78)
	a3	1.41	1.70	0.94	1.67	1.66	−0.02
				(0.35)			(0.98)
	a5	2.32	2.81	1.09	2.56	2.82	0.66
				(0.28)			(0.51)
	a13	1.93	2.72	1.51	2.59	2.66	0.45
				(0.13)			(0.65)
Neonic-free logo	a8	2.21	2.08	1.40	2.01	1.98	0.20
				(0.26)			(0.84)
	a9	1.53	2.71	1.53	2.50	2.71	−0.08
				(0.13)			(0.93)
	a11	2.27	2.5	1.10	2.31	2.46	0.60
				(0.27)			(0.55)
Mean of annuals in absence of neonicotinoids		2.32		–	2.32		–
Presence of neonicotinoids (0)							
Treated with neonics	a6	1.32	2.03	1.90	1.74	1.98	0.73
				(0.06)			(0.46)
	a7	1.50	2.32	2.18	1.93	2.31	1.15
				(0.03)			(0.25)
	a10	1.77	2.58	1.90	2.23	2.54	0.85
				(0.06)			(0.39)
	a12	1.24	2.00	2.21	1.77	1.93	0.53
				(0.03)			(0.59)
Protected by neonics	a2	1.69	2.53	1.78	2.22	2.47	0.61
				(0.08)			(0.54)
	a4	1.15	1.81	2.92	1.60	1.75	0.49
				(0.06)			(0.62)
	a14	1.18	2.15	2.53	1.84	2.04	0.58
				(0.02)			(0.56)
Mean of annuals in presence of neonicotinoids		2.04		–	2.04		–
Mean of all annual plants by knowledge groups		1.68	2.31	5.92	2.09	2.26	1.90
				(0.00)			(0.06)

Notes: Numbers in parentheses are *p*-values. Annual bedding plants are in 4-inch containers. Annual bedding plants a1, a2, a5, a8, and a10 were impatiens; a3, a4, a9, a12, and a14 were marigold; and a6, a7, a11, and a13 were pentas. The same types of plants were identical to one another in appearance, whereas the neonicotinoid labeling and container attributes changed among alternatives. K represents the knowledgeable group and NK represents the not knowledgeable group. Participants were defined as knowledgeable about neonicotinoids if they selected 4 or higher on the knowledge rating scale. Similarly, participants were defined as knowledgeable about pollinator-attractive plants if they selected 5 or higher on the knowledge rating scale.

Table 3b. Distribution of Bid Values by Neonicotinoid Labeling Types and Different Knowledge Groups, Perennial Plants

		Knowledge about Neonicotinoids			**Knowledge about Pollinator-Attractive Plants**		
		Mean Bid Value ($)		**Paired-*t* Test (NK-K)**	**Mean Bid Value ($)**		**Paired-*t* Test (NK-K)**
Labeling	**Item**	**K**	**NK**	***t*-Statistic**	**K**	**NK**	***t*-Statistic**
Absence of neonicotinoids (1)	p3	3.51	3.71	0.40	3.82	3.64	−0.40
Neonic-free text				(0.69)			(0.69)
	p6	3.98	4.25	0.43	4.49	4.12	−0.68
				(0.67)			(0.51)
	p9	4.16	4.11	−0.07	4.24	4.14	−0.19
				(0.94)			(0.85)
	p12	3.89	4.04	0.26	4.17	3.98	−0.40
				(0.79)			(0.69)
Neonic-free logo	p1	3.68	3.97	0.57	4.21	3.82	−0.87
				(0.57)			(0.39)
	p7	4.18	4.32	0.22	4.44	4.28	−0.29
				(0.83)			(0.77)
	p10	4.42	4.76	0.50	4.98	4.63	−0.61
				(0.62)			(0.54)
Mean of annuals in absence of neonicotinoids		4.13		–	4.13		–
Presence of neonicotinoids (0)							
Treated with neonics	p2	3.33	3.99	1.01	3.90	3.90	0.00
				(0.32)			(1.00)
	p11	3.51	4.43	1.32	4.17	4.36	0.32
				(0.19)			(0.75)
	p13	3.25	3.51	0.44	3.35	3.59	0.47
				(0.66)			(0.64)
	p14	3.16	3.78	1.06	3.59	3.76	0.32
				(0.29)			(0.75)
Protected by neonics	p4	2.84	3.66	1.57	3.36	3.63	0.62
				(0.12)			(0.54)
	p5	3.34	4.17	1.26	4.03	4.05	0.03
				(0.21)			(0.97)
	p8	3.01	3.99	1.83	3.65	3.93	0.61
				(0.07)			(0.55)
Mean of annuals in presence of neonicotinoids		3.78		–	3.78		–
Mean of all annual plants by knowledge groups		3.59	4.05	2.86	4.02	3.99	−0.29
				(0.00)			(0.78)

Notes: Numbers in parentheses are p-values. Perennial plants are in 1-gallon containers. Perennial plants p1, p3, p4, p8, and p12 were dianthus; p2, p5, p6, p10, and p11 were chrysanthemums; and p7, p9, p13, and p14 were salvia. The same types of plants were identical to one another in appearance, whereas the neonicotinoid labeling and container attributes changed among alternatives. K represents the knowledgeable group and NK represents the not knowledgeable group. Participants were defined as knowledgeable about neonicotinoids if they selected 4 or higher on the knowledge rating scale. Similarly, participants were defined as knowledgeable about pollinator-attractive plants if they selected 5 or higher on the knowledge rating scale.

and variance σ_u^2. Because $E\left(bid_{ij}^{*}|\boldsymbol{x}_{ij}\right)$ is linear in x, the estimated coefficients from the random effects Tobit model are the marginal effect on the latent variable bid^{*}. However, the "unconditional" partial effects, $E\left(bid|\boldsymbol{x}_{ij}\right)$, which is the average partial effects (APEs) across all sample observations in equation (2) for a given binary variable $\boldsymbol{x}_j$, are of interest in this study and are discussed in the following section.

$$(2) \qquad \widehat{APE}\left(x_j\right) = N^{-1}\sum_{i=1}^{N}\left\{\Phi\left[\left(\boldsymbol{x}_{ij}^{(1)}\hat{\boldsymbol{\beta}} + c\right)/\hat{\sigma}_u\right] - \Phi\left[\left(\boldsymbol{x}_{ij}^{(0)}\hat{\boldsymbol{\beta}} + c\right)/\hat{\sigma}_u\right]\right\}.$$

Further, the predicted WTP for a specified group (e.g., evaluated at $\boldsymbol{x}_{ij} = 1$ for the neonic-free label, or evaluated at $\boldsymbol{x}_{ij} = 0$ for labels communicating the presence of neonics) were computed using the following equations:

$$(3a) \qquad \hat{E}\left(bid\right)|_{x_{ij}=1} = N^{-1}\sum_{i=1}^{N}\Phi\left[\left(\boldsymbol{x}_{ij}^{(1)}\hat{\boldsymbol{\beta}} + c\right)/\hat{\sigma}_u\right]$$

$$(3b) \qquad \hat{E}\left(bid\right)|_{x_{ij}=0} = N^{-1}\sum_{i=1}^{N}\Phi\left[\left(\boldsymbol{x}_{ij}^{(0)}\hat{\boldsymbol{\beta}} + c\right)/\hat{\sigma}_u\right].$$

Estimation Results

To exploit the data generated on consumers' preferences for the neonic labels, we measured the effects of neonic labels on WTP bids at different levels. Overall, participants value plants with labels disclosing the absence of neonics (Table 4, Model 1). Model 1 is the baseline regression to obtain consumers' WTP for the neonic-free attribute. The effect is captured by the binary variable (*neonic-free label*) which equals 1 if the plant was labeled as "neonicotinoid free" (text) or "Bee Better Certified" (logo) and 0 if the plant was labeled as "treated with neonicotinoids" or "protected from problematic pests by neonicotinoids." The estimated coefficient of the *neonic-free label* was 0.40 (statistically significant at the 1% level). On the basis of marginal WTP (APE), the consumers were willing to pay nearly \$0.34 more for plants labeled as neonic-free (Table 4, Model 1). Using equations (3a) and (3b), predicted WTP was \$3.21 for plants labeled as neonic-free and \$2.87 for plants labeled as containing neonics.

The sample was then divided into two subsets in Table 4 (Model 2, absence of neonics category, and Model 3, presence of neonics category) to further investigate the impact of different framings (logos and text for the absence of neonics or different text framings for the presence of neonics) on participants' bids. The coefficient of the *neonic-free logo* reflects the WTP difference between the text and logo communicating the absence of neonics (Table 4, Model 2). The binary variable *neonic-free logo* equals 1 if the plant was labeled as "Bee Better Certified" (logo) and 0 if the plant was labeled as "neonicotinoid free" (text). A calculation of marginal effects (APE) indicates that participants were willing to pay \$0.20 more for plants labeled with the "Bee Better Certified" logo compared to the "neonicotinoid free" text. Participants were willing to pay \$3.32 for plants labeled as "Bee Better Certified" (logo) and a slightly lower amount of \$3.12 for plants labeled with the "neonicotinoid free" text. However, it is important to acknowledge that some of the premium generated by the logo may derive from additional features (beyond neonic-free production), such as ease of understanding and other factors not controlled for in this experiment. Therefore, a logo with an easy-to-understand graphic may improve understanding and acceptance compared to text that is relatively unfamiliar (i.e., "neonicotinoid free"). This finding indicates that even though text messages are the most direct, straightforward method, logos with pollinator-related information might be more appealing to consumers. The binary variable *neonic-treated* captured whether consumers differentiate information formats when a plant was grown with neonics. The estimated coefficients were insignificant, indicating that consumers were indifferent to the format for presence of neonics labels (Table 4, Model 3).

Table 4. Random Effects Tobit Regression Results: By Labeling Category, Format, and Framing

	Model 1 Absence vs. Presence of Neonics		**Model 2 Absence of Neonics Logo vs. Text**		**Model 3 Presence of Neonics Treat vs. Protect**	
Variables[a]	**Coeff.**	**APE**	**Coeff.**	**APE**	**Coeff.**	**APE**
Plant attributes						
Neonic-free label	0.40^{***}	0.34	–		–	
(binary)[b]	(0.05)	−0.05				
Neonic-free logo	–		0.22^{***}	0.20	–	
(binary)[c]			(0.07)	(0.06)		
Neonic-treated	–		–		−0.14	NS
(binary)[d]					(0.12)	
Biodegradable	0.34^{***}	0.29	0.36^{***}	0.32	0.32^{***}	0.26
container	(0.06)	(0.05)	(0.09)	(0.08)	(0.08)	(0.07)
Live product	0.69^{*}	0.58	0.65^{*}	0.57	0.80^{*}	0.67
	(0.39)	(0.33)	(0.38)	(0.33)	(0.47)	(0.41)
Plant dummy[e]						
Marigold	-0.63^{***}	−0.48	-0.68^{***}	−0.54	-0.68^{***}	−0.48
	(0.09)	(0.07)	(0.12)	(0.10)	(0.13)	(0.10)
Pentas	-0.25^{***}	−0.20	-0.24^{*}	−0.20	-0.28^{*}	−0.20
	(0.10)	(0.08)	(0.13)	(0.11)	(0.15)	(0.11)
Dianthus	1.38^{***}	1.19	1.39^{***}	1.24	1.32^{***}	1.07
	(0.09)	(0.08)	(0.10)	(0.09)	(0.15)	(0.13)
Chrysanthemum	1.89^{***}	1.67	1.93^{***}	1.76	1.87^{***}	1.57
	(0.09)	(0.08)	(0.12)	(0.11)	(0.13)	(0.11)
Salvia	1.43^{***}	1.24	1.52^{***}	1.36	1.38^{***}	1.12
	(0.10)	(0.09)	(0.13)	(0.12)	(0.15)	(0.13)
σ_c	1.99		1.93		2.38	
	(0.13)		(0.13)		(0.16)	
σ_u	1.54		1.41		1.51	
	(0.02)		(0.03)		(0.03)	
ρ[f]	0.63		0.65		0.71	
	(0.03)		(0.03)		(0.03)	
No. of obs.	3,550		1,774		1,776	
Log likelihood	−6,456.34		−3,229.52		−3,170.96	

Notes: Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level. Robust standard errors are reported in parentheses. APEs were calculated by Delta-method and computed for statistically significant plant attributes only. APEs for individual characteristics were suppressed from the table. In addition, significance levels for APEs were also suppressed. NS indicates nonsignificance.

[a] The estimated coefficients for individual characteristics and constant were suppressed from the table but are available from the authors upon request.

[b] Labels disclosing the presence of neonicotinoids (i.e., the "presence of neonics" group) were used as the base group.

[c] Labels with the text "neonicotinoid free" were used as the base group.

[d] Labels with the text "protected from problematic pests by neonicotinoids" were used as the base group.

[e] Impatiens was used as the base group.

[f] $\rho = \frac{\sigma_c^2}{\sigma_c^2+\sigma_u^2}$ captures the importance of the panel-level variance. When ρ is 0, the random effects Tobit estimators are equivalent to the standard pooled Tobit estimators.

In line with earlier studies (Yue et al., 2010, 2016), participants were willing to pay \$0.26–\$0.32 more for biodegradable containers. Participants in the live product auction were willing to pay \$0.57–\$0.67 more than those in the product image auction (Table 4, Models 1–3). This result echoes Bushong et al.'s (2010) finding that the physical presence of a real item increases WTP when compared to text or pictorial representations.

When compared to impatiens (the base group in the regression analysis), consumers were willing to pay \$0.48 less for marigolds and \$0.20 less for pentas (Table 4, Model 1). For perennial plants, consumers were willing to pay \$1.19, \$1.67, and \$1.24 more for dianthus, chrysanthemum, and salvia, respectively. The significant increases in WTP for perennials is likely due to the size difference between annual and perennial plants.[10] In addition, perennial plants live longer, which could lead to a higher valuation. Consistent with Breeze et al. (2015), the results of the random effects Tobit model also indicated that consumer preferences were more influenced by plant attributes than individual characteristics.[11] Individual demographic variables had no significant impact on consumer WTP after controlling for unobserved individual effects. The estimated coefficient of ρ, which captured the panel-level variance, was larger than 0.6 (significant at the 1% level) indicating the random effects Tobit was more appropriate than a standard Tobit model.[12]

To account for the impact of heterogeneous individual knowledge on preferences for neonic labeling, individual participants' knowledge variables were incorporated into the random effects Tobit model (Table 5). The interactions between participants' knowledge and the *neonic-free label* binary variables captured preferences for neonic labels by heterogeneous knowledge groups. This is important because prior knowledge and beliefs impact consumer responses to information, preferences, and WTP (Bronnenberg et al., 2015; Gustafson, Lybbert, and Sumner, 2016).

The first column (Specification 1) in Table 5 reports results utilizing the individual *knowledge about neonics* variable. The price premium of neonic-free labels was consistently estimated at \$0.33 without distinguishing individual consumer's knowledge type. On the other hand, the self-reported knowledgeable participants were willing to pay \$0.80 less compared to not knowledgeable participants. On average, the predicted WTP for a plant was \$2.42 for knowledgeable and \$3.23 for not knowledgeable participants. After including an interaction between participants' knowledge about neonics and the neonic-free label (*neonic_free* × *knowledge about neonics*) in Specification 2 (Table 5), the price premium for neonic-free labels for a person who was knowledgeable about neonics was \$0.74. This aligns with Rihn and Khachatryan's (2016) finding that consumers' awareness/knowledge of neonics was positively associated with purchase likelihood for "neonic-free" plants. However, on average, knowledgeable participants had a lower WTP level. For a neonic-free plant, the predicted WTP of a knowledgeable participant was \$2.53, while the WTP was \$3.16 for a not knowledgeable participant.

Similarly, Specification 3 in Table 5 reports the results utilizing an individual's knowledge about pollinator-attractive plants. Knowledge about pollinator-attractive plants generally did not affect participants' WTP, as the coefficient was not significant. However, a knowledgeable participant was willing to pay a \$0.57 premium for plants labeled as neonic-free (Specification 4). These regression results provide statistical support for the observations obtained from the raw data in Figure 1(b).

Discussion and Conclusion

The presented results provide interesting implications for the ongoing debate about mandatory disclosure of neonics on labels in the United States, which was recently introduced by several large

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[10] In regression models separating annual and perennial plants, consumers were willing to pay \$0.52 less for marigold plants and \$0.22 less for pentas (using impatiens as the base group) and \$0.48 more for chrysanthemums compared to dianthus (base group in the regression). The salvia plant indicator coefficient was not statistically significant. Detailed regression results are available from the authors upon request.

[11] Therefore, results related to individual demographic variables were suppressed from reporting in Tables 4 and 5.

[12] When $\rho = 0$, random effects Tobit estimators are not different from the standard Tobit estimators.

Table 5. Random Effects Tobit Regression Estimates from Extending Model 1: Incorporating Individual Heterogeneity in Knowledge about Neonicotinoids and Pollinator-Attractive Plants

	Specification 1		Specification 2		Specification 3		Specification 4	
Variables[a]	Coefficient	APE	Coefficient	APE	Coefficient	APE	Coefficient	APE
Plant attributes								
Neonic-free label	0.40***	0.33	0.25***	0.21	0.40***	0.33	0.24***	0.21
(binary)[b]	(0.05)	(0.05)	(0.06)	(0.05)	(0.05)	(0.05)	(0.07)	(0.06)
Neonic_free × knowledge about neonics[c]	–		0.72***	0.53[f]	–		–	
			(0.13)	(0.10)				
Neonic_free × knowledge about p-attractive plants[d]	–		–		–		0.44***	0.36[g]
							−0.11	−0.09
Biodegradable container	0.34***	0.29	0.34***	0.29	0.35***	0.30	0.35***	0.30
	(0.09)	(0.05)	(0.06)	(0.05)	(0.06)	(0.05)	(0.05)	(0.05)
Live product	0.75*	0.64	0.76**	0.64	0.56	NS	0.56	NS
	(0.38)	(0.33)	(0.39)	(0.33)	(0.39)		(0.40)	
Plant dummy[e]								
Marigold	−0.63***	−0.48	−0.63***	−0.48	−0.61***	−0.47	−0.61***	−0.47
	(0.09)	(0.07)	(0.09)	(0.07)	(0.09)	(0.07)	(0.09)	(0.07)
Pentas	−0.25***	−0.20	−0.25***	−0.20	−0.25***	−0.20	−0.25***	−0.20
	(0.10)	(0.08)	(0.10)	(0.08)	(0.10)	(0.08)	(0.10)	(0.08)
Dianthus	1.38***	1.19	1.38***	1.19	1.39***	1.21	1.39***	1.21
	(0.09)	(0.08)	(0.09)	(0.08)	(0.09)	(0.08)	(0.09)	(0.08)
Chrysanthemum	1.9***	1.67	1.90***	1.67	1.93***	1.71	1.93***	1.71
	(0.09)	(0.08)	(0.09)	(0.08)	(0.09)	(0.08)	(0.09)	(0.08)
Salvia	1.43***	1.24	1.43***	1.24	1.46***	1.27	1.46***	1.27
	(0.10)	(0.09)	(0.09)	(0.09)	(0.10)	(0.09)	(0.10)	(0.09)
Knowledge variables								
Knowledge about neonics	−0.98**	−0.80	−1.36***	−1.10	–		–	
	(0.47)	(0.81)	(0.47)	(0.36)				
Knowledge about p-attractive plants	–		–		−0.23	NS	−0.45	NS
					(0.39)		(0.39)	
σ_c	1.96		1.96		1.98		1.98	
	(0.13)		(0.13)		(0.13)		(0.13)	
σ_u	1.54		1.54		1.54		1.54	
	(0.02)		(0.02)		(0.02)		(0.02)	
ρ[f]	0.62		0.62		0.62		0.62	
	(0.03)		(0.03)		(0.03)		(0.03)	
No. of obs.	3,550		3,550		3,606		3,494	
Log likelihood	−6,454.15		−6,438.58		−6,381.89		−6,374.04	

Notes: Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level. Robust standard errors are reported in parentheses. The estimated results for individual characteristics and constant were suppressed from the table but are available from authors upon request. APEs were calculated by Delta-method and computed for statistically significant plant attributes only. In addition, significance levels for APEs were also suppressed. NS indicates nonsignificance.

[a] Labels disclosing the presence of neonicotinoids (i.e., the "presence of neonics" group) were used as the base group.

[b] Knowledge about neonics is a binary variable indicating whether a participant self-identified as knowledgeable (i.e., by selecting 4 or higher on the Likert scale). 29 participants were categorized as knowledgeable, while 112 participants were categorized as not knowledgeable about neonicotinoids.

[c] Knowledge about pollinator-attractive plants is a binary variable indicating whether a participant correctly answered at least three of the total four quiz questions. 48 participants were categorized as knowledgeable, while 91 participants were categorized as not knowledgeable about pollinator-attractive plants.

[d] Impatiens was used as the base group.

[e] $\rho = \frac{\sigma_c^2}{\sigma_c^2+\sigma_u^2}$, captures the importance of the panel-level variance. When ρ is 0, the random effects Tobit estimators are equivalent to the standard pooled Tobit estimators.

[f] APE was evaluated at "knowledge about neonics" = 1.

[g] APE was evaluated at "knowledge about pollinator-attractive plants" = 1.

retailers in the ornamental horticulture industry. Given consumers' positive response to retailers' labeling policies in this study, one anticipates a bottom-up movement away from using neonics along the industry's supply chain. As a result, this signal of corporate social responsibility (CSR) may further strengthen individual firms' reputations and lead to improved corporate financial performance. This strategy could also work for the garden center industry as a whole. Timely adoption of CSR measures may improve the collective reputation of the independent garden center (IGC) segment of the ornamental horticulture retail industry, while contributing to the IGC industry's financial performance.

Results also indicate that policy makers should take a prudent policy approach by encouraging voluntary disclosure of the absence of neonics on labels given consumers' strong preference for neonic-free products. Before policy intervention becomes necessary (i.e., mandatory labeling of neonics), policy makers may consider engaging the general public as part of a large pollinator conservation movement. Increasing public awareness and engaging consumers is one technique to change consumer shopping behaviors by selecting products produced using sustainable practices. While mandatory neonics labeling is still under investigation by the U.S. federal government, major ornamental horticulture industry stakeholders may want to consider utilizing the first-mover advantage by participating in voluntary labeling strategies communicating the absence of neonics to capture this positive consumer surplus. In this specific situation, this study simultaneously presented labels indicating the absence and presence of neonics. The use of both absence and presence labels could be applied to other industries facing regulatory transitions in their labeling polices. For instance, while GMO-free labeling (a voluntary scheme) predominantly prevails, consumers in Connecticut, Vermont, and Maine (where GMO labeling mandates were passed) may simultaneously see both absence and presence labeling ("produced with genetic engineering" and "non-GMO" labeling).

Further, this study demonstrates several benefits to firms and policy makers when utilizing different message formats to attract consumers. For instance, firms promoting sustainability-related products may be able to engage consumers by utilizing logos. While text labels are the most straightforward to communicate that a product is grown without neonics, using a logo is attractive given that consumers are not familiar with neonics. Even though third-party certification may impose additional costs on producers, those costs are likely to be offset by consumers' higher valuations. However, suitable caution may be necessary when interpreting the higher valuation for the logo. The "Bee Better Certified" logo does not explicitly state neonic-free production. In fact, to become Bee Better Certified$^{\mathrm{TM}}$, producers must commit to providing pollinator habitat, while mitigating the negative impacts from pesticides, including not using neonics. The higher premium for this logo could result from a broader interpretation of the logo depending upon participants' knowledge. Therefore, for policy makers considering labeling policies, these results suggest framing neonic-free promotions with easily recognizable graphics (e.g., a bee logo) and neonic-free text to communicate that a product is grown without neonics if consumer knowledge is limited. In future studies, one could consider collecting information on consumers' awareness and understanding of the "Bee Better Certified" logo to derive WTP directly linking to the neonic-free element versus other pollinator friendly attributes. These findings also highlight the effectiveness of communicating additional information on labels that are often emphasized in information and consumer valuations literature (Gifford and Bernard, 2006; Liaukonyte et al., 2013). Finally, there are broader implications for policies focused on environmentally friendly production practices. Specifically, to increase consumers' interest in more sustainably produced goods, clearly defined logo messages should be developed and promoted to improve public interest and valuation.

This study has a number of limitations, primarily due to its stated preference-based framework. Even though the second-price auction was incentivized, the estimated WTP for attributes disclosing the presence or absence of neonics may still be subject to some hypothetical bias. With more scanner data available for plant purchases, future studies may consider combining experimental (auction) data and scanner data to evaluate consumer preferences for important plant attributes.

Even though we aimed to measure participants' knowledge both subjectively (based on self-revealed rating scale) and objectively (based on quiz questions), additional objective measures (e.g., expertise, occupational information) could be acquired and used to classify participants into "experts" and "average" plant purchasers. For instance, Bronnenberg et al. (2015) classified consumers into expert consumers (e.g., chefs, pharmacists) and average consumers to reflect knowledge differences. Another caveat from this experiment is the potential ordering effect because of the fixed order of the annual bedding and perennial plant auctions (i.e., between-round effects) on participants' bid values in the product image auction. The analysis demonstrated no evidence that the (within-round) ordering effect had significant impact on the bids for the annual bedding plants in the product image auction. Conversely, some differences were observed in the perennial plant auctions, implying that the results should be interpreted cautiously. However, due to the differences in two auction formats and settings, one cannot attribute the differences in bids for perennial plants solely to between-round ordering effects.

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Online Supplement: Consumer Preferences for Labels Disclosing the Use of Neonicotinoid Pesticides: Evidence from Experimental Auctions

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Table S1. Comparison of Population and Sample Demographics

	Sample Total	**Live Product Auction**	**Product Image Auction**	**Florida Population[b]**
Gender (Male)	25.7%	30.8%	21.3%	48.9%
Age (65+)	35.3%	37.5%	33.3%	19.9%
Ethnicity				
Caucasian	84.9%	83.1%	86.5%	75.9%
African American	5.8%	1.5%[a]	9.5%[a]	16.1%
Hispanic	4.3%	4.6%	4%	24.1%[c]
Asian	1.4%	3.1%	0%	2.6%
Native American	0%	0%	0%	0.3%
Pacific Islander	0.7%	1.5%	0%	0.1%
Other	2.9%	6.2%	0%	2.5%
Household Size (mean)	2.68	2.78	2.59	2.64
Education				
High School +	100%	100%	100%	87.2%
Bachelor's degree +	50.7%	60%	46.6%	27.9%
Household Income				
$100,000+ (%)	25.5%	34.4%[a]	12.3%[a]	19.6%
Median	$60,000-$79,999	$60,000-$79,999	$60,000-$79,999	$48,900
Mean	$60,000-$79,999	$60,000-$79,999	$40,000-$59,999	$69,936
Shopping Behavior (in 2016)				
No. of visits per year (mean)	7.9	8.8	7.2	–
Average amount spent per visit (mean)	$33.00	$29.40	$36.10	–
Total amount (mean)	$100-$199	$100-$199	$100-$199	–
Allergic to pollen (%)	27.9%	23.1%	32%	–
Allergic to sting (%)	27.9%	33.9%	22.7%	

Notes: [a] Indicates the difference between live product auction and product image auction was statistically significant ($p < 0.05$). based on pairwise t-test.

[b] 2012–2016 American Community Survey 5-Year estimates for Florida, United States Census Bureau (https://www.census.gov/).

[c] The category of Hispanic may be of any race and includes other race categories.

Table S2. Summary of Bid Distribution

Annual	**Bid Value (Mean)**	**Maximum Bid Value**	**Perennial**	**Bid Value (Mean)**	**Maximum Bid Value**
a1	$2.32	$10.29	p1	$3.91	$12.99
a2	$2.36	$12.15	p2	$3.86	$15.00
a3	$1.64	$8.25	p3	$3.67	$12.35
a4	$1.67	$10.45	p4	$3.49	$12.99
a5	$2.71	$12.00	p5	$4.00	$16.00
a6	$1.89	$13.40	p6	$4.20	$15.00
a7	$2.15	$11.80	p7	$4.29	$15.99
a8	$2.61	$12.50	p8	$3.79	$12.00
a9	$1.96	$8.90	p9	$4.12	$16.99
a10	$2.41	$10.00	p10	$4.69	$15.99
a11	$2.62	$10.00	p11	$4.24	$20.00
a12	$1.84	$9.78	p12	$4.01	$12.35
a13	$2.38	$11.00	p13	$3.46	$12.25
a14	$1.95	$9.99	p14	$3.65	$15.99
Average	$2.18	$10.75	Average	$3.96	$14.71

Notes: Annual bedding plants are in 4-inch containers; perennial plants are in 1-gallon containers.

Table S3. Distribution of Bid Values by Neonicotinoid Labeling Types and Neonicotinoid Awareness Groups

			Bid Value (Mean)		
Labeling			**Aware of Neonics**	**Not Aware of Neonics**	**Paired-*t* Test**
Annual bedding plants (1-inch container)					
Neonic-free	Neonic-free text	a1	\$1.93	\$2.46	7.53
		a3	\$1.36	\$1.74	(*p*-value=0.00)
		a5	\$2.26	\$2.88	
		a13	\$2.10	\$2.80	
	Neonic-free logo	a8	\$1.47	\$2.15	
		a9	\$2.21	\$2.77	
		a11	\$1.93	\$2.55	
With Neonics	Treated with neonics	a6	\$1.37	\$2.08	
		a7	\$1.55	\$2.38	
		a10	\$1.75	\$2.66	
		a12	\$1.21	\$2.08	
	Protected by neonics	a2	\$1.65	\$2.62	
		a4	\$1.13	\$1.87	
		a14	\$1.17	\$2.23	
Perennial plants (1-gallon container)					
Neonic-free	Neonic-free text	p3	\$3.58	\$3.70	3.14
		p6	\$3.86	\$4.32	(*p*-value = 0.00)
		p9	\$4.22	\$4.08	
		P12	\$4.02	\$4.00	
	Neonic-free logo	p1	\$3.75	\$3.97	
		p7	\$4.31	\$4.28	
		p10	\$4.27	\$4.84	
With Neonics	Treated with neonics	p2	\$3.20	\$4.10	
		p11	\$3.39	\$4.56	
		p13	\$3.34	\$3.51	
		p14	\$3.28	\$3.79	
	Protected by neonics	p4	\$2.94	\$3.69	
		p5	\$3.28	\$4.26	
		p8	\$3.25	\$3.99	

Notes: Participants who answered "yes" to the "Have you heard of neonicotinoid pesticides?" question were defined as aware of neonics and those who answered "no" were defined as not aware of neonics.

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