Consumer Willingness to Pay for Nano-packaged Food Products: Evidence from Experimental Auctions

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Consumer Willingness to Pay for Nano-packaged Food Products: Evidence from Experimental Auctions

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Abstract: Using experimental auctions, this paper evaluates the impact of information on consumers' willingness to pay (WTP) for nano-packaged food products. Positive, negative and neutral information about the risks and benefits of nanotechnology in food processing was presented to consumers to measure the influence of information on consumer WTP. Double hurdle model results show that the specific information about nanotechnology from various sources has a negative effect on the probability of consumers valuing nano-packaged products. For consumers who did value nano-packaged products, general and specific information about nanotechnology had a positive effect on their WTP for nano-packaged salad and apple sauce. The effects of information on the WTPs of consumer who valued the products were more idiosyncratic, varying across the type of product, prior knowledge about nanotechnology, age, income, gender, marital status, and education.

Keywords: nanotechnology, willingness to pay, shelf-life, experimental auction

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1. Introduction

Technical innovation in the food production, storage, processing and packaging is in part responsible for the abundant, affordable and safe food enjoyed throughout much of the developed, and increasingly the developing, regions of the world. While many innovations have been widely accepted within the food system (e.g., food fortification and homogenization), others have been controversial even to the extent of being shunned within the food system (e.g., genetically engineered Bt potatoes and herbicide tolerant wheat; and food irradiation). Nanotechnology is one of the latest controversial innovations working its way into the food system.

Nanotechnology is the understanding and control of matter at the nano-scale, a dimension approximately between 1 and 100 nanometers, where unique phenomena can occur (The National Nanotechnology Initiative).[4] Through nanotechnology, material can now be deconstructed into its constituent atoms, molecules and super-molecular structures, and then reconstruct into new forms with novel properties (Scrinis, 2006a). In 2012, there were about 100 nanotechnology-based food and packaging products available to consumers. These products range from Nanotea to a nanoceutical slim shake (Maynard and Michelson 2006; Dudo et. al. 2010). To our knowledge, there are currently no nano-packaged food products in the market, though there are nanosilver food storage containers on the market which claim to keep food fresh longer. There are around 1,200 companies, mainly in the United States, with more than 180 food applications of nanotechnology under development and it has been estimated that the market for

[4] Nanoscale particles are substantially smaller than the width of a single strand of human hair (about 80,000 to 100,000 nanometers) and only visible through a microscope.

food related nanotechnology applications will grow from 7.0 to 20.4 billion USD between 2015 and 2020 (Helmut Kaiser Consultancy, 2011).

While nano food and packaging already appear in the market and more nano products are on the horizon, their introduction has been controversial. Companies developing and marketing these products advocate for the potential benefits they can provide such as targeting delivery of nutrients to specific sites of action (Weiss et al., 2006), enhancing flavor by selectively removing chemicals (Joseph and Morrison, 2006), controlling gas movement through packaging to improve the shelf-life of perishable products (Nanobio-RAISE project, 2011), and signaling spoilage with sensors that change color when pathogens are present (ETC Group, 2004). Alternatively, environmental groups such as ETC and Friends of the Earth have countered industry claims, asserting potential hazards such as food contamination by toxic particles with no nutritional value (Friends of the Earth, 2008), exposure of workers to toxic nano particles (Friends of the Earth, 2008), and unanticipated effects of nutrients with altered uptake or greater absorption (Parry, 2006). Governmental organizations such as European Food Safety Authority and United States Food and Drug Administration (FDA) have acknowledged nanotechnology can be beneficial, but also admit to lacking knowledge about the effects of nanotechnology on human and environmental health (European Food Safety Authority, 2009; FDA, 2009).

Many consumers remain largely unaware of nano food applications and hold different opinions. In 2010, surveys indicated that nearly two-thirds in the United States (Food Safety News, 2010) and 40 percent in Europe (European Commission, 2010) knew nothing about nano food applications. Even with limited knowledge, a majority in the United States felt nanotechnology was more beneficial than risky (Cobb and Macoubrie, 2004), while Europeans tended to be less supportive (Gaskell et al., 2005). Furthermore, it has been found that consumer attitudes toward nano food varies by application (Siegrist et. al, 2007; Siegrist et al., 2009), trust in the food industry (Siegrist et al., 2007), and along cultural and political lines (Kahan et. al., 2007).

The purpose of this study was to examine how nano food packaging designed to enhance shelf-life affects consumer Willingness to Pay (WTP) for perishable products in order to better understand how the controversy surrounding nanotechnology is likely to affect its market success. Specifically, we explore how consumer WTP for nano packaging differs across different types of perishable products (e.g., salad, apple sauce and dried peanuts) when secondary positive (from private industry), negative (from an environmental group), and neutral (from a government agency) information about nanotechnology is provided. The paper is different from previous studies on nanotechnology in two ways. First, we use experimental auctions with real nano packaged food products to elicit the WTP instead of hypothetical surveys to elicit the WTP or buying intentions. Second, we test how information about the benefits and risks of nanotechnology from various sources affects the WTP.

2. Materials and Methods

This section details the experimental methods, experimental set-up, auction participants, products and information made available to participants. The section also details the econometric methods used to interrogate the auction results.

I. Experimental Method.

Experimental auctions place consumers in a setting that uses both real money and real products to provide incentives for truthful preference revelation. In cases where the consumer WTP is elicited through hypothetical auctions or surveys, consumers do not always reveal their true preferences, leading to hypothetical bias (Harrison and Rutström, 2008). Experimental evidence confirms that experimental auctions are a valuable tool for estimating the true value of consumer WTP (Umberger and Feuz, 2004). In the literature investigating consumer WTP for nano-packaged food, consumers have not been presented with the real nano-packaged products. The consumers were aware of the hypothetical existence of the nano-packaged products in the experiments and hence these experiments elicited hypothetical instead of actual WTPs (Bieberstein et al., 2012). The current study goes a step further by making the actual nano-packaged products available to consumers so they make real purchases if they win the auction. This experiment also builds on the literature that explores the effect of negative, positive and neutral information on consumer WTP (Rousu et al., 2007).

Auction Mechanism

The auction mechanism used in the experiment was the demand revealing Becker-DeGroot-Marschak (BDM) mechanism (Noussair et al., 2004). Each participant submits the price he or she is willing to pay to purchase the product. At the end of the auction, the market price is drawn randomly. If the bid for auctioned good is equal to or higher than the market price, the participant is required to buy the product. Thus the auction mechanism is incentive compatible because bidders have no strategic incentive to bid above or below their true WTP. During the experiment, participants were explicitly made aware of the fact that bidding their true WTP was their best strategy.

Sample Selection

The experiment was conducted in St. Paul, Minnesota in April 2012 over a period of two weeks. In total, 109 participants were recruited through an advertisement in 13 local newspapers having wide readership in all the socio-economic classes in the Minneapolis and St. Paul metropolitan area. The advertisement specified that only the grocery shopper in a household can participate in the experiment. To avoid bias, nanotechnology was not mentioned in the advertisement. Out of the 109 observations, three were dropped because of uncompleted data, making the sample used for further analysis 106.

Auctioned Products

The experiment focused on the WTP for apple sauce (12 oz.), spring mixed salad (5 oz.) and peanuts (12 oz.) packaged in nano-containers. These food products were chosen because of their perishable nature, allowing us to investigate how consumers react to the main function of nano-packaging — keeping food fresh longer. The three products were available in organic and conventional versions. Thus there were six different products for participants to bid on and potentially purchase.

Nanotechnology has been excluded from organic food production in Canada, the European Union, the United Kingdom and Australia (The Organic and Non-GMO Report, 2010). Currently, there are no regulations prohibiting the use of nanotechnology in organic products in the United States even though there is opposition to nanotechnology from the organic industry (Scrinis et al. 2012) and the National Organics Standards Board has proposed to vote to ban its use (Kessler 2011, Center for Food Safety, 2009). Regardless, consumers are generally unaware of the use of nanotechnology in the organic food production (Paull and Lyons, 2008). In our study, we elicit the consumer WTP for nano-packaged organic food products so we can understand to what extent, if any, consumers may value the use of nanotechnology in organic food packaging.

Bidding Rounds & Nanotechnology Information

The experiment was comprised of three rounds of bidding, each with six products (three conventional and three organic products). In the first round, the products were with "plain-labels," such that there was no indication that the products were in nano-packaging. In the second and third rounds, the products were with "nano-labels." Both the "plain-labels" and "nano-labels" displayed the contents and weight of the products, and whether or not the products were organic. The nano-label displayed 'Nano-Silver Technology' with the logo 'Stays Fresh Longer' which is typical labeling found on nano-containers currently on the market. Figure 2 and 3 show an example of plain and nano-labels which were displayed on the products. We followed the common experimental procedure of presenting the products sequentially (Huffman et. al. 2003, Kanter et. al. 2009, Liaukonyte et. al. 2013).

During the experiment, participants were shown two sets of information in two different steps, and participants were asked to submit their bids for the products after viewing each set of information. The first set of information was general about nanotechnology and its application in the food industry, which is the same as the information used by Roosen et al. (2011). The second set of information was a statement on nanotechnology from three different sources: private industry, an environmental group and the FDA.

The private industry statement was mainly about the positive applications of nanotechnology in food packaging and its ability to keep food fresh longer and prevent food-borne illness. The environmental group's statement was mainly negative about nanotechnology, presenting the harmful side-effects and informing participants about the migration of harmful nanomaterials such as zinc oxide and titanium oxide from the nano-packaging into food products. It also mentioned the presence of silver nano-particles in consumer products and its adverse effects such as the destruction of useful bacteria and development of antibacterial resistant bacteria. This information was from the Friends of the Earth, a well-known environmental protection group. The FDA's statement was neutral in terms of confirming the usefulness of nanotechnology for increasing shelf-life and preventing food-borne illness, but also in terms of warning about the unknown nature of the emerging technology and its untested level of long-term risk. The text of the information displayed to the participants is shown in Table 5.

To avoid income and substitution effects, we randomly drew which of the real auction rounds and products would be binding, so no participant could purchase more than one product (Melton et al., 1996; List and Lucking-Reilly, 2000). If a participant won the binding product in the binding round, she/he was required to purchase the product and pay the market price. The experimental protocol was submitted to and approved by the University Institutional Review Board.

Implementation

The experiment was set up on a computer. The product images, information about nanotechnology and the instructions for the experiment were made available on the computer screen. This allowed for little to no interaction between the participants and the proctor of the experiment, thus reducing any errors caused by miscommunication.

The diagrammatic representation of the experimental flow is shown in Figure 1. On arrival participants were asked to sign a consent form. They were then instructed about how to use the computer and mouse to traverse from one screen to another, and entering the bids on the separate bid sheet. To make the experimental auction procedure smoother, participants viewed the information about nanotechnology and the images of the auctioned products on the computer screen. Participants were informed that the exact same real products shown in the image were being auctioned and if a participant won the auction, he/she would receive the item and pay the market price.

When the computer application was launched, there was a practice round with a candy bar. Following the practice round, participants were asked to bid on six plain-labeled products. The following screen displayed general information about nanotechnology and its application in food production and packaging. This was followed by the six products with nano-labels and instructions for participants to write down their WTP for each product. Then the three different sets of positive, negative and neutral information were displayed sequentially on different screens. The sequence of the three sets of information was randomized to control potential order effects. Table 4 shows the randomized sequences and the number of participants, in each sequence during the experiment. The six products with nano-labels were then displayed once again with instructions for participants to write down the price they were willing to pay for each product. This ended the bidding.

After the auction, participants completed a survey asking their opinions about the risks and benefits of nanotechnology and nano-packages along with typical socio-demographic questions. It should be noted that the products in the different rounds were displayed in the packages with the same appearance but with different labels. The products were displayed with plain-labels in the first round of bidding and then with nano-labels in the second and the third round of bidding. Participants took 30 -45 minutes to complete the experiment and 15 - 20 minutes to complete a post-experiment survey.

II. Econometric Methods.

A common occurrence in auction experiments with controversial products is that a substantial number of participants prefer not to buy the product and submit a zero bid implying a zero WTP. This was also true in our experiment, particularly in the second and third rounds when participants knew the products were in nano-packaging. In such instances, a Tobit (e.g., Lusk et. al. 2001) or double hurdle model (e.g., Roosen et al., 1998) is commonly used to estimate the distribution of WTPs. The Tobit model assumes that the probability of a zero WTP and the magnitude of a positive WTP are both affected by the same factors and in the same way. Alternatively, the double hurdle model is more flexible because it allows the factors influencing the probability of a zero WTP to differ from the factors influencing the magnitude of a positive WTP. Therefore, the double hurdle model was used in our analysis.

With the double hurdle model, the first hurdle measures the probability that a participant's WTP is positive. The second hurdle measures the participant's WTP given it is positive. Let h_r^i be a latent variable that reflects the desirability of the product to the *i*th participant in round *r* and define

$$h_r^i = X_{1r}^i \beta_1 + \varepsilon_{1r}^i \tag{1}$$

where X_{1r}^i is a vector of observable explanatory variables that influence the product's desirability, β_1 is a conformable parameter vector, and ε_{1r}^i is a mean zero, independently distributed, standard normal error. Let WTP_r^i be the *i*th participant's willingness to pay for the product in round *r* given it is positive and define

$$WTP_r^i = X_{2r}^i \beta_2 + \varepsilon_{2r}^i \tag{2}$$

where X_{2r}^i is a vector of observable explanatory variables that influence the participant's WTP given it is positive, β_2 is a conformable parameter vector, and ε_{2r}^i is a mean zero, independently distributed, normal error with variance σ^2.

Using equation (1), the probability of a positive WTP can be written as

$$\text{Prob}\left(h_r^i \geq 0\right) = \Phi(-X_{1r}^i \beta_1) \tag{3}$$

where $\Phi(\cdot)$ is the standard normal cumulative distribution. This implies the probability of a zero WTP is $\text{Prob}\left(h_r^i < 0\right) = \Phi(X_{1r}^i \beta_1)$. The probability of WTP_r^i given it is positive can be written as

$$\text{Prob}\left(WTP_r^i | h_r^i < 0\right) = \Phi(-X_{1r}^i \beta_1) \frac{\phi\left(\frac{WTP_r^i - X_{2r}^i \beta_1}{\sigma}\right)}{\sigma\Phi\left(\frac{X_{2r}^i \beta_1}{\sigma}\right)} \tag{4}$$

where $\phi(\cdot)$ is the standard normal density. For i = 1,…,N, equations (3) and (4) imply the log-likelihood function is

$$L = \sum_{n=1}^{N} \left(\ln\left(\text{Prob}\left(h_r^i < 0\right)^{1-\mathrm{p_i}}\right) + ln\left(\text{ Prob}\left(WTP_r^i | h_r^i < 0\right)^{p_i}\right)\right) \tag{5}$$

where N is the number of participant bids being analyzed, and $p_i = 1$ for a positive bid and zero otherwise.

In the double hurdle models we pooled the observations for all three rounds, but estimated separate models for salad, applesauce and peanuts. The explanatory variables for both hurdles included an Organic variable equal to one if the product was organic and zero otherwise; an Information 1 variable equal to one for bids in round 2 and zero otherwise, an Information 2 variable equal to one for bids in round 3 and zero otherwise, interactions between the Organic variable and Information 1 and 2 variables, and variables for a participant's prior knowledge about nanotechnology, gender, age, income, level of education, marital status, and size of household. Of particular interest are the magnitude, sign and statistical significance of the parameter estimates for the Information 1 and 2 variables, and the interaction of these variables with the Organic variable. The parameter estimates for the Information 1 variable measure how the general information about nanotechnology affected the probability that a participant's WTP was positive and the magnitude of participants' positive WTPs. The parameter estimates for the Information 2 variable measure how the positive, negative and neutral information about nanotechnology in addition to the general information affected the probability that a participant's WTP was positive and the magnitude of participants' positive WTPs. The parameter estimates for the interaction of these variables with the Organic variable measure to what extent the effect of the information on the probability of a positive WTP and the magnitude of positive WTPs differ when the product is organic.

The models were estimated using STATA 11 with the craggit command, a user-developed command for estimating double hurdle models (Burke 2009).

3. Results

The study sample consisted of 73 percent women (Table 1). The average age was 55 years and the average income was $63,000, which is consistent with the findings in the literature that most grocery shoppers are women and tend to be older (Bawa and Ghosh, 1999; Goodman, 2008). The average household size was 2.5 and about 56 percent of participants were married or in a relationship. Over half had a college degree.

Table 2 reports the average of all WTPs, percent of zero WTPs and average of the positive WTPs by round. It also reports changes in the WTPs between rounds. The averages of all WTPs for all products increased from round 1 to 2, and then decreased from round 2 to 3. This same pattern is observed for the averages of the positive WTPs. However, the averages of the positive WTPs in round 2 were higher than the averages of the positive WTPs in round 3. These results indicate that with general information on nanotechnology and a nanotechnology label participants were, on average, willing to pay a premium ranging from 2.7 percent for peanuts to 16.7 percent for apple sauce. Alternatively, with specific positive, negative and neutral information, in addition to general information on nanotechnology, and a nanotechnology label, participants were, on average, willing to pay a premium for apple sauce, but discounted salad and peanuts. The percentage of zero WTPs in the second round was higher than in the first, with the highest percentage occurring in the third round. Interestingly, participants with positive bids in rounds 1 and 2 increased their bids on average with general information on nanotechnology and a nanotechnology label. Participants with positive bids in rounds 1 and 3, decreased their bids modestly on average with specific positive, negative and neutral information, in addition to general information on nanotechnology, and a nanotechnology label. These results suggest that most perceived nano-packaging as adding value to the product when they only had general information about the technology, though there were some that perceived the technology detracted from the value of the product. When individuals had specific positive, negative and neutral information, in addition to general information, about one in ten perceived the technology as detracting completely from the value of the product, while the rest perceived that the technology did little to add or detract from the value of the product.

Table 3 shows the double hurdle model parameter estimates when the bids for all rounds are pooled. There are two columns each for salad, apple sauce and peanuts. The first column shows the parameter estimates for the first hurdle (the probability the WTP was positive), while the second column shows the parameter estimates for the second hurdle (the magnitude of the positive WTPs).

For the first hurdle, all of the estimated parameters for the Information 1 variable (general information) are not statistically significant. Thus, the general information given to participants in the second round did not have a significant effect on probability of a positive WTP for nano-packaged products. All of the estimated parameters for the Information 2 variable (positive, negative and neutral information) are negative and statistically significant. This indicates that seeing more specific information on nanotechnology packaging from positive, negative and neutral perspectives decreased the probability of a positive WTP for nano-packaged products. The parameter for the variable denoting the participant's prior knowledge about nanotechnology is significant and positive for apple sauce, showing that participants who had prior knowledge about nanotechnology were more likely to have a positive WTP for nano-packaged apple sauce. Results also show that women were less likely to have a positive WTP for salad and apple sauce. Similarly, participants with larger households were less likely to have a positive WTP for peanuts.

The parameter estimates for the second hurdle indicate that participants with a positive WTP were willing to pay more for organic nano-packaged products. There are various studies which have shown similar results with consumers willing to pay a premium for organic products (Batte et al., 2007; Akaichi et al., 2012). The results also indicate that both the general information and specific information had a positive effect on a participants' WTP for salad and apple sauce for those with a positive WTP. The effect was higher for apple sauce than for salad, for both information variables.[5] The interaction term for Organic and Information 1 is significant for apple sauce, but not for salad and peanuts, implying that general information had an even larger effect on positive WTPs for nano-packaged organic apple sauce.

Women with positive WTPs were willing to pay more for nano-packaged products than men with positive WTPs. Older participants with positive WTPs had lower WTPs for nano-packaged salad compared to younger participants with positive WTPs. This finding is consistent with the literature that has found older people less accepting of nanotechnology (Bieberstein et

[5] The parameters for the information effect on positive WTPs for salad and apple sauce were statistically different from each other at one percent significance.

al., 2012). Education had an increasing effect on positive WTPs for salad and income had an increasing effect on positive WTPs for peanuts. This result is consistent with previous studies that have found consumers with higher education and income seek innovative products while grocery shopping (Ailawadi and Neslin, 2001). The results also show that prior knowledge about nanotechnology had an increasing effect on positive WTPs, which is consistent with previous studies that that have found prior beliefs about an emerging technology impact acceptance (Huffman et al., 2007, Bieberstein et al., 2012).

4. Conclusion

This study explored the influence of information on the WTP for nano-packaged food products using an experimental auction conducted with participants from a major metropolitan area in the United States (Minneapolis and St. Paul, Minnesota). Consumers are important stakeholders in the food industry, so understanding how they value nano-packaging is important to food companies considering the introduction of this new technology into their product lines. Understanding this technology's value to consumers is also important for government regulators who are under increasing pressure by some environmental and consumer groups with concerns about nanotechnology.

The results of the experiment show that the probability a participant's WTP is positive and the magnitude of positive WTPs for nano-packaged products were influenced by general and more specific positive, negative and neutral information about nanotechnology in different ways. While general information did not affect the probability of a positive WTP, specific information reduced this probability. Positive WTPs for nano-packaged products were influenced positively by both the general and more specific information about nanotechnology. Participants with a positive WTP were willing to pay more for nano-packaged salad and apple sauce after seeing both general and specific information on nanotechnology. It is also worth noting that participants with a positive WTP and prior knowledge about nanotechnology were willing to pay a premium for all nano-packaged products.

Consumer preference and WTP for nano-packaged food products vary by products. The participants, who submitted a positive bid for the nano-packaged products, were willing to pay a premium for the nano-packaged apple sauce and salad, but not for nano-packaged peanuts. This might be due to the various perishability of the products. Salad, a fresh produce, has a shorter shelf-life, apple sauce, a processed food has a medium shelf-life, and peanuts, a dried food have a comparatively long shelf-life. The primary benefit of nano-packaging is its ability to keep food fresh for a longer period of time. The results suggest that participants were willing to pay a higher premium for nano-packaged apple sauce than for the nano-packaged salad and peanuts. Apple sauce is a processed food product with a medium shelf-life and gets spoiled if not refrigerated or stored in an air-tight container. Salads are green vegetables which are intended for immediate consumption, while peanuts have a relatively long shelf life, which might explain why participants were willing to pay a lower premium or discount nano-packaged salad and peanuts. The participants were also willing to pay a premium for organic nano-packaged food products compared to the conventional counterparts, which suggests that many consumers would still value organic products more even if they were packaged using nanotechnology.

These results contribute to understanding consumer attitudes towards nano-packaged food as a function of product shelf-life, which has important food marketing implications. The food processing industry can use this knowledge to evaluate which products nano-packaging can add the most value to and the extent to which different sources of information can affect this value. There is also a potential for further research. Consumer WTP for nano-packaged fresh produce and processed food products like fresh vegetables, fresh juices and herbs, bread, jams, jellies, sauces and milk products such as cheese and milk, can be further explored to better understand the intricacies of consumer attitudes towards nano-packaging food products with shelf-lives that largely depends upon how they are stored. The National Organic Standard Board can further investigate the extent to which nano-packaging will detract from the value of organic food products and apply these findings to their policy decisions.

In closing, it is worth reflecting on some of the limitations of this study, so the results can be interpreted with suitable caution. Subjects were recruited from in and around the Minneapolis and St. Paul, a large metropolitan area in the Midwest, so our results may not be representative of consumers in other regions of the U.S. or consumers in other countries. The sample size was also relatively small when compared to hypothetical surveys. While these limitations suggests our results should be interpreted with some caution, they also point to directions for future research that could provide additional information for policy makers and the food industry for a challenging problem — the use of new technologies in food products.

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Table 1

Summary statistics of participants' socio-demographic background variables (n=106)

Variable	**Description**	**Mean**	**Standard Deviation**
Gender	Gender of participants, 1 if Female, 0 if male	0.73	0.44
Age	Age of participants in years	54.09	15.47
Annual Income	Annual Income of participants in USD	61432.04	27978.26
Education	Participants' education level, 1 if college graduate or higher, 0 otherwise	0.57	0.49
Marital Status	0 if Single, 1 otherwise	0.56	0.49
Size of Household	Number of people in the household	2.47	1.53
Prior knowledge of Nanotechnology	Self-Reported Knowledgeable about Nanotechnology, 1 if they had some knowledge about nanotechnology, 0 otherwise.	0.49	0.50

Table 2

Summary statistic for WTPs by round and changes in WTPs between rounds by product

	Salad	**Apple Sauce**	**Peanuts**
Average of All WTPs			
Round 1	1.88	1.62	2.21
Round 2	2.00	1.89	2.27
Round 3	1.82	1.72	2.07
Percent With WTPs Equal to Zero			
Round 1	1.0	2.4	1.0
Round 2	5.2	5.2	4.3
Round 3	11.4	13.3	11.9
Average of Positive WTPs			
Round 1	1.90	1.66	2.23
Round 2	2.11	1.99	2.38
Round 3	2.06	1.98	2.35
% change in WTP			
Round 2 - Round 1	6.4	16.7	2.7
Round 3 - Round 1	-3.2	6.2	-6.3
Average Change in positive WTPs			
Round 2 – Round 1	0.21	0.33	0.15
Round 3 – Round 1	0.16	0.32	0.12

Table 3

Effect of Information on WTP (Double hurdle model parameter estimation)

Variable	**Salad**		**Apple Sauce**		**Peanuts**	
	First Hurdle	Second Hurdle	First Hurdle	Second Hurdle	First Hurdle	Second Hurdle
Organic	0.006 (0.551)	0.536*** (0.129)	0.197 (0.411)	0.539*** (0.145)	0.000 (0.539)	0.543*** (0.1462)
Information 1	-0.632 (0.453)	0.302*** (0.132)	-0.285 (0.346)	0.404*** (0.147)	-0.598 (0.447)	0.208 (0.149)
Information 2	-1.258*** (0.423)	0.247** (0.135)	-0.875*** (0.314)	0.427*** (0.151)	-1.185*** (0.418)	0.190 (0.153)
Information 1 * Organic	-0.269 (0.629)	-0.122 (0.183)	-0.204 (0.514)	0.368** (0.201)	-0.190 (0.621)	-0.544 (0.209)
Information 2 * Organic	-0.079 (0.601)	-0.118 (0.188)	-0.194 (0.471)	-0.125 (0.207)	-0.049 (0.587)	-0.138 (0.213)
Prior knowledge about nanotechnology	0.143 (0.254)	0.171*** (0.081)	0.347** (0.178)	0.221** (0.089)	0.143 (0.186)	0.350*** (0.092)
Gender	-0.495*** (0.254)	0.410*** (0.093)	-0.620*** (0.255)	0.208*** (0.097)	-0.249 (0.230)	0.331*** (0.103)
Age	-0.009 (0.008)	-0.007*** (0.003)	-0.010 (0.008)	-0.001 (0.003)	-0.010 (0.008)	0.002 (0.003)
Income/1000000	-0.538 (3.650)	2.183 (1.460)	-2.484 (3.476)	2.523 (1.596)	-2.991 (3.600)	5.180*** (1.660)
Education	0.003 (0.086)	0.116*** (0.034)	0.114 (0.082)	0.058 (0.037)	0.020 (0.084)	0.025 (0.039)
Marital Status	-0.097 (0.204)	0.047 (0.089)	0.205 (0.190)	-0.002 (0.097)	0.163 (0.198)	0.083 (0.101)
Size of Household	-0.066 (0.080)	0.072*** (0.033)	-0.120 (0.077)	0.062** (0.036)	-0.134** (0.078)	0.053 (0.038)
Constant	3.886 (0.967)	0.167 (0.036)	2.786 (0.837)	0.149 (0.336)	3.332*** (0.888)	0.026 (0.351)

***, **, * represent significance level at p <0.01, 0.05, 0.1 respectively. Standard errors are reported in parentheses.

Table 4

Six different sequences of the information presented to the participants

Sequence	First Information	Second Information	Third Information	No. of participants.
1	Private Industry	Environmental Group	Government	17
2.	Private Industry	Government	Environmental Group	21
3.	Government	Private Industry	Environmental Group	16
4.	Government	Environmental Group	Private Industry	17
5.	Environmental Group	Government	Private Industry	17
6.	Environmental Group	Private Industry	Government	17

Table 5

Information from various sources displayed to the participants.

Source	Information presented
Information 1	
General Information	Nanotechnology refers to materials, systems and processes which exist or operate at the scale of atoms and molecules. This is a scale between 1 and 100 nanometres (nm). One nanometre is one millionth of a millimeter (mm). Materials at the nano-scale show novel properties that lead to novel applications in diverse fields like medicine, cosmetics, biotechnology, energy production and environmental science. There is uncertainty regarding how nano-materials may interact with human health and the environment. Nanotechnology offers new opportunities for food industry application. Manufactured nano-materials are already used in some food products, nutritional supplements and food-packaging applications(Bieberstein et. al.2013, Roosen et al., 2011).
Information 2	
Private Industry (Positive Information)	Nano-packaging has created a modified atmosphere in packaging in order to control the flow of gases resulting in improving the shelf-life of products like vegetables and fruits. One of the most promising innovations in smart packaging is the use of nanotechnology to develop antimicrobial packaging. Scientists at big name companies including Kraft, Bayer and Kodak, as well as numerous smaller companies, are developing a range of smart packaging materials that will absorb oxygen, detect food pathogens, and alert consumers to spoiled food. These smart packages, which will be able to detect public health pathogens such as *Salmonella* and *E. coli*. (Nanobio-RAISE project, 2011)
Environmental Agency (Negative Information)	Anti-bacterial nanofood packaging and nano-sensor technologies have been promoted as delivering greater food safety by detecting or eliminating bacterial and toxin contamination of food. However it is possible that nanomaterials (such as silver, zinc oxide and titanium dioxide) will migrate from antibacterial food packaging

	into foods, presenting new health risks. This appears inevitable where nano-films or packaging are designed to release antibacterial onto the food surface in response to detected growth of bacteria, fungi or mould. Silver nanoparticles are found in an increasing number of consumer products such as food packaging, odor resistant textiles, household appliances and medical devices. The potential for nanosilver to adversely affect beneficial bacteria in the environment, especially in soil and water, is of particular concern. Conversely, there is also a risk that use of silver nanoparticles ("nanosilver") will lead to the development of antibiotic resistance among harmful bacteria. (Friends of the Earth, 2008).
Governmental Agency (Neutral Information)	Nano-packaging has the potential to help improve the safety, shelf-life, and convenience of food. At present there is insufficient data publicly available to reach meaningful conclusions on the potential toxicity of food or color additives incorporating nano-materials, although the available information does not give us cause for concern. (Food and Dietary Association, 2007)

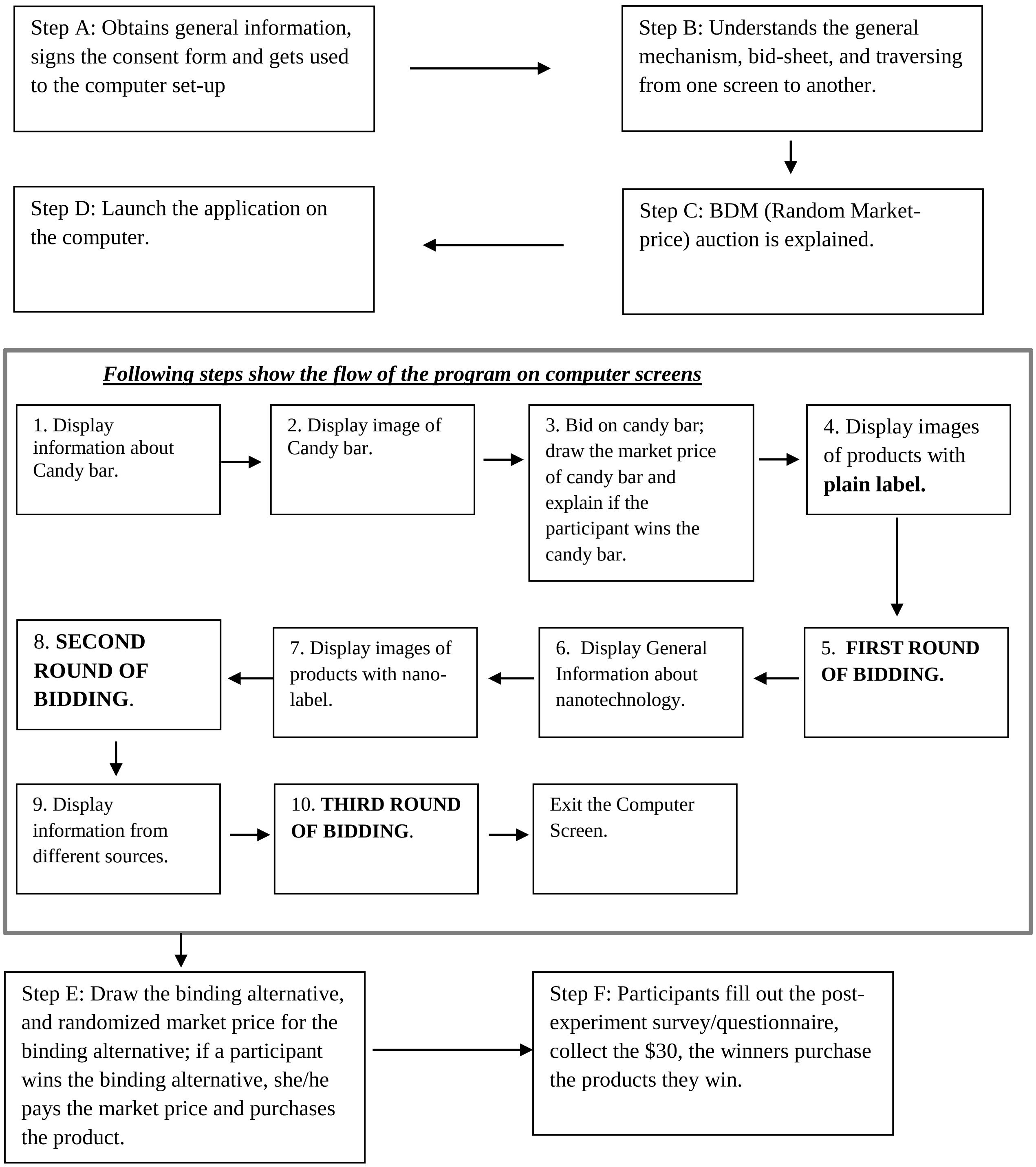

Figure 1. Diagrammatic Representation of the Flow of the Experimental Auction

Figure 2. Nano-labeled product displaying the ‘Stays Fresh Longer’ nanotechnology label

Figure 3. Plain-labeled product