ECONOMIC VALUES OF PORK ATTRIBUTES:
HEDONIC PRICE ANALYSIS OF EXPERIMENTAL AUCTION DATA

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Many fresh foods, such as fruits, vegetables, and meats, exhibit nearly continuous quality differences that cause consumers to value similar, but not identical, packages or lots of the food differently. Fresh pork chops are among the foods that typically exhibit these quality differences. Thus, although several packages of pork chops may be available at a particular price per pound, consumers will typically select among them based on perceived or expected quality differences.

How consumers perceive and value these quality differences is of great interest to pork producers and grocery store managers. For example, it is unclear whether consumers perceive the same attributes when viewing advertising as they perceive in the actual product. Also unclear is how appearance relates to consumers' perceptions of taste or how attribute values change as consumers obtain new information (advertising versus appearance versus taste) about the product.

Answers to these questions might signal changes in genetics and management of pork production and in the type of pork that grocery stores stock in meat counters. This may also provide advertisers, retailers, and other pork marketers with new information about fresh pork demand and how consumers perceive and value pork quality attributes. Such information is essential to effective pork advertising and marketing programs, such as the "Other White Meat" campaign of the National Pork Producer's Council (NPPC).

Methods of experimental economics — the structured application of experimental methods to analyses of economic phenomena — have recently become popular among economists as an effective means of examining consumer preferences and valuations (e.g., Hoffman et al.; Buhr et al.). However, these methods have historically been limited to binomial consumer choices (e.g., Shogren). In these studies, consumers have considered a single characteristic or set of characteristics which they observe at only one of two levels. As a result, experimental economics has been of limited use in valuing the multiple attributes that contribute to the nearly continuous variation observed in fresh pork quality.

Melton et al., however, have extended the methods of experimental economics to analyze consumer preferences for multidimensional products. They integrated statistical methods of experimental design and methods of experimental economics so that it is possible to identify differences in consumers' preferences for products that exhibit continuous variance in multiple quality attributes or characteristics. They illustrated the method with an experimental auction of fresh pork chops that vary in color, marbling, and size. In this study, methods of hedonic price analysis are applied to derive new estimates of the economic value of these particular pork traits. Going a step beyond traditional approaches, the effects of socioeconomic variables on an attribute's economic value are also considered.

The Economic Model

Assume that a consumer's utility depends upon the level of purchased goods consumed and leisure. Further assume that one of the purchased goods (e.g., pork chops) varies in a number of observable or measurable attributes which contribute to a consumer's level of utility. A consumer's utility function can then be expressed in terms of the level of the m different attributes...
consumed in pork chops and the consumption of other goods (y):

\[ U = U(x_1, x_2, \ldots, x_i, \ldots, x_m, y). \]  

(1)

Also assume the consumer maximizes equation (1) subject to a budget constraint,

\[ I = \sum_j p_j q_j + p_y y, \]

(2)

where \( p_j \) is the price of the \( j \)th quality of pork, \( p_y \) is the price of other (nonpork) goods, and \( I \) is the consumer's fixed money expenditures.

If prices are constant such that \( \frac{\partial p_j}{\partial q_j} \) and \( \frac{\partial p_y}{\partial y} = 0 \), then the traditional first-order conditions for consumer utility maximization prevail. The marginal utility (divided by the Lagrangean multiplier) of each pork quality, \( q_j \), is equal to its price:

\[ \frac{1}{\lambda} \left( \frac{\partial U}{\partial q_j} \right) = p_j \]

(3)

\[ j = 1, 2, \ldots, n. \]

Also assume a specialized technology (Lancaster) exists such that:

\[ x_i = \sum_{j=1}^{n} x_{ij} q_j, \]

(4)

where \( x_{ij} \) is the constant level of the \( i \)th attribute embodied in a unit of the \( j \)th quality of pork consumed at a level of \( q_j \). Thus, the marginal utility of \( q_j \) in a quality differentiated product model is now derived as the weighted sum of the marginal utilities of its contributed attributes:

\[ \frac{\partial U}{\partial q_j} = \sum_i \frac{\partial U}{\partial x_i} \frac{\partial x_i}{\partial q_j} = \sum_i U_i x_{ij} \]

(5)

where \( U_i \) is the partial derivative of the utility function equation (1) with respect to \( x_i \). This relationship is the core of hedonic price analysis (Griliches) or what Ladd refers to as a consumer goods characteristics model (CGM). In each case, the price of the qualitatively heterogeneous consumer good depends on the level of its embodied attributes and the marginal utility of those attributes expressed in value terms.  

In a competitive market, the relevant consumer decision is typically the optimal level of the alternative goods, \( q_j \) and \( y \), to be consumed at a fixed market price, which leads directly to the derivation of rather traditional consumer demand functions for each good. In an auction setting, however, the quantity of each quality of fresh pork available is fixed. Under these conditions, the relevant decision by the consumer is the maximum price he or she is willing to pay (WTP) for that fixed quantity. The price of a unit of fresh pork offered in the market depends on: (1) the marginal utilities of attributes, \( U_j \); (2) the concentrations, \( x_{ij} \), of those attributes in the product (as shown in equations (3), (4), and (5)); (3) the price of other goods, \( p_y \), the level of consumer income, \( I \); (4) and the marginal utility of income, \( \lambda \).

Experimental Data

Data were obtained from an experimental auction designed to estimate consumers' willingness-to-pay (WTP) for fresh "rib-cut" pork chops that varied in color, marbling (intra-muscular fat), and size. Furthermore, the experimental auction included consideration of presentation format in that the consumers (experimental subjects) were asked to evaluate and value (WTP) the chops based on: (1) visual appraisals of chop photos, (2) visual appraisals of fresh chops packaged to correspond to local marketing standards, and (3) tasting comparable (adjacent rib) chops.

The experiment was conducted as a second-price, ascending bid auction (similar to a Vickrey second-price auction) in which the highest bidder purchases the chop at the second highest price established after successive rounds of ascending bids (Vickrey). That is, after each round of bidding the consumers were told the highest bid for each chop and allowed to increase their bid, if desired. The auction was continued in this manner until no one wished to increase their bid for any chop.  

The data thus include both bid prices and market prices (defined as the second highest bid price) for each experimental chop. Details of the

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1Price effects of qualitative differences in fresh foods were initially studied by Waugh who offered no model, but by intuition founded hedonic price analysis.

2At this point a sale was assumed to be consummated, although given the design of the auction the actual sale occurred only after all presentation phases were completed.
Experimental design and conduct are provided by Melton et al. The experiment is summarized briefly in the following sections.

**Experimental Treatments**

Each consumer was asked to evaluate and bid on eight different pork chops in the experiment. To simplify the experimental representation of the consumer’s decision problem, each of the three nearly continuous attributes (color = C, marbling = M, and size = S) was indexed on a discrete scale of 1 (C = light gray, M = slight, S = small) to 5 (C = dark red, M = abundant, S = large). With the condition that all chops of a treatment were from the same carcass, the experimental design required selecting eight treatments (chops) that best represented the 125 possible combinations of the three attributes in question \((5^3=125)\) in no more than three replications.

Extremes of the attributes infrequently occur in nature (i.e., either 1 or 5 of one attribute with either 1 or 5 of another attribute). Hence, the extremes of each attribute were initially ignored to reduce the primary number of combinations to a maximum of 27 \((3^3=27)\). Size effects were treated as independent of either color or marbling so that nine combinations of marbling and color encompassed the three sizes.

A central-composite response design (Cochrane and Cox) was adopted and modified for use in this trial by defining the central point of the response surface to be a 3-3-3 (C-M-S) chop. Four additional treatments (chops) were selected from the perimeter of the nine combinations that define the primary color-marbling response surface \((2-2-3, 2-4-3, 4-2-3, \text{and} 4-4-3)\) and two from the central point \((3-3-2 \text{ and } 3-3-4)\) to reflect size differences in a total of seven treatment chops. To explore the extremes in a limited way, an eighth and final chop was then selected from the extremes of the color-marbling response surface \((1-1-3, 5-1-3, \text{and} 5-5-3)\) to be partially replicated between the three replications of the trial.

The amount of information consumers have about a chop may also affect their evaluations and bids. To address this issue, information was presented to consumers participating in the auction in three different formats: (1) p equals evaluations based on photographs of the chops; (2) a equals evaluations of fresh chops under conditions comparable to a supermarket purchase; and (3) t equals evaluations of fresh chops after tasting comparably prepared chops from adjacent ribs. Each consumer was provided information through the above presentation formats in order — p, a, and then t. Finally, as a point of informational reference and to reflect the potential availability of “meat” alternatives in consumers’ purchase decisions, a USDA Choice T-bone steak and bone-in chicken breast were added to the trial.

**Experimental Subjects**

The subjects of the experiment were 33 primary shoppers of meat-consuming households representing a stratified random sample drawn from an earlier random telephone survey of local consumers. The means or target levels of the strata used in the experiment were 35 years old, household income of $35,000 per year, two-thirds female, and 13 years of education. The 33 consumers were randomly assigned by income to the three replications using confidential identification numbers.

**Mean Preferences, Bids, and Market Prices**

In addition to bidding on the chops, consumers were asked to evaluate all of the chops for various appearance and taste attributes on an undemarcated scale that ranged from “Strongly Like” to “Strongly Dislike.” To evaluate the consistency of consumers’ evaluations across presentation formats a cardinal index was constructed from the experimental data by scoring subjective evaluations on a standardized scale.

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The experimental subjects must be statistically drawn from a well-defined population in order to generalize conclusions beyond the experimental sample itself. For example, if all the participants were selectively chosen college students, as has often been the case in many experimental economics trials, the results would be applicable only to that narrow segment of the consuming population. In this experiment a random sample of 36 local households was drawn to broaden the population represented by the experimental data. Of the 36 consumers intended, two were no-shows and one yielded unusable data, resulting in 33 experimental subjects for analysis.

The value may be influenced by income level, equal income distributions across replications should help maintain consistency of the mean valuations observed for the experimental chops. Each consumer was paid $20 for participating in the trial.
from 0 to 100 (Morey). These means, taken from Melton et al., are summarized in Table 1.

The price differences associated with subjective evaluations can be analyzed in terms of both bid (one per consumer per chop for a total of 264 = 33 x 8 chops) and market prices (one per replication per chop for a total of 24 = 3 x 8 chops). The bid price provides an indication of each consumer's WTP for a fixed supply, whether or not a sale is actually consummated at that price. The experimental market price approximates the competitive market price that could be observed in a non-experimental setting in that some consumers have been "-priced" out of the market at the currently prevailing market price and are thus unobserved. Table 2, also taken from Melton et al., summarizes mean values for individual bid and market prices by treatment and presentation format.

Average bid prices tended to follow the pattern of overall preferences — higher bids are offered for larger, less marbled, and lighter color chops when evaluated visually. After tasting, however, consumers tended to bid more for more marbling, darker color, and smaller chops. Market prices exhibited a similar pattern, although differences tended to be greater because market prices reflected the preferences of the highest two bidders in each replication.

The similarity between average bid prices and average overall rankings of chops should be expected in that the prices bid by each consumer should be a monotonic transformation of his/her overall cardinal preferences for the attribute combination represented in the chop. The overall evaluation of a fresh chop's appearance should thus correspond closely to what the consumer is willing to pay (bid) for the chop, and the two values for each consumer should be highly correlated. The correlations between overall evaluations and bid prices across presentation formats are, however, much lower (ρpa = 0.1308, ρpm = -0.0048, and ρas = 0.1914). This suggests that overall evaluations of attributes in one presentation format may be a poor indicator of consumers' WTP in another presentation format. That is, evaluations based solely on appearance, in either photographs or fresh product, may not be a good indication of WTP after tasting, or when repeat purchases are a large share of potential product sales, as in the case of fresh foods.

### Hedonic Analysis of Fresh Pork Attribute Values

In hedonic analyses of product prices, double-log or semi-log algebraic functions have been frequently chosen for estimation. Combining equations (4) and (5), price is a linear function of the attribute levels, x_i, equals concentrations, if the marginal utility of the attribute, U_i, is constant:

$$ p_j = \frac{1}{\lambda} \sum_i U_i x_i. \quad (6) $$

A non-linear functional form for equation (6) provides an appealing alternative in that U_i is a non-linear function of x_i. For this study, the basic empirical hedonic fresh pork price equation is specified as a semi-log function,

$$ \ln p_{jk} = \beta_{ok} + \sum_h \delta_{hk} + \sum_i \beta_{ik} x_{ij} + v_{jk}, \quad (7) $$

where the k subscript is added to denote presentation format (appearance in photos or fresh pork and after tasting); \( \beta_{ok} \) is the intercept (reflecting the sum of the values contributed by excluded attributes); \( \delta_{hk} \) is the coefficient of the dummy variable for the hth replication estimated under the constraint that the sum of the replication effects is zero; \( \beta_{ik} \) is the coefficient, \( U_i / \lambda \), of the ith attribute (marbling, color, or size); and \( v_{jk} \) is a random error term assumed to have a normal distribution of \( v_{i} \sim \text{NID}(0, \sigma) \). In estimating equation (7), pork attributes of color and marbling are treated as continuous and size is measured in square inches.

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3 Although consumers priced out of the market are not a factor in the current market price, their perceptions are nonetheless important. They represent the segment of the demand curve associated with excess demand. Hence, they are the pool of potential consumers who, under lower prices associated with expanded quantities supplied, would become consumers.

4 Alternative function forms, including linear and log-linear variations, were also explored, but none provided better statistical performance than the exponential form chosen.
<table>
<thead>
<tr>
<th>Treatment (C-M-S)</th>
<th>Color</th>
<th>Marbling</th>
<th>Bone</th>
<th>Size</th>
<th>Overall</th>
<th>Taste</th>
<th>Juiceiness</th>
<th>Tender</th>
<th>Flavor</th>
<th>Eatability</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-2-3</td>
<td>37.5</td>
<td>50.3</td>
<td>51.5</td>
<td>58.6</td>
<td>46.3</td>
<td>41.0</td>
<td>54.5</td>
<td>43.9</td>
<td>60.9</td>
<td>56.5</td>
</tr>
<tr>
<td>2-4-3</td>
<td>40.0</td>
<td>41.5</td>
<td>36.7</td>
<td>58.6</td>
<td>48.4</td>
<td>50.8</td>
<td>40.7</td>
<td>49.3</td>
<td>48.6</td>
<td>50.5</td>
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<tr>
<td>3-2-3</td>
<td>48.1</td>
<td>36.8</td>
<td>28.8</td>
<td>37.3</td>
<td>41.0</td>
<td>41.0</td>
<td>52.6</td>
<td>45.2</td>
<td>39.7</td>
<td>35.7</td>
</tr>
<tr>
<td>3-3-2</td>
<td>58.9</td>
<td>52.7</td>
<td>51.2</td>
<td>51.2</td>
<td>53.3</td>
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<td>42.6</td>
<td>43.4</td>
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<tr>
<td>3-3-3</td>
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<td>61.0</td>
<td>44.5</td>
<td>68.5</td>
<td>59.8</td>
<td>55.5</td>
<td>48.8</td>
<td>48.8</td>
<td>47.8</td>
<td>47.8</td>
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<td>3-4-4</td>
<td>42.3</td>
<td>65.1</td>
<td>66.5</td>
<td>47.1</td>
<td>63.7</td>
<td>37.2</td>
<td>48.0</td>
<td>34.1</td>
<td>36.9</td>
<td>39.0</td>
</tr>
<tr>
<td>4-4-4</td>
<td>44.3</td>
<td>51.3</td>
<td>41.2</td>
<td>47.9</td>
<td>41.7</td>
<td>37.3</td>
<td>35.4</td>
<td>42.3</td>
<td>38.8</td>
<td>38.8</td>
</tr>
<tr>
<td>Overall</td>
<td>49.6</td>
<td>48.3</td>
<td>46.9</td>
<td>49.0</td>
<td>46.5</td>
<td>44.5</td>
<td>47.6</td>
<td>44.7</td>
<td>47.5</td>
<td>44.6</td>
</tr>
</tbody>
</table>

Table 1. Means of Consumers’ Subjective Evaluation Scores of Pork Chop Characteristics by Presentation Format (Scale = 1 to 100)

*Simple means of all evaluations.

Source: Melton, Huffman, Shogren.
Table 2. Summary of Average Consumers Bid and Market Prices For Pork Chops by Presentation Format

<table>
<thead>
<tr>
<th>Treatment (C-M-S)</th>
<th>Photos Mean</th>
<th>SE</th>
<th>Appearance Mean</th>
<th>SE</th>
<th>Taste Mean</th>
<th>SE</th>
<th>Photos Mean</th>
<th>SE</th>
<th>Appearance Mean</th>
<th>SE</th>
<th>Taste Mean</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-2-3</td>
<td>1.97</td>
<td>0.16</td>
<td>1.94</td>
<td>0.16</td>
<td>1.49</td>
<td>0.12</td>
<td>2.97</td>
<td>0.32</td>
<td>2.98</td>
<td>0.39</td>
<td>2.13</td>
<td>0.11</td>
</tr>
<tr>
<td>2-4-3</td>
<td>2.03</td>
<td>0.15</td>
<td>1.95</td>
<td>0.14</td>
<td>2.10</td>
<td>0.14</td>
<td>3.02</td>
<td>0.38</td>
<td>2.62</td>
<td>0.07</td>
<td>2.67</td>
<td>0.12</td>
</tr>
<tr>
<td>3-3-2</td>
<td>1.72</td>
<td>0.14</td>
<td>1.62</td>
<td>0.18</td>
<td>1.88</td>
<td>0.15</td>
<td>2.38</td>
<td>0.07</td>
<td>2.67</td>
<td>0.17</td>
<td>2.67</td>
<td>0.08</td>
</tr>
<tr>
<td>3-3-3</td>
<td>2.22</td>
<td>0.15</td>
<td>1.69</td>
<td>0.12</td>
<td>1.59</td>
<td>0.12</td>
<td>3.28</td>
<td>0.20</td>
<td>2.32</td>
<td>0.07</td>
<td>2.30</td>
<td>0.05</td>
</tr>
<tr>
<td>3-3-4</td>
<td>2.17</td>
<td>0.15</td>
<td>1.95</td>
<td>0.12</td>
<td>1.66</td>
<td>0.10</td>
<td>3.33</td>
<td>0.33</td>
<td>2.67</td>
<td>0.08</td>
<td>2.17</td>
<td>0.04</td>
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<tr>
<td>4-2-3</td>
<td>2.36</td>
<td>0.17</td>
<td>1.79</td>
<td>0.18</td>
<td>1.71</td>
<td>0.14</td>
<td>3.30</td>
<td>0.25</td>
<td>3.00</td>
<td>0.29</td>
<td>2.25</td>
<td>0.06</td>
</tr>
<tr>
<td>4-4-3</td>
<td>1.94</td>
<td>0.14</td>
<td>1.76</td>
<td>0.14</td>
<td>2.10</td>
<td>0.13</td>
<td>2.60</td>
<td>0.15</td>
<td>2.40</td>
<td>0.24</td>
<td>2.75</td>
<td>0.00</td>
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<td>Additional Chop Treatments:</td>
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</tr>
<tr>
<td>1-1-3</td>
<td>2.13</td>
<td>0.29</td>
<td>2.08</td>
<td>0.15</td>
<td>1.71</td>
<td>0.14</td>
<td>2.50</td>
<td>0.26</td>
<td>2.42</td>
<td>0.15</td>
<td></td>
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<tr>
<td>5-1-3</td>
<td>1.97</td>
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<td></td>
<td></td>
<td>3.50</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>5-5-3</td>
<td>1.53</td>
<td>0.21</td>
<td></td>
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<td></td>
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<tr>
<td>Overall*</td>
<td>2.03</td>
<td>1.85</td>
<td>1.78</td>
<td></td>
<td>2.91</td>
<td>2.70</td>
<td>2.42</td>
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</tbody>
</table>

*Simple mean of all prices.
Source: Melton et al.
Economic interpretations of these estimated hedonic price equations are straightforward. The effect on pork price of a change in the level of an attribute is defined to be the marginal value of the attribute, \( V_{ijk} \). In this formulation, value depends on the current price for the \( j \)th fresh chop:

\[
V_{ij} = \frac{\partial p_{x_{ij}}}{\partial x_{ij}} = \beta_{ik} x_{ij}.
\]

However, the price flexibility, \( F_{ijk} \), of an attribute depends only on the estimated coefficient and level of the attribute in the chop in question:

\[
F_{ijk} = \frac{\partial p_{x_{ijk}}}{\partial x_{ijk}} = \beta_{ik} x_{ijk}.
\]

These marginal values indicate the effect on the pork price expected as an attribute changes that is independent of current average price. Hence, estimates of \( F_{ijk} \) may prove to be a more useful guide to pork producers and marketers than values, \( V_{ijk} \), as they attempt to improve and promote their product.

Hedonic price analyses have traditionally been applied to secondary data. That is, data have been obtained by observing the actual market prices paid for products with varying levels of attributes. As a result, little is known about the socioeconomic variables of either purchasers or consumers "priced out of the market. If socioeconomic variables are considered, then the "average" socioeconomic levels of all actual and potential consumers (i.e., average per capita annual income) must be relied upon. If consumption of a product is predominantly among consumers that share some common level of a socioeconomic variable, such as high income or children in the household, then these estimates can be biased.

Experimental economics provides an interesting methodological alternative because market prices can be observed for chops of varying levels of attributes and bids of individual consumers can be observed — including bid prices that are below the market price. Data from the experimental auction are thus an important aid to exploring the effects of socioeconomic variables on consumers' utility derived from pork attributes and their willingness-to-pay and identifying attributes' values to different classes or groups of consumers. Hence, following sections examine the value of pork attributes in terms of both experimental market and bid price data for alternative consumer presentation formats.

**Attribute Values from Experimental Market Prices**

An analysis of experimental "market prices" corresponds closely to traditional hedonic analysis of actual market prices in that no attempt is made to differentiate price effects of attributes between individuals or classes of consumers. The relatively small number of market prices (3 replications x 8 chops = 24 degrees of freedom) limits the analysis. However, hedonic price equation estimation for pork attributes explain approximately 50 percent of the variance observed in experimental auction market prices obtained after consumers viewed photographs or tasted the product, but only about 25 percent of the price variance based on viewing fresh chops (Table 3). This result suggests that consumers have greater uncertainty when viewing pork attributes than when tasting them, especially when the attributes are viewed in fresh chops. The photos, although of high quality, may exaggerate differences in the attributes compared to what consumers can discern when viewing fresh chops in a setting comparable to supermarkets’ meat counters.

Marbling scores are consistently important in explaining market prices, but the coefficient of the marbling score is sometimes positive and sometimes negative. When consumers bid based on appearance in either photographs or fresh product, market prices decline as marbling scores increase (-0.063 and -0.060). However, after consumers have tasted the product, market prices increase with additional marbling (0.058). This finding supports the belief that food is a multiple attribute commodity for consumers and their negative reaction to seeing fat is quite different from the positive effects that a small amount of fat has on taste. Extremely low-fat chops are very dry to taste, but a little marbling may also add flavor and juiciness that consumers value positively. Hence, the marginal value of marbling based on
### Table 3. Hedonic Analysis of Fresh Pork Market Prices, Values, and Flexibilities by Presentation Format Evaluated at the Sample Mean Prices for a 3-3-3 Chop (avg. 6 sq in)

<table>
<thead>
<tr>
<th>Price Effect</th>
<th>Photos Coefficient</th>
<th>Photos t-Value</th>
<th>Appearance Coefficient</th>
<th>Appearance t-Value</th>
<th>Taste Coefficient</th>
<th>Taste t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.7372</td>
<td>3.50</td>
<td>1.1887</td>
<td>5.11</td>
<td>0.9883</td>
<td>7.33</td>
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<tr>
<td>Discrete Variables*</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Replication 1</td>
<td>0.0952</td>
<td>2.26</td>
<td>0.0403</td>
<td>0.94</td>
<td>-0.0338</td>
<td>-1.36</td>
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<tr>
<td>Replication 2</td>
<td>-0.0607</td>
<td>-1.44</td>
<td>0.0600</td>
<td>-1.40</td>
<td>0.0209</td>
<td>0.84</td>
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<tr>
<td>Replication 3</td>
<td>-0.0344</td>
<td>---</td>
<td>0.0197</td>
<td>---</td>
<td>0.0129</td>
<td>---</td>
</tr>
<tr>
<td>Quality Characteristics:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td>0.0054</td>
<td>0.18</td>
<td>-0.0082</td>
<td>-0.23</td>
<td>-0.0261</td>
<td>-1.26</td>
</tr>
<tr>
<td>Marbling</td>
<td>-0.0627</td>
<td>-2.08</td>
<td>-0.0601</td>
<td>-1.69</td>
<td>0.0582</td>
<td>2.82</td>
</tr>
<tr>
<td>Size</td>
<td>0.0817</td>
<td>2.84</td>
<td>-0.0039</td>
<td>-0.13</td>
<td>-0.0328</td>
<td>-1.91</td>
</tr>
<tr>
<td>Estimate Statistics</td>
<td>R² 0.4703</td>
<td>MSE 0.0199</td>
<td>R² 0.2554</td>
<td>MSE 0.0220</td>
<td>R² 0.4605</td>
<td>MSE 0.0074</td>
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<tr>
<td>Characteristic Effect</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td>0.0157</td>
<td>0.0162</td>
<td>-0.0221</td>
<td>-0.0246</td>
<td>-0.0632</td>
<td>-0.0783</td>
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<tr>
<td>Marbling</td>
<td>-0.1825</td>
<td>-0.1881</td>
<td>-0.1623</td>
<td>-0.1803</td>
<td>0.1408</td>
<td>0.1746</td>
</tr>
<tr>
<td>Size</td>
<td>0.2377</td>
<td>0.4902</td>
<td>-0.0105</td>
<td>-0.0234</td>
<td>-0.0794</td>
<td>-0.1968</td>
</tr>
</tbody>
</table>

*Coefficients estimated under the restriction that the sum of the discrete variable effects is zero.

visual appraisals is negative, but positive after tasting.  

When consumers bid based on photographic information, lighter color and larger size are positively valued relative to darker and smaller chops. When consumers bid after seeing fresh chops or tasting, however, lighter color and larger size have negative marginal values, although the effect of color on market price tends to be insignificant at the 5 percent level in each presentation format. Future research should be undertaken to identify what attributes of smaller or darker chops (e.g., tenderness, flavor, etc.) provide greater market value when chops are tasted. 

These results also support that information (presentation format) is an important consideration in determining the market price of a multiple attribute commodity such as fresh pork. When market prices from an experimental auction are explained using hedonic models, the marginal values of chop attributes depend heavily on the consumer presentation format and may change from one attribute to another in both magnitude and sign. Thus, considerable care regarding presentation format is necessary when examining market data, especially from an experimental trial, so that revealed marginal values will accurately reflect the likely real market behavior of consumers in both sign and relative magnitude. Furthermore, these results indicate that considerable care is warranted in selecting advertising materials (photo presentations) for products such as fresh pork. Advertising and other informational or educational materials must balance sales effectiveness (increased consumer demand) against the contradictory signals (e.g., “it looks good, but tastes bad”) that may be provided to consumers — which could reduce long-term product demand. 

### Attribute Values from Experimental Bid Prices

A traditional hedonic price analysis explains the effects of attributes on actual market prices for goods or commodities. However, information collected in an experimental auction can also be used to examine the effects that characteristics of consumers and their households have on individual bid prices.

---

*Flexibilities follow the pattern of attribute values in the results, suggesting that pork producers might expect long-run prices to rise by about 0.17 percent if marbling score were increased by 1 percent. However, consumers must first be encouraged to taste the increased marbling product and this will potentially require about a 0.18 percent price reduction.
ECONOMIC VALUES OF PORK ATTRIBUTES: HEDONIC PRICE ANALYSIS Melton, Huffman, Shogren

Socioeconomic characteristics of the consumers and consumers’ household are added to equation (7) to explain individual bid prices for pork chops. These variables include continuous variables reflecting differences in household income level, consumer age, and education. They also include discrete variables reflecting differences between experimental replications, sex, or household type. Hence, the modified hedonic price equation to be estimated is:

\[ \ln p_{ik} = \beta_{ok} + \sum_h \delta_{hk} + \sum_j \beta_{jk} x_{ij} + \sum_g \alpha_{gk} z_g + v_{jk} \]  

(10)

where \( z_g \) is the level of the \( g^{th} \) socioeconomic variable with price effect \( \alpha_{gk} \) in the \( k^{th} \) presentation format and all other variables are as previously defined.\(^8\)

For the \( g^{th} \) socioeconomic variable, the marginal effect on individual bid price is:

\[ V_{gik} = \frac{\partial p_j}{\partial Z_g} = \alpha_{gk} p_j \]  

(11)

More to the point for a hedonic analysis of pork attributes, however, the marginal effect of the \( g^{th} \) socioeconomic variable on the \( i^{th} \) attribute’s value is:

\[ V_{glik} = \alpha_{gk} \beta_{ik} p_j \]  

(12)

These effects identify differences in an attribute’s value as perceived by different consumer groups. Estimates of price flexibilities for the socioeconomic variables (e.g., income, age, education, and household size) can also be computed in a manner analogous to that for product attributes. These flexibilities indicate how the bid prices and attribute values might change as socioeconomic attributes of the consuming population change over time (e.g., the overall population ages or is more educated).

When the hedonic bid-price equations are estimated using the experimental data on individual consumer’s bid-price, the data available (33 consumers x 8 chops = 264 degrees of freedom) in the analysis increases. The fitted equations explain about 40 to 50 percent of the variance for each presentation format (Table 4). A majority of the estimated regression coefficients are statistically significant (0.05 level) in each bid price equation. A test of the null hypothesis that all socioeconomic consumer variables have a zero effect on individual bid prices (against the alternative that they are not zero) yields sample F-values of 7.3, 10.3, and 5.4 for the three consumer presentation formats of photographs, product appearance, and tasting, respectively. The critical value of the F-statistic with 16 and 205 degrees of freedom at the 5 percent level is 1.69. Hence, the socioeconomic variables make a statistically significant contribution to explaining individual bid prices across presentation formats.

A test of the null hypothesis that all quality attributes of chops jointly have zero effect on individual consumer’s bid prices (against the alternative that they are not zero), yields sample F-values of 3.5, 4.6, and 5.1 for photographs, actual appearance, and after tasting, respectively. The critical value of the F-statistic value with 3 and 205 degrees of freedom is 2.65 at the 5 percent level of significance. Hence, the attributes of the chops also make a statistically significant contribution to explaining individual bid prices in all three presentation formats.

Most socioeconomic variables have consistent and anticipated effects across presentation format (Tables 4 and 5). Regardless of presentation format, women, shoppers with children in the household, and members of multi-income households, tend to bid less for a chop. Furthermore, bid prices also tend to fall as the consumer’s age and household size increases, but increase slightly or remain unchanged as the consumer’s education levels increases. These results suggest that the price consumers are willing to pay for fresh pork chops, which require significant preparation time in cooking, may be significantly reduced by the opportunity cost of the consumer’s home time. Most empirical studies have found meat consumption to be a normal good, and our positive income effects on bid price support this finding. Hence, a balance between the positive bid effect of an increase in household income and the negative bid effects of multi-income households is possible. For example, to maintain a constant bid price for photographs, fresh appearance, and fresh appearance after tasting, an additional income earner

\(^8\)For simplicity, all socioeconomic variables are represented as continuous in this equation. In fact, several were discrete and estimated as dummy variables under the restriction that the sum of the dummy variable effects for each discrete socioeconomic variable equaled zero.
Table 4. Hedonic Analysis of Consumers’ Fresh Pork Bids by Presentation Format

<table>
<thead>
<tr>
<th>Price Effect</th>
<th>Photos</th>
<th>Appearance</th>
<th>Taste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.3308</td>
<td>0.7763</td>
<td>0.9589</td>
</tr>
<tr>
<td>Coefficient</td>
<td>0.73</td>
<td>1.52</td>
<td>1.86</td>
</tr>
</tbody>
</table>

**Discrete Variables:**

- Replication 1: 0.1311 (2.44)
- Replication 2: 0.1226 (2.20)
- Replication 3: -0.2538 (-1.71)
- Household Type 1: 0.1281 (1.67)
- Household Type 2: -0.9831 (-7.17)
- Household Type 3: 0.4796 (2.31)
- Household Type 4: 0.6531 (3.71)
- Household Type 5: -0.2778 (-0.65)
- Last Consumption - Week: -0.2604 (-2.96)
- Last Consumption - Month: 0.2145 (3.30)
- Last Consumption - Other: 0.0459 (0.30)
- Frequency - Week: -0.0867 (-1.37)
- Frequency - Month: -0.1000 (-1.24)
- Frequency - Other: 0.1866 (1.42)
- Stock i Home: -0.1508 (-3.01)
- Children (<16) in Household: -0.0967 (-1.41)
- Sex = Female: -0.2213 (-4.34)
- Multi-income Household: -0.1179 (-2.76)

**Continuous Demographic Variable**

- Household Income ($1000): 0.0086 (3.07)
- Age of shopper (years): -0.0139 (-3.60)
- Household size (number): -0.0586 (-2.07)
- Education of shopper (years): 0.0280 (1.32)

**Quality Characteristics:**

- Color Score (C=1 to 5): -0.0037 (-0.13)
- Marbling Score (M=1 to 5): -0.0428 (-1.48)
- Size (Area in sq in): 0.0789 (2.85)

**Estimate Statistics:**

<table>
<thead>
<tr>
<th></th>
<th>R²</th>
<th>MS</th>
<th>R²</th>
<th>MS</th>
<th>R²</th>
<th>MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photos</td>
<td>0.3947</td>
<td>0.2017</td>
<td>0.4971</td>
<td>0.2511</td>
<td>0.3752</td>
<td>0.2552</td>
</tr>
<tr>
<td>Appearance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taste</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

must increase the household’s total annual income level by $13,709, $26,495, or $14,919, respectively, to offset the negative bid price effects associated with the second income. Furthermore, higher income levels tend to offset the negative bid price effects of increases in consumer’s age, household size, and children in the household.\(^9\)

The effects of pork attributes on consumer’s bid prices are not nearly so clear or consistent as the socioeconomic effects. Darker color tends to reduce the bid price across presentation formats, although its effect is not statistically significant in any format. Increased marbling reduces the bid price when consumers bid from photographs (-0.043), but significantly increases their bid prices after tasting (0.138). Chop size tends to significantly increase bid prices based on photographs (0.079) and viewing the actual product (0.106), but reduce bid prices (non-significantly) after consumers taste the chop (-0.002). Hence, the empirical results obtained from examining consumer’s individual bid prices also support the

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\(^9\) Young children prefer foods such as hamburgers and hot dogs rather than pork chops.
Table 5. Consumers' Bid Values and Price Flexibilities for Fresh Pork Characteristics and Selected Demographics Evaluated at the Sample Means for a 3-3-3 Chop (average 6 sq in)

<table>
<thead>
<tr>
<th>Fresh Pork Attribute:</th>
<th>Photos Value</th>
<th>Flexibility</th>
<th>Appearance Value</th>
<th>Flexibility</th>
<th>Taste Value</th>
<th>Flexibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>-0.0074</td>
<td>-0.0110</td>
<td>-0.1205</td>
<td>-0.1954</td>
<td>-0.0514</td>
<td>-0.0866</td>
</tr>
<tr>
<td>Marbling</td>
<td>-0.0869</td>
<td>-0.1284</td>
<td>0.0096</td>
<td>0.0156</td>
<td>0.2458</td>
<td>0.4143</td>
</tr>
<tr>
<td>Size</td>
<td>0.1601</td>
<td>0.4733</td>
<td>0.1969</td>
<td>0.6385</td>
<td>-0.0035</td>
<td>-0.0118</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Demographic Variables:</th>
<th>Value</th>
<th>Flexibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income</td>
<td>0.0200</td>
<td>0.2628</td>
</tr>
<tr>
<td>Age</td>
<td>-0.0282</td>
<td>-0.5165</td>
</tr>
<tr>
<td>Household Size</td>
<td>-0.1190</td>
<td>-0.1653</td>
</tr>
<tr>
<td>Education</td>
<td>0.0568</td>
<td>0.3659</td>
</tr>
</tbody>
</table>

Effects of Demographic Variables on Attribute Values:

<table>
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<tr>
<th>Fresh Pork Attribute:</th>
<th>Color Value</th>
<th>Flexibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income</td>
<td>-0.000064</td>
<td>-0.01264</td>
</tr>
<tr>
<td>Age</td>
<td>0.000103</td>
<td>0.002572</td>
</tr>
<tr>
<td>Household Size</td>
<td>0.000436</td>
<td>0.011038</td>
</tr>
<tr>
<td>Education</td>
<td>-0.000208</td>
<td>-0.002999</td>
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</table>

<table>
<thead>
<tr>
<th>Demographic Variables:</th>
<th>Marbling Value</th>
<th>Flexibility</th>
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</thead>
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<tr>
<td>Income</td>
<td>-0.000746</td>
<td>0.000101</td>
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<tr>
<td>Age</td>
<td>0.001206</td>
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<tr>
<td>Household Size</td>
<td>0.005092</td>
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<td>Education</td>
<td>-0.002429</td>
<td>0.000239</td>
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<table>
<thead>
<tr>
<th>Fresh Pork Attribute:</th>
<th>Size Value</th>
<th>Flexibility</th>
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</thead>
<tbody>
<tr>
<td>Income</td>
<td>0.001375</td>
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<tr>
<td>Age</td>
<td>-0.002222</td>
<td>-0.004203</td>
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<tr>
<td>Household Size</td>
<td>-0.009384</td>
<td>-0.018040</td>
</tr>
<tr>
<td>Education</td>
<td>0.004477</td>
<td>0.004901</td>
</tr>
</tbody>
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The hypothesis that presentation format is important in individual consumer’s WTP for pork chops.

These effects can be seen more clearly in the estimated marginal values and flexibilities of the attributes (Table 5). A unit of color has a negative value in the appearance format (-0.1387 per pound), but a small positive effect in the after taste format ($0.0064 per pound). These results suggest consumers prefer the appearance of lighter color pork when all other attributes are held constant. However, that preference is modified significantly after tasting. Pork color variation is largely a fresh pork attribute observed in the raw product, and all pork tends to be nearly the same color after cooking. These results suggest that the Other White Meat® advertising campaign of the NPPC may increase “first-time” purchases of pork, but because consumers re-order their preferences after tasting pork, the ads could have negative effects on repeat pork chop sales to consumers.

The marbling score has a negative marginal value in photos (-0.0645) and when consumers bid based on the appearance of fresh pork chops (-0.0068 per pound), but it has a large positive marginal value when consumers bid after tasting ($0.3291 per pound). A 1 percent increase in marbling score increases bid price after taste by 0.49 percent and a one-third increase from marbling score 3 to 4 would increase bid price by nearly 16 percent. Furthermore, the effects of marbling on individual consumer’s WTP, as judged by bid prices, are considerably greater than would be implied from market prices, especially after tasting. Hence, the willingness of consumers to pay for marbling scores differ greatly based on whether they have tasted the product and those...
effects are quite large for some consumers who may never have tasted a "good" chop or, more to the point, do not know what a "good" chop looks like before cooking. Chops purchased on visual assessment alone will, on average, unduly discount marbling.

Size has a positive marginal value in bids based on photographs and appearance before tasting ($0.1578 and $0.2162 per pound, respectively), but a small and statistically insignificant negative marginal value in bids formulated after tasting the product (-$0.0208 per pound). Consumer bid prices could thus be enhanced by increasing size due to the appearance of the larger chop, but that increased size should not significantly reduce either eating quality or consumer bid prices after tasting.

**Implications**

The finding that socioeconomically different consumers value pork attributes differently is expected. However, the finding that their valuations change sign after tasting, as with marbling, is not, and these conflicting effects create a dilemma for the pork industry. If consumers are attracted to a product that does not meet their taste expectations, the frequency of repeat sales will be low. At the same time, unless consumers make an initial purchase, the repeat sales option does not exist. To expand market demand, an industry must make a compromise. It must attract initial purchases of its products based on advertising (photographic appearance) and counter appeal (actual appearance) and also taste good so consumers will want to make repeat purchases (after tasting).

Assume that chops of different quality can be produced and marketed at the same cost. The profit maximizer will market the chop that yields the highest price — taking account of both initial and repeat purchases. To reflect this, assume the long-run market price $P$ can be represented as the weighted sum of consumers' WTP for chops based on appearance, $P_a$, and appearance after taste, $P_t$: 

$$P = \theta P_a + (1 - \theta) P_t,$$  \hspace{0.5cm} (13)

where $\theta$ is the weight (0 ≤ $\theta$ ≤ 1) attached to consumers' WTP based only on appearance.

Substituting the predicted hedonic prices for $P_a$ and $P_t$ into equation (13), the long-run market price in terms of the pork attributes and the weight attached to initial (a = appearance) and repeat (t = after tasting) purchases can be expressed as:

$$P = \theta e^{lnP_a} + (1 - \theta) e^{lnP_t}.$$  \hspace{0.5cm} (14)

The profit-maximizing levels of the attributes (i.e., those that maximize aggregate price) are obtained by setting the partial derivatives of equation (14) with respect to each attribute being considered equal to zero and simultaneously solving the resulting set of first-order conditions (subject to the constraints that each attribute must fall within a biologically defined range; i.e., from 1 to 5 for color and marbling score and from 1 to 15 square inches for size).

As expected, corner solutions are obtained for alternative levels of $\theta$ ranging from zero to one (Table 6). However, these results indicate that when preferences after tasting a chop are equally or more important than appearance, as with a concern for repeat purchases, the ideal chop should typically be lightly colored (C=1) and heavily marbled (M=5).

Two practical advantages accrue to the production and marketing of such a chop. First, as a result of its lighter color, the amount of marbling is not readily distinguishable by visual inspection. Thus, consumers will be more willing to try it based on their perception of fat content and more inclined to repeat the purchase based on a favorable eating experience. Second, the light color is consistent with and reinforces the "Other White Meat" campaign, which is alleged to have been quite successful. Size tends to have a non-significant effect on taste. Thus, larger chops should be acceptable based on taste and preferred based on their visual appeal.

The current average chop (a 3-3 with size of 6 square inches) is sub-optimal under all conditions. When equation (14) is solved for $\theta$, the current average chop yields a maximum price only when all of the weight is given to appearance of the fresh product (i.e., $\theta$=1). Hence, the U.S. pork industry may currently be producing a product having acceptable appearance, but one that does not taste good enough to maintain strong, repeat sales. This strategy of modifying the product might be a formula for long-run success and be a step ahead of problems associated with too little
<table>
<thead>
<tr>
<th>Appearance Weight (β)</th>
<th>Photos versus After Taste</th>
<th>Actual versus After Taste</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0%</td>
<td>25%</td>
</tr>
<tr>
<td>Price/pound</td>
<td>$1.84</td>
<td>$1.82</td>
</tr>
<tr>
<td>Color Score</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Marbling Score</td>
<td>5.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Size (sq. in.)</td>
<td>1.00</td>
<td>15.00</td>
</tr>
</tbody>
</table>

**Maximum Average Price from Experimental Bid Price Estimates**

**Maximum Average Price from Experimental Market Price Estimates**

| Price/pound           | $3.39 | $2.96 | $4.21 | $5.53 | $6.87 | $3.39 | $3.14 | $2.87 | $2.96 | $3.05 |
| Color Score           | 1.00 | 1.00 | 1.00 | 5.00 | 5.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Marbling Score        | 5.00 | 5.00 | 1.00 | 1.00 | 1.00 | 5.00 | 5.00 | 1.00 | 1.00 | 1.00 |
| Size (sq. in.)        | 1.00 | 1.00 | 15.00 | 15.00 | 15.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
fat that have recently begun to plague the Danish pork industry.

Summary and Conclusions

In this study experimental auction data were used to evaluate consumer perceptions, willingness-to-pay, and attribute values for fresh pork chops that differ simultaneously in multiple quality attributes: (1) color, (2) marbling, and (3) size. Furthermore, the consumer presentation format of the experimental treatments was varied: (1) the appearance of the chop in photographs, (2) the appearance of fresh chops, and (3) the appearance of the chops after tasting comparable chops.

Results confirm that consumers can distinguish rather subtle differences in embodied attributes of a heterogeneous product such as fresh pork chops. Furthermore, consumers are able to simultaneously value those differences across presentation formats. However, hedonic analyses of price differences for either market or bid prices showed marked differences across presentation format. Marbling has a negative marginal value in both market and bid prices based on photographs, but a positive marginal value after consumers taste the chops. Size and color tend to display similarly inconsistent marginal values across presentation formats. Hence, a researcher or store manager can not draw reliable conclusions regarding either prices or attribute marginal values in one presentation format from results obtained in another format.

The experimental auction data also facilitated analyses of socioeconomic factors affecting individual consumer bids (WTP) that would be virtually impossible in a traditional hedonic analysis of actual (secondary) market data. Marbling was more important to all consumers than would be concluded from an examination of market price data alone. Similarly, the other attributes of color and size tend to be less important than indicated by market price differences.

Based on consumer bids after taste, women, households with children, and multi-income households tend to bid less for chops — perhaps because of a higher opportunity cost of household labor to prepare a meal with fresh pork chops. At the same time, greater household income increases chop bid prices; but an older age and an additional year of education of shopper and larger household size reduce chop bid prices.

Although additional and larger-scale studies of this type will be required, pork producers might benefit from larger chops that are lighter in color with higher marbling. Such a chop is visually acceptable and consistent with the “Other White Meat”® advertising campaign of NPPC, but also yields a more acceptable eating experience that may enhance repeat purchases.

These results demonstrated the potential effectiveness of experimental auction data to elicit consumer prices and attribute values for widely varying products such as fresh pork. Furthermore, presentation format and auction protocol affect bids and market prices in ways that make results difficult to compare across formats and are a warning to those who try to promote fresh meat products based on photo advertising. Even with these caveats in mind, experimental auctions have the potential to help agricultural producers and marketers identify and capitalize on important qualitative attributes of their heterogeneous products and to identify consumer differences that may affect product values. The nature of consumer preferences and the WTP for pork attributes depend upon the characteristics of the consumer, the product, and the way product information is presented to consumers.

References


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