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Comparing Parts with the Whole: Willingness to Pay for Pesticide-Free, Non-GM, and Organic Potatoes and Sweet Corn

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Auction experiments were used to investigate demand relationships and willingness to pay (WTP) for four versions of potatoes and sweet corn—conventional, organic, and two parts of organic: no pesticides and non-genetically modified (non-GM). Elasticities showed strong and asymmetric substitute relationships between organic and its parts. Combined premiums of the parts were not significantly different than the whole organic premium, suggesting WTP for the attributes are not additive. A two-stage heteroskedastic tobit model found significant WTP for each part dependent on demographics and beliefs about conventional versions. Results suggest segments for parts of organic could be established alongside the whole.

Key Words: auction experiments, organic, pesticides, potatoes, sweet corn, willingness to pay

Introduction

In the past, agricultural products were typically viewed as homogeneous. Today, numerous agricultural products are sold in differentiated markets where the product's attributes are marketed to consumers. One food category that has seen tremendous growth is the organic sector. Organic sales have increased rapidly over the past decade, with annual sales growth of approximately 20% for most of the 1990s (Dimitri and Greene, 2002). Sales in 2005 reached $13.8 billion, an increase of 16.2% over the previous year (Organic Trade Association, 2006).

Recent figures suggest nearly two-thirds (65%) of Americans have tried organic foods and beverages. The primary reason cited for buying organic foods was the avoidance of pesticides (70.3% of respondents), while avoiding genetically modified (GM) foods was ranked fourth with 55% of respondents (Whole Foods Market, 2005).[1] Although surveys reveal numerous reasons why consumers purchase organic food products, little is understood about the values they place on the individual parts of organic. If organic is viewed as a bundle of attributes, then it is important to understand the relationships between the value of the whole bundle and the values for the individual parts.

A better understanding of the value for organic as a whole compared to the value of some of its component parts would be of interest to a number of different groups. For example, farmers could potentially benefit from pesticide-free markets without taking on the full expenses of converting to an organic operation. Those in the rest of the market system would

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[1] The second and third reasons cited were freshness and health and nutrition. However, neither of these are part of the definition for certified organic foods.

also gain by a more complete understanding of possible niche markets for the parts within organic. Depending on demand for the parts of organic, policy makers could also gauge the possibility of creating certification programs, similar to that for organic, for some of its most-valued parts.

The goal of this research was to examine demand relationships and WTP for potatoes and sweet corn in four versions: conventional, organic, and two individual parts of organic—pesticide-free and non-GM.[2] The foods were selected for two reasons. First, the fruits and vegetables sector accounts for the largest portion of organic food sales, with $5,369 million sales in 2005, representing 39% of total organic food sales (Organic Trade Association, 2006). Second, potatoes have the highest average per capita consumption among vegetables (all uses), with sweet corn third (Lucier et al., 2006).

Data were collected through auction experiments where consumers bid for a five-pound bag of white potatoes and five ears of sweet corn in each version. Demand relationships were investigated by calculating own- and cross-price elasticities, while WTP was analyzed using two-stage heteroskedastic tobit models based on subject demographics and beliefs regarding conventional varieties. This latter analysis allowed a related objective of developing demographic profiles for consumers interested in each version. Our findings could aid in understanding how markets for organic and the parts of organic may be segmented. Results could have a positive impact on produce markets beneficial for both consumers and producers.

Literature Review

A considerable amount of research has been conducted regarding consumers and organic foods. Krystallis, Fotopoulos, and Zotos (2006) listed over 40 studies on organic food consumption since 1995. Yiridoe, Bonti-Ankomah, and Martin (2005) have provided an extensive review of the literature on consumer preferences and perceptions of organic and conventional foods. The studies reviewed tended to cover issues such as consumer knowledge, understanding, and WTP for organic, as well as investigating the profile of an organic consumer.

Of studies looking at the parts of organic, the one with the largest focus has arguably been GM and non-GM foods. The literature examining consumers' attitudes and WTP for GM and non-GM foods was well covered in a meta-analysis by Lusk et al. (2005). However, these studies do not typically place non-GM within the context of being one part of the organic standard as emphasized here. In contrast, the role of the use of pesticides in consumer interest in organic produce has been more directly studied. Huang (1996) surveyed consumers to assess, in part, their preferences for organic produce. He reported that 45% of respondents ranked pesticide use as their primary food concern, and this was the main reason motivating consumers' preference for organic over conventional fresh produce. Govindasamy and Italia (1999) found that 60% of respondents indicated pesticides pose a very serious risk to human health. Thirty-five percent of respondents expressed WTP a premium of at least 10% for organic produce.

Several other studies have examined consumers' WTP a premium for pesticide-free fresh produce. In a survey of supermarket shoppers, Ott (1990) reported that two-thirds of respondents were willing to pay at least 5% higher prices for certified pesticide residue-free (CPRF)

[2] Although it represents only a small portion of the market, GM sweet corn has been available from Syngenta since 1998 (Syngenta, 2004). GM potatoes were sold by Monsanto from 1995 until 2001, and are still approved for use (Monsanto Co., 2010). Subjects in the experiments were told the products had been developed and approved for use, but were not given any information on the extent of their presence in the marketplace.

fresh produce. In a similar study, Misra, Huang, and Ott (1991) found that of the respondents who were willing to pay a higher price for CPRF produce, 54% were not willing to pay more than a 5% premium. Weaver, Evans, and Luloff (1992) examined consumers' concern about pesticide use in tomato production and their WTP for chemical pesticide residue-free tomatoes. Although consumers surveyed expressed concern about the use of pesticides, the majority did not report any change in their buying habits. Of those who did, 41% bought more organic or CPRF produce. Finally, results indicated 19% of consumers were not willing to pay more for chemical pesticide residue-free tomatoes.

Other studies have assessed multiple attributes, including those that are part of the organic standard. Hwang, Roe, and Teisl (2005) examined consumer concerns regarding eight food technologies, including the use of pesticides and genetic modification. They found pesticide use to be of high concern and genetic modification ranked as an intermediate concern. While they did not directly relate these to WTP or to organic, the effort did suggest a possible scale of importance for the parts in this study. Loureiro and Hine (2002) used contingent valuation techniques to determine consumers' value for three attributes of potatoes: organic, GMO-free, and Colorado-grown. Their findings showed a higher percentage of respondents were willing to pay a premium for Colorado-grown (72%) compared to either organic (58%) or GMO-free (47%).

Batte et al. (2007) examined consumer interest and WTP for organic, pesticide-free, non-GM, better flavor, and locally grown processed food products. Using hypothetical surveys where participants indicated ranges, the authors found consumers were willing to pay a large premium for pesticide-free, non-GM, and organic versions. When comparing the magnitude of the premium for the full organic version to the premiums for the parts, their results suggested the latter premiums would be non-additive. To our knowledge, however, no previous study has used nonhypothetical methods to examine organic produce and two of its key components.

Last, as noted by Lin, Yen, and Huang (2008), despite the interest in consumer demand for organic foods, few studies have reported elasticities. Their examination of organic and conventional fruit elasticities yielded two key findings: (*a*) organic versions were found to be more price-sensitive than conventional versions, and (*b*) there were substantial asymmetries in the cross-price elasticities. According to their results, price changes in conventional versions were more likely to move consumers to organic versions than the reverse. These asymmetries were also observed by Glaser and Thompson (1998) for conventional and organic frozen vegetables. Based on their findings, consumers are less likely to revert back to conventional once they are accustomed to organic. Our research extends these studies by identifying elasticity relationships in a situation where versions representing parts of organic are present.

Conceptual Framework

The primary issue investigated is the comparison of WTP for the individual parts of organic and WTP for organic in total. A common assumption has been that these WTP numbers are additive, such that the sum of the WTP for the parts equals the WTP for the whole. However, Louviere, Hensher, and Swait (2000) suggest the assumption of strictly additive utility will not be satisfied in many real-market applications. The additive approach may miss important complement or substitute relationships among attributes (Nalley, Hudson, and Parkhurst, 2006). For example, Dhar and Foltz (2005) use retail prices for rBST-free and organic milk to infer the WTP for the remaining attributes of organic milk, assuming additive utility. In contrast, an auction experiment study by Bernard and Bernard (2009) finds WTP for organic milk attributes to be nonadditive, while Bond, Thilmany, and Bond (2008) find attribute bundling effects and nonadditive relationships between nutrition claims and organic labels.

In examining this framework, let $\mathbf{B} = \{b_1, b_2, R\}$ be a vector of individual parts of organic where, without loss of generality, b_1 represents non-GM, b_2 represents pesticide-free, and R denotes the remaining attributes of organic. The question is how the overall WTP for **B** compares with the WTP for these individual parts. If the utility gained from the attributes is additive, the relationship between the WTP measures could be expressed as:

$$(1) \qquad WTP(\mathbf{B}) = WTP(b_1) + WTP(b_2) + WTP(R).$$

In the event of joint relationships between attributes, the overall WTP for **B** will not equal the sum of the WTP for the individual parts. As noted by Bateman et al. (1997), under standard theory for normal goods where the parts are viewed as substitutes, the following inequality would be expected:

$$(2) \qquad WTP(\mathbf{B}) < WTP(b_1) + WTP(b_2) + WTP(R).$$

For the case where the attributes are viewed as complements, the inequality above would be reversed.[3] Depending on the extent of the inequality, comparisons of bundles could lead to a "more is less" phenomenon as considered by List (2002), where a bundle with a subset of organic attributes surpassed the value for the aggregate organic bundle. Combining two substitute attributes should not be as beneficial to a consumer since this implies a degree of overlap between them. For complements, their combination gives an added benefit to the consumer that should be reflected in higher overall WTP.

Although Melton et al. (1996) stress the importance of considering multiple attributes as part of auction experiment design, few studies have done so. Indeed, Lusk and Hudson (2004) note that a major question for WTP studies has been whether a sufficient number of relevant alternatives were included. Studies on nonmarket environmental valuation have suggested WTP measurements are biased if appropriate substitutes/complements are not included (Hoehn and Loomis, 1993; Cummings, Ganderton, and McGuckin, 1994).

When considering the WTP for organic food products, the challenge is that the demand for individual attributes may be hidden within the overall value. By missing possible relationships among attributes and the values for these parts of organic, the potential for other attributes to exist in the market cannot be determined. Assuming a linear function that includes price as a component, a consumer's utility for potatoes could be written as:

$$(3) \qquad U_{Potatoes} = \rho_0 + \rho_1 Price + \rho_2 Organic + \mathbf{X}\boldsymbol{\beta},$$

where *Price* is the price of potatoes, *Organic* is a dummy variable with the value of 1 if the potatoes are labeled as organic, and **X** is a vector of other characteristics (such as type of potatoes, which may be russet or red, for example). Here, *Organic* serves as a proxy for its component attributes. Construction forces the conclusion that the sum of the utilities of these attributes is represented by ρ_2, making this a less than ideal proxy for understanding the demand for organic potatoes.

[3] Cases where some attributes were viewed as substitutes for one another and others as complementary would necessarily be more complex.

By using a formulation that examines some of the individual components of organic, more could be learned about potential market segments. Consider an expanded analysis which accounts for two specific aspects of organic potatoes: non-GM and the absence of pesticide use:

$$(4) \qquad U_{Potatoes} = \alpha_0 + \alpha_1 Price + \alpha_2\, Non\text{-}GM + \alpha_3\, NoPesticides + \alpha_4\, RemainOrganic + \mathbf{X\beta},$$

where *Non-GM* and *NoPesticides* are dummy variables representing those versions, *Remain Organic* is a dummy representing the remaining attributes of organic, and α denotes marginal utilities. The larger the substitutability potential among the parts of organic, the less accurate inferences from equation (3) would be (Lusk, 2003). For instance, Dickinson and Bailey (2002) found that bids for a meat sandwich with attributes pooled were lower than the sum of bids for the attributes individually. From the above equation, this would imply $\alpha_2 + \alpha_3 + \alpha_4 > \rho_2$, which corresponds to equation (2) and would not be consistent with the additive utility assumption. The strength of WTP for these individual components can determine the possibility of profitable niche markets and also further the understanding of consumer WTP for organic.

Experimental Design

The issues described above were investigated through the use of auction experiments. Subjects for the experiments were recruited from the general population through classified ads, flyers at supermarkets, and assistance from various civic and religious organizations. In order to avoid selection bias, which could result from mentioning non-GM or organic, the experiment was promoted as a "food marketing study." In total, seven auction sessions were conducted between late 2004 and early 2005. Each session consisted of 15 to 25 subjects, with a total of 154 participants, and lasted 90 minutes. The subject pool contained representation from four states: Delaware, Maryland, Pennsylvania, and New Jersey. In an effort to minimize subject transportation costs, sessions were held at multiple locations in different states. Payment was approximately $35 per person, with additional earnings of up to $1 possible in practice auctions, minus the price of any food purchased in the actual auctions.

Each session began with subjects completing a pre-experiment questionnaire covering their knowledge and attitudes toward various food production technologies and practices. Following this, subjects read the instructions for the auction mechanism. The experiment used a generalization on Vickrey's second-price auction, where the number of participants who could purchase a unit was set to one-fourth of the group size (Bernard and Bernard, 2009). This format, which was typically implemented as either a fourth- or fifth-price auction, retains the incentive-compatible nature of the second-price auction (Lusk and Shogren, 2007).

Subjects were informed that the best strategy in the auctions was to bid their actual willingness to pay, and examples with possible outcomes due to deviation from the recommended strategy were covered. Subjects were encouraged to participate in identifying the market price and calculating profits in the examples. Three practice rounds with induced values then were conducted. Values were randomly generated from $0 to $1.00, with subjects given a different value in each round. Results from the practice rounds suggested subjects understood the recommended best strategy, as average bids were less than 1% different from induced values.

Next, subjects were provided information about the key food product attributes: genetically modified, no pesticides used, organic, and conventional. This process was considered important, as previous studies have found a lack of awareness and understanding of these terms (Bernard, Pan, and Sirolli, 2005). Definitions were designed to be factual and neutral since the type of information and its presentation can have substantial influence on WTP responses (Gifford and Bernard, 2004, 2006; Huffman et al., 2007). Genetic modification was defined as biotechnology used to transfer a gene with a known function into existing crop varieties. The use of pesticides was presented as the application of chemicals to protect crops from pests, with the U.S. government having established limits for acceptable residues. "Organic" was defined according to the USDA standards, including not being GM and the absence of synthetic pesticides as well as sewage sludge or chemical-based fertilizers. "Conventional" was noted as not organic, but with other aspects of its production unknown (such as whether or not the plant was GM or pesticides had been applied).

Subjects were advised that only one auction would be binding, and that the food and version (e.g., organic sweet corn) associated with the binding auction had been predetermined. The description of this food and version was sealed in an envelope visible throughout the session and would be opened by a subject at the conclusion of all auctions. The food auctions were conducted with bids collected in a single round to avoid the possibility of affiliation of values with repeated rounds. Several studies have shown subjects adjust bids toward the behavior of others by following final prices over trials (Corrigan and Rousu, 2006; Bernard, 2005; Harrison, Harstad, and Rutström, 2004). For both potatoes and sweet corn, bids were collected simultaneously for four varieties: conventional, organic, non-GM, and no use of pesticides. Additional characteristics for potatoes were white baking potatoes in five-pound quantity, and the sweet corn was a quantity of five ears. No bidding information was revealed for any of the foods or versions.

Once bids had been collected for all foods in all versions, subjects were asked to complete a post-experiment questionnaire. The purpose of this questionnaire was to collect subjects' demographic information as well as their beliefs about various attributes of the conventional variety of potatoes and sweet corn. Finally, a volunteer was asked to reveal the binding auction. The purchase price was announced and subjects who purchased a unit were identified. Subjects were paid at the end of the session.

Data and Descriptive Statistics

The distributions of bids for each variety of potatoes and sweet corn are presented in figures 1 and 2, respectively. The distributions were mostly as expected, with bids for conventional the lowest and organic the highest. Zero bids were received for all varieties of each product, which is not uncommon in auction experiments.

For potatoes, the majority of bids for conventional potatoes fell between \$1.50 and \$1.99, which corresponded to the \$1.99 supermarket price for conventional at the time of the study. Conventional potato bids were in the lower end of the distribution, with none over \$3.49. Bids for organic potatoes were centered between \$2.00 and \$2.50, with some bids over \$4.00. Bids for the no-pesticides version were centered in the range of \$2.00 to \$2.49, while bids for the non-GM version were centered in the range of \$1.50 to \$1.99; both versions had bids over \$4.00.

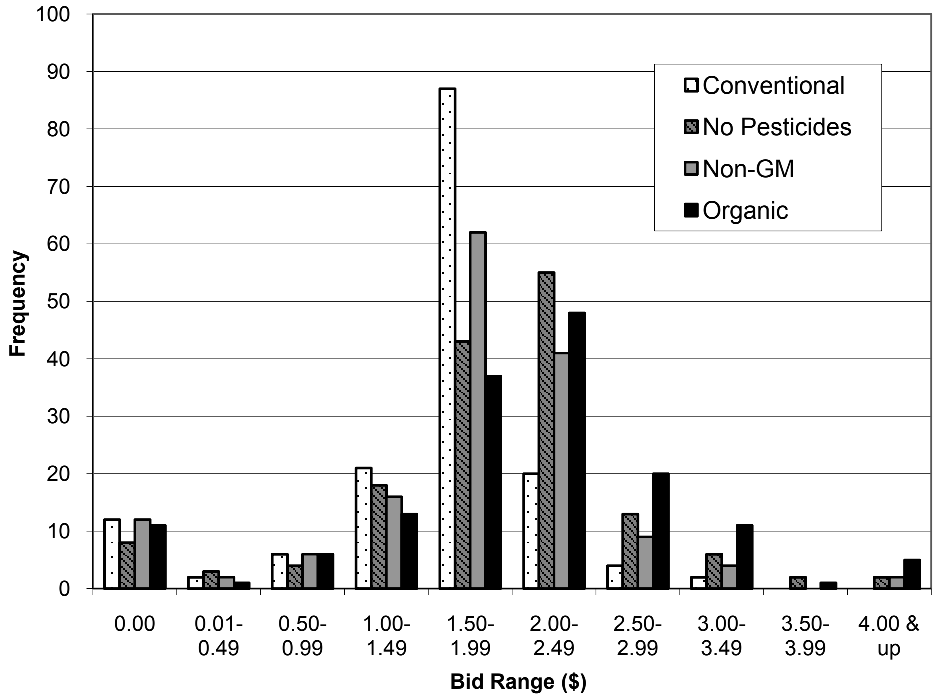

Figure 1. Potato bid distribution

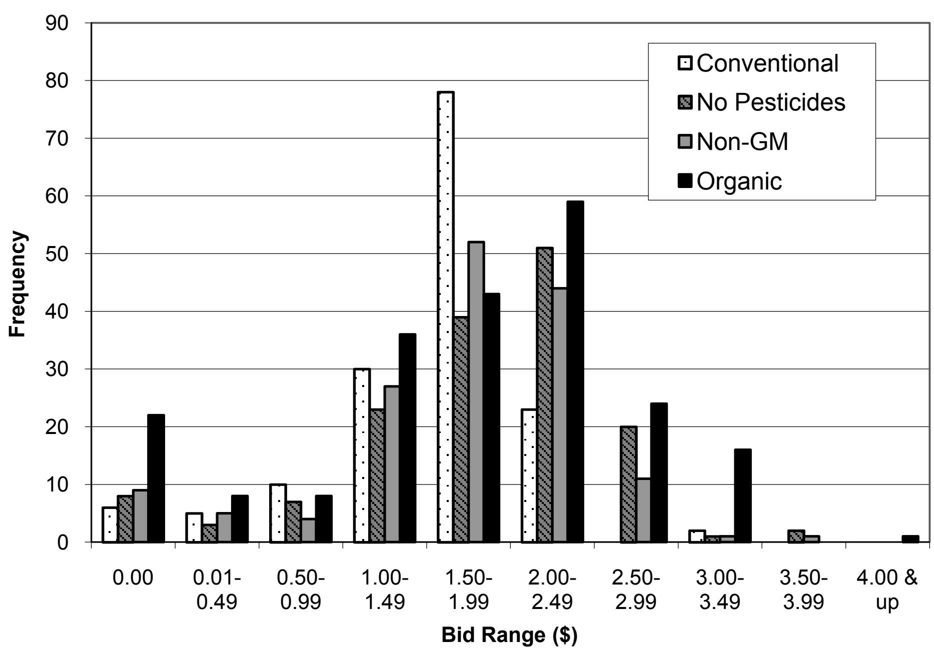

Figure 2. Sweet corn bid distribution

Table 1. Descriptive Statistics for Bid Premiums

Variety / Premium	Mean	Standard Deviation	Signed Rank *p*-Value
Potatoes:			
No Pesticides over Conventional	0.28	0.51	< 0.01
Non-GM over Conventional	0.14	0.49	< 0.01
No Pesticides over Non-GM	0.13	0.43	< 0.01
Organic over No Pesticides	0.12	0.59	< 0.01
Organic over Non-GM	0.26	0.59	< 0.01
Organic over Conventional	0.40	0.78	< 0.01
Organic over Conventional (implied) [a]	0.42	0.90	< 0.01
Sweet Corn:			
No Pesticides over Conventional	0.22	0.53	< 0.01
Non-GM over Conventional	0.14	0.49	< 0.01
No Pesticides over Non-GM	0.09	0.42	< 0.01
Organic over No Pesticides	0.13	0.43	< 0.01
Organic over Non-GM	0.21	0.55	< 0.01
Organic over Conventional	0.35	0.68	< 0.01
Organic over Conventional (implied) [a]	0.36	0.94	< 0.01

[a] Implied premium is the sum of the non-GM and no-pesticide premiums over conventional.

Similarly, for conventional sweet corn, a large number of bids fell in the range of $1.50 to $1.99, with a corresponding supermarket value of $1.99. Only two conventional bids were greater than $2.49, falling in the range of $3.00 to $3.49. Bids for organic sweet corn were centered in the range of $2.00 to $2.49, and this was the only version for which bids over $4.00 were submitted. The maximum bids received for both the no-pesticides and non-GM versions ranged from $3.50 to $3.99. Bids for the no-pesticides version were again centered in the range of $2.00 to $2.50, and bids for non-GM ranged from $1.50 to $1.99.

Descriptive statistics for the bid premiums are presented in table 1. Premiums were calculated as the difference in the mean bids between each pair of versions of each food. To examine the premiums, the first step was to run the nonparametric Friedman test on the bids. The null hypothesis was that the bids were the same, while the alternative was that at least one bid series was different (for details on the test, see Sprent and Smeeton, 2001). For both sweet corn and potatoes, the null was easily rejected at better than the 1% level. Following this finding, paired comparisons of the bids were conducted. As the bids were not normally distributed, the premiums resulting from examining each pair were investigated using the nonparametric Wilcoxon signed rank test. The null hypothesis was that the premiums were equal to zero (details are also found in Sprent and Smeeton). Two findings were suggested from these statistics. First, for both potatoes and sweet corn, each bid premium was found to be statistically significant. This showed consumers value separately the two individual parts of organic as well as valuing organic. Also of note were the significant premiums of pesticide-free over non-GM, which seemed to follow the ranking reported by Hwang, Roe, and Teisl (2005).

The second finding was based on a comparison of the actual premium and a constructed implied premium for organic over conventional. The actual premium was simply the difference between the bids for the organic version and the conventional version. The implied premium was calculated as the sum of the premiums for no pesticides over conventional and non-GM over conventional. Note that this should be viewed as an implied minimum premium, since a positive value for any other attribute of organic would be expected to increase the premium. Nevertheless, for both potatoes and sweet corn, the implied minimum premium was larger than the actual premium (0.4221 compared to 0.4000 for potatoes; 0.3642 compared to 0.3502 for sweet corn). These differences were not statistically significant (p-value = 0.7453 for potatoes and p-value = 0.7751 for sweet corn), leaving no value assigned to the remaining components of organic.

Two possibilities could explain this finding. First, consumers actually did not possess any WTP for the remaining attributes for organic. This seemed unlikely given values for other individual attributes seen in such studies as Hwang, Roe, and Teisl (2005) cited above. However, the possible values for other attributes for the products here remain an avenue open for further empirical investigation. Arguably more likely would be that, as noted when comparing equations (1) and (2), substitution possibilities among the parts has led to the situation where the separate premiums consumers were willing to pay surpassed the amount they would be willing to pay for the complete bundle of organic attributes. It appears consumers expected to pay less for the organic bundle, and thus the possible premiums for each valued component cannot be fully captured once combined.

Descriptive statistics for the relevant demographic variables from the full sample are presented in table 2. Since the largest segment of the sample was from Delaware (54%) or the nearby vicinity (with 28% from Pennsylvania, 14% from Maryland, and 4% from New Jersey), comparisons of the sample demographics were made to the 2000 Delaware census. These revealed gender and age to match well with the census, showing the population to be a comparable 48.6% male with a median age of 36 (U.S. Census Bureau, 2003). Subjects indicated their highest education from five categories, which were reduced to two after likelihood-ratio tests were performed. The 56% of respondents who had at least some college education or greater closely reflected the 51.1% reported in the census. Our experiment participants did have higher incomes—approximately \$74,000—compared with the census mean of \$59,100. A direct comparison was possible for one other demographic variable, whether the respondent had children living at home. Relative to the census number (35.4%), 50% of the subjects in our sample reported having children at home.

In addition to demographics, two questions were asked about subjects' beliefs regarding the conventional version of each product: (*a*) What percentage chance did you think there was that conventional potatoes (sweet corn) were GM potatoes (sweet corn)? and (*b*) What percentage chance did you think there was that conventional potatoes (sweet corn) were treated with synthetic pesticides? For *Belief GM*, the average was slightly over 53% for potatoes and almost 62% for sweet corn. The finding for potatoes was somewhat surprising given that Bt potatoes containing built-in resistance to the Colorado potato beetle were commercially introduced in 1996 and withdrawn in 1999 (Fernandez-Cornejo and Caswell, 2006). The average percentage *Belief GM* response was also surprisingly high since, while GM varieties accounted for 52% of all corn planted in the United States in 2005 [U.S. Department of Agriculture/Economic Research Service (USDA/ERS), 2008], only a small amount of GM sweet corn was planted.

For *Belief Pesticides*, the average was over 78% in each case. The sweet corn *Belief Pesticides* percentage was considered to be somewhat low as 95.8% of planted corn acres in

Table 2. Definitions of Variables and Descriptive Statistics

Variable	Description	Mean	Standard Deviation
Age	Age (years)	38.79	14.00
Income	Annual household income ($000s)	74.18	49.13
College Plus	= 1 if subject had some college education or more; 0 otherwise	0.56	0.50
Male	= 1 if subject is male; 0 if female	0.45	0.50
Children	= 1 if children in household; 0 otherwise	0.50	0.50
Farm Experience	= 1 if subject has lived or worked on farm; 0 otherwise	0.36	0.48
Belief Pesticides_Potatoes	Percent chance subject believes conventional potatoes were grown with use of pesticides	78.19	28.00
Belief GM_Potatoes	Percent chance subject believes conventional potatoes were GM	53.46	31.50
Belief Pesticides_Corn	Percent chance subject believes conventional corn was grown with use of pesticides	78.59	27.92
Belief GM_Corn	Percent chance subject believes conventional corn was GM	61.81	32.06

2005 were treated with some pesticide (USDA/ERS, 2007). Similarly, for potatoes, this percentage *Belief Pesticides* was low, given that the majority of acreage of fall potatoes in 2005 was treated with at least some form of pesticide. Specifically, herbicides were applied to 92% of the acres planted, insecticides were applied to 79% of the planted acreage, and fungicide treatments were applied to 90% of the acres planted (USDA/National Agricultural Statistics Service, 2006). Subjects' beliefs about the use of pesticides in conventional farming, although relatively low, suggested a greater awareness of the practice and possible concern about their use. This may have translated to higher bids for the no-pesticides varieties compared to the non-GM varieties.

Empirical Specification

Elasticities

Own- and cross-price elasticities were used to examine the demand relationships between each of the potato and sweet corn varieties. These were calculated based on the method introduced by Lusk and Schroeder (2006). To generate these values, bids served as WTP estimates to determine which version the subject would prefer at different prices under standard utility maximization. Specifically, subjects would be expected to select the version with the largest positive difference between their bid and that price. The overall share of subjects selecting one version at one price was compared to the share at a second price. Since bids were limited, the change in price was set at 5% from the mean bids to ensure a measurable share difference. The ratios of these share changes to price changes were the own-price elasticities. As an example, the own-price elasticity for conventional sweet corn was calculated using a price change from the mean bid of $1.51 to $1.59 with the formula:

$$\left[(S_{conv}^{1.59} - S_{conv}^{1.51}) / S_{conv}^{1.51}\right] / \left[(1.59 - 1.51) / 1.51\right],$$

where S is the share of consumers who would purchase conventional sweet corn at the indicated prices. Note that by this construction, the resulting values are arc-elasticities.

Standard deviations to accompany these elasticity estimates were calculated using bootstrap techniques, again following Lusk and Schroeder (2006). Here, 1,000 bootstrap samples were generated from the original sample and elasticities calculated for each sample. The standard deviations from these 1,000 estimates are the standard deviations reported. Cross-price elasticities and their standard deviations were calculated in an analogous fashion.

Tobit Models

Two-stage heteroskedastic tobit models were constructed to determine the WTP for the potato and sweet corn varieties, following Long (1997). The tobit model was appropriate to account for the censored nature of the data as bids were restricted to nonnegative dollar values. In the first stage, the belief variables were tested for endogeneity using the Hausman test (see Greene, 2000, for a full description) based on findings reported in Bernard and Bernard (2009) that suggested these could be a concern. First-stage regressions for each belief variable for each food were modeled as functions of the demographic variables collected and subjects' stated knowledge and opinions of GM foods and pesticides, as appropriate. Results confirmed *Belief GM* and *Belief Pesticides* were endogenous for both products with p-values < 0.0001, leading to the use of their predicted values from those regressions as instruments in the second stage of the models. For the second stage, estimations of bids and variances for each food variety were performed. Variances were additionally tested and, where necessary, corrected for heteroskedasticity.

For the model, it was assumed a latent variable bid^* existed representing each subject's true WTP for each potato (sweet corn). If a subject's true WTP was negative, the latent variable could not be captured by observed bids. In the relationship between the two, it was assumed there existed latent variables bid_{ij}^* representing subject i's bid for potato (sweet corn) version $j \in$ {conventional, non-GM, no pesticides, organic} that related to observed bids, bid_{ij}, by:

$$(5) \qquad bid_{ij} = \begin{cases} 0 & \text{if } bid_{ij}^* \le 0, \\ bid_{ij}^* = \alpha_j + \mathbf{x}\boldsymbol{\beta} + \varepsilon_i & \text{if } bid_{ij}^* > 0, \end{cases}$$

where α_j represents the intercepts for each food version, $\mathbf{x}$ represents a vector of relevant independent variables described in table 2 and dummy variables for the food attributes, and $\boldsymbol{\beta}$ is a vector of coefficients. The error term, ε_i, is independent and normally distributed with mean zero and variance $\sigma^2(\exp(\mathbf{z}_i\boldsymbol{\gamma}))$, where $\mathbf{z}_i$ represents another vector of independent variables, $\boldsymbol{\gamma}$ another vector of coefficients, and σ^2 is the variance when $\mathbf{z}_i\boldsymbol{\gamma}$ equals zero. The components of $\mathbf{z}_i$ are determined through testing the variables in $\mathbf{x}$ to identify whether they contribute to any heteroskedasticity in the model.

The nested aspect of the non-GM and no-pesticides parts within organic is captured by the following model based on equation (4):

$$bid_{ij} = \alpha_j + x_i\beta + \delta_N x_i \beta^N + \delta_P x_i \beta^P + \delta_O x_i \beta^O + e_{ij},$$

where δ_N is a dummy variable equaling 1 when $j \in$ {non-GM, organic}, δ_P is a dummy variable equaling 1 when $j \in$ {no pesticides, organic}, and δ_O is a dummy variable equaling 1 when the version is organic. Here, β captures how x_i influences the bid for the conventional versions, while β^N, β^P, and β^O capture the influence of x_i on bids for non-GM, no pesticides, and the remaining components of organic, respectively. Estimation is by maximum likelihood in the QLIM procedure in SAS (SAS Institute, Inc., 2003).

Hypotheses were considered for all variables in table 2. Previous studies have found mixed results with regard to the effect of age although, in general, older consumers were less willing to pay a premium for organic (Williams and Hammitt, 2000; Govindasamy and Italia, 1999; Loureiro and Hine, 2002). Higher levels of income have been associated with higher WTP for CPRF and organic produce; however, the threshold income level varied (Misra, Huang, and Ott, 1991; Huang, 1993; Govindasamy and Italia, 1999; Loureiro and Hine, 2002).

More educated consumers have been found to be less likely to pay a premium for either less pesticide residues or organic produce (Misra, Huang, and Ott, 1991; Thompson and Kidwell, 1998; Govindasamy and Italia, 1999). Females have been reported to have higher WTP compared to males (Huang, 1993; Govindasamy and Italia, 1999). The effect of the presence of children or household size on WTP was unclear, as studies have found mixed results (Thompson and Kidwell, 1998; Williams and Hammitt, 2000; Govindasamy and Italia, 1999).

It was hypothesized that consumers who had lived or worked on a farm would have lower WTP for the no-pesticides and organic produce versions. It was assumed those persons would have a better understanding of the use of pesticides, GM seed varieties, and other conventional farming practices and their relative safety. This knowledge would possibly translate into being less likely to purchase organic produce.

Finally, it was hypothesized that consumers with firmer beliefs that the conventional variety was either grown with the use of pesticides or was GM would have higher bids for the corresponding varieties of potatoes and sweet corn. It was hypothesized that the belief variables served as a proxy for consumers' knowledge and understanding, as well as possible concerns, of conventional farming practices. Several studies have found that higher WTP for CPRF produce, or greater likelihood to purchase organic, was associated with higher levels of concern about pesticide residues and support for the need to test for and certify produce as being pesticide-residue free (Misra, Huang, and Ott, 1991; Huang, 1993, 1996). Belief variables were also found to be significant for auction bids for different versions of milk in Bernard and Bernard (2009). In that study, the greater the belief by subjects that conventional milk came from cows treated with rBST or antibiotics, the higher their WTP to avoid these production practices.

Results

Elasticities

The own- and cross-price elasticities and their standard deviations for the four versions of potatoes and sweet corn are presented in table 3. As can be seen from several of the large standard deviations, some estimates were unlikely to be significant. However, the point estimates provide a useful guide of the possible relationships. Beginning with the own-price elasticities, the interest was in determining the relative price sensitivities among the different versions of each product. A similar pattern existed for both food items: conventional and organic versions tended to be relatively less sensitive to price changes. These suggested higher price responsiveness than had been reported for frozen vegetables, which ranged from −1.630 to −2.268 in Glaser and Thompson (1998), but were similar to many of the estimates

Table 3. Own- and Cross-Price Elasticities

	Potato Variety – 1% Price Change			
Potato Variety	Conventional	No Pesticides	Non-GM	Organic
Conventional	−3.15	1.77	1.97	1.20
	(0.85)	(0.58)	(0.72)	(0.64)
No Pesticides	4.97	−4.33	1.37	1.98
	(2.57)	(1.97)	(1.82)	(2.04)
Non-GM	4.26	4.36	−5.89	2.12
	(1.99)	(1.02)	(1.73)	(1.08)
Organic	0.49	1.77	2.00	−3.02
	(0.51)	(0.58)	(0.70)	(1.07
	Sweet Corn Variety – 1% Price Change			
Sweet Corn Variety	Conventional	No Pesticides	Non-GM	Organic
Conventional	−3.04	1.74	2.00	0.38
	(0.89)	(0.94)	(0.78)	(0.30)
No Pesticides	4.28	−8.85	2.82	2.12
	(2.43)	(2.33)	(5.03)	(1.07)
Non-GM	3.91	0.74	−6.40	2.40
	(1.83)	(1.16)	(1.74)	(2.63)
Organic	0.79	2.11	4.02	−4.54
	(0.49)	(0.84)	(0.94)	(1.34)

Note: Numbers in parentheses are standard deviations.

for fresh fruits in Lin, Yen, and Huang (2008). The two parts of organic—no pesticides and non-GM—were found to be highly price sensitive. These findings suggest consumers of conventional and organic would be less likely to shift their demand due to price changes, but consumers of the other two versions could shift their consumption patterns easily if prices changed. Marketers of these versions in particular need to be concerned with how price increases may alter their customer base.

Demand relationships were apparent from the cross-price elasticities. First, as would be anticipated, all versions were viewed as substitutes for one another. Of note, though, was the substantial degree of asymmetry in the patterns of substitution. The largest of these asymmetries appeared to be between the conventional versions and both the no-pesticides and non-GM varieties. Illustrating with an example, a 1% price increase in the price of conventional sweet corn would lead to a 4.28% increase in demand for the no-pesticides variety, while a 1% increase in the price of the no-pesticides variety would lead to only a 1.74% increase in demand for conventional. These results seem to confirm the notion that once consumers move to an extra attribute version, they are less likely to return to a base conventional version (Glaser and Thompson, 1998; Lin, Yen, and Huang, 2008). By the same analysis, price increases to conventional versions would find many consumers moving to one of the additional attribute versions. This was a positive finding regarding the market potential for such versions.

Still, it was somewhat unexpected that conventional price increases did not lead to large share increases for organic. Increases in prices of organic versions also tended to increase

Table 4. Effects of Variables on Error Variance

Potato Model			Sweet Corn Model		
Variable	Estimate	*p*-Value	Variable	Estimate	*p*-Value
Age	−0.024	< 0.001	*Age*	−0.019	< 0.001
Male	−0.730	< 0.001	*Male*	−0.467	< 0.001
College Plus	−0.913	< 0.001	*Children*	−0.366	0.005
Children	−1.572	< 0.001	*Farm Experience*	−0.349	0.017
Farm Experience	−0.795	< 0.001			
Belief GM	0.032	< 0.001			

demand for the component attributes more so than for conventional versions. Here it may be that consumers were not willing to substitute all the way toward conventional, and instead were attempting to substitute toward the component parts. Findings for price increases on either of the component attributes were more varied between the two products. With potatoes, increases in prices for a no-pesticides version appear to lead people to the non-GM option, while for sweet corn, the movement is more toward organic. This result could suggest avoiding pesticides is important enough to these consumers that they wish to retain the attribute while moving up to organic. This response pattern was also true with sweet corn for an increase in price of a non-GM version which showed a strong movement toward organic that would retain the non-GM aspect. In contrast, the demand response for non-GM potatoes was nearly equal between movement toward conventional and toward organic. In total, price changes appear to switch demand to the versions closest to the original, with a greater tendency toward versions with additional attributes.

Tobit Models

Continuing with the estimation of the tobit models, the null hypothesis of homoskedastic error variance was rejected. Sources of variation significant at the 5% level in each model are presented in table 4. For the potatoes model, the *Belief GM* variable was a source of variation, with the positive coefficient indicating that the larger the percentage belief that conventional potatoes may be GM, the wider the variance of the bids. In other words, some subjects with high beliefs regarding the potential for GM potatoes were willing to pay a lot to avoid GM, while others did not feel the need to pay more to avoid it. Also in the potatoes model, older persons, males, those with higher education, households with children, and those with farm backgrounds had narrower bid distributions. For the sweet corn model, fewer elements affected the variance. Neither beliefs about GM nor education level mattered, although the remaining variables were the same as with potatoes and with the same signs.

Regression results for the potatoes and sweet corn models, with coefficients significant at the 10% level or better identified by a single asterisk, are presented in tables 5 and 6, respectively. The primary interest in examining the two tables was in understanding how demographics could account for the differences in WTP and premiums discussed in table 1. The absence of remaining premiums left for organic after accounting for those for non-GM and no pesticides already noted can be observed in more detail across the demographics. For most variables, particularly in the model for potatoes, the differences in WTP for the remaining attributes of organic were not significant. In all instances where the variable for the remaining

Table 5. Two-Stage Heteroskedastic Tobit Regression Results for Potatoes (parameters and *p*-values)

Variable	Conventional	No Pesticides	Non-GM	Remaining Organic
Intercept	1.045*	−0.360	−0.156	0.068
	(0.019)	(0.566)	(0.805)	(0.939)
Age	0.010*	0.012*	0.009*	−0.007
	(0.091)	(0.015)	(0.083)	(0.409)
Income	0.002*	0.001	−0.001	0.001
	(0.071)	(0.898)	(0.870)	(0.505)
College Plus	0.033	−0.271*	−0.115	−0.249
	(0.850)	(0.095)	(0.517)	(0.309)
Male	0.242*	0.087	0.216*	−0.174
	(0.027)	(0.418)	(0.047)	(0.354)
Children	0.198	0.285*	0.274*	−0.453*
	(0.181)	(0.054)	(0.065)	(0.078)
Farm Experience	−0.062	−0.219*	−0.174*	0.013
	(0.602)	(0.053)	(0.084)	(0.949)
Belief Pesticides	0.002	0.010*	0.004	−0.004
	(0.612)	(0.081)	(0.554)	(0.670)
Belief GM	−0.005	−0.001	0.003	0.005
	(0.452)	(0.928)	(0.770)	(0.683)

Notes: An asterisk (*) denotes significance at the 10% level or lower. Numbers in parentheses are *p*-values.

Table 6. Two-Stage Heteroskedastic Tobit Regression Results for Sweet Corn (parameters and *p*-values)

Variable	Conventional	No Pesticides	Non-GM	Remaining Organic
Intercept	0.721*	0.290	−0.094	−0.031
	(0.041)	(0.556)	(0.849)	(0.965)
Age	0.005	0.018*	0.014*	−0.014*
	(0.272)	(< 0.001)	(0.001)	(0.047)
Income	−0.001	−0.003*	−0.001	0.002
	(0.589)	(0.097)	(0.466)	(0.524)
College Plus	−0.176	−0.224*	−0.060	−0.031
	(0.253)	(0.085)	(0.697)	(0.907)
Male	0.415*	0.188*	0.265*	−0.337*
	(< 0.001)	(0.096)	(0.014)	(0.073)
Children	0.068	0.207*	0.238*	−0.375*
	(0.571)	(0.089)	(0.049)	(0.073)
Farm Experience	−0.050	−0.290*	−0.077	−0.023
	(0.700)	(0.025)	(0.550)	(0.917)
Belief Pesticides	−0.007	0.010	0.002	0.006
	(0.253)	(0.914)	(0.853)	(0.599)
Belief GM	−0.005	−0.004	0.018*	0.002
	(0.613)	(0.725)	(0.011)	(0.909)

Notes: An asterisk (*) denotes significance at the 10% level or lower. Numbers in parentheses are *p*-values.

parts of organic was significant, its sign was negative and balanced against positive significant signs for the two examined pieces of organic. As an example, in both models, subjects with children in the household were willing to pay significantly more for both key components of organic, but the amount they were willing to pay for the remaining aspects of organic was less than the sum of these premiums, ceteris paribus. In the sweet corn model, this was additionally the case for both older consumers and males. Thus no demographic could be identified that was linked to a WTP more for the organic bundle than for the sum of the components.

Beyond demographics, the models also report on the influence of subjects' beliefs about the conventional versions of the products. The results here were mixed. For the potato model, the belief regarding the potential of the conventional version to have been grown with pesticides was significantly positive. A 1% increase in belief that conventional potatoes were grown with the use of pesticides meant that consumers' WTP for the no use of pesticides variety increased by 0.0098. In other words, a consumer with a 100% belief that conventional potatoes were grown with pesticides would be willing to pay \$0.98 more for those grown without pesticides compared to a consumer with a 0% belief. In the sweet corn model, it was the belief regarding the possibility the conventional version may be GM that mattered. Specifically, WTP was \$1.82 higher for a consumer with a 100% belief that conventional sweet corn was GM.

To summarize table 5, consumers who were older, less educated, had children in the household, had no farm background, and had a higher percentage belief that conventional potatoes were grown with the use of pesticides were found to have a higher WTP for the no use of pesticides version of potatoes. The set of consumers willing to pay more for non-GM potatoes was similar, with the addition of males having higher WTP, but education and beliefs about the conventional version were not significant. As considered in the conceptual framework, no category of consumers had higher WTP for the remaining attributes of organic potatoes that surpassed the sum of the premiums for no use of pesticides and non-GM. Households with children had a lower WTP for the remaining components of organic potatoes.

To summarize table 6, all of the demographic variables were significant in explaining consumer WTP for sweet corn grown without pesticides. These findings showed that consumers who were older, had higher income, were less educated, male, had children in the household, and had no farm background expressed a higher WTP for the no use of pesticides version of sweet corn. Those who were older, male, had children in the household, and had a higher percentage belief that conventional sweet corn was a GM variety were found to have a higher WTP for non-GM sweet corn. Again, no category of consumers had higher WTP for the remaining attributes of organic sweet corn that surpassed the sum of the premiums of the component attributes. Older consumers, males, and those with children present in the household had a lower WTP for the remaining components of organic sweet corn.

Conclusion

This study has examined demand relationships and WTP between conventional and organic potatoes and sweet corn and versions of those foods that featured two individual organic parts—no use of pesticides and non-GM. An understanding of how values for organic as a whole compared with the values for its parts was considered important in identifying market segments to match consumer interest and policies for promoting development of niche products. The research used bids from experimental auctions to determine own- and cross-price elasticities and to model WTP by demographics and beliefs held by consumers regarding conventional varieties.

For the demand relationships, all versions of each food were viewed as substitutes for one another, although with some asymmetries. In particular, price increases for conventional versions were much more likely to shift consumers toward the two organic parts than for the reverse to occur. This seemed to indicate consumers of products with extra attributes do not easily move away from them. Shifts between organic and its parts were larger than with conventional, suggesting the parts were viewed as strong substitutes for the whole.

In terms of WTP, consumers were willing to pay significant premiums for organic and its parts over conventional versions for both foods. In comparing the parts and the whole, however, the sum of the premiums for the parts was not significantly different than the premium for organic. While it cannot be said that the remaining parts of organic hold no value to consumers, our findings suggest that either their value within the bundle was limited or that substitution possibilities were very important in WTP estimates. These results support the importance of determining the appropriate set of relevant alternatives in WTP studies rather than considering bundles, such as organic, in isolation.

The WTP results further show the potential to develop market segments based on demographic characteristics. From a marketing, management, or policy perspective, these findings imply that a more efficient labeling system could be devised which could generate higher revenues for small farm operations and welfare for consumers. Small farm operations should consider the profitability of eliminating pesticides rather than facing the full cost of organic certification, since marketing fresh produce grown without pesticides could capture significant premiums. With respect to policy, it may be beneficial to move from a system of voluntary guidelines for non-GM food products to a certification program. Certification, if similar to the National Organic Program, could provide consumers with quality assurance and producers with the incentive to develop niche markets.

This study could be extended in several ways while addressing some limitations. The most obvious approach would be to expand on the products investigated, either within produce or beyond to examine part and whole relationships with processed organic foods. Another possibility would be to consider potential regional differences. Consumers in prominent potato-producing states such as Idaho and Washington and consumers in prominent corn-producing states such as Iowa, Illinois, and Nebraska may have different preferences. A third issue would be the set of alternatives presented. Considering potatoes, possible relevant alternatives such as red potatoes or sweet potatoes were not addressed. More research may be needed to determine when the set of alternatives becomes too confusing for subjects. The same holds for the product attributes to include. While two prominent parts of organic were employed here, it remains uncertain how a more complete set of parts may affect findings.

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