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Auction bids on environmental attributes of pork products: evidence against part-whole bias

Abstract

This article examined how different quantities and levels of environmental attributes affect consumers' valuation of pork products in various regions and the national market. Evidence was examined from a multi-trial Vickrey auction to compare consumers' willing-to-pay (WTP) for a single pork product with multiple environmental attributes and their WTP for multiple products each with a single environmental attribute. One major finding is that the introduction of environmental attributes could lower the consumers' WTP for pork products without those attributes. Furthermore, the sum of consumers' WTP for products with a single environmental attribute is not statistically different from their WTP for a product with multiple environmental attributes, which suggests the premiums for the environmental attributes are additive. Contrary to some previous studies, this experiment found that the part-whole bias did not exist.

Kewords: environmental attributes, pork, vickrey auction, WTP, part-whole bias.
JEL Classification: Q13, Q51, Q53, C91.

Introduction

Since the early 1980's, there has been a structural change in the U.S. hog industry where individual pork producers have expanded their operations by shifting to larger production facilities in more confined spaces to capture economies of size. Specifically, from 1986 to 2002, fewer farms produced more hogs, which resulted in more than a 78% decline in the number of hog farms (Mattera, 2003). In 2007, the largest 110 hog producers held approximately 54% of the total hog inventory (Key and McBride, 2007). With this expansion, concerns regarding the effect of pork production on the environment have been rising (Herriges, Secchi and Babcock, 2003; McBride and Key, 2003; Sneeringer, 2009; Donham, 2010). These issues can be segmented into two broad areas: managing air quality issues which stem from the by-product of odor from production, and managing water quality by storing and utilizing manure in a way that will not contaminate surface and ground water.

In 2003, the United States Environmental Protection Agency (EPA, 2004) under the authority of the Clean Water Act released a new set of regulations for non-point source pollution concerning concentrated animal feeding operations (CAFO). These regulations affect pork producers if their operation meets the definition of being an animal feeding operation (AFO) and produces at least 2,500 swine over 55 pounds or 10,000 swine under 55 pounds[1]. Examining the concentration ratio of pork-to-farms in the top three producing states shows that Iowa, North Carolina, and Minnesota may be heavily affected by the EPA regulations on CAFO's. This is especially true for North Carolina producers that have an average of 17,568 hogs per farm (USDA, 2009).

This article examines how consumers value environmental attributes embedded in pork products. The primary objective of this research is to provide evidence whether the environmental attributes embedded in the pork products are additive through experimental auctions, i.e., whether the consumers' willingness-to-pay (WTP) for multiple attributes embodied in a single pork product is equal to the sum of the WTP for each separate attribute embedded in multiple pork products.

Many studies using experiments have examined how consumers' WTP is affected by a single attribute, such as food safety (Fox et al., 1994, 1995 and 1996; Hayes et al., 1996; Roosen et al., 1998; Baker, 1999; Grunert, 2005; Loureiro and Umberger, 2007; Wang, Mao and Gale, 2008), GMO-free (Rousu et al., 2004a, 2004b; Lusk et al., 2004; Colson et al., 2011), traceability (Umberger, 2004; Chung, Boyer and Han, 2009; Ubilava and Foster, 2009; Cicia and Colantuoni, 2010), and food labeling or certification (Dhar and Foltz, 2005; Kanter, Messer and Kaiser, 2009; Kolodinsky, 2008; Ubilava et al., 2011), or different attributes (e.g., Melton et al., 1996a, 1996b; Enneking, Neumann and Henneberg, 2007; Ward, Lusk and Dutton, 2008; Bond, Thilmany and Bond, 2008; Michel, Anders and Wismer, 2011).

In recent year, a few studies have attempted to examine part-whole bias in an experimental setting which was first examined by Bateman et al. (1997), who focused on consumers' WTP for a private product. The part-whole bias is said to exist if the value of the component attributes added together is different than the value of those attributes bundled together. For example, Bernard and Bernard (2009) examined and compared the consumers' WTP for organic,

[1] The definition of an AFO is a "lot or facility (other than an aquatic animal production facility) where animals (other than aquatic animals) have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period AND where crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility (EPA, p. 3)."

rBST-free, and no-antibiotics milk. rBST-free and no-antibiotics attributes are considered to be two major component attributes (part) of the organic attribute (whole). They found no significant difference between the sum of the WTP for rBST-free and no-antibiotics attributes and the WTP for organic. From this finding, they inferred that WTP for the attributes are non-additive, i.e., part-whole bias exists, because organic attribute consists of other remaining attributes in addition to rBST-free and no-antibiotics. Bernard and Bernard (2010) later did a similar study for organic potatoes and sweet corn. Again, they found that combined premiums for non-GM and no-pesticides attributes are not statistically different than the premium for organic attribute, and inferred that WTP for attributes are non-additive. However, Bernard and Bernard's (2009, 2010) conclusion of part-whole bias is not scientifically sound because of two reasons. First, the part-whole bias was inferred since valuation of the remaining attributes was not analyzed and no empirical tests on all the component attributes vs. the whole attribute were conducted. Second, more importantly, their experiment was flawed for testing the part-whole bias because the whole attribute consists of more than the studied component attributes.

Different from Bernard and Bernard's studies, the experimental design in the present research is better suited for testing the part-whole bias. Valuations for all the component attributes of a whole were collected during the experiment. In addition, different from Bateman et al.'s (1997) study where part-whole bias was tested and found in a private product experiment, this article contributes to the literature by empirically testing the part-whole bias in a product with various combinations of different environmental attributes (public product) using experimental auctions. It specifically examines how different quantities and levels of environmental attributes affect the valuation of pork products. Furthermore, it sheds light on the question whether it might help the pork industry to extract more premiums by packaging multiple environmental attributes into a single product.

The experimental auction data are analyzed at a national level and for six locations across the country: Ames, Iowa; Iowa Falls, Iowa; Manhattan, Kansas; Raleigh, North Carolina; Burlington, Vermont; and Corvallis, Oregon. The results from the national and regional models are consistent. The consumers' valuation when the environmental attributes were absent was only $0.04 less than their valuation when the environmental attributes information was released to the experiment participants. Another major finding is that the premiums for component attributes can be summed to equate the premium for the product with whole attribute. It implies that consumers are not necessarily willing to pay higher premiums for a product that has a bundle of multiple attributes.

1. Background

According to the 2007 USDA Agricultural Census, Iowa, North Carolina, and Minnesota accounted for 55% of the total U.S. pork production. At approximately $4.8 billion in sales, 8,758 Iowa farms produced 47.3 million pigs and hogs. North Carolina ranked second behind Iowa with $3.1 billion in sales and 43.2 million hogs produced on 2,459 farms. Minnesota is the third largest producer with the production of 22.8 million pigs and hogs on 4,748 farms, and $2.1 billion in sales. These states are also the top three states in the U.S. in terms of production concentration measured by the average number of pigs and hogs produced (USDA, 2009).

Due to increased cost of production of adopting technologies that create environmental attributes in pork products, there seems to be little market incentive outside of niche marketing for pork producers to produce products with environmental attributes. However, by producing a niche pork product that incorporates environmental attributes, the producer might gain because higher premiums can be charged via product differentiation and consumers' growing environmental awareness[1]. A necessary condition for the viability of a niche market for pork products with environmental attributes is for producers to be able to cover all the associated additional costs required to incorporate the environmental attributes. If this is possible, producers need to identify the best way to market the environmental attributes embedded in the product in anticipation of extracting more premiums. This implies that the producer needs to understand how consumer values pork with embedded environmental attributes. It is not a priori obvious that consumers would be willing to pay a premium for pork products with embedded environmental attributes. Since pork is primarily produced far away from the typical pork consumer, the consumer does not usually gain any direct benefits from purchasing pork that has environmental characteristics. Even though consumers may not receive a direct benefit from consuming pork with environmental attributes, they may receive what Andreoni (1990) termed "a warm-glow effect from giving."

[1] Throughout this paper, pork with embedded environmental attributes is discussed. Pork with embedded environmental attributes is defined as pork that has been produced in a production system that has less of an impact to the environment in comparison to what would be termed the typical system. This does not imply that pork production in general is harmful to the environment; rather, it means that the pork discussed in this paper was produced in a way that attempts to mitigate effects on the environment due to production.

Neither is it obvious whether pork consumers would prefer to purchase a single product with multiple attributes, or multiple products with single-level attributes.

Given that consumers value products with environmental characteristics, then what mix of environmental attributes would they prefer? By bundling multiple environmental attributes into a single product, the consumer is forced to potentially purchase a product that has some characteristics that are not desirable or not bundled in the correct proportions. On the other hand, if the producer sells goods that only have a single attribute, the consumer would be forced to purchase multiple products if they want to consume the multiple environmental attributes.

2. Conceptual model

The standard consumer maximization problem posits that consumers attempt to maximize their utility given a budget constraint. They derive utility from the consumption of goods which have a bundle of various characteristics. Utility is derived from the direct consumption of goods rather than the embedded characteristics. Lancaster (1966) points out that utility is derived from characteristics embedded in a product rather than the product itself which is a bundle of characteristics.

Following Lancaster (1966), our conceptual model is based on three assumptions. The first assumption is that the good is a mechanism to carry attributes, where attributes provide the direct utility to the consumer. Another assumption is that one good can possess multiple attributes, and each attribute can be shared in multiple goods. The third assumption is that attributes consumed together could provide different utility than attributes consumed separately. This allows for attributes when consumed together to provide more utility than if they were consumed separately.

Suppose there are m products with n distinct attributes. Consumers obtain utility from consuming the attributes which are embedded in the products. Therefore, a typical consumer's constrained utility maximization problem can be represented by the following equation:

$$\begin{aligned} &\underset{x_1,x_2,\dots,x_m}{\text{Max}}\ U(A_1,A_2,\dots,A_n),\\ &\text{where } A_i = f_i(x_1,x_2,\dots,x_m), \\ &s.t. \sum_{j=1}^{\mathrm{m}} p_j x_j \le I \end{aligned} \tag{1}$$

The attributes $A_1, A_2, \dots, A_n$ represent the characteristics/attributes that the consumer derives utility from, where the utility function $U(\cdot)$ represents a continuous twice differentiable function mapping characteristics to utility which is assumed to have the standard convexity properties. Income is represented by I, while p_j represents the price of the x_j commodity the consumer can purchase. The $f(\cdot)$ function maps the attributes of the bundles consumed into characteristic space. Both the $x_i{}'s$ and the $A_i{}'s$ are assumed to be non-negative.

Consumers are assumed to choose products to maximize their utility. Thus, for each product x_j, the first order condition of the consumer utility maximization problem can be written as:

$$\frac{\partial U}{\partial x_j} - \lambda p_j = \sum_{i=1}^{n} \frac{\partial U}{\partial A_i}\frac{\partial f_i}{\partial x_j} - \lambda p_j = 0, \tag{2}$$

where $i = 1,2,\dots,n$ indicates attributes, $j = 1,2,\dots,m$ denotes products, and λ is the Lagrange multiplier. For any individual product x_s, the physical attributes are easily recognized by the consumer. However, there might be certain underlying/hidden attributes embedded in x_s that the consumer would not know their existence if she was not informed.

Suppose for product x_s there are l hidden attributes embedded in the product along with the physical attributes. After the information about these l attributes is released, the consumer may want to change her consumption choice at the price p_s. Define p_s' as the price that will induce the consumer to consume the same bundle of goods after the hidden attributes were known. Therefore, before and after the information release, the consumer faces the same utility-maximization problem described in equation (1) when choosing product x_s with two different sets of attributes, and two first-order conditions should satisfy the following equation:

$$\sum_{s=1}^{n} \frac{\partial U}{\partial A_i}\frac{\partial f_i}{\partial x_s} - \lambda p_s = \sum_{s=1}^{n+l} \frac{\partial U}{\partial A_i}\frac{\partial f_i}{\partial x_s} - \lambda' p_s' = 0. \tag{3}$$

After the l attributes embedded in the product are released to the consumer, the prices of the same product x_s would satisfy the relationship below:

$$p_s' = \delta p_s + \frac{1}{\lambda'} \sum_{s=n+1}^{n+l} \frac{\partial U}{\partial A_i}\frac{\partial f_i}{\partial x_s}, \tag{4}$$

where $\delta = \lambda / \lambda'$. Equation (4) shows that the new price of product s, p_s' with more known attributes is a function of its original price, p_s, and all the marginal utilities from the newly released attributes. The model set-up motivates a hedonic approach (Rosen, 1974) to analyze the price of the goods based on valuing each of the attributes embedded in the product. It also allows for testing part-whole bias discussed by Bateman et al. (1997).

3. Data collection and methods

Many studies have used experimental auctions to value product attributes. Hoffman et al. (1993), Menkhaus et al. (1992), Umberger et al. (2009) investigated WTP for beef that is sold in different packages under different information sets. Hayes et al. (1996), Rozan et al. (2004), Loureiro and Umberger (2007), and Wang et al. (2008) did various experiments to obtain consumer's WTP for food safety attributes. Melton et al. (1996a, 1996b) studied consumer's WTP for pork chops with different visual characteristics. Rousu et al. (2004a) examined what consumers would be willing to pay for differing tolerance levels of genetically modified attributes embedded in canola oil, tortilla chips, and russet potatoes. Ubilava et al. (2011) found consumers' WTP for the certified pork chop is higher when it is branded. Bond, Thilmany and Bond (2008) used a hypothetical choice experiment to evaluate consumers' WTP for the label information regarding red leaf lettuce attributes. Hurley, Miller and Kliebenstein (2006) followed the experiment mechanism introduced in Shogren et al. (1994a, 1994b) and extended in List and Shogren (1999), and estimated consumers' WTP for pork chop products. They found consumers' WTP are affected by gender, age, education and monthly pork consumption.

Following Hurley, Miller and Kliebenstein (2006), the auction method used was a classic second-priced sealed-bid auction segmented into five bidding rounds. To familiarize the participants with the auction process, a preliminary auction with candy bars was used. After the preliminary practice, a multiple-trial second price auction with the pork products was conducted. The participants were not aware of the number of bidding rounds prior to the experiment.

In the first three rounds, participants bid only on the physical attributes of the product, such as color and marbling. They have no other information except for the previous round's second-highest bids. This allowed participants to become gradually comfortable with the auction process and obtain feedback on price information. In the fourth round, the participants were informed of the specific environmental attributes associated with the respective products. This release of information allowed for determining what the effect of the released environmental information had on participants' bids. In the fifth round, the implications of the environmental attributes were further explained and the participants were allowed to bid a final time. Following Fox et al. (1995, 1996), wealth effects were controlled by randomly choosing at the end of the experiment one product from one selected round to be the product sold[1], and the participants were debriefed on this information prior to the experiment. After the experiment, since the environmental attributes in the fourth and fifth rounds were unverifiable to the participants, only one product from one of the first three rounds where participants bid solely on the physical attributes was sold.

The products used to elicit bids were two-pound packages of uniformly cut, boneless, 1¼ inch pork loin chops. These packages were developed to look as uniform as possible. The first three rounds of bidding allowed for identifying if the packages provided were perceived as similar. Thus, in round four, participants were bidding on the environmental attribute information provided. Bid responses would reflect the value of the environmental attribute. The participants were allowed to simultaneously bid on 10 different packages of pork chops each having different environmental attributes. The packages of pork chops were arranged in a row, and placed on ice in one of three white coolers. Each of the ten packages was labeled as package j, where $j = 1,\ldots,10$. For each experiment, after the third round each participant was told that one package was a "typical package" with no particular environmental attributes. In this same round, the other nine packages were assigned varying levels of environmental attributes associated with ground water, surface water, and odor described in Table 1. Odor reduction was at two levels: a 30-40% reduction and an 80-90% reduction over the "typical" product. Ground water and surface water impacts were also available at two levels: a 15-25% reduction and a 40-50% reduction over the "typical" product. Packages were provided with single attributes (only air, ground water, or surface water), double attributes, or all three bundled attributes. The double- and triple-attribute pork packages were all at the high reduction levels.

Experiments were conducted in six different areas of the United States: Ames, Iowa; Iowa Falls, Iowa; Manhattan, Kansas; Raleigh, North Carolina; Burlington, Vermont; and Corvallis, Oregon. Three experiments were conducted at each site with each experiment lasting about two hours. A random sample of individuals from the area being studied was used to obtain participants for the experiment. This sample was obtained by a random computer-generated sample drawn from telephone numbers in the respective local telephone directory. Each participant was paid $40 before the auction for participating in the experiment.

[1] Wealth effects occur when participants change their bids because they won an earlier trial (Fox et al., 1995). See Davis and Holt (1993) for a discussion of wealth effects in experimental markets.

Of the 333 participants in the study, results from 329 were usable[1]. The number of participants ranged from 75 for Raleigh, North Carolina, 60 for Corvallis, Oregon and Manhattan, Kansas locations and 27 for Burlington, Vermont. In Iowa, the Ames location had 49 participants while the Iowa Falls location had 58 participants.

Table 1 provides a summary of the average bids for each product during each round for all the participants. It also provides the t-statistics related to the hypothesis test that the average bid from the current round is equal to the average bid in the previous round for the same product. For round one, the highest average bid was \$3.47 for the package of pork chop which was later identified with the low-level odor reduction attribute (30-40% odor reduction). The lowest average bid in round one was \$3.21 for the package aligned with low-level ground water improvement (15-25% reduction in the impact to ground water). When testing the hypothesis that these two means are equal, a sample t-statistic of 1.60 is calculated. This implies that the null hypothesis cannot be rejected at the 95% level of significance. Thus statistically, they are not significantly different.

Examining the average bids in round two compared to round one, it appears that all the average bids increased. Testing the hypothesis that the average bids in round two are equal to the average bids for the same product in round one, it is discovered that at the 95% significance level that the bids in round two are greater than the bids in round one. Two explanations can be offered for these bids not being equal. One is that the participants were still in the process of discovering their preferences and responding to the market information. Another is that participants did not fully understand the intuition behind the second price auction. This type of bid increase has been observed in previous studies (e.g., Fox, 1994; Fox et al., 1994; Fox et al., 1995). In round three, there were further increases in the aggregate bids of all the bids, but not by as much as from round one to round two. The question arises whether the bids seem to converge, i.e., whether the average bid in round three is statistically equal to the average bid in round two. If participants were truthfully revealing their preferences, little change in bids should be seen when no substantial new information has been released. As seen in Table 1, all the average bids for the products in round three are not statistically different at the 95% significance level to the average respective bids in round two. Hence, at the aggregate level, it appears that bids are converging by round three. This result provides further evidence for the initial findings of Coppinger et al. (1980) and Cox et al. (1985) that participants eventually discover their preferences and the Vickrey auction with multiple trials does obtain true WTP.

4. Econometric model

Based on the consumer's utility maximization problem described in equation (4), the product prices with and without new attributes share a mathematical relationship. In this experiment, the only difference between the no information rounds and information rounds is the release of information regarding the environmental attributes in each product. We assume that the consumer's utility function $U(A_1, A_2, \ldots, A_n)$ is continuous, monotone and convex on R_+^n. Given the same physical attributes, equation (4) can be estimated using the following regression:

$$BID4_{i,j} = \alpha_0 + \alpha_1 * \mathrm{BID3}_{i,j} + \alpha_2 * LOA_{i,j} + \alpha_3 * HIA_{i,j} + \alpha_4 * LGW_{i,j} + \alpha_5 * HIGW_{i,j} + \alpha_6 * LSW_{i,j} + \alpha_7 * HISW_{i,j} + \alpha_8 * HIAGW_{i,j} + \alpha_9 * HIASW_{i,j} + \alpha_{10} * HIAGSW_{i,j} + \varepsilon_{i,j}, \quad (5)$$

where i represents the ith bidder, and j represents the jth package, α_1 is the estimate of δ, the single-, dual- and triple-attribute dummies are the marginal attributes from consuming the packages, i.e., $\frac{\partial f}{\partial x_i}$, and coefficients α_2 to α_{10} are the value of the marginal utility from consuming the specific environmental attributes, i.e., $\delta \frac{\partial U}{\partial A}$, in equation (4). There are nine environmental attributes embedded in different packages that are included in the consumer's utility function. $BID3_{i,j}$ and $BID4_{i,j}$ are vectors of bids for the 10 packages in the auction from round 3 and 4 respectively. Bids from these two rounds are selected because after the first two trial bidding rounds, bids in round 3 represent bidders' converged WTP with no environmental information and the bids in round 4 and 5 are statistically the same with environmental informationas indicated in Table 1. $LOA_{i,j}$, $HIA_{i,j}$, $LGW_{i,j}$, $HIGW_{i,j}$, $LSW_{i,j}$, and $HISW_{i,j}$ represent vectors of dummy variables where 1 denotes that the product being bid upon was a single-level attribute package that had the low or high air quality attribute, the low or high ground water quality attribute, and the low or high surface water quality attribute respectively. $HIAGW_{i,j}$ and $HIASW_{i,j}$ represent vectors of dummy variables for the products that contained double environmental attributes. $HIAGSW_{i,j}$ represents a dummy variable vector for the product with all three high-level environmental attributes. The vector of errors is represented by ε and is assumed to have the standard properties that make ordinary least squares (OLS) appropriate for analysis.

[1] Four participants were omitted because they did not finish the experiment and surveys. One person had to leave during the study because she was ill. The other three did not complete the survey for unknown reasons.

The estimated coefficient α_1 can be interpreted as the value of the physical attributes once the environmental information has been released. This value represents how much an ex-ante dollar worth of physical attributes is valued once there are products with environmental attributes on the market. If the environmental information has no effect on the value of the physical attributes, then α_1 should be equal to one. A coefficient of less than one for this value implies that the physical attributes in the product are being negatively affected by the environmental information, while a value of greater than one implies that the environmental attributes have a positive effect on the physical attributes. The coefficients for α_2 through α_{10} can be interpreted as the WTP for the respective attribute(s) embedded in the product. It is expected that the coefficients for the low-level products should be less than the high value products. Products with multiple attributes are expected to be higher than products that have only a single environmental attribute. If the consumer values the environmental attribute(s) embedded in the product, these coefficients should be positive.

5. Empirical results and implications

Before explaining the results from the regression, it is important to examine the aggregate 3290 bids from round three to round four in Table 1. In round three, the average bid for the ten packages of pork chops is \$4.12 with a standard deviation of \$2.21, while in round four when the environmental information is released about the packages the average bid increases to \$4.16 with a standard deviation of \$2.30. Examining the null hypothesis that the bids between these two rounds are equal, it is found using a paired-sample t-test that the null hypothesis cannot be rejected at the 95% confidence level (t = 1.57). The same tests were conducted for different locations and similar results were obtained. Hence, the environmental information did not significantly affect the overall average bid. This implies that the participants did not spend significantly more when they discovered that most of the products had environmental attributes. This is a significant result suggesting that the pork producers might not be able to capture more of the consumer food dollar as revenue by producing output with environmental attributes.

Equation (5) was estimated for all the participants and for the six locations respectively. Seven OLS estimation results are presented in Table 2. On the national level, the coefficient for BID3 is estimated at \$0.87 which demonstrates that releasing environmental information does have an effect on consumers' WTP for the physical attributes of the pork products. For every dollar that was bid in round three when the only information the participants possessed about the products was regarding the physical attributes, \$0.87 of that value carried over to round four when the environmental attributes became known. This result implies that releasing environmental information about the product can have a negative effect to those products that only maintain physical attributes without incorporating any environmental attributes. Testing the null hypothesis that this value is equal to one using a standard t-test, it is found that this hypothesis can be rejected at the 99% confidence interval with a p-value less than 0.01. Similar results were obtained for all the six locations.

In the national model, the coefficients related to the dummy variables in Table 2 shows that all values are significantly greater than zero at the 99% level except for low-level air quality improvement coefficient. This implies that the participants in the study valued environmental attributes embedded in the products. Their additional valuation could result from the warm-glow feeling (Andreoni, 1990; Hurley and Kliebenstein, 2003). Comparing the single-attribute products to the multiple-attribute products shows that the multiple-attribute products received higher premiums than the products with only a single level attribute. In general, the magnitude of the WTP for the attributes increased when a higher level of a single attribute was present.

The only exception to the premium not having the expected magnitude for ranking purposes was for the single low- and high-level attribute for ground water where the low-level attribute was valued at \$0.43 and the high-level of the attribute was valued less at \$0.41. Upon a closer examination of the bid data for the low-level product, it was found that the average bid for the low-level product was less than any other product in round three by at least \$0.13. Hence, the magnitude of this premium may represent two affects – an attribute effect and a parity effect. The attribute effect would be the amount of money that the participant is willing to pay for the environmental attribute. The parity effect is the part of the premium that is paid to adjust the bidding on the product to match the other products having the same physical characteristics.

In the six regional models, we found consistent results. The coefficients of all the multi-environmental attributes dummies were statistically greater than zero at 90% significance level. Consumers in all locations value the pork products with multiple environmental attributes higher than the ones with a single level attribute.

Table 3 presents the results of examining whether the value of the environmental attributes in multiple products is equal to the value of the premium given for a combination of attributes combined in one product, i.e., whether part-whole bias exists. It appears at first glance that in all cases the value of multiple attributes from the purchase of a single product is different than the combined value of the equivalent attributes when the participant had to purchase from multiple packages. For example, in the national model, the premiums for the three single-level attribute products add up to \$1.33, whereas the product with the three equivalent attributes combined into one product had a premium of \$1.46. Testing the restriction that the coefficient for the multiple-attribute product is equal to the addition of the coefficients from the multiple packages shows that at the 99% level of confidence that none of the null hypotheses can be rejected. Our results strongly suggest, contrary to some previous part-whole analyses (e.g., Bateman et al., 1997; Dickinson and Bailey, 2002; Bernard and Bernard, 2009, 2010), that the premiums for the attributes appear to be additive. It implies that from the consumer standpoint, there is nothing significantly gained by consuming multiple attributes in one product. The part-whole bias exists in some cases but not in all.

While the premiums above appear to be additive, does WTP for a product with single-level attributes differ from WTP for a product with multiple environmental attributes? Before information about environmental attributes was released to the participants, it was found that the average bid for the packages was \$4.12. This leaves open the question of which producers would receive higher premiums from a market that had pork products with embedded environmental products. Using the results from Table 4 and equation (5), each product can be examined in an ex-post fashion to see what the expected price would be for each package containing embedded environmental attributes. In the national model, if the expected price is greater than the average bid from round three, i.e., \$4.12, then the producer could receive higher revenues by producing a package with that combination and/or level of environmental attributes[1]. However, if the value is less than \$4.12, the producer would receive higher premiums if none of the pork products in the market had any embedded environmental attributes. The average bids from round three for Ames, Manhattan, Raleigh, Burlington, Iowa Falls and Corvallis are \$3.96, \$4.36, \$4.14, \$3.98, \$4.79, and \$3.38, respectively. So if the expected price of a particular package in the region is greater than the regional average, then the producer would obtain a higher premium from it. Otherwise, selling the pork product without any environmental attributes could generate a higher premium. Like the national model, in all six regions, pork producers would receive a higher premium by selling packages with dual or triple environmental attributes.

[1] This statement is only valid from the standpoint that the producer would be compensated for the loss of the environmental attributes. This is not considering whether the premium gained compensates for the cost of producing a product with the particular embedded environmental attributes.

Results in Table 4 suggest that the expected price the participants would be willing to pay for a product that has a single level attribute, in general, would not be more than if there were no products with environmental attributes. This implies that the producers of products with single-level attributes would receive a lower premium. The producers that would gain higher ex-post revenues in selling pork products with environmental attributes would be those producing outputs with double or triple environmental attributes. On the national level, the product with a high-level impact reduction in surface water appears to be on the margin whether this product would be beneficial to the producer. These findings imply that if a pork producer is in a market where pork products with environmental attributes exist, then that producer should produce hogs that have multiple attributes.

Conclusion

This article examines from the consumers' standpoint whether producers can gain higher premiums by selling pork products with embedded environmental attributes separately or in combination. A consumer experiment utilizing a multi-product second-price auction with five bidding rounds was conducted to provide empirical evidence. In the first three rounds of the auction, the participants bid only on physical characteristics of the pork products. In round four of the bidding, consumers were made aware of the environmental attributes embedded in each of the ten products being auctioned. With the bidding data collected from the experiment, a standard ordinary least squares was used to estimate the value of each environmental attribute embedded in a single product, as well as the value of multiple environmental attributes bundled in one product.

There are three major findings. First, it was discovered that pork producers, in general, are not able to extract higher premiums if only a subset of them sell products with environmental attributes. The average bid from round three when the environmental attributes were unknown to the participants was only \$0.04 less than the average bid in round four when participants were made aware of the environmental attributes embedded in the products. This did not represent a significance difference in the bids. The second major finding was that when information about environmental attributes embedded in pork products was released, the producer should expect that the consumer would value the physical attributes of the product less. For each dollar that was spent on the physical attributes in round three, only \$0.87 was estimated to be spent in round four for those same attributes. It implies that selling a pork product with environmental attributes would devalue all the other pork products without those attributes by approximately 13%. This result confirms the finding in Kanter, Messer and Kaiser's (2009) study where the introduction of rBST-free milk and organic milk lowers the consumers' WTP for regular milk. Finally, and most importantly, we found that the premiums for single-level attributes can be additively combined to match the premium for the product with multiple attributes, i.e., there exists no part-whole bias. This implies that the consumer is not significantly gaining from a single product that has multiple attributes combined, i.e., the bundling of the attributes does not provide significant cross effects.

There are many avenues that can be followed for continuing research regarding embedding environmental attributes in products. Since this study used pork products as the basis of comparison, it would be interesting to examine WTP if a different product was chosen as a comparison, such as a substitute product, i.e., chicken or beef. It is conjectured that if a different product is used as the basis for environmental improvement, then the consumer might significantly shift part of her consumer dollar away from the industry of comparison to the industry purporting products with environmental attributes. A further extension is to examine what would happen to bids if the participants were required to purchase a combination of single-level attribute products that could generate the same utility as having one single product with multiple attributes. It is unknown whether the consumer would discount the value of the environmental attributes if she had to purchase multiple products.

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Appendix

Table 1. Average bid for each product by bid round (all participants)

Pork chop environmental attributes (level of improvement over typical)	Package labeling for experiment	Average bids ($)				
		No environmental information			Environmental information	
		R1	R2	R3	R4	R5
No particular environmental attributes (typical)	Package 1	3.35	3.91 (3.32)	4.13 (1.28)	3.61 (-2.96)	3.57 (-0.22)
Odor 30-40%	Package 2	3.47	4.01 (3.37)	4.26 (1.57)	3.87 (-2.41)	3.90 (0.16)
Odor 80-90%	Package 3	3.22	3.81 (3.49)	4.05 (1.45)	3.92 (-0.77)	3.91 (-0.04)
Ground water 15-25%	Package 4	3.21	3.72 (3.00)	3.91 (1.13)	3.85 (-0.33)	3.86 (0.03)
Ground water 40-50%	Package 5	3.25	3.84 (3.61)	4.03 (1.18)	3.94 (-0.50)	4.00 (0.36)
Surface water 15-25%	Package 6	3.43	4.00 (3.27)	4.15 (0.87)	3.99 (-0.93)	4.05 (0.34)
Surface water 40-50%	Package 7	3.26	3.82 (3.38)	4.06 (1.43)	4.10 (0.23)	4.12 (0.14)
Odor 80-90%/Ground water 40-50%	Package 8	3.43	4.10 (3.94)	4.25 (0.88)	4.56 (1.77)	4.68 (0.65)
Odor 80-90%/Surface water 40-50%	Package 9	3.45	4.08 (3.53)	4.17 (0.52)	4.58 (2.22)	4.66 (0.37)
Odor 80-90%/Ground water 40-50%/Surface water 40-50%	Package 10	3.46	4.06 (3.28)	4.19 (0.67)	5.13 (5.00)	5.17 (0.23)

Note: The number in parenthesis is the t-statistic for the test of whether the average bid in the current round is equal to the average bid in the previous round.

Table 2. Explanatory variables and estimated coefficients

Variable	Estimated coefficients						
	All areas (n = 3,290)	Ames, IA (n = 490)	Manhattan, KS (n = 600)	Raleigh, NC (n = 750)	Burlington, VT (n = 270)	Iowa Falls, IA (n = 580)	Corvallis, OR (n = 600)
Intercept	0.04 (0.08)	0.36 (0.21)	0.48*** (0.19)	-0.23 (0.15)	-0.15 (0.30)	-0.15 (0.22)	0.09 (0.15)
BID3	0.87*** (0.01)	0.77*** (0.03)	0.80*** (0.02)	0.90*** (0.02)	0.87*** (0.04)	0.90*** (0.03)	0.91*** (0.02)
LOA	0.14 (0.09)	0.18 (0.26)	0.03 (0.22)	0.33* (0.18)	0.17 (0.35)	0.23 (0.25)	-0.17 (0.20)
HIA	0.37*** (0.09)	0.51** (0.26)	0.25 (0.22)	0.54*** (0.18)	0.30 (0.35)	0.41* (0.25)	0.14* (0.20)
LGW	0.43*** (0.09)	0.51** (0.26)	0.40* (0.22)	0.62*** (0.18)	0.63* (0.35)	0.37 (0.25)	0.10 (0.20)

Table 2 (cont.). Explanatory variables and estimated coefficients

Variable	Estimated coefficients						
	All areas (n = 3,290)	Ames, IA (n = 490)	Manhattan, KS (n = 600)	Raleigh, NC (n=750)	Burlington, VT (n = 270)	Iowa Falls, IA (n = 580)	Corvallis, OR (n = 600)
HIGW	0.41*** (0.09)	0.67*** (0.26)	0.29 (0.22)	0.40** (0.18)	0.73** (0.35)	0.36 (0.25)	0.24 (0.20)
LSW	0.36*** (0.09)	0.48* (0.26)	0.13 (0.22)	0.43** (0.18)	0.49 (0.35)	0.40 (0.25)	0.27 (0.20)
HISW	0.55*** (0.09)	0.83*** (0.26)	0.48** (0.22)	0.62*** (0.18)	0.68* (0.35)	0.53** (0.25)	0.17 (0.20)
HIAGW	0.85*** (0.09)	1.11*** (0.26)	0.72*** (0.22)	0.91*** (0.18)	0.92*** (0.35)	1.08*** (0.25)	0.34* (0.25)
HIASW	0.94*** (0.09)	1.09*** (0.26)	0.94*** (0.22)	1.05*** (0.18)	1.15*** (0.35)	0.99*** (0.25)	0.52*** (0.20)
HIAGSW	1.46*** (0.09)	1.67*** (0.26)	1.41*** (0.22)	1.61*** (0.18)	1.68*** (0.35)	1.41*** (0.25)	1.17*** (0.20)
R^2	0.72	0.64	0.66	0.80	0.67	0.68	0.78
F-value							

Note: Standard deviations are in the parentheses. ***$p < 0.01$, **$p < 0.05$ and *$p < 0.1$.

Table 3. Hypothesis tests for part-whole bias

Null hypothesis*	Summation of single package premiums	Premium for multiple attribute product	F-value	Prob > F
All areas				
HIA + HIGW + HISW = HIAGSW	$1.33	$1.46	0.42	0.52
HIGW + HIASW = HIAGSW	$1.35	$1.46	0.69	0.41
HISW + HIAGW = HIAGSW	$1.40	$1.46	0.27	0.60
HIA + HISW = HIASW	$0.92	$0.94	0.01	0.93
HIA + HIGW = HIAGW	$0.78	$0.85	0.16	0.69
Ames, IA				
HIA + HIGW + HISW = HIAGSW	$2.01	$1.67	0.42	0.52
HIGW + HIASW = HIAGSW	$1.76	$1.67	0.05	0.82
HISW + HIAGW = HIAGSW	$1.94	$1.67	0.54	0.46
HIA + HISW = HIASW	$1.34	$1.09	0.48	0.49
HIA + HIGW = HIAGW	$1.18	$1.11	0.03	0.86
Manhattan, KS				
HIA + HIGW + HISW = HIAGSW	$1.02	$1.41	0.78	0.38
HIGW + HIASW = HIAGSW	$1.23	$1.41	0.31	0.58
HISW + HIAGW = HIAGSW	$1.20	$1.41	0.49	0.49
HIA + HISW = HIASW	$0.73	$0.94	0.49	0.49
HIA + HIGW = HIAGW	$0.54	$0.72	0.31	0.58
Raleigh, NC				
HIA + HIGW + HISW = HIAGSW	$1.56	$1.61	0.02	0.89
HIGW + HIASW = HIAGSW	$1.45	$1.61	0.42	0.51
HISW + HIAGW = HIAGSW	$1.53	$1.61	0.11	0.74
HIA + HISW = HIASW	$1.16	$1.05	0.20	0.66
HIA + HIGW = HIAGW	$0.94	$0.91	0.02	0.90
Burlington, VT				
HIA + HIGW + HISW = HIAGSW	$1.71	$1.68	0.00	0.97
HIGW + HIASW = HIAGSW	$1.88	$1.68	0.16	0.69
HISW + HIAGW = HIAGSW	$1.60	$1.68	0.03	0.86
HIA + HISW = HIASW	$0.98	$1.15	0.12	0.73
HIA + HIGW = HIAGW	$1.03	$0.92	0.05	0.82
Iowa Falls, IA				
HIA + HIGW + HISW = HIAGSW	$1.30	$1.14	0.06	0.81
HIGW + HIASW = HIAGSW	$1.35	$1.41	0.03	0.86
HISW + HIAGW = HIAGSW	$1.61	$1.41	0.29	0.59
HIA + HISW = HIASW	$0.94	$1.08	0.03	0.87
HIA + HIGW = HIAGW	$0.77	$0.99	0.79	0.38

Table 3 (cont.). Hypothesis tests for part-whole bias

Null hypothesis*	Summation of single package premiums	Premium for multiple attribute product	F-value	Prob > F
All areas				
Corvallis, OR				
HIA + HIGW + HISW = HIAGSW	$0.65	$1.17	2.45	0.12
HIGW + HIASW = HIAGSW	$0.76	$1.17	2.13	0.15
HISW + HIAGW = HIAGSW	$0.51	$1.17	5.58	0.02
HIA + HISW = HIASW	$0.31	$0.52	0.58	0.45
HIA + HIGW = HIAGW	$0.38	$0.34	0.03	0.87

Notes: *At the 99% significance level, the null hypothesis is rejected if Prob > F is less than or equal to 0.01.

Table 4. Bids evaluated at the average for the estimated equation (5) with the particular environmental attribute(s)

Package containing given environmental attribute	Expected value of package with environmental attributes						
	All areas	Ames, IA	Manhattan, KS	Raleigh, NC	Burlington, VT	Iowa Falls, IA	Corvallis, OR
Odor 30-40%	$3.72	$3.23	$3.52	$4.06	$3.63	$4.54	$2.91
Odor 80-90%	$3.95	$3.56	$3.74	$4.27	$3.76	$4.72	$3.22
Ground water 15-25%	$4.01	$3.56	$3.89	$4.35	$4.09	$4.68	$3.18
Ground water 40-50%	$3.99	$3.72	$3.78	$4.13	$4.19	$4.67	$3.32
Surface water 15-25%	$3.94	$3.53	$3.62	$4.16	$3.95	$4.71	$3.35
Surface water 40-50%	$4.12	$3.88	$3.97	$4.35	$4.14	$4.84	$3.25
Odor 80-90%/Ground water 40-50%	$4.43	$4.16	$4.21	$4.64	$4.38	$5.39	$3.42
Odor 80-90%/Surface water 40-50%	$4.52	$4.14	$4.43	$4.78	$4.61	$5.30	$3.60
Odor 80-90%/Ground water 40-50%/ Surface water 40-50%	$5.04	$4.72	$4.90	$5.34	$5.14	$5.72	$4.25