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Consumer Likelihood to Purchase Chickens with Novel Production Attributes

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Typical supermarket chickens are produced with novel or controversial attributes. This continues despite contrasting growth in consumer interest in organic and natural foods. This study surveyed Delaware consumers' likelihood to purchase chicken given different attributes: free range, given antibiotics, irradiated, fed genetically modified (GM) feed, GM chicken, and price. Examining conjoint analysis data with a heteroskedastic two-limit tobit model, GM chicken and other novel attributes were found to lower purchase likelihood significantly. Understanding these results should help the industry meet consumer preferences while aiding its continued expansion to benefit workers and growers across the South.

Key Words: antibiotics, chicken, conjoint analysis, genetically modified, heteroskedastic, irradiated, tobit

JEL Classifications: Q13, D12, C24

Chicken attributes have changed as new technologies have been applied to production. For example, today a large percentage of the corn and soybeans grown in the United States and used for chicken feed are genetically modified (GM) varieties. Additionally, the use of irradiation on chicken products to help prevent foodborne illnesses has been granted increasing approval over the last 15 years. Yet these technologies are ones that consumers continue to have little awareness or understanding of. The possibility of a GM chicken, while currently hypothetical, could further confuse or alarm consumers. Other existing attributes, such as antibiotic use, although perhaps more familiar to consumers, may be viewed negatively or with uncertainty.

These issues and concerns, which are not unique to the chicken industry, have led to an increase in consumers' awareness and concern for what is involved in the production of their food and what consequences their families may face in terms of food safety. The food industry has responded over the past decade with the development of organic and natural versions of many products. These markets began as small niches, but have grown substantially over recent years with expanding offerings in most supermarket chains and at giant retailer Wal-Mart. Organic foods alone have seen sales increases commonly cited as 20% per year, with a strengthening since the certification program of the U.S. Department of Agriculture (USDA) (Dimitri and Greene).

The concern motivating this research was how the introduction of novel attributes into the production of chicken may affect consumer purchase intentions, particularly in light of consumer movement toward organic and

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natural offerings. The response will be important if the industry is to continue to increase consumption as it has since the 1940s. This steady rise in popularity led chicken to surpass pork in 1993 to become the second most consumed meat in the United States (after beef) at 26.85 kg (59.2 lbs.) per capita per year in 2004 (Buzby and Farah). Part of this growth in chicken consumption came when consumer preferences toward beef changed due to health concerns regarding consumption of red meat. During the 1980s in particular, there was increased promotion of chicken as a healthier alternative. The question would be if the new technologies that are or could be used in the production of chicken may change consumer health or safety perceptions and impact consumer likelihood to purchase chicken.

The current structure of the chicken industry and the firms within it is of high concentration and almost complete vertical integration. Production is concentrated with the primary firms, referred to as integrators, operating in the South, with Georgia and Arkansas the top two producing states. Most of the integrators use similar methods of production. These include the common use of GM feeds and, at least in the past, the use of antibiotics for both therapeutic and subtherapeutic reasons. Changes in consumer purchase patterns could have a dramatic effect, especially if the industry were slow to recognize and adjust to consumer changes. Such shifts would affect not just the integrators, but the large number of growers and workers throughout the South. In addition, consumers would be worse off if chicken products in the marketplace did not match their preferences.

The purpose of this research was thus to examine how several attributes influence consumers' likelihood to purchase chickens. Six attributes were selected: price, fed GM feed, GM to improve production, irradiated, treated with antibiotics, and free range. Price was chosen for its obvious influence on purchase intentions, while the next four were included as the most likely novel or controversial attributes to influence consumer decisions. The last attribute, free range, was added as one consumers may look upon favorably. A conjoint analysis survey of consumers in Delaware was administered to examine these issues. Use of a survey over other elicitation methods was needed because of the hypothetical nature of a GM chicken and some of the combinations of attributes selected to explore. Measuring purchase likelihood instead of willingness to pay (WTP) was done in acknowledgment of the extensive literature demonstrating problems with estimating the latter from surveys (Lee and Hatcher; Voelckner). Data were analyzed with a two-limit tobit regression model, to account for the common instances of censoring in responses, with the incorporation of corrections for heteroskedasticity.

Background

Several studies have looked at one or more of the attributes considered here. This is especially true with regard to foods containing GM ingredients. Genetic modification is accomplished by inserting genes from one species into the DNA of another species. This alters an organism's DNA to meet a specific purpose such as accelerating growth or improving its resistance to insects or diseases. It allows genetic researchers to add desired traits to plants or animals more rapidly than could typically be done through traditional breeding.

The successful first generation GM applications have been crops. GM soybeans were the most widely and rapidly adopted GM crops in the United States, with 81% of total soybean plantings in 2003 being GM varieties (USDA-ERS, 2003a). These primarily consisted of Roundup Ready soybeans, resistant to the herbicide Glyphosate. For corn, 40% of the total U.S. crop was GM (USDA-ERS, 2003b). The major variety was Bt corn, genetically modified to protect the plants from the European corn borer. Since these are the two primary feed ingredients, chickens are highly likely to have consumed GM feed.

The quick adoption has not been without critics. Although there is no accepted evidence showing GM foods are harmful to humans, concerns have been expressed by various

groups. These include issues regarding health, food safety, and the environment. The controversy has led to researchers examining consumer acceptance and WTP for GM food products. Many of these were reported in a meta-analysis by Lusk et al. Their summary of the studies indicated consumers on average were willing to pay between 23% and 42% more for a non-GM version of a food. While these results varied to some extent by region and elicitation method, it was apparent that GM components should lower purchase likelihood.

Fewer studies have dealt with GM meat products, although consumers tend to be more concerned and less accepting of GM animals (Knight; Pew Initiative). An intermediate issue would be consumer response to animals fed GM feed. Limited work has revealed U.S. consumers willing to pay premiums to avoid such foods, but less than their European counterparts (Lusk, Roosen, and Fox). Lusk et al. examined five studies looking at WTP for GM meat products, four of which used conjoint analysis. Corresponding to the GM chicken here, their model showed consumers willing to pay a 39–45% premium to avoid a GM meat product with no consumer benefit. This would suggest a rather large decrease in likelihood to purchase in the framework here. A few studies have focused directly on GM chicken. Heiman, Just, and Zilberman found Israeli consumers preferred GM chickens to prevent disease over chickens treated with antibiotics. West et al. identified a niche market for GM chicken with health benefits among Canadian consumers, albeit at a reduced price relative to conventional chicken. In contrast, Larue et al. found many Canadian consumers would avoid buying GM chicken breasts even if the modification made the product more heart healthy.

Irradiation is another novel attribute. During food irradiation packaged or bulk food is treated with ionizing radiation energy. Commercial irradiation equipment uses either gamma rays, electron beams, or X-rays to expose food products to ionizing radiation. Although it is an older technology, the Food and Drug Administration (FDA) first approved its use on poultry in 1990. In 1992, the USDA's Food Safety and Inspection Service approved guidelines for use of irradiation in raw packaged poultry. The primary purpose of irradiating chicken is to enhance food safety by reducing pathogens. The FDA requires that irradiated foods be labeled.

Like GM foods, the use of irradiation is not without controversy, and few food processors offer irradiated foods. Limited markets for irradiated poultry developed in the mid-1990s for healthcare or foodservice establishments serving customers at higher risk of foodborne disease. The small size of the irradiated food market has been attributed to both the high capital cost of the equipment and the perception among food manufacturers that few consumers are willing to purchase irradiated foods. Advocates believe the practice is a safe and useful means to kill bacteria within foods. However, opponents believe irradiation lowers food quality and raise environmental concerns over the radioactive materials used in the gamma ray technology.

Results on consumer attitudes toward irradiation have varied. Frenzen et al. found consumer concerns over purchasing irradiated poultry included insufficient information about risks and benefits, concerns about safety of consuming such food, environmental impact, price, and taste or appearance. Hwang, Roe, and Teisl showed definite consumer concerns. In an early study, Nayga found males, the higher educated, and those with higher incomes viewed irradiation as safer than other consumers. However, studies that include education on the reasons for irradiation have shown consumers willing to pay a premium (Nayga, Poghosyan, and Nichols; Nayga, Woodward, and Aiew; Shogren et al.). In Hayes, Fox, and Shogren it was determined that negative information could outweigh positive, suggesting a good amount of skepticism about the technique. This study used a short neutral description of irradiation and its purpose.

Antibiotic use may also attract consumers' attention and concerns. Antibiotics may be given at high dose levels to prevent or treat disease or at low levels to increase feed efficiency while raising a chick (Mathews,

Buzby, and Tollefson). Use of antibiotics in poultry production for increasing feed efficiency has been controversial since the practice began. Although a withdrawal period is required from administering antibiotics before a bird can be slaughtered, some fear drug residues may remain in birds or livestock, enter into final food products, and cause human illness (Mathews). Additionally, scientists have found that some microorganisms are becoming resistant to antibiotic drugs (Mathews, Buzby, and Tollefson). This raises concerns about the role of antibiotics in food-producing animals and their possible threats to human health. Recently, because of these issues, large poultry companies such as Tyson and Perdue have moved away from subtherapeutic antibiotic use (Weise). Concerns persist, though, since research shows that antibiotic resistance may be passed down from parents to chicks (Smith et al.).

Consumer concerns with antibiotic use on animals have been previously reported. The Nayga study determined that white, male, younger, and more educated consumers felt meat from treated animals was safer than other consumers believed, as long as the dosage was within approved levels. This implied that demographics could be important in purchase likelihood. Consumers in Hwang, Roe, and Teisl, however, selected antibiotic use as their third highest food technology concern after pesticides and hormones. Since neither of the latter applies to chickens, this suggested that antibiotics would be a major determinant of purchase likelihood. In terms of pricing, Lusk, Norwood, and Pruitt found consumers willing to pay substantial premiums for pork produced without antibiotics. Their study was in part to analyze welfare effects of a governmental ban on subtherapeutic antibiotic usage. In such a case, no other option would be available to consumers, potentially increasing prices beyond their WTP.

The final production attribute considered was free range. By definition, a chicken is free range if it is allowed access to the outside during its raising (USDA-FSIS). While free range is only one component to the requirement for an organic chicken, in Harper and Makatouni many consumers believed the two were equivalent, or at least that the animal welfare issue was the key element. Similarly, Carlsson, Frykblom, and Lagerkvist found animal welfare attributes to have among the highest WTP of a series of production attributes. These correspond with growing awareness in the United States and European Union about free-range chicken, with more consumers interested in an alternative to factory farm poultry and eggs (Mitchell). However, large space requirements mean farmers must purchase more land or keep fewer chickens. Thus consumer likelihood to purchase will play a role in the extent to which this market develops.

While the attributes examined here have been looked at in past studies in various forms, there is still much to learn about consumer purchasing intentions for each. There also are benefits to looking at the attributes in combination. As noted in Hwang, Roe, and Teisl, studies typically examine attributes in isolation, or perhaps in pairs. Limiting the possible attributes consumers are asked to consider eliminates the potential for them to consider the overall product as it is available in the market. If there exists a dynamic nature to consumers' preference formation among these attributes it would be missed in studies on smaller sets. By using a major commodity in chicken and a wide set of attributes, important new information can be gained from the current study.

Conjoint Design

Conjoint analysis has been used to measure buyers' acceptance or preference among multi-attribute products for a wide variety of problems in consumer research since the 1970s (Green and Rao; Johnson). It has been used in literally thousands of studies and has been detailed in many sources, including Louviere. New product evaluation, repositioning, competitive analysis, pricing, and market segmentation are the principal types of application (Wittink and Cattin). In food areas, conjoint analysis has been used to assess consumers' acceptance and preferences of porcine somato tropin (PST)

supplemented pork (Halbrendt et al.), fruits and vegetables (van der Pol and Ryan), wine (Gil and Sanchez), olive oil (Martinez, Aragones, and Poole), GM labeling formats (Harrison and Mclennon), and numerous other products and practices. A strength of the technique is its ability to evaluate hypothetical products, such as the GM chicken included here.

The primary methods of conjoint analysis are ratings based and choice based.[1] Ratings-based analysis has a long history while choice-based analysis has become prominent recently.[2] Studies, however, have been unable to demonstrate empirically the superiority of either, and how to select the appropriate conjoint method remains an open question (Bradlow). Moore has claimed the better method depends on the nature of the attributes. His comparison suggested that when levels of attributes are easy to compare, a prominent attribute is more likely to dominate a respondent's decision in a choice-based than a ratings-based setting. Given concern that the GM chicken attribute could overwhelm consumer's choice consideration, and experience with past successful studies, ratings-based conjoint was selected for this research.

Designing a conjoint experiment involves selecting attributes and setting their levels, which combine to generate complete product profiles. The product being investigated in this study was boneless, skinless, chicken breasts from a nationally known (but unidentified) brand. The first attribute, price, was chosen based on economic theory and past studies (Gil and Sanchez; Halbrendt et al.; van der Pol and Ryan). The other attributes were selected because of their importance in consumers' purchasing decisions and based on the literature above. Each of these attributes was set at two levels, indicating either its presence or absence.

Several factors were considered in selecting price levels. First was the U.S. city average price for bone-in chicken breast, which was \$2.10 per pound for the period January 1993 to June 2002 (Bureau of Labor Statistics). Second, prices were manually collected for boneless chicken breast from several supermarkets in Delaware. The lowest price was \$0.99 per pound and the highest \$5.99 per pound. The final consideration was the model design. Since it was hypothesized that price would have a quadratic relationship with purchase likelihood, a minimum of three price levels were needed. However, there was an interest in capturing reaction to some of the extreme prices in the market. Thus to the necessary three prices, generated within a reasonable range of the average, two outlying prices were added. Using a constant increment of \$1.30, the five prices were \$0.99, \$2.39, \$3.59, \$4.89, and \$6.19 per pound.

In ratings-based conjoint analysis, consumers are presented product profiles comprised of the different levels of attributes and asked to rate these according to their preferences. Given five levels for price and two levels for the other five attributes, $5 \times 2 \times 2 \times 2 \times 2 \times 2 = 160$ possible chicken profiles were generated. Since it is infeasible for respondents to rate 160 profiles, the number was reduced through fractional factorial design using Clark's conjoint designer software (Box, Hunter, and Hunter). This technique reduces the number of profiles to rate while retaining sufficient information to estimate the main effects for each attribute. A disadvantage of this design is that it does not allow estimation of interactions among the attributes, although this concern has been shown to have only limited effect on analysis (Harrison, Özayan, and Meyers).[3] Estimation of interactions between attributes and demographics remains feasible.

[1] Rankings are seldom used in modern studies for several reasons, including the inability to allow for ties in subject preferences (Boyle et al.).

[2] Proponents of choice-based analysis commonly cite its ability to more closely mimic a consumer's task in the marketplace (Elrod, Louviere, and Davey). Mackenzie and others have supported ratings-based analysis since it can provide more information for analysis.

[3] Other limitations exist, often involving reliability concerns that can affect interpretation. These include issues such as the repeatability of the results over time, changes in results from different profile sets, influence of the number of attributes, and the method of collecting responses (Reibstein, Bateson, and Boulding).

Table 1. Conjoint Profiles

Profile	*Block*	*Price*	*GMfed*	*FreeRange*	*Irradiated*	*Antibiotics*	*GMchicken*
1	1	$0.99	No	No	No	No	No
2	1	$2.29	No	No	Yes	Yes	Yes
3	1	$3.59	Yes	No	Yes	No	No
4	1	$4.89	Yes	No	No	Yes	Yes
5	1	$6.19	Yes	Yes	No	Yes	No
6	1	$2.29	Yes	Yes	Yes	No	Yes
7	1	$3.59	No	Yes	Yes	Yes	No
8	1	$4.89	No	Yes	No	No	Yes
9	2	$0.99	Yes	Yes	Yes	Yes	Yes
10	2	$2.29	Yes	Yes	No	No	No
11	2	$3.59	No	Yes	No	Yes	Yes
12	2	$4.89	No	Yes	Yes	No	No
13	2	$6.19	No	No	Yes	No	Yes
14	2	$2.29	No	No	No	Yes	No
15	2	$3.59	Yes	No	No	No	Yes
16	2	$4.89	Yes	No	Yes	Yes	No

Fractional factorial design reduced the number of profiles to 16. Despite this, Halbrendt et al. and others have suggested that rating more than 10 product profiles can lead to respondent fatigue. To maintain a manageable number of profiles for respondents to consider, a pseudo-attribute block was introduced. The 16 profiles were divided into two blocks, shown in Table 1. To allow for a check across the blocks, one profile, selected randomly from each, was added to the other block giving each nine product profiles for consumers to rate.

Data

Data for the research were collected through a mail survey of 1,000 randomly selected Delaware consumers in 2003.[4] Delaware was selected in part because of the importance of the industry to the state's economy. The total value of chicken production was $597.88 million in 2001, which accounted for 70.4% of Delaware farm sales (USDA-NASS 2003a). Delaware growers produced 257.4 million broiler or roaster chickens in 2002 (USDA-NASS 2003b), ranking 10th in the number of birds produced and seventh in value of production. Sussex County remained the number one producing county in the United States. It was thus believed Delaware consumers would be interested in the survey, aiding in response rate.

The survey was conducted in multiple stages, following Dillman. In the first stage, a prepostcard announcement was sent to the full mailing list. A few days later the first full mailing was sent. This included a cover letter, the survey, a description of the attributes, a stamped return envelope, and one dollar. Half of the respondents were randomly selected to receive block one profiles while the second half received block two profiles. Code numbers were included on the return envelope to reduce the size of future mailings. The following week a postcard reminder was sent. Finally, a second full mailing was sent to all that had not responded.

The survey consisted of two sections. The first contained the nine profiles for respondents to rate according to their purchasing likelihood. The second section contained questions to collect demographic information, including age, gender, education, and income. A sheet of attribute descriptions was included to ensure that respondents understood the definitions. The descriptions were designed to be neutral so as to not influence respondents.

When the survey was closed, 498 had been returned. We subtracted the 10 surveys that

[4] The sample was purchased over the Internet from USAData.

Table 2. Characteristics of Respondents

Category	Survey Percent	State Census Percent
Age		
Under 25	2.54	6.60
25 to 34	16.03	13.90
35 to 44	19.85	16.30
45 to 54	23.66	13.30
55 to 64	18.07	9.10
65 or above	19.85	12.90
Gender		
Female	46.17	51.40
Race		
White	88.40	74.60
African American	6.44	19.20
Other	5.16	6.20
Education		
Less than high school	0.26	17.40
High school	20.20	31.40
Some college	30.18	26.10
College	28.64	15.60
Post graduate	20.72	9.40
Income		
Below $15,000	2.49	12.20
$15,000 to $34,999	14.13	23.50
$35,000 to $74,999	45.43	38.20
$75,000 to $99,999	15.30	12.10
$100,000 or above	22.65	14.00

were undeliverable and calculated a 50.3% response rate. Demographic information for the sample is given in Table 2. Where applicable, these numbers were compared to the state census figures. These showed the sample to be more highly educated, have higher incomes and be less racially diverse than the census indicated, which is common to many surveys.

Model and Hypotheses

Consumers' likelihood to purchase was modeled as a function of the product attributes, respondent demographics, and the interactions between the attributes and demographics. The first and last of these categories were the primary elements of interest. As is standard in conjoint studies, a key goal was to determine how various types of consumers respond differently to attributes. The demographics themselves add little information for analysis but are included for completeness. This created the potential for a large model given the six attributes and several demographic factors collected. To alleviate this concern, likelihood ratio tests were planned to eliminate demographics and interactions where consumer responses were found homogeneous.

For each profile, consumers' likelihood to purchase was restricted to be between 0 and 10, where 0 meant definitely not purchase and 10 meant definitely purchase. This results in both an upper and lower censoring of the data for the dependent variable, making either the two-limit tobit or ordered probit model possible methods for analysis.[5] Past studies have shown that both lead to consistent results (Boyle et al.; Harrison and Sambidi; Harrison, Stringer, and Priyawiwatkul). Concern has been expressed, though, with using the former on ratings data since the data are ordinal (Harrison, Gillespie, and Fields). In other words, respondents may not use a uniform ratings scale. Use of ordered probit depends on the parallel regression assumption (Long).[6] For this data set, the assumption was rejected, making ordered probit inappropriate.[7]

A larger issue was the possible existence of heteroskedasticity. Tobit, probit, and other models will produce inefficient estimates when heteroskedasticity exists (Haefele and Loomis). A model was fitted that estimated the variance as a function of the attributes and demographic variables in a fashion similar to Bernard, Zhang, and Gifford. Analysis of these potential sources was conducted using the procedures available in SAS's QLIM procedure.

[5] Another option would be to consider the panel nature of the data resulting from each subject making several ratings. Examination with LIMDEP found no evidence of a common random effect, and this approach was not found to be feasible with these data (Greene). Au: In the sentence beginning "Examination with LIMDEP" please spell out or explain LIMDEP unless it will be understood by your readers.

[6] Also known as the parallel slopes assumption, or, for ordered logit, the proportional odds assumption.

[7] An ordered probit analysis was conducted despite this, and the results, as in the aforementioned studies, were not different from the tobit results reported here.

For the two-limit tobit model it is assumed there exists a latent variable y^* representing each respondent's likelihood to purchase each profile (Rosett and Nelson). For example, a profile with a highly undesirable attribute, such as a high price, may well be given an internal negative value that can only be observed as a zero rating. Thus interest lies in this latent variable. The observed profile rating, y, is related to y^* by

$$
\begin{aligned}
& y_i = 0 && \text{if } y_i^* \le 0, \\
(1) \quad & = y_i^* = x_i\beta + \varepsilon_i && \text{if } 0 \le y_i^* \le 10, \\
& = 10 && \text{if } y_i^* \ge 10,
\end{aligned}
$$

with

$$\varepsilon_i \sim N\left(0, \sigma^2(\exp(z_i\gamma))\right).$$

In this general form, x_i represents a vector of relevant independent variables and β is a vector of coefficients. The error term, ε_i, is independent and normally distributed with mean zero and variance $\sigma^2(\exp(z_i\gamma))$, where z_i represents a second vector of relevant independent variables, γ is a second vector of coefficients, and σ^2 is the variance[8] when $z_i\gamma$ is zero.[9] An advantage of this model is that since the latent variable is the one of interest, model coefficients may be interpreted as in ordinary least squares regression. The model was estimated using maximum likelihood through use of the QLIM procedure in SAS (SAS).

Hypotheses generated *a priori* were used to construct the initial variables of the vector x. The first were made with respect to the attributes. It was believed that, given their possible controversial aspects and probable lack of consumer understanding, consumers would be less likely to purchase GM chickens and those fed GM feed or irradiated. It was additionally thought that GM chicken, being the most novel, would have the largest negative effect. The use of antibiotics was also anticipated to lower purchase likelihood, despite the technology being better understood. Free-range chicken was hypothesized to increase purchase likelihood since consumers may be concerned about animal welfare. A negative relationship was anticipated between price and purchase likelihood. Price squared was included, and expected to be positive, to allow the rate of decrease in purchase likelihood to decrease with increasing price.

The remaining hypotheses were generated for interactions between demographic variables and the attributes. Results of previous studies suggested that gender, age, income, education, and the existence of children under 18 in the household should be considered relevant to consumer responses to the attributes.[10] Beginning with gender, it was expected that females would tend to have lower likelihood to purchase GM or irradiated chicken and potentially for fed GM feed and antibiotic use. Females were also hypothesized to be more sensitive to price levels, with a negative interaction with price. Hypotheses for households with children under 18 were the same, except for the price relationship. The rationale for these was that parents would be hesitant to purchase foods if they had concerns about health effects on their children.

Interactions for age and income with price were hypothesized next. For the latter, with higher incomes, price should not be as important and thus a positive sign would be expected. With age, the interaction with price was uncertain. Hypotheses for age were also created for the remaining variables, again with the signs uncertain. Younger consumers may not view technologies such as GM to be as novel as older consumers and may be more accepting. However, it may be that younger consumers are more interested in organic and natural foods. Similarly, the hypothesized signs for education were uncertain. It may be that educated consumers are better able to understand the technologies resulting in greater acceptance. However, better understanding

[8] Thus this term plays a role similar to the intercept in the means part of the model.

[9] Other choices for the functional form of the variance are possible. The one used was chosen because it always estimates a positive variance.

[10] Race was also briefly considered, but tests conducted for both the mean and variance found it to be insignificant.

Table 3. Variable Names and Definitions

Name	Definition
Block	1 if respondents completed the second block of profiles, 0 for the first block
Price	Price per pound for chicken, in dollars
GMfed	1 if chicken was fed GM feed, 0 otherwise
FreeRange	1 if chicken was free range, 0 otherwise
Irradiated	1 if chicken was irradiated, 0 otherwise
Antibiotics	1 if chicken was treated with antibiotics, 0 otherwise
GMchicken	1 if chicken was GM to improve production, 0 otherwise
Female	1 if respondent was female, 0 if male
Income	Income of respondent, in thousands
Under18	1 if there were children under the age of 18 in the respondent's household, 0 otherwise
Age	Age of respondent, in years
SomeColl	1 if respondent's education was some college or higher, 0 if respondent had a high school education or less

could lead to concerns about the technology and lower likelihood to purchase.

Finally, previous studies generally assumed that variations did not exist across respondent demographics, and therefore the model error variance was assumed to be homoskedastic. Bernard, Zhang, and Gifford found that education and gender were sources of model heteroskedasticity. It was hypothesized here that any of the attribute or demographic variables could influence the model error variance. However, it was anticipated that the nonprice attributes of chicken would not be significant following similar results found in Bernard, Zhang, and Gifford. In addition, it was hypothesized that interactions between price and price squared with the demographic variables could also be a source of heteroskedasticity. While it seemed likely these variables could have an effect, it was not certain what that would be.

Results and Discussion

The model was first estimated based on the above hypotheses. This formulation was examined using likelihood ratio tests on each section of demographics and their interactions with the attributes. These test results unexpectedly revealed a large degree of respondent homogeneity. With the completion of testing, the only meaningful interactions were between age and gender and the attribute price. This suggested that for the nonprice attributes, there was a high degree of similarity in consumer likelihood to purchase reaction. These elements were removed from the model in the interests of clarity and simplicity. For the final model, the explicit form for y_i was

$$
\begin{aligned}
y_i^* = {} & \beta_0 + \beta_1 Block_i + \beta_2 Price_i \\
& + \beta_3 GMfed_i + \beta_4 FreeRange_i \\
& + \beta_5 Irradiated_i + \beta_6 Antibiotics_i \\
& + \beta_7 GMchicken_i + \beta_8 Female_i \\
& + \beta_9 Female_i * Price_i + \beta_{10} Income_i \\
& + \beta_{11} Under18_i + \beta_{12} Age_i \\
& + \beta_{13} Age_i * Price_i + \varepsilon_i,
\end{aligned} \tag{2}
$$

with

$$\varepsilon_i \sim N(0, \sigma^2(\exp(z_i\gamma)))$$

and

$$
\begin{aligned}
z_i\gamma = {} & \gamma_1 Price_i + \gamma_2 Price_i^2 + \gamma_3 Female_i \\
& + \gamma_4 Age_i + \gamma_5 Income_i + \gamma_6 SomeColl_i,
\end{aligned}
$$

where the variables are as defined in Table 3 and ε_i is the error for the ith respondent. The errors are independent and normally distributed with mean zero and variance $\sigma^2(\exp(z_i\gamma))$.

Another important concern in estimating the model was to identify whether the maximum obtained was global rather than

Table 4. Likelihood to Purchase Heteroskedastic Two-limit Tobit Regression Results

Model Section	Parameter	Estimate	Standard Error	*p*-Value
Regression				
	Intercept	9.2886	0.8300	<.0001
	Block	0.2677	0.1710	.1174
	Price	−0.6421	0.2079	.0020
	GMfed	−0.7455	0.1620	<.0001
	FreeRange	−0.1371	0.1599	.3911
	Irradiated	−1.1129	0.1696	<.0001
	Antibiotics	−0.6062	0.1612	.0002
	GMchicken	−1.4934	0.1629	<.0001
	Female	−1.0173	0.4186	.0151
	*Female * Price*[a]	0.2208	0.1158	.0567
	Income	0.0068	0.0021	.0012
	Under18	−0.9668	0.1744	<.0001
	Age	0.0176	0.0148	.2343
	*Age * Price*	−0.0184	0.0041	<.0001
Variance				
	Sigma	6.1824	0.6494	<.0001
	Price	−0.8652	0.0945	<.0001
	Price squared	0.1213	0.0139	<.0001
	Female	0.3060	0.0719	<.0001
	Age	0.0127	0.0024	<.0001
	Income	−0.0018	0.0009	.0455
	SomeColl[a]	−0.1725	0.0894	.0536

[a] Although these *p*-values are slightly above .05, the *p*-values in the corresponding likelihood ratio tests used in determining the model were below this level.

local. For homoskedastic tobit models, a simple change of variables makes the log-likelihood function have a negative semi-definite Hessian so that it has a unique maximum (Olsen). There is no such result, however, for heteroskedastic models, making estimation more complex. Several convergence methods available in SAS were invoked yielding two different local maxima, −6642.238 and −6642.407.[11] Results reported in Table 4 for the final model's regression and variance are based on the larger maximum.

The potential adverse impact on consumer purchase likelihood of novel or controversial attributes was immediately apparent in the regression results. All parameter estimates for attributes in these categories were negative and significant. The attribute found to lower likelihood to purchase the most was GM chicken, which lowered a consumer's rating by nearly 1.5. This was consistent with hypotheses and would suggest that it would be difficult to introduce such a product. Such a product appears to be too novel for the average consumer to accept, which is consistent with previous studies mentioned earlier that have found consumers to be more concerned about the application of biotechnology to animals than plants.

Irradiation was found to have the next largest negative impact, lowering a consumer's rating by 1.1. This was also as hypothesized and may suggest that although this is an older technology, consumers remain unfamiliar with and uncertain about it. While other studies appear to show education makes consumers more accepting of irradiation, in the absence of a compelling argument consumers remain

[11] While this is a very small difference, there were several changes in the coefficients that were greater than 10%, specifically price, gender, gender by price interaction, and age. The *p*-value for the gender by price interaction is 0.0567 in the first and 0.1292 in the second. The other conclusions remained the same.

uninterested. Given that irradiated chicken is mostly absent from the market, this may already be understood by the industry. The issue would be the response if one sizeable, or a series of smaller, prominent food scares involving chicken were to occur. Without an obvious and cogent reason for irradiation, it appears consumers will continue to see no need for such a product and avoid those placed on the shelves.

The next largest negative effect was for the attribute fed GM feed, lowering consumer likelihood to purchase by 0.7. While the sign met expectations, the magnitude was somewhat surprising given the small premiums to avoid such animals in Lusk, Roosen, and Fox. The result here was believed to be further indication of the low degree of knowledge of the existence and use of GM crops by the average consumer. Since there are currently no label requirements for chicken fed GM feed and there has been limited media coverage in recent years, many consumers remain unaware of the existence of this attribute (Bernard, Pan, and Sirolli). The question remains how a change in this awareness, such as through a labeling requirement, would influence consumer purchasing. Those involved in the industry should be ready for possible shifts in consumer reaction to chicken products if the situation were to alter.

The negative results for antibiotics were also anticipated, although in this case the extent was less than expected. Survey respondents were found to be much more aware of this technology than the above novel and controversial attributes (Bernard, Pan, and Sirolli). While also controversial, the lack of novelty may have contributed to the lower negative effect. As it was, the negative effect was additional evidence to support the industry's move away from this practice. It could also lend weight to further governmental consideration of a ban at least on subtherapeutic antibiotic usage.

The insignificant attribute was free range. This result was surprising since it was designed to capture a main component of the purchasing desire for organic chicken, and it was in contrast with Harper and Makatopuni and Carlsson, Frykblom, and Lagerkvist. One interpretation could be that there is only a small segment of consumers who consider this attribute important when purchasing chicken. However, it may be that when considering this attribute within profiles containing negatively viewed attributes, the animal welfare component was overwhelmed by concerns of personal welfare. Either way, the potential market for organic chicken was already established above, since the most negatively viewed attributes were all those that organic prohibits.

Two demographic variables, gender and age, had significant interactions with price. These effects can best be observed graphically. Figure 1 shows ratings for males and females based on price. As expected, for both genders, the likelihood to purchase decreased as price increased. Examining Figure 1 in more detail revealed that for lower prices, females were more sensitive but for higher prices males were more sensitive. However, the changeover did not occur until near the upper extremes of prices used in the design. This could suggest that males were in general less concerned about price, but reacted more dramatically to high prices.

Figure 2 displays ratings for various ages based on price. As with gender, purchase likelihood decreased and sensitivity to price among the categories switched as prices increase. At lower prices, younger consumers were the most sensitive and the oldest consumers the least. This reversed at a price point relatively near the average market price at the time of the study, and clearly lower than the gender crossover occurred. At the highest price levels, the difference in sensitivity across the ages became more pronounced. For the top price category, the oldest consumers had nearly a one point lower rating than the youngest consumers. This discrepancy and price sensitivity will be important as the population ages.

Four demographic variables remained in the model because of their significance, although their use in analysis was limited. The first two of these, age and gender, had more meaningful interactions with price as

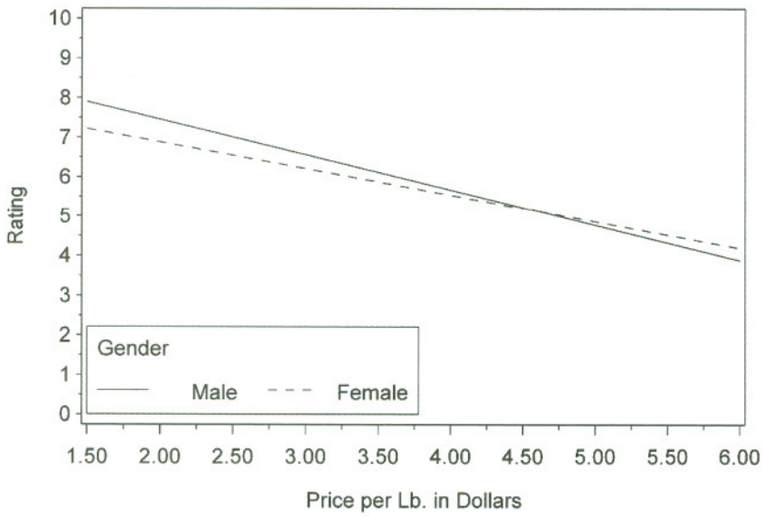

Figure 1. Interaction between Gender and Price

discussed above. Income and having children under 18 in the household also influenced overall ratings of the profiles. Finally, note that the variable block was insignificant, meaning that responses were not dependent on which of the two sets of profiles they received. This additionally demonstrated the success of the conjoint design used.

For the variance results, there were several interesting findings. Based on results, the model needed to be adjusted for heteroskedasticity for the following variables: price, price squared, gender, age, income, and some college education. The effect of price on variance was found to be negative and the effect of price squared was positive. This relationship can best be observed graphically in Figure 3. The variance was lowest in the middle range of prices, which reflect those most commonly faced by consumers. At both the high and low ranges, the variances were substantially higher. For the lower price

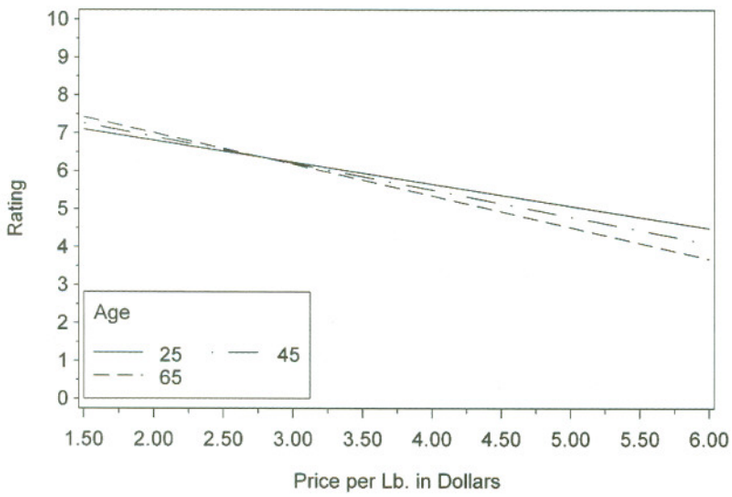

Figure 2. Interaction between Age and Price

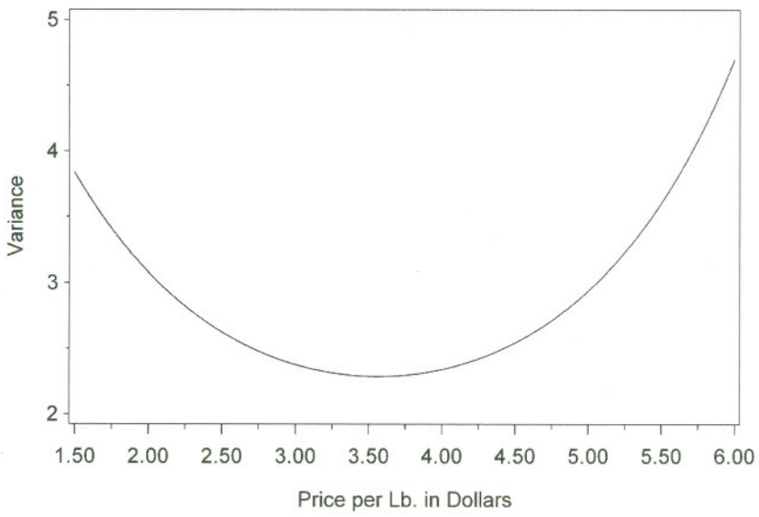

Figure 3. Variance Graphed against Price

ranges, this could be due to some consumers seeing the price as a "great deal," while others may have viewed it as "too good to be true," representing perhaps an inferior chicken product. The increased variance for the higher price ranges is most likely due to exceeding some consumers' budget limits.

In terms of demographics, the effect on variance for female and age were both positive. For the former, that meant that there was a higher variance in ratings for females than for males. Similarly, older respondents had a higher variance in ratings. This may suggest that older consumers, having experienced more price changes for chicken, have differing views on what an appropriate price should be compared with younger consumers. Finally, although education was not significant in terms of means, it was found that consumers with at least some college had a lower variance in ratings compared with those with a high school degree or less. These showed that even when mean effects are not present, demographics can be a factor in variances.

Conclusion

Today's consumer faces foods made using many novel or controversial production attributes. Some consumers with knowledge of these changes have turned to organic or natural versions, often believing them to be safer or healthier. This study explored consumer purchase likelihood for many of these attributes in the chicken industry. Included were those for which consumers have little familiarity, such as fed GM feed, irradiated, and the hypothetical GM chicken, as well as the possibly controversial antibiotic usage.

Results suggest that the more novel an attribute, the lower consumer purchase likelihood will be. According to this study, introducing GM chicken into the market would meet strong consumer opposition. This would obviously depend on consumer knowledge that the chicken was GM; most consumers already consume chickens fed GM feed but, because of the lack of labeling requirements, they are largely unaware of this fact. Such chickens also received negative ratings that do not currently carry over into the market. The results for both of these aspects gave indication that if labeling were introduced, purchase likelihood for these chickens would decrease.

Another production attribute found to be a strong consumer negative was the use of irradiation. While recently approved for expanded use in the poultry industry, results

suggested consumers would be less likely to purchase chicken that has undergone this process. Since labeling of this technology is required, it is understandable given the findings here that its usage is not more widely adopted. Antibiotic usage, already on the decline, also lowered purchase likelihood. Again, this showed the industry may already understand some consumer issues.

Concerns for these attributes suggest a strong potential for an organic chicken market, and difficulties for the current production practices of the industry if consumer preferences shift further. Although the one organic attribute specifically included, free range, was not significant, all the above negatively considered ones are those that organic prohibits. There appears to be room to turn portions of production to organic and natural, particularly if consumers continue to become more aware of the novel techniques employed. The other option would be to better educate consumers so the novelty of these attributes is reduced and consumer concerns allayed.

Several avenues could be pursued from here. Not much is yet understood about how consumer preferences about these issues were developed. The degree of novelty appears to be a key factor, but more work on understanding this could yield important insights on new products and technologies. These would all aid education efforts. It would also be useful to better understand the reasons for the differences in the variances of ratings based on demographics. This aspect has often been neglected in past studies and warrants greater attention.

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