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A Conjoint Analysis of the U.S. Broiler Complex Location Decision

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A national survey of broiler industry executives is conducted to analyze site-specific factors related to the broiler-complex location problem. Conjoint analysis is used to analyze the broiler complex location decision. Feed costs, community attitude toward the broiler industry, availability of geographically concentrated growers, unemployment rates, and wage rates were found to be the top five factors affecting broiler company location decisions. The quality of roads between feed mill and growers; electricity, heating, water, and sewage costs; and the number of potential growers in the region were also found to be important.

Key Words: broilers, conjoint analysis, location, poultry industry

JEL Classifications: R12, O18

The United States broiler industry is concentrated primarily in the southern regions of the United States. These regions account for 85% of the domestic broiler meat supply. The top broiler-producing states are Georgia, Arkansas, Alabama, Mississippi, and North Carolina, which account for more than 60% of the total U.S. broiler supply. In 2001, U.S. Census data indicated that Arkansas was the top state in terms of poultry establishments with 50 processing plants, whereas Georgia ranked second with 38 establishments. During the same year, Georgia was the leading state in terms of total broiler output, producing approximately 6.24 billion pounds, followed by Arkansas producing 5.74 billion pounds. Other states leading in broiler production include Alabama, Mississippi, North Carolina, Texas, Delaware, Virginia, and Kentucky. Although broiler production is typically the largest animal industry in many other southern states, broiler operations remain relatively low in Florida, Louisiana, South Carolina, Oklahoma, and Tennessee. The reason some regions of the United States are better suited for broiler production than other states is not well understood. The purpose of this study is to analyze broiler executive's decisions regarding where to locate a broiler complex in the United States. The objectives are to (1) identify factors affecting the site locations of broiler complexes in the United States, and (2) measure the effects and relative importance of these factors on the broiler complex location decision.

Literature Review

Numerous factors may be considered when determining a suitable site location for a business, but finding the least-cost location of procuring raw materials and producing and distributing the final product play an important role. Location theories as developed separately by Von Thünen, Weber, and Hoover are useful

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for analyzing how these costs affect site selection in the broiler industry. All three theories utilize the principle of factor substitution, where an industry selects a site from alternative locations, depending on the relative costs of labor, land, transportation, and other primary inputs.

The Von Thünen theory of location is based on evaluating tradeoffs between transportation costs and location-specific land rents. Site selection is determined by minimizing production costs given tradeoffs between product-specific transportation costs and land rents. Weber also argued that the orientation of industries is determined by substitution between transportation costs and nontransportation cost factors, including labor costs and agglomeration forces. Low-cost nontransportation factors may exert a "locational pull" that attract an industry from the point of minimum transportation cost to a point of higher transportation. This occurs as long as the savings in the nontransportation cost factors are greater than additional transportation costs incurred due to the shift from the point of minimum transportation cost. Hoover's theory included institutional determinants as well as transportation and production factors. His inclusion of institutional factors provides a more comprehensive theory of location than either theories of Von Thünen or Weber, who focused on production and transportation costs. A distinguishing feature of Hoover's theory is the introduction of fuel and raw material costs, agglomeration forces, and the costs generated by factors such as taxes and climate on the location decision.

Several studies have addressed factors affecting the location decision of the broiler industry. Easterling, Braschler, and Kuehn conducted a study on optimal location of the U.S. broiler industry. They used a transportation linear programming model to determine optimal locations for broiler industry. Results from their study showed that energy cost was relatively unimportant in determining the location of broiler growing and processing. They found that the southern producing regions, especially Georgia and Alabama, had substantial cost advantages with respect to labor, and that the cost of importing feed relative to the cost of locally produced feed was critical to broiler production in the South.

Lopez and Henderson examined determinants of location choices of new food processing plants in the Mid-Atlantic region. They performed 56 telephone interviews, of which four were related to poultry processing. The sample also included fruit and vegetable, egg, and seafood processors. Out of the 41 factors surveyed, the variables considered most important for the poultry industry were the cost of water waste disposal, availability of a waste treatment/disposal facility, water pollution regulations, availability of an existing plant facility, stringency of enforcement of environmental regulation, and capital expenditure for pollution abatement. The results also showed that labor factors and state and local policies are relatively less important in the location decision of a poultry company (Lopez and Henderson).

Aho analyzed regional trends in broiler production. During the period from 1996 to 1998, seven new complexes were established in the United States, of which three were established in Kentucky and one each in Tennessee, Texas, Oklahoma, and Alabama. High feed costs were the main disadvantages for broiler production in the North, whereas high costs of production (especially transportation cost) were the main disadvantages for production in the West. Although the Midwest has an advantage in grain costs, it is associated with high land and labor costs. Aho attributed inexpensive land and labor, a favorable business climate, and low rail rates as the main advantages for broiler location in the South. Berry analyzed factors involved in site selection for new and modified poultry facilities in Oklahoma. His analysis showed that availability of utilities (i.e., availability and quality of water, electricity, and natural gas) was the most important factor considered during site selection.

The present study differs from previous studies in two respects. First, top executives within the broiler industry are surveyed, and location factors for broiler growing, feed milling, and broiler processing are analyzed. Second, conjoint analysis is used to estimate tradeoffs between location factors and measure the relative importance of each factor on the location decision.

Methodology

Conjoint analysis (CA) is a technique used to measure respondents' preferences (i.e., "part-worth" utilities) for selected attribute levels given to their evaluation of hypothetical products or services (Green and Srinivasan 1978). Principal applications of CA pertain to new product/concept evaluation, product repositioning, competitive analysis, pricing, and market segmentation (Wittink and Cattin). However, the use of CA to study location decisions is also possible. For instance, a study by Hopman, van Niejenhuis, and Renkema used CA to elicit growers' preferences for locating horticultural enterprises in the Netherlands. Similarly, this study uses conjoint analysis to examine broiler executives' preferences for alternative broiler complex locations in the United States. CA is useful in analyzing the location problem since site selection is a multiattribute decision-making process. This approach assumes that the stated preferences of the executive are consistent with the profit maximizing behavior of the firm.

Selection of Attributes and Levels

The selection of attributes for the broiler-complex location decision was based on a review of previously cited studies and personal interviews with broiler industry experts. The experts interviewed during questionnaire development and pretesting included a retired chief executive officer (CEO) for a U.S. poultry company, a top executive with the Chicken Council, and various extension personnel currently working in the poultry industry. State policy makers and community leaders were not included in the attribute selection process, as the primary purpose of the study was to analyze site selection from the perspective of business leaders. Initially, the process revealed as many as 30 attributes affecting site selection for a broiler complex. However, through pretesting and personal interviews with industry experts we narrowed the list to 12 attributes, which were judged to be the most pertinent factors affecting the location decision. Reducing the number of attributes was necessary, as numerous attributes complicate the evaluation of hypothetical sites by the respondents. Even 12 attributes is a relatively large number for respondents to evaluate in a single conjoint design, so the analysis was divided into separate designs based on the three key enterprises of the broiler complex. These include broiler growing, feed mill operations, and broiler processing. Each of these enterprises is associated with a subset of factors expected to influence an executive's decision regarding its respective location. Some of the attributes affecting each enterprise are mutually exclusive across enterprises, whereas other attributes are common across the entire broiler complex. Therefore, the decision regarding the best location for a broiler complex is dependent on the location decisions of the three separate enterprises.

To model the interdependency across enterprises, a technique that allows for the "bridging" of part-worth estimates across three conjoint designs is applied. The technique involves dividing the total number of attributes into three sets of attributes and developing separate experimental designs with at least one common attribute across each design (Green and Srinivasan 1990). Each respondent is administered all three designs, which are analyzed separately. The next step requires use of the common attribute to rescale the part-worths from each enterprise into an overall set of part-worth estimates for the entire broiler complex.

Table 1 lists the attributes and levels for the three conjoint designs in this study. The broiler-growing enterprise includes six attributes with two levels per attribute. The feed mill enterprise includes three attributes, one attribute with three levels and two attributes with two levels each. Finally, the broiler processing enterprise includes seven attributes, each with two levels. All three enterprises have one attribute in common (community attitude), with the broiler-growing and -processing enterpris-

Table 1. Attributes Involved in Conjoint Analysis of Broiler Complex Enterprises

Attributes	Levels
Broiler-growing enterprise	
Community attitude toward broiler industry	1) Favorable
	2) Not favorable
Water cost	1) High cost, $2.50/1,000 gallons
	2) Low cost, $1.00/1,000 gallons
Electricity cost	1) High cost, 6.50 cents/kWh
	2) Low cost, 4.00 cents/kWh
Heating cost	1) High cost, LP gas $1.00/gallon
	2) Low cost, LP gas $0.90/gallon
Number of growers and potential growers available	1) 75–100
	2) 250–300
Distance between feed mill and grower	1) 30 miles
	2) 100 miles
Feed mill enterprise	
Community attitude toward broiler industry	1) Favorable
	2) Not favorable
Cost of feed ingredients	1) $160.00/ton
	2) $260.00/ton
	3) $310.00/ton
Quality of roads from feed mill to growers	1) Poor
	2) Good
Broiler-processing enterprise	
Community attitude toward broiler industry	1) Not favorable
	2) Favorable
Water cost	1) High cost, $2.50/1,000 gallons
	2) Low cost, $1.00/1,000 gallons
Electricity cost	1) High cost, 6.50 cents/kWh
	2) Low cost, 4.00 cents/kWh
Proximity to major metropolitan markets	1) 400 miles
	2) 800 miles
Unemployment rate in the region	1) High
	2) Low
Average hourly wage in the region	1) Low wage, $7.50/hour
	2) High wage, $8.50/hour
Sewer cost	1) Low cost, $1.00/1,000 gallons
	2) High cost $3.00/1,000 gallons

es having three attributes in common. Since only two enterprises can be bridged at a time, this study utilizes a two-stage bridging technique similar to that applied by Francois and MacLachlan. Details of the bridging technique will be discussed later in the paper.

Conjoint Designs and Questionnaire

The experimental designs used in this study utilize a full-profile approach, which allows respondents to evaluate hypothetical site locations based on the complete set of attribute levels. A disadvantage of the full-profile approach is the possibility of information overload on the part of the respondent, since a full factorial design may require a large number of hypothetical locations to be evaluated (Green and Srinivasan 1978). For instance, since there are six attributes with two levels each in the broiler-growing conjoint design, there are $2 \times 2 \times 2 \times 2 \times 2 \times 2 = 64$ possible broiler-growing locations. Similarly, there are 3 × 2 × 2 = 12 possible locations for the feed mill, and 2 × 2 × 2 × 2 × 2 × 2 × 2 = 128 possible sites for the broiler processing enterprise.

Researchers commonly use a fractional factorial design to overcome the information overload problem. The primary advantage of a fractional design is that the number of hypothetical products a subject must evaluate is greatly reduced, whereas enough information is retained to estimate all part-worth main effects. A disadvantage of the fractional design is that interaction part-worth effects are not usually recoverable. However, this may not be a significant restriction, as previous research has found attribute interactions to have negligible effects on total utility (Harrison, Özayan, and Meyers 1998). The Bretton-Clark designer program was used to select the fractional designs for this study. This program produces a subset of hypothetical products based on the attribute levels provided by the researcher. More specifically, the program minimizes the confounding of attribute main effects by selecting a subsample of orthogonal product combinations.

The conjoint portion of the questionnaire consisted of three sections. The first section deals with the broiler-growing enterprise. This section contains eight hypothetical location profiles as prescribed by the Bretton-Clarke software. Similarly, the second and third sections contained the feed mill and broiler-processing conjoint designs, each of which also consisted of eight hypothetical location profiles as described by the fractional design. The survey was administered to CEOs of 43 broiler companies in the United States using Dillman's Total Design Method (Dillman). The survey was conducted from September to December 2002. Responses were received from 13 CEOs, of which three questionnaires were incomplete, thus leaving 10 usable questionnaires for a response rate of 23.3%. These 10 companies accounted for approximately 55% of total U.S. broiler output. The CEOs reported that their companies are presently operating 73 broiler complexes in the United States. Forty percent of the respondents indicated their oldest broiler complex was constructed over 40 years ago. Moreover, 40% of the respondents indicated that they expanded their poultry operations by building a new broiler complex in the last 5 years. Thirty percent of the respondents employed more than 10,000 workers in their broiler operations and had sales of more than $1 billion in the last fiscal year. Sixty percent of the respondents were planning to expand their broiler operations in the next 5 years.

Model Specification

The two most commonly used methods for coding consumer preferences in the CA literature are rank order (RO) and interval rating (IR) scales. The primary difference between these methods is associated with the restriction each places on the metric and nonmetric properties of the subject's preference function. The RO method requires subjects to unambiguously rank all hypothetical product choices, which provides a nonmetric ordering of respondent preferences. The IR method allows subjects to express order, indifference, and intensity across product choices, a feature that allows for both metric and nonmetric properties to be elicited. Since RO scaling provides no provision for subjects to express indifference or intensity across product attributes, information is lost if respondents wish to express cardinal properties in their preference ordering. Moreover, IR scales tend to be easier for respondents to use because they do not require a unique ordering. In this study, respondents were asked to rate the previously described profiles using an IR scale from 0 to 10, where 0 represents the least preferred combination of location features and 10 represents the most preferred combination of location features.

The method used to scale preferences has implications regarding the selection of an appropriate model for estimating part-worth values. If RO scaling is used, then the dependent variable (i.e., the RO scale) is clearly ordinal and ordered regression models such as ordered probit or logit are best suited for estimating conjoint parameters. However, model selection becomes less clear if the IR method is used.

For instance, a number of studies have used the two-limit Tobit (TLT) model to estimate part-worth parameters (Harrison, Stringer, and Prinyawiwatkul; Roe, Boyle, and Teisl; Stevens, Barrett, and Willis). These studies implicitly assume that utility is cardinal (i.e., the IR scale is continuous) between upper and lower bounds of the scale. Other researchers argue that ordered probit or logit (OLP) models are best suited for conjoint estimation, since IR scales are measured as a discrete variable (Mackenzie 1990, 1993; Sy et al.). However, a disadvantage of OLP models is that they assume preferences are ordinal, which fails to account for cardinal information if respondents express intensity in their responses. Another disadvantage of OLP models is that they require additional degrees of freedom to estimate part-worth parameters.

Both TLT and ordered probit models were estimated in the present study. The TLT and ordered probit part-worth estimates were found to be of the same sign and were quite close in terms of magnitude. This is consistent with previous literature, which found little difference between TLT and OLP estimates in conjoint analysis (Boyle et al.; Harrison, Stringer, and Prinyawiwatkul). Since the TLT model provides additional degrees of freedom, and therefore greater efficiency, only TLT results are presented in the paper.[1]

The TLT models are specified as follows:

$$U_n^i = \boldsymbol{\beta}^i \mathbf{X}^i + \varepsilon_n^i, \quad \text{and}$$

$$IR_n^i = \begin{cases} 0, & \text{if } U_n^i \le 0; \\ U_n^i, & \text{if } 0 < U_n^i < 10; \quad \text{and} \\ 10, & \text{if } 10 \le U_n^i, \end{cases}$$

where U_n^i *is the* nth respondent's unobservable preference for a particular combination of location attribute levels for enterprise i; IR_n^i is the nth respondent's observed rating scale for a particular combination of location attribute levels for enterprise i; $\boldsymbol{\beta}^i$ is a row vector of part-worth and marginal utility effects for the ith enterprise; $\mathbf{X}^i$ is a column vector of location attribute levels for the ith enterprise; and ε_n^i is the error term. The superscript $i = 1, 2,$ or 3 and denotes the broiler growing, feed mill, and broiler processing models, respectively.

The attribute vector ($\mathbf{X}^1$) for the broiler-growing model contains a series of dummy variables defined as follows: $X_1^1 = 1$ or -1 if community attitude toward the broiler industry is favorable or unfavorable, respectively; $X_2^1 = 1$ or -1 if water costs in the region are \$2.50/1,000 gallons or \$1.00/1,000 gallons, respectively; $X_3^1 = 1$ or -1 if electricity cost in the region is 6.50 cents/kWh and 4.00 cents/kWh, respectively; $X_4^1 = 1$ or -1 if heating cost in the region is \$1.00/gallon or \$0.90/gallon, respectively; $X_5^1 = 1$ or -1 if there are 250–300 growers/potential growers in the region or 75–100 growers/potential growers in the region, respectively; and $X_6^1 = 1$ or -1 if the average distance is 30 miles between the feed mill and the growers or 100 miles between the feed mill and the growers, respectively.

The attribute vector $\mathbf{X}^2$ for the feed mill model contains a series of dummy variables defined as follows: $X_1^2 = 1$ or -1 if community attitude toward the broiler industry is favorable or unfavorable, respectively; $X_2^2 = 1$ and $X_3^2 = 0$ if feed in the region costs \$160/ton, or $X_2^2 = 0$ and $X_3^2 = 1$ if feed costs are \$260/ton, or $X_2^2 = -1$ and $X_3^2 = -1$ if feed costs are \$310 per ton; and, $X_4^2 = 1$ or -1 if there are good- or poor-quality roads between the feed mill and growers, respectively.

The attribute vector $\mathbf{X}^3$ for the processing model contains a series of dummy variables defined as follows: $X_1^3 = 1$ or -1 if community attitude toward the broiler industry is favorable or unfavorable, respectively; $X_2^3 = 1$ or -1 if water cost in the region is \$2.50/1,000 gallons or \$1.00/1,000 gallons, respectively; $X_3^3 = 1$ or -1 if electricity cost in the region is 6.50 cents/kWh or 4.00 cents/kWh, respectively; $X_4^3 = 1$ or -1 if the site location is 400 or 800 miles in proximity to a major metropolitan market, respectively; $X_5^3 = 1$ or -1 if there is a high or low unemployment rate in the region, respectively; $X_6^3 = 1$ or -1 if the

[1] Random effects ordinary least squares models were also fit for each of the j enterprises to provide a preliminary test for correlation of errors across responses. The Lagrange Multiplier Test rejected the random effects hypothesis.

Table 2. Two-Limit Tobit Part Worth Estimates and Relative Importance of Attributes for Broiler Growing Enterprise

Variable	Coefficient	*b*/SE[a]	Relative Importance
Constant	3.685***	11.325	
Community attitude toward broiler industry			29.04
Favorable	1.048***	3.221	
Not Favorable	−1.048***	−3.221	
Water cost			7.79
High cost, $2.50/1,000 gallons	−0.279	−0.859	
Low cost, $1.00/1,000 gallons	0.279	0.859	
Electricity cost			16.08
High cost, 6.50 cents/kWh	−0.576*	−1.774	
Low cost, 4.00 cents/kWh	0.576*	1.774	
Heating cost			10.89
High cost, LP gas $1.00/gallon	0.390	1.200	
Low cost, LP gas $0.90/gallon	−0.390	−1.200	
Number of growers and potential growers available			10.97
250–300	0.393	1.210	
75–100	−0.393	−1.210	
Distance between feed mill and grower			25.22
30 miles	0.903***	2.775	
100 miles	−0.903***	−2.775	
χ^2log L: 21.56***			

[a] The parameter estimate divided by the standard error.
* Significant at the $\alpha = .1$ level; ** Significant at the $\alpha = .05$ level; *** Significant at the $\alpha = .01$ level.

average hourly wage is $8.50/hour or $7.50/hour, respectively; and, $X_7^3 = 1$ or -1 if sewer costs are $3.00/1,000 gallons or $1.00/1,000 gallons, respectively.

Once part-worth utilities are estimated, relative importance values are calculated for each attribute in the respective models. Relative importance (RI) weights for each attribute are calculated using a method described in Halbrendt, Wirth, and Vaughn. The first step is to determine the highest and lowest part-worth values for each attribute. The differences between the highest and lowest values represent the utility range for that attribute. Once the utility range for each attribute is determined, the relative importance for the *i*th attribute is calculated as follows:

$$RI_i = \frac{R_j}{\sum R_j \; \forall \; Attributes} \times 100,$$

where R_j is the range of part-worth values for the *j*th attribute, and RI_j is defined as the relative importance for the *j*th attribute.

Results

The part-worth estimates and relative importance coefficients for broiler growing, feed mill, and broiler processing enterprises are presented in Tables 2, 3, and 4, respectively. The log-likelihood ratio tests show that all three models are significant at the $\alpha = .01$ level.

Broiler Growing Analysis

The broiler growing coefficient associated with a favorable community attitude is positive (1.048) and significant at the $\alpha = .01$ level, indicating that a favorable community at-

Table 3. Two-Limit Tobit Part-Worth Estimates and Relative Importance of Attributes for Feed Mill Enterprise

Variable	Coefficient	b/SE[a]	Relative Importance
Constant	3.896***	8.923	
Community attitude toward broiler industry			29.23
Favorable	1.956***	4.659	
Not Favorable	−1.956***	−4.659	
Cost of feed ingredients			55.52
$160.00/ton	4.632***	6.656	
$260.00/ton	−1.830***	−2.855	
$310.00/ton	−2.802***	−5.014	
Quality of roads from feed mill to growers			15.24
Good	1.023**	2.465	
Poor	−1.023**	−2.465	
χ^2log L: 58.46***			

[a] The parameter estimate divided by the standard error.
* Significant at the α = .1 level; ** Significant at the α = .05 level; *** Significant at the α = .01 level.

titude toward the broiler industry increases the average respondent's preference for a potential location. In contrast, the negative sign on the unfavorable community attitude part-worth (−1.048) indicates that CEO preferences for a potential site decrease where local residents express reservations about the broiler industry. Moreover, the RI coefficients indicate that community attitude was the most important factor in the CEO's decision regarding the broiler-growing aspect of the broiler complex location decision. That is, 29.04% of the variation in the total preference scores were attributed to community attitude (Table 2).

The importance of community attitude may reflect the CEO's knowledge that state and local environmental regulations are likely to be more severe in regions where the public's concern regarding the negative aspects of broiler growing is high. The odor associated with waste products, the discharge of large amounts of broiler litter, and the need for dead bird disposal are all negative aspects of broiler growing. Although factors affecting a community's attitude toward the broiler industry are complex, communities where the residents are less sensitive to (or aware of) the negative aspects of broiler growing are likely to be more attractive to broiler companies.

The part-worth values indicating distance between the feed mill and growers is also found to be significant at the α = .01 level. The coefficient associated with the 30-mile distance is positive (.903), indicating that as driving distances between the feed mill and growers decrease, the average respondent's preference for a potential production area increases. This result is consistent with previously described location theories, which predict that transportation cost is an important determinant of site location. The distance between feed mill and growers is the second most important factor, contributing approximately 25% to the variation in total preference rating.

The coefficients representing water, heating, and electricity cost are not significant, which may be attributed to the fact that integrators are not responsible for utility costs under the terms of the typical broiler production contract. The integration provides technical assistance, baby chicks, feed, and medication to the growers. The grower is responsible for chicken houses, land, labor, litter, equipment,

Table 4. Two-Limit Tobit Part-Worth Estimates and Relative Importance of Attributes for Broiler Processing Enterprise

Variable	Coefficient	*b*/SE[a]	Relative Importance
Constant	4.632***	18.291	
Community attitude toward broiler industry			29.48
Favorable	1.436***	5.652	
Not Favorable	−1.436***	−5.652	
Water cost			6.57
High cost, $2.50/1,000 gallons	−0.320	−1.265	
Low cost, $1.00/1,000 gallons	0.320	1.265	
Electricity cost			10.94
High cost, 6.50 cents/kWh	−0.533**	−2.105	
Low cost, 4.00 cents/kWh	0.533**	2.105	
Proximity to major metropolitan markets			5.75
400 miles	0.286	1.129	
800 miles	−0.286	−1.129	
Unemployment rate in the region			19.11
High	0.931***	3.674	
Low	−0.931***	−3.674	
Average hourly wage in the region			17.18
High wage, $8.50/hour	−0.837***	−3.301	
Low wage, $7.50/hour	0.837***	3.301	
Sewer cost			10.96
High cost, $3.00/1,000 gallons	−0.534**	−2.108	
Low cost, $1.00/1,000 gallons	0.534**	2.108	
χ^2log L: 49.67***			

[a] The parameter estimate divided by the standard error.
* Significant at the α = .1 level; ** Significant at the α = .05 level, *** Significant at the α = .01 level.

taxes, utilities, and insurance associated with growing broilers.

Feed Mill

All coefficients associated with the feed mill attribute-levels are found to be significant at the α = .01 level; except for the quality of roads between the feed mill and growers, which is significant at the α = .05 level. The coefficient associated with low feed cost is positive (4.632), indicating that as the cost of feed decreases, the preference for a particular site location increases. Conversely, higher feed costs reduce the preference for a particular site location. This is shown by the negative coefficient on the intermediate (−1.830) and high feed cost levels (−2.802). Thus, in accordance theory, in order to lower cost of production, firms locate at sites with relatively lower feed costs. The quality of roads between the feed mill and growers and the community attitude toward the broiler industry are also found to be significant. Good roads and a favorable community attitude have a positive effect (1.023; Table 3) on site selection. Perhaps more importantly, the results show that poor quality roads in regions where integrators transport feed from mill to growers will negatively impact the preference for a particular location (note the −1.023 coefficient in Table 3). Moreover, the RI coefficients show that feed costs are the most important attribute for the feed mill enterprise, accounting for 55.5%

of the variation in preference rating. This indicates that the feed cost component of the broiler complex plays a prominent role in the location decision. Following feed costs, community attitude toward the broiler industry is the second most important factor, accounting for 29.23% of the variation in the preference rating. Although quality of roads is the least important attribute, it is significant and accounts for 15.24% of the variation in preference rating.

Broiler Processing

Most of the coefficients for the broiler processing enterprise are found to be significant at the $\alpha = .01$ level. Exceptions include electricity cost and sewer cost, which are significant at the $\alpha = .05$ level. The coefficients for water cost and proximity to major metropolitan markets have the correct sign, but are not significantly different from zero.

The coefficient associated with a favorable community attitude is positive (1.436), indicating that broiler company executives are also sensitive to community attitudes associated with broiler processing. Conversely, unfavorable community attitudes reduce the preference for a particular site location. This is shown by the negative coefficient on the unfavorable community attitude (−1.436). The coefficient associated with higher unemployment rates is positive (0.931), indicating that broiler companies prefer regions with surplus labor. Conversely, low unemployment rates reduce the preference for a particular site location. This is shown by the negative coefficient on the low unemployment rate (−0.931). This result is consistent with economic theory, which predicts that firms relying on low-skilled labor would prefer locations where low-skilled workers are more available. Average hourly wage in the region is also found to be significant. The coefficient is negative (−0.837), indicating that higher wage rates decrease the average respondent's preference for a particular site. This result is consistent with economic theory, which predicts that firms prefer locations where labor costs are low in order to lower the total cost of production. The result is also consistent with the findings of Easterling, Braschler, and Kuehn, and Aho, who concluded that low labor costs are among the critical factors for the broiler industry concentration in the South. The coefficients associated with electricity cost, sewer cost, and water cost all have negative signs, indicating that high utility costs will also have a negative effect on site selection.

The RI coefficients show that community attitude is the most important attribute for the processing aspect of the broiler complex, accounting for approximately 30% of the variation in the preference rating. The prominence of community attitude in the processing model may be due to the fact that broiler processing emits large amounts of solid and liquid waste, which places greater demands on the community's sewage system and may create environmental concerns for local residents. The processing enterprise may also be the most visible aspect of the broiler complex, as processing tends to locate closer to urban centers, whereas broiler growing and feed mills are more geographically dispersed in rural areas.

Following community attitude, the unemployment rate (19.11%) and average hourly wage in the region (17.18%) are found to be the second and third most important attributes, respectively. Proximity to major metropolitan markets was found to be the least preferred attribute, accounting for only 5.75% of variation in the preference rating.

Overall Attribute Effects

Recall that a broiler complex is composed of broiler growing, feed mill, and processing enterprises. The RI coefficients presented in Tables 2, 3, and 4 are calculated using the TLT estimates for the three models. In order to estimate overall RI coefficients for each attribute affecting the broiler complex location decision, a bridging technique is applied that utilizes the results from the three separate conjoint models. The procedure is similar to techniques discussed by Baalbaki and Malhotra, and Francois and MacLachlan. The technique is based on the assumption that common attributes provide a basis (or common denominator) for measuring the relative importance across all attributes in the three models.

Bridging part-worth values is only possible for two models at a time, and the broiler growing and broiler processing enterprises are bridged first (stage one). After stage one is complete, the resulting estimates are bridged with the feed mill enterprise to calculate overall part-worth (OPW) values and relative importance weights. The algorithm utilizes a bridging scalar that is constructed using the ratio of common part-worth ranges across two enterprises. The scalar for the broiler growing and processing designs is calculated as follows:

$$B = \sum_{j=1}^{3} \frac{R_j^1}{R_j^3},$$

where B is the stage-one bridging scalar, R_j^1 is the range of part-worth estimates for the jth attribute in the broiler growing model, and R_j^3 is the range of part-worth estimates for the jth attribute in the broiler processing model. Subscript j denotes common attributes between enterprises 1 and 3, where $j = 1, 2,$ and 3 for community attitude, water costs, and electricity costs, respectively. The bridging scalar (B) is used to rescale the broiler processing part-worths, and B^{-1} is used to rescale the broiler growing part-worths. The complete formulas for calculating the stage one part-worth values are presented the Appendix.

Once broiler growing and processing models are bridged, the final step is to bridge stage one part-worth estimates with the feed mill model. In this step, community attitude is the only common attribute between the three enterprises. The final bridging scalar is calculated as follows:

$$FB = \frac{R_1^w}{R_1^2},$$

where FB represents the final bridging scalar; R_1^w is the range of part-worth estimates for the community attitude attribute in stage one (i.e., W_{lm} in the Appendix); and R_1^2 equals the range of part-worth estimates for community attitude in the feed mill model. Similar to stage one, FB and FB^{-1} are used in conjunction with TLT part-worth estimates to calculate OPW values. Formulas for these calculations are also presented in the Appendix.

The OPW values are nonlinear functions of the TLT estimates. In order to provide confidence intervals for these values, we use a bootstrapping procedure. The procedure involves generating OPW estimates from 200 bootstrap samples of the original data. Each bootstrap sample contains 80 observations, which provide 200 sets of TLT part-worth estimates for the three enterprises. These estimates are used to compute distributions of OPW values for the broiler complex and standard errors for the bridged part-worths. According to Efron and Tibshirani, a 200 bootstrap sample is normally sufficient to provide estimates for standard errors (p. 52). Once standard errors are obtained, confidence intervals are constructed assuming an $\alpha = .05$ level of significance.

The OPW estimates, confidence intervals, and RI coefficients for a broiler complex are presented in Table 5. Results indicate that cost of feed is the most important factor affecting the location of a broiler complex. It accounts for approximately 25% of the variation in the preference for a broiler complex location. Moreover, the 95% confidence interval for feed cost indicates its degree of importance is statistically higher than community attitude, the second highest ranked attribute. As the cost of feed increases, the preference for a particular location decreases as indicated by OPW estimates of 10.43 for \$160.00/ton, −4.12 for \$260.00/ton, and −6.31 for \$310.00/ton, respectively. This result is consistent with other studies, which found feed costs to be an important factor affecting site location for the broiler industry (Easterling, Braschler, and Kuehn).

Other findings indicate that community attitude toward the broiler industry is the second most important factor affecting the location decision, accounting for 13.2% of the variation in preference rating. Confidence intervals associated with the community attitude OPW estimates indicate it is significantly higher

Table 5. Bridging Estimates of Part-Worth Calculations for Broiler Complex

Attributes	Upper[a]	OPW[b]	Lower[a]	RI[c]	Rank[d]
Community attitude toward broiler industry				13.20	2
Favorable	4.49	4.41	4.33		
Not favorable	−4.33	−4.41	−4.49		
Water cost				3.23	11
High cost, $2.50/1,000 gallons	−1.01	−1.08	−1.15		
Low cost, $1.00/1,000 gallons	1.15	1.08	1.01		
Electricity cost				6.10	7
High cost, 6.50 cents/kWh	−1.95	−2.04	−2.13		
Low cost, 4.00 cents/kWh	2.13	2.04	1.95		
Heating cost				4.61	10
High cost, LP gas $1.00/gallon	1.62	1.54	1.46		
Low cost, LP gas $0.90/gallon	−1.46	−1.54	−1.62		
Number of growers				4.67	9
250–300	1.74	1.56	1.38		
75–100	−1.38	−1.56	−1.74		
Distance between feed mill and grower				10.71	3
30 miles	3.66	3.58	3.50		
100 miles	−3.50	−3.58	−3.66		
Proximity to major metropolitan markets				2.81	12
400 miles	1.01	0.94	0.87		
800 miles	−0.87	−0.94	−1.01		
Unemployment rate in the region				9.19	4
High	3.17	3.07	2.97		
Low	−2.97	−3.07	−3.17		
Average hourly wage in the region				8.26	5
High wage, $8.50/hour	−2.60	−2.76	−2.92		
Low wage, $7.50/hour	2.92	2.76	2.60		
Sewer cost				5.27	8
High cost, $3.00/1,000 gallons	−1.68	−1.76	−1.84		
Low cost, $1.00/1,000 gallons	1.84	1.76	1.68		
Cost of feed ingredients				25.05	1
$160.00/ton	10.60	10.43	10.26		
$260.00/ton	−4.00	−4.12	−4.24		
$360.00/ton	−6.17	−6.31	−6.45		
Quality of roads between feed mill and grower				6.88	6
Good	2.39	2.30	2.21		
Poor	−2.21	−2.30	−2.39		

[a] Indicates the confidence intervals for the estimates.
[b] Indicates the overall part-worth estimates.
[c] Indicates the relative importance (RI) of the attribute in the location decision of a broiler complex.
[d] Indicates the rank of the attribute.

than lower ranked attributes. Community attitude captures the broiler executive's perception of the receptiveness of a particular community to the broiler industry. This attribute is difficult to measure, but may include factors such as waste water discharge and solid waste disposal regulations, as well as other environmental regulations that may be more stringent in regions where communities are sensitive to the negative aspects of the broiler industry. It may also include the executive's perception of the farming community's attitude toward broiler production, including farmer preferences for contract production.

Other important factors include the distance between the feed mill and growers, which ranked third in order of importance. The OPW confidence interval indicates distance between feed mill and grower is significantly higher in order of importance relative to lower ranked attributes. This suggests broiler companies prefer locations where they can contract with geographically concentrated growers. Growers located in close proximity to the feed mill lower the cost associated with transporting feed to broiler houses. Vest and Lacy also found that companies specify a maximum allowable distance between a broiler farm and the feed mill or processing plant in order to lower the cost of transportation.

The fourth and fifth ranked location attributes were found to be the unemployment rate and hourly wage in the region. These accounted for 9.19% and 8.26% of the variation in the preference rating, respectively. Confidence intervals for both attributes indicate they are significantly more important than lower ranked attributes, and they are significantly different from one another. This suggests that availability of workers and the cost of labor play an important role in the broiler complex location decision.

Electricity, heat, water, and sewage costs individually are less important to the location decision compared with other factors such as feed cost, community attitude, unemployment, and the wage rate. However, their combined affect accounted for 19.2% (electricity + heating + water + sewage costs) of variation in the preference rating. Electricity cost was found to be most important among the utility costs accounting for 6.10% of variation in preference rating. Confidence intervals for these attributes indicate they are significantly higher in rank relative to lower ranked attributes and they are significantly different from one another. The number of growers in the region ranked ninth in order of importance, but was not found to be significantly different from the heating cost attribute, as indicated by their respective confidence intervals. Proximity to major metropolitan markets was found to be the least important factor, accounting for just 2.81% of variation in preference rating.

Comparison of Model Results with Industry Trends

A comparison of our results with historical trends in the broiler industry is complicated, since results show many factors play a significant role in the broiler complex location decision. For instance, it is difficult to measure the community attitude variable, and even if one assumes it is associated with environmental regulations in a particular region and/or farmer attitude toward contract production, a complete accounting of these variables would be difficult. On the other hand, data for other important variables such as feed costs and wage rates are available regionally, and these data show that tradeoffs between feed costs and wage rates do in fact exist across geographic regions. This section of the paper compares the model's results with geographic trends in broiler production—as these trends relate to differences in feed costs and wage rates.

The finding that feed costs are the most important attribute suggests the Midwest Corn Belt should be an attractive location for broiler production, since it is a source of relatively low-cost feed. For instance, in 2001 the average costs of corn and soybean meal were \$5.95 and \$12.00/cwt in the Midwest, respectively (USDA/NASS). These costs are low compared with average costs of \$9.94 and \$15.80/cwt for corn and soybean meal in the Southeastern states, respectively; \$8.66 and \$14.00/cwt for corn and soybean meal in the

Mississippi Delta states, respectively; and, $7.29 and $13.70/cwt in Appalachian states, respectively (USDA/NASS). However, despite this apparent advantage, Midwest states have experienced little growth in broiler production and processing in recent years. For instance, the only Midwest state to see an increase between 1990 and 2001 was Illinois, where the number of establishments increased from eight to nine (12.5%; U.S. Census Bureau). By comparison, states outside the primary corn and soybean producing regions of the United States have seen significant increases in broiler production over this period. Most notably, between 1990 and 2001 the number of establishments have increased from three to eight in Louisiana (167%), two to four in Kentucky (100%), 7 to 14 (100%) in South Carolina, two to three in West Virginia (50%), 38 to 50 in Arkansas (32%), and 9 to 11 in Tennessee (22.2%; U.S. Census Bureau). This evidence suggests that feed costs alone do not explain the geographic location of broiler complexes. This supports results from the present study, which suggests that although feed costs are important (contributing 25% to preference of a particular site), they are not the overriding determinant. There are tradeoffs between low-cost feeds and other factors that are also important to the location decision.

Let us also consider differences in wage rates across geographic regions. The average wage is $9.27/hour in Midwest states compared with $8.17, $7.64, and $7.37/hour in Appalachian, Southeastern, and Mississippi Delta states, respectively (USDA/NASS). This suggests that lower feed costs in the Midwest are partially offset by higher labor costs relative to other regions. Since the broiler industry has experienced significantly more growth in the Mississippi Delta, Appalachian, and Southeastern states relative to the Midwest, one must conclude that lower labor costs in these regions, in combination with other factors that may include more favorable community attitudes and lower utility costs, more than offset low feed costs in the Midwest. The findings from the present study support this conclusion, as results show that combined effects from other attributes contribute as much as 75% to the preference for a particular site.

Conclusions

The objectives of this paper were to identify factors affecting site locations of broiler complexes in the United States and measure the effects and relative importance of these factors on the broiler complex location decision. The study applied conjoint analysis to the broiler industry location problem. Location attributes were selected based on a review of related literature, interviews with industry executives, and questionnaire pretesting. A total of 12 attributes were selected for the analysis and grouped according to the three primary enterprises in a broiler complex—broiler growing, feed production, and broiler processing. A survey of 43 chief executive officers within the broiler industry was conducted, of which 10 CEOs responded, yielding a response rate of 23.3%. These 10 companies account for approximately 55% of total U.S. broiler output. Separate models were estimated for broiler growing, feed production, and processing, and conjoint bridging techniques were used to measure the relative importance of all attributes affecting the location of a total broiler complex.

The relative importance estimates showed that low feed costs, a favorable community attitude toward the broiler industry, availability of geographically concentrated growers, high unemployment rates, and low wage rates are the top five attributes affecting broiler company location decisions. Sixty-six percent of the variation in site preferences was found to be attributed to these five attributes. Other factors, by order of importance, include the quality of roads between the feed mill and growers, the cost of electricity, the cost of sewage, the number of potential growers in the region, heating costs, water costs, and proximity to metropolitan areas.

Since optimal site selection almost always involves evaluating tradeoffs between location attributes (i.e., low feed costs may be offset by unfavorable community attitudes, the lack of growers, and/or high wage rates in a particular region), estimating the order of importance for location attributes is an important contribution of the present study. This information can aid economic development specialists in understanding relative tradeoffs between location attributes that affect location of the broiler industry, which leads to better decisions regarding policies aimed at attracting the broiler industry to rural communities.

Results of the present study also provide a partial explanation for concentration of broiler complexes in the Mississippi Delta, the Southeast, and Appalachian states. Although feed costs are higher in these regions relative to the Midwest, the combination of lower wage rates and other factors that may include favorable community attitudes in rural areas of the south and greater availability of growers relative to the Midwest creates a "locational pull" away from low-cost feeds toward regions with relatively low-cost rural labor. This conclusion is consistent with location theory and with the findings of Easterling, Braschler, and Kuehn, and Aho, who also concluded broiler companies prefer regions with low labor costs.

Since tradeoffs between feed cost, community attitude, and labor costs were found to be important to the location decision, future research should focus on analyzing cost differentials of feed and labor across regions to better explain the geographic location of the broiler industry. A limitation of the present study has to do with our specification of the community attitude variable. This attribute is likely a proxy for more specific attributes, such as environmental concerns of the community and/or farmer preferences for contract production, which were not measured in the present study. Future research that more closely measures community attitude may be particularly fruitful in better quantifying the location decision. Another limitation relates to the length of the survey, which may lead to respondent fatigue and/or learning biases across the three models. Survey techniques that employ experimental designs to avoid or allow for testing of these types of biases would be beneficial.

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Appendix

Calculations for Overall Part-Worth Effects

The procedure for bridging part-worth estimates across the three models begins with utilization of TLT part-worth estimates from the broiler growing and processing enterprises and the previously defined scalar (B). Three formulas are used in this first stage. The formulas differ depending on whether common attributes between the two enterprises are bridged and according to the enterprise being bridged. The steps for calculating first-stage bridged part-worths are as follows:

(i) Calculate bridged part-worths for common attributes between broiler-growing and -processing enterprises (denoted W_{lm}). The formula is

$$(5) \qquad W_{lm} = (P^1_{jk} \cdot B^{-1}) + (P^3_{jk} \cdot B),$$

where B is the bridging scalar and P^1_{jk} and P^3_{jk} are part-worth estimates for level k of attribute j in the broiler-growing and -processing enterprises, respectively. Subscript $j = 1, 2,$ and 3 for the common attributes of community attitude, water cost, and electricity cost, respectively. W_{lm} has two subscripts, where $l = 1, 2,$ and 3 for the first three bridged attributes, and m represents levels for the bridged attribute l.

(ii) Calculate bridged part-worths for unique attributes of the broiler growing enterprise. The formula is

$$(6) \qquad W_{lm} = (P^1_{jk} \cdot B^{-1}) + (P^1_{jk}),$$

where all variables are as previously defined. However, here $j = 4, 5,$ and 6 for heating cost, number of growers and potential growers available, and distance between feed mill and grower, respectively. Similar to step (i), the subscript k represents levels for attribute j; subscript l equals 4, 5, and 6, representing the fourth through sixth bridged attributes; and m represents their respective levels.

(iii) Calculate part-worths for unique attributes of the broiler processing enterprise. The formula is

$$(7) \qquad W_{lm} = (P^3_{jk}) + (P^3_{jk} \cdot B),$$

where all variables are as previously defined. Similar to step (ii), j is equal to 4, 5, 6, and 7, but note these are the fourth through seventh attributes in the broiler processing enterprise—that is, proximity to major metropolitan markets, unemployment rate in the region, average hourly wage in the region, and sewer cost, respectively. As before, the subscript k represents the respective levels for attribute j, but l is defined as 7, 8, 9, and 10, representing the last set of first-stage bridged part-worths.

Procedures for calculating OPW effects (denoted *OPW*) for the broiler complex utilize first stage bridged effects and TLT part-worth estimates for the feed mill enterprise. As before, formulas differ depending on whether one is bridging common attributes or attributes unique to a particular enterprise. The steps are as follows:

(iv) Calculate part-worths for common attributes between the feed mill, broiler-growing, and broiler-processing enterprises. The formula is

$$(8) \qquad OPW = (W_{lm} \cdot FB^{-1}) + (P^2_{jk} \cdot FB),$$

where FB is the previously defined bridging scalar and P^2_{jk} are part-worth estimates for level k of attribute j in feed mill enterprise, and W_{lm} is as previously defined. Here j and l equal 1, representing part-worth estimates for community attitude toward the broiler industry in the feed mill enterprise and the bridged community attitude effect from the first stage. In this case, OPW is the OPW estimate for the effect of community attitude on the location decision.

(v) Next we calculate OPW effects for attributes unique to the first-stage bridged results (i.e., unique to broiler growing and broiler processing). The formula is

$$(9) \qquad OPW = (W_{lm} \cdot FB^{-1}) + (W_{lm}),$$

where all variables are as previously defined. However, here $l = 2, 3, \ldots, 10$, representing the second through 10th attributes in the first-stage bridged results.

(vi) Finally we calculate the OPW effects for attributes unique only to the feed mill enterprise. The formula is

$$(10) \qquad OPW = (P^2_{jk}) + (P^2_{jk} \cdot FB),$$

where all variables are as previously defined, but here j is equal to 2 and 3, representing the second and third attributes in the feed mill enterprise—that is, the cost of feed ingredients and the quality of roads from feed mill to grower, respectively.