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Comparing Consumer Preferences for Livestock Production Process Attributes Across Products, Species, and Modeling Methods

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Consumer preferences for four livestock products were investigated to determine consumer willingness to pay (WTP) for livestock production process attributes. We use an inferred method of attribute nonattendance (ANA) using the coefficient of variation on individual specific parameter estimates to assess the variability of preference intensity for various product characteristics. We find that accounting for ANA did not significantly impact mean estimates of WTP. Implications of our findings on the reliability of existing work in the area of consumer preferences for animal welfare attributes are discussed.

Key Words: animal welfare, attribute nonattendance, consumer demand, random parameters logit

JEL Classifications: Q00, Q10, Q13

Abundant evidence exists on food labels, in grocery stores, restaurant advertisements, and in news and media stories that U.S. consumers are increasingly interested in how their food is produced. In particular, meat and milk products evoke a sentiment in consumers toward the livestock animals used in their production. Although ample evidence of this exists in the literature, the level of concern and specific practices of concern (i.e., gestation crates for pigs, pasture access for dairy cows, cage size/designs for laying hens) are not necessarily the same across all species of livestock animals. Moreover, consumers in supermarket outlets and restaurants are purchasing meat and dairy products, not livestock animals. Thus, there is potential for variation in consumer sentiment based on the specific item being purchased rather than on the animal from which it was produced.

Consumer preferences for food attributes, ranging from production practices to country or region of origin, have been of growing interest in the United States and abroad (Bonnet and Simioni, 2001; Cicia, Del Guidice, and Scarpa, 2002). Choice experiments and derived consumer willingness to pay (WTP) values have become a prevalent way of assessing consumer demand and preferences for various practices used to raise livestock animals. Studies have assessed consumer WTP for animal welfare attributes in numerous meat and dairy products (Carlsson, Frykblom, and Lagerkvist, 2007a, 2007b; Lijenstolpe, 2008; Lusk, Norwood, and Pruitt, 2006; McKendree et al., 2013; Nocella et al., 2012; Nocella, Lionel Hubbard, and

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Scarpa, 2010; Tonsor et al., 2005; Tonsor, Olynk, and Wolf, 2009) as well as evaluated voting and ballot initiatives on animal-rearing practices (Tonsor and Wolf, 2010; Tonsor, Wolf, and Olynk, 2009). Olynk and Ortega (2013), Olynk, Tonsor, and Wolf (2010), and Wolf, Tonsor, and Olynk (2011) all found that consumer WTP for dairy cow welfare attributes varied across production practice as well as the entity verifying those practices. Olynk, Tonsor, and Wolf (2010) also found evidence that social desirability bias, with respect to livestock animal welfare attributes, varies between dairy cows and pigs, and hypothesized that consumer association of affinity for the particular species studied may have played a role in the finding.[1] Nocella, Lionel Hubbard, and Scarpa (2010) found differing trust for farmers, with reference to animal-friendly practices, across countries within the European Union, thus providing evidence of crosscultural differences in consumer preferences and behaviors. Furthermore, Nocella et al. (2012) explores relationships between heterogeneity of consumer preferences and psychological constructs. Additional work on heterogeneity in consumer preferences for various livestock species and/or products (including issues of social desirability as well as cultural and psychological factors) will enhance our understanding of decision-making in agricultural and food markets.

We hypothesize that if consumers' association with a specific livestock species has the potential to influence WTP for welfare attributes, perhaps the individual meat or dairy product itself does as well, even if coming from the same livestock species. Consumers could associate certain products more closely with the animal where it came from. Consumer WTP for welfare attributes may be the result of perceptions of the species and the specific product purchased simultaneously. Following this idea, Olynk and Ortega (2013) investigated consumer WTP for verified welfare attributes across dairy products, specifically ice cream and yogurt. They found that mean WTP estimates were higher for the same verified attributes in yogurt than in ice cream, although both are made from milk produced by dairy cows. Their study concludes that WTP for dairy cattle welfare was statistically different depending on the type of product consumers were purchasing. Similarly, McKendree et al. (2013) analyzed two different ham products (smoked ham and ham lunchmeat) and found that although consumer WTP varied depending on the attribute and verifying party, no statistical differences relative to the product price levels were found across products for the same verified attribute. Therefore, past evidence exists that consumers' preferences vary across livestock species and for some livestock species (but perhaps not others) across the specific product purchased.

Recent research has focused on the identification of decision rules that individuals may use when processing information in stated choice experiments (Hensher and Greene, 2010). Recent discussions in the choice literature have emerged around the potential use of decision heuristics on behalf of consumers to simplify choice tasks. "Attribute nonattendance" (hereafter ANA) refers to respondents ignoring attributes when choosing between alternatives (Hensher and Greene, 2010; Scarpa et al., 2009). Past research has found significant evidence of ANA with meaningful impacts on WTP estimates. Scarpa et al. (2009) identified over 90% of their survey population not attending to the price variable; this caused unrealistically high WTP estimates for rural landscape valuation. These type of effects are especially concerning to researchers, marketers, and industry professionals, because failing to account for ANA in prior studies may have impacted the marketing and policy conclusions drawn from previous research.

Layton and Hensher (2008) point out that accounting for ANA may increase or decrease WTP values. Differences in consumer WTP across species highlighted by previous work led to questions on how accounting for ANA may impact WTP estimates across various livestock products. This analysis reinvestigates the results from previous choice experiment data sets for four individual products: ice cream, yogurt, smoked ham, and ham lunchmeat. An inferred

[1] Social desirability bias is defined as consumers' incentive to self-report answers on socially sensitive topics (specifically farm animal welfare, in this case) in ways that conform to perceived social norms.

method of ANA proposed by Hess and Hensher (2010) based on the coefficient of variation of random parameter estimates is used and various threshold definitions for ANA are evaluated under this method. We use this particular method because it allows for the incorporation of ANA into the modeling framework without relying on additional information that may not have been collected.

Theoretical Framework

Research suggests that consumers possess heterogeneous preferences and using a model that allows for heterogeneous preferences is appropriate (Alfnes, 2004; Lusk, Roosen, and Fox, 2003; Train, 1998). Random parameters logit (RPL) models are a common method of capturing preference heterogeneity in random utility models. Under RPL, the deterministic component of utility V_{nit} takes the form of

$$V_{nit} = \beta' x_{nit} \tag{1}$$

where β is a vector of random parameters that has its own mean and variance, representing individual preferences, and x_{nit} is the vector of attributes found in the i^{th} alternative. The probability that individual n chooses alternative i from the choice set C in situation t is given by

$$P_{nit} = \int \frac{\exp(V_{nit})}{\sum_j \exp(V_{njt})} f(\beta) d\beta \tag{2}$$

where the distribution of the random parameter $f(.)$ is predetermined (Train, 2003). If the parameters are fixed at β_c (nonrandom), the distribution collapses, i.e., $f(\beta_c) \rightarrow \infty$ and $f(\beta) = 0$ otherwise.

Data

Hypothetical choice experiments, or simulated shopping experiences, without the actual exchange of money or products, were designed to estimate consumers' WTP for dairy and ham production process attributes and verifying agencies. The dairy and ham choice experiments were conducted in separate consumer surveys administered in 2011 and 2012, respectively. To reduce potential response fatigue, consumers were randomly allocated to a choice experiment for only one dairy (ice cream or yogurt) or one ham (smoked ham or ham lunchmeat) product.

The dairy choice experiments incorporated various dairy cattle rearing practices and verification entities as well as the product price. Consumers received information about whether pasture access was required or not required, antibiotic use was permitted or not permitted, rbST/rbGH use was permitted or not permitted, and whether the verification entity was the U.S. Department of Agriculture Process Verified Program (USDA-PVP),[2] the dairy industry, or a retailer. The verification or certification entity refers to the entity providing verification to the consumer of the animal welfare and handling claims made on the product. Claims surrounding livestock rearing, handling, and housing all encompass credence attributes of the production process, which have many associated challenges with verification, including the inability or difficulty associated with verification of claims through testing (Olynk, Tonsor, and Wolf, 2010). Therefore, consumers must often rely on labeling for information regarding such practices. The verification entity included in these experiments is the entity presented on the product as providing assurance of the claims made regarding the production processes used. Ice cream and yogurt were offered at three different price levels: \$1.99/pint, \$4.49/pint, or \$6.99/pint and \$0.30/six-oz container, \$0.75/six-oz container, or \$1.20/six-oz container, respectively. These prices were selected to be consistent and comparable with retail prices for the products of the specified sizes (ice cream sold in pint containers and yogurt sold in six-oz individual containers) at the time the survey was administered.

The ham choice experiment had a similar setup, where participants received information

[2] The Grain Inspectors, Packers and Stockyard Administration (GISPA) PVP has official procedures in place for verification of products assigned to GISPA and services associated with marketing these products (USDA/Grain Inspection, Packers and Stockyards, 2007). Verification services through GISPA are voluntary and are available to producers, marketers, processors, and other associated service providers of agricultural products for a fee (USDA/Grain Inspection, Packers and Stockyards, 2007).

on pork-rearing practices, verifying entities and product price. In this case, individual crates/stall were permitted or not permitted, pasture access was required or not required, and antibiotic use was permitted or not permitted. The verifying entities were selected to be the USDA-PVP, a retailer, or the Pork Industry. The two ham products were offered at three different price levels: smoked ham price levels were \$1.69/lb., \$5.79/lb., or \$9.89/lb., and ham lunchmeat price levels were \$2.49/lb., \$6.74/lb., or \$10.99/lb. Prices were chosen to be comparable and consistent with retail prices at the time the survey was conducted. Appendices A and B summarize the attributes and corresponding levels for the dairy products and ham products, respectively.

The same statistical design was used to create the choice experiment for all four products investigated, although the specific attributes and levels incorporated were product-specific. The choice sets allowed participants to choose between purchasing one of two product alternatives or neither. A D-efficient design allowing for the estimation of necessary effects was used to create the hypothetical choice scenarios (Lusk and Norwood, 2005); the final choice design resulted in 24 choice sets, which were blocked into three groups of eight.[3] To mitigate any ordering impacts, the order of choice sets was randomized (Loureiro and Umberger, 2007). Sample choice sets for the dairy and ham products investigated are shown in Appendices C and D, respectively.

In each of the choice experiments, a product-purchasing situation, or shopping experience, was simulated; however, the exchange of real meat and dairy products or money did not take place. Information was provided to survey participants as part of a "cheap-talk" strategy aimed to reduce hypothetical bias by informing survey participants of this bias before participation (Lusk, 2003). The instructions to the participants stated, "The experience from previous similar surveys is that people often state a higher willingness to pay than what one actually is willing to pay for the good. It is important that you make your selections like you would if you were actually facing these choices in your retail purchase decisions, noting that allocation of funds to these products means you will have less money available for other purchases."

Four distinct data sets are used for this analysis: two dairy products: ice cream ($n = 500$) and yogurt ($n = 500$), and two pork products: smoked ham ($n = 399$) and ham lunchmeat ($n = 399$). The data were obtained through two online surveys representative of U.S. consumers. Internet surveys are becoming more popular as a result of their low costs and speedy completion times and have been found to not exhibit nonresponse bias (Gao and Schroeder, 2009; Louviere et al., 2008; Olynk, Tonsor and Wolf, 2010; Olynk and Ortega, 2013; Ortega et al., 2011; Tonsor and Wolf, 2010). Fleming and Bowden (2009) as well as Marta-Pedroso, Freitas, and Domingos (2007) found no significant differences when comparing results between web-based surveys and conventional mail and in-person interview surveys. Moreover, Olsen (2009) found no significant differences in mean WTP estimates between Internet surveys and mail surveys when specifically studying choice experiments.

Decipher, Inc., a marketing research services provider that specializes in online survey programming, data collection, data processing, and custom technology development, implemented the surveys. The surveys were administered online to U.S. households and participants were recruited from a large opt-in panel by Survey Sampling International to be representative of the U.S. population, at least 18 years in age, and familiar with the food-purchasing behavior of their household. Additional information on the dairy and pork surveys, data collection, and initial analyses can be found in Olynk and Ortega (2013) and McKendree et al. (2013), respectively. A brief summary of demographic characteristics from both samples is

[3] Recent methodological contributions and advancements in work by Scarpa and Rose (2008) and Vermuelen et al. (2011) highlight the outperformance of D-efficiency criteria in choice experiment design when eliciting WTP by C-efficiency criterion. Vermuelen et al. (2011) finds that use of the C-efficiency criteria leads to more precise estimation of WTP and reductions in the occurrence of overly high WTP estimates.

shown in Table 1. Both of the surveys included the aforementioned choice experiments to elicit consumer preferences for animal welfare attributes.

Model

Through the use of the RPL model, we can directly estimate heterogeneity in consumer preferences across the evaluated attributes. The estimated model for yogurt and ice cream is specified as:

$$\begin{aligned} V_i = {} & \beta_1 OptOut_i + \beta_2 Price_i + \beta_3 Pasture_i \\ & + \beta_4 Antibiotics_i + \beta_5 rbST_i \\ & + \beta_6 Retailer_i + \beta_7 USDA_i \end{aligned} \tag{3}$$

where *Price* is the price of the good and *OptOut* is a constant included to capture the disutility associated with not having the product in consumer's choice set (OptOut = 1 if option C is selected, *OptOut* = 0 otherwise). *Pasture, Antibiotics,* and *rbST* indicate pasture access, antibiotic use, and rbST/rbGH, respectively. *Retailer* and *USDA are* verifying entities.

The model estimated for smoked ham and ham lunchmeat is specified as:

$$\begin{aligned} V_i = {} & \beta_1 OptOut_i + \beta_2 Price_i + \beta_3 Pasture_i \\ & + \beta_4 Antibiotics_i + \beta_5 Crates_i \\ & + \beta_6 PorkInd_i + \beta_7 USDA_i \end{aligned} \tag{4}$$

where *Crates* indicates the use of individual crates or stalls, *PorkInd* indicates Pork Industry Verification, and all other terms are defined as described previously. Effects coding was used to avoid confounding effects of attribute levels with the opting-out option presented to consumers. In effects coding, rather than the typical 0,1 dummy variable coding, the attributes take on a value of one when applicable, a value of –1 when the base category applies, and zero otherwise.[4] The β coefficients on all of the explanatory variables were specified to vary normally across consumers. The random parameters were assumed to be drawn from a normal distribution, which allowed WTP estimates to be either positive or negative (Lusk, Roosen, and Fox, 2003; Tonsor et al., 2005).[5]

The coefficients estimated in a random utility model have little interpretive standalone value; therefore, WTP estimates are commonly calculated. The WTP for attribute k in this analysis was calculated as:

$$WTP_k = -\left(\frac{2 * \beta_k}{MUI}\right), \tag{5}$$

where β_k is the coefficient on an attribute k and *MUI* is the marginal utility of income, which is proxied by the price coefficient.[6] Estimated mean WTP values can be interpreted as being representative for the entire surveyed consumer group if the standard deviations of the attribute constants are not statistically different from zero. Evidence of preference heterogeneity exists if standard deviations are statistically significant.

Ninety-five percent confidence intervals for WTP estimates were calculated using a parametric bootstrapping technique proposed by Krinsky and Robb (1986).[7] One thousand observations for each WTP estimate were simulated by drawing from a multivariate normal distribution parameterized with the coefficients estimated in the RPL model and the variance–covariance matrix resulting from the same model (Krinsky and Robb, 1986). The 95% confidence intervals surrounding mean estimates of WTP

[4] Adamowicz, Louviere, and Williams (1994) provide motivation and justification for the use of effects coding in a choice experiment setting; Bech and Gyrd-Hansen (2005) provide further in-depth discussion of effects coding and its use in such settings.

[5] For the intended purposes of this analysis, models were estimated without accounting for correlations in preferences across attributes; it is acknowledged that previous investigations by McKendree et al. (2013) and Olynk and Ortega (2013) using differing model specifications have found evidence for correlations among verified attributes (interaction terms between verifiers and production process attributes).

[6] In all four of the data sets analyzed in this study, the coefficient on the verified attribute is multiplied by two in the WTP ratio in this analysis as a result of effects coding (Lusk, Roosen, and Fox, 2003).

[7] A variety of methods exist to determine confidence intervals on the WTP estimates, including delta, Fieller, Krinsky Robb, and other bootstrap methods; however, these methods have been found to be reasonably accurate and to yield similar results to one another (Hole, 2007).

Table 1. Selected Demographics of Samples Used in Analysis

	Respondents Completing the Choice Experiment on Ice Cream (n = 500)		Respondents Completing the Choice Experiment on Yogurt (n = 500)		Respondents Completing the Choice Experiment on Smoked Ham (n = 399)		Respondents Completing the Choice Experiment on Ham Lunchmeat (n = 399)	
Variable Description	Percent of Sample	Mean	Percent of Sample	Mean	Percent of Sample	Mean	Percent of Sample	Mean
Female		0.54		0.48		0.53		0.51
Age		46		44		47		46
Adults per household		1.97		1.98		1.94		1.93
Total children per household		0.61		0.52		0.46		0.53
Annual pretax income								
• Less than $20,000	25		23		22		17	
• $20,000–39,999	30		29		32		30	
• $40,000–59,999	19		18		20		23	
• $60,000–79,999	12		15		13		12	
• $80,000–99,999	6		6		7		8	
• More than $99,999	8		9		9		11	

are presented in brackets after the WTP estimates in the results.

Following McKendree et al. (2013) and Olynk and Ortega (2013), this study seeks to determine if consumers' WTP for individual attributes and verifiers differ between the two dairy products and two ham products analyzed. To statistically evaluate differences in two WTP series, a complete combinatorial method proposed by Poe, Giraud, and Loomis (2005) was used. Comparisons between the dairy and ham products is complicated by the varying mean price levels and distributions of prices used in the choice experiments for each of the four products. To eliminate any scale effects resulting from differing price levels, the test was conducted on the ratio of WTP for each attribute to the average product price ($4.49 for ice cream, $0.75 for yogurt, $5.79 for smoked ham, $6.74 for ham lunchmeat).

Attribute Nonattendance

Traditionally, discrete choice experiments assume that individuals attend or consider all of the attributes presented (and their specific levels) when evaluating choice scenarios. Recent research suggests that individuals rely on various information processing strategies to simplify specific choice tasks (Hensher, Rose, and Greene 2005; Hess and Hensher, 2010). Therefore, estimated utility coefficients may not accurately reflect underlying preferences. In this study, we rely on an inferred method of ANA proposed by Hess and Hensher (2010), which uses the coefficient of variation (the ratio of standard deviation to the mean) on individual specific parameter estimates to measure the degree of noise-to-signal ratio on the variability of taste intensity for a given attribute as exhibited by the individual's choice behavior. Scarpa et al. (2013) point out that the issue of threshold definition using this method is a delicate and somewhat arbitrary one. Although a value of two has been used in previous studies to indicate the presence of ANA, we evaluate three cutoff values (one, two, and three) to explore the effects of different threshold choices. Therefore, we estimate the RPL models by restricting an individuals' utility coefficient to be zero if an attribute is not attended.[8] All models were estimated using NLOGIT© 5.0 (Econometric Software, Inc., Plainview, NY).

Results and Discussion

This study examines consumer preferences and demand for various livestock production process attributes and parties verifying those attribute claims for specific products. The vast majority of the estimated means for dairy and ham product attribute and verifying entity parameters were statistically significant in these models. Standard deviation parameters were statistically significant for several attributes in each model; specifically, a total of four, five, three, and four standard deviation parameters were significant for ice cream, yogurt, ham, and ham lunchmeat, respectively. Tables 2 and 3 display the mean estimated coefficients, with confidence intervals as well as estimated standard deviation estimates for all four initial models evaluated.

Attribute Nonattendance

Following Hess and Hensher (2010), the coefficient of variation was calculated using individual-specific mean and standard deviation coefficient estimates. Per Hess and Hensher (2010), "while working with the coefficient of variation incorporates uncertainty into our approach, the task still remains to decide how to allocate respondents to different groups on the basis of the coefficient of variation." For their work, Hess and Hensher (2010) allocated respondents as ignoring an attribute if the absolute value of the coefficient of variation exceeded two, but recognize that "the choice of a value of 2 is rather arbitrary but conservative

[8] Individuals with coefficients of variation for specific attributes exceeding the specified cutoff criteria (one, two, or three) were assigned values of –888. Per Greene (2012), "we note one specific feature of the data set that is unusual is the 'ignored value code,' –888, described in Section N18.9. This special code is used to signal values that are deliberately omitted from the data set by the observed individual—they are 'missing values,' with a specific understanding for why they are missing."

Table 2. Parameters [confidence intervals] for Ice Cream and Yogurt from Random Parameters Logit without Accounting for Attribute Nonattendance

Variable	Ice Cream Coefficient Estimates	Ice Cream Standard Deviation Estimates	Yogurt Coefficient Estimates	Yogurt Standard Deviation Estimates
Opt out (do not buy)	–1.480* [–1.786 to –1.173]	2.931*	−0.783* [−1.112 to −0.544]	2.755*
Price	–0.484* [–0.542 to –0.425]	0.433*	−1.366* [−1.606 to −1.126]	1.541*
Pasture access	0.371* [0.297 to 0.446]	0.398*	0.322* [0.260 to 0.394]	0.393*
Antibiotic use	0.246* [0.168 to 0.323]	0.398*	0.328* [0.242 to 0.414]	0.644*
rbST/rbGH use	0.242* [0.171 to 0.314]	0.352*	0.248* [0.178 to 0.318]	0.336*
USDA-PVP certification	0.267* [0.184 to 0.351]	0.054	0.380* [0.295 to 0.465]	0.323*
Retailer certification	–0.141* [–0.456 to –0.226]	0.0138	−0.386* [−0.499 to −0.273]	0.128

Notes: Presented models were estimated using NLOGIT 5.0, with Halton draws, and 1000 replications for simulated probability. Asterisk indicates statistical significance at the 0.05 level. Ninety-five confidence intervals are presented [in brackets] for mean estimates to facilitate comparison across products.

threshold, and more work is required to evaluate the impact of the threshold choice on results." In this study, three different threshold choices for the coefficient of variation are investigated: one, two, and three.

Tables 4 and 5 display the percent of respondents in each data set who were inferred to have ignored various attributes when participating in the choice experiments. It is interesting to note that the proportion of the sample inferred to exhibit ANA under the different thresholds varies not only by threshold (as expected), but also depending on the attribute and livestock product in question. For example, there is little evidence of ANA for certifying entities for both dairy products; in fact, only USDA-PVP certification for yogurt attributes has any percent of respondents meeting the thresholds for inferred ANA with 22%, 5%, and 3% of the sample under the criteria of coefficient of variation greater than one, two, and three, respectively. In contrast, there is evidence of ANA for verifying

Table 3. Parameters [confidence intervals] for Ham and Ham Lunchmeat from Random Parameters Logit without Accounting for Attribute Nonattendance

Variable	Ham Coefficient Estimates	Ham Standard Deviation Estimates	Ham Lunchmeat Coefficient Estimates	Ham Lunchmeat Standard Deviation Estimates
Opt out (do not buy)	–1.998* [–2.325 to –1.672]	3.153*	–2.174* [–2.540 to –1.808]	3.072*
Price	–0.284* [–0.321 to –0.248]	0.279*	–0.324* [–0.361 to –0.286]	0.264*
Pasture access	0.317* [0.247 to 0.387]	0.073	0.317* [0.246 to 0.388]	0.044
Antibiotic use	0.310* [0.222 to 0.399]	0.578	0.257* [0.170 to 0.345]	0.486*
Individual crates/stalls	0.126* [0.058 to 0.193]	0.024	0.149* [0.079 to 0.219]	0.171*
USDA-PVP	0.587* [0.479 to 0.694]	0.483*	0.477* [0.381 to 0.574]	0.052
Pork Industry certification	–0.384* [–0.507 to –0.261]	0.157	–0.262* [–0.380 to –0.143]	0.133

Notes: Presented models were estimated using NLOGIT 5.0, with Halton draws, and 1000 replications for simulated probability. Asterisk indicates statistical significance at the 0.05 level. Ninety-five confidence intervals are presented [in brackets] for mean estimates to facilitate comparison across products.

Table 4. Rate of Attribute Nonattendance by Varying Criteria for Coefficient of Variation (CoV) for Ice Cream and Yogurt

Criteria for Ignoring Attributes	Percent of Respondents Ignoring Attributes for Ice Cream			Percent of Respondents Ignoring Attributes for Yogurt		
	CoV >1	CoV >2	CoV >3	CoV >1	CoV >2	CoV >3
Opt out (do not buy)	28	15	9	31	16	10
Price	23	13	8	35	16	10
Pasture access	42	16	9	49	18	12
Antibiotic use	63	32	19	57	27	17
rbST/rbGH use	62	26	14	57	21	11
USDA-PVP certification	0	0	0	22	5	3
Retailer certification	0	0	0	0	0	0

entities, USDA-PVP and Pork Industry certification, for both smoked ham and ham lunchmeat, ranging from 4% to 36% of the sample depending on the threshold criteria used. All of the attributes (pasture access, antibiotic use, rbST/rbGH use, and individual crates and stalls) investigated had some evidence of ANA for each product evaluated, except pasture access for smoked ham. There is no evidence of ANA for pasture access for any of the thresholds used for smoked ham in this analysis.

Each of the four models described was re-evaluated accounting for ANA at the various threshold levels described, resulting in a total of four models estimated for each of the four products in question. Tables 6 and 7 display the mean parameter coefficient estimates and estimated standard deviations for the models accounting for inferred ANA resulting from the coefficient of variation threshold of one, two, and three. Tables 2 and 3 as well as 6 and 7 all display confidence intervals on mean parameter estimates to allow for comparison of coefficient estimates resulting from the original models (which did not account for ANA) and the models accounting for ANA inferred from various thresholds of the coefficient of variation.

Willingness to Pay and Comparisons between Products and Attribute Nonattendance Thresholds

Because the interpretation of individual coefficients is generally discouraged, coefficients were used to compute estimates of consumer WTP under varying criteria for inferred ANA. Estimated mean WTP, with simulated 95% confidence intervals, for each of the attributes and verifying agencies for ice cream and yogurt

Table 5. Rate of Attribute Nonattendance by Varying Criteria for Coefficient of Variation (CoV) for Ham and Ham Lunchmeat

Criteria for Ignoring Attributes	Percent of Respondents Ignoring Attributes for Smoked Ham			Percent of Respondents Ignoring Attributes for Ham Lunchmeat		
	CoV >1	CoV >2	CoV >3	CoV >1	CoV >2	CoV >3
Opt out (do not buy)	22	13	9	20	9	6
Price	32	15	10	19	10	6
Pasture access	0	0	0	6	3	1
Antibiotic use	44	27	17	29	14	10
Individual crates/stalls	35	18	11	30	16	10
USDA-PVP	36	17	12	18	7	4
Pork Industry certification	22	10	5	33	14	8

Table 6. Parameters for Ice Cream and Yogurt from Random Parameters Logit Accounting or Attribute Nonattendance (ANA) Corrections

Product	Ice Cream					
Criteria for ANA	Coefficient of Variation >1		Coefficient of Variation >2		Coefficient of Variation >3	
	β[a]	σ[b]	β	σ	β	σ
Opt out (do not buy)	–2.899* [–3.359 to –2.439]	3.859*	–2.319* [–2.690 to –1.948]	3.351*	–2.208* [–2.568 to –1.848]	3.199*
Price	–0.784* [–0.861 to –0.706]	0.418*	–0.662* [–0.730 to –0.595]	0.448*	–0.611* [–0.680 to –0.543]	0.468*
Pasture access	0.846* [0.740 to 0.951]	0.290*	0.581* [0.495 to 0.667]	0.354*	0.496* [0.418 to 0.574]	0.300*
Antibiotic use	0.891* [0.729 to 1.052]	0.729*	0.514* [0.412 to 0.617]	0.557*	0.426* [0.333 to 0.518]	0.524*
rbST/rbGH use	0.921* [0.797 to 1.045]	0.094	0.511* [0.423 to 0.598]	0.260*	0.397* [0.319 to 0.475]	0.240*
USDA-PVP certification	0.296* [0.206 to 0.386]	0.314*	0.267* [0.182 to 0.352]	0.159	0.260* [0.176 to 0.345]	0.180
Retailer certification	–0.403* [–0.520 to –0.285]	0.173	–0.361* [–0.475 to –0.246]	0.085	–0.334* [–0.448 to –0.220]	0.108
Product	Yogurt					
Criteria for ANA	Coefficient of Variation >1		Coefficient of Variation >2		Coefficient of Variation >3	
	β	σ	β	σ	β	σ
Opt out (do not buy)	–1.944* [–2.527 to –1.361]	4.580*	–1.378* [–1.784 to –0.972]	3.600*	–1.253* [–1.647 to –0.859]	3.219*
Price	–2.562* [–2.838 to –2.286]	0.999*	–1.903* [–2.138 to –1.667]	1.081*	–1.643* [–1.868 to –1.419]	1.163*
Pasture access	0.811* [0.705 to 0.916]	0.207	0.513* [0.434 to 0.592]	0.338*	0.436* [0.360 to 0.513]	0.360*
Antibiotic use	0.882* [0.709 to 1.054]	1.009*	0.546* [0.428 to 0.665]	0.834*	0.445* [0.344 to 0.547]	0.746*
rbST/rbGH use	0.784* [0.682 to 0.887]	0.000	0.481* [0.405 to 0.558]	0.095	0.386* [0.314 to 0.459]	0.112
USDA-PVP certification	0.668* [0.579 to 0.758]	0.011	0.461* [0.377 to 0.546]	0.232*	0.430* [0.347 to 0.512]	0.212
Retailer certification	–0.477* [–0.584 to –0.370]	0.072	–0.418* [–0.527 to –0.309]	0.041	–0.405* [–0.513 to –0.297]	0.004

[a] β are mean coefficient estimates.

[b] σ are standard deviation estimates.

Notes: Presented models were estimated using NLOGIT 5.0, with Halton draws, and 1000 replications for simulated probability. Asterisk indicates statistical significance at the 0.05 level. Values presented [in brackets] are 95% confidence intervals.

Table 7. Parameters for Smoked Ham and Ham Lunchmeat from Random Parameters Logit Accounting for Attribute Nonattendance (ANA) Corrections

Product	Ham					
Criteria for ANA	Coefficient of Variation >1		Coefficient of Variation >2		Coefficient of Variation >3	
	β	σ	β	σ	β	σ
Opt out (do not buy)	–2.821* [–3.324 to –2.318]	5.359*	–2.331* [–2.735 to –1.928]	4.296*	–2.065* [–2.453 to –1.678]	3.793*
Price	–0.460* [–0.512 to –0.409]	0.391*	–0.337* [–0.377 to –0.296]	0.324*	–0.302* [–0.340 to –0.264]	0.289*
Pasture access	0.370* [0.290 to 0.451]	0.300*	0.349* [0.273 to 0.424]	0.205*	0.337* [0.263 to 0.410]	0.171*
Antibiotic use	0.645* [0.512 to 0.777]	0.625*	0.492* [0.378 to 0.605]	0.630*	0.404* [0.302 to 0.507]	0.583*
Individual crates/stalls	0.224* [0.136 to 0.312]	0.102	0.163* [0.088 to 0.238]	0.056	0.157* [0.086 to 0.229]	0.018
USDA-PVP	0.906* [0.765 to 1.046]	0.581*	0.705* [0.587 to 0.823]	0.518*	0.653* [0.539 to 0.767]	0.492*
Pork Industry certification	–0.446* [–0.585 to –0.308]	0.035	–0.418* [–0.546 to –0.290]	0.229	–0.399* [–0.523 to –0.275]	0.259
Product	Ham Lunchmeat					
Criteria for ANA	Coefficient of Variation >1		Coefficient of Variation >2		Coefficient of Variation >3	
	β	σ	β	σ	β	σ
Opt out (do not buy)	–2.736* [–3.246 to –2.225]	3.953*	–2.531* [–2.949 to –2.114]	3.472*	–2.539* [–2.921 to –2.157]	3.340*
Price	–0.452* [–0.499 to –0.404]	0.260*	–0.390* [–0.433 to –0.347]	0.270*	–0.361* [–0.401 to –0.322]	0.274*
Pasture access	0.401* [0.325 to 0.478]	0.099	0.364* [0.291 to 0.438]	0.047	0.358* [0.283 to 0.432]	0.093
Antibiotic use	0.441* [0.326 to 0.555]	0.511*	0.346* [0.242 to 0.451]	0.567*	0.329* [0.232 to 0.425]	0.542*
Individual crates/stalls	0.220* [0.125 to 0.315]	0.232*	0.199* [0.115 to 0.283]	0.240*	0.198* [0.118 to 0.277]	0.244*
USDA-PVP	0.628* [0.512 to 0.744]	0.382*	0.581* [0.476 to 0.686]	0.201	0.549* [0.447 to 0.650]	0.074
Pork Industry certification	–0.359* [–0.495 to –0.223]	0.043	–0.362* [–0.491 to –0.233]	0.120	–0.336* [–0.462 to –0.211]	0.176

[a] β are mean coefficient estimates.

[b] σ are standard deviation estimates.

Notes: Presented models were estimated using NLOGIT 5.0, with Halton draws, and 1000 replications for simulated probability. Asterisk indicates statistical significance at the 0.05 level. Values presented [in brackets] are 95% confidence intervals.

is presented in Table 8. Mean WTP varied as different thresholds for inferred ANA were investigated, although confidence intervals generally overlapped. Mean WTP estimates for the attributes generally increased, whereas WTP for USDA verification generally decreased after accounting for ANA. Beyond comparing mean WTP across various thresholds for ANA, statistical evidence of differences between dairy products, ice cream and yogurt, was also of interest. Table 8 also displays evidence of differences in WTP between products for the various models estimated. For both ice cream and yogurt, there was evidence at the 1% level that consumer WTP for pasture access, antibiotic use, rbST/rbGH use, and USDA-PVP certification differed depending on which dairy product was in question (after accounting for differences in mean price levels of these products). This result is in keeping with findings in Olynk and Ortega (2013) indicating statistically significant differences in WTP across dairy products. However, in the present analysis, we show this difference to be robust to the threshold defining inferred ANA based on the coefficient of variation.

Mean WTP estimates for smoked ham and ham lunchmeat, along with simulated 95% confidence intervals, are displayed in Table 9. Although mean WTP estimates appear to vary depending on threshold value, an examination of 95% confidence intervals suggests that these differences are not statistically significant from the base model.[9] When looking at smoked ham, mean WTP was lower, although not statistically different, when a coefficient of variation of two was used as the threshold for ANA corrections for opting out and pasture access; it was found to be higher for antibiotic use, individual crates/stalls, USDA-PVP certification,

[9] Examination of overlapping 95% confidence intervals is intuitive and allows comparison by visual inspection when confidence intervals are presented. It is acknowledged that comparing of 95% confidence intervals and examining overlap is more conservative than the standard method of significance testing when the null hypothesis is true and falsely fails to reject the null hypothesis more frequently than the standard method when the null hypothesis is false (Schenker and Gentleman, 2001).

Table 8. Mean Willingness to Pay (WTP; $) Estimates and 95% Confidence Intervals (CIs) for Ice Cream and Yogurt

	Ice Cream Mean WTP ($/pint) Estimates [95% CI]				Yogurt Mean WTP ($/6oz) Estimates [95% CI]				Statistical Evidence of Differences between WTP among Products[a,b]			
										Coefficient of Variation > __		
	Not Accounting for ANA	CoV >1	CoV >2	CoV >3	Not Accounting for ANA	CoV >1	CoV >2	CoV >3	Not Accounting for ANA	1	2	3
Opt out (do not buy)	−6.12 [−7.21, −5.02]	−7.40 [−8.48, −6.40]	−7.00 [−8.01, −6.09]	−7.22 [−8.26, −6.18]	−1.15 [−1.60, −0.71]	−1.52 [−1.96, −1.07]	−1.45 [−1.85, −1.03]	−1.53 [−2.02, −1.07]				
Pasture access	1.54 [1.19, 1.86]	2.16 [1.88, 2.49]	1.75 [1.49, 2.04]	1.62 [1.37, 1.91]	0.47 [0.36, 0.62]	0.63 [0.54, 0.74]	0.54 [0.44, 0.65]	0.53 [0.43, 0.65]	***	***	***	***
Antibiotic use	1.02 [0.67, 1.38]	2.27 [1.75, 2.74]	1.55 [1.25, 1.89]	1.39 [1.08, 1.76]	0.48 [0.35, 0.65]	0.69 [0.55, 0.84]	0.57 [0.44, 0.72]	0.54 [0.40, 0.70]	***	***	***	***
rbST/rbGH use	1.00 [0.71, 1.34]	2.35 [1.96, 2.71]	1.54 [1.29, 1.84]	1.30 [1.03, 1.59]	0.36 [0.26, 0.49]	0.61 [0.52, 0.71]	0.51 [0.42, 0.60]	0.47 [0.37, 0.59]	***	***	***	***
USDA-PVP certification	1.10 [0.75, 1.49]	0.76 [0.52, 1.02]	0.81 [0.55, 1.09]	0.85 [0.54, 1.17]	0.56 [0.40, 0.75]	0.52 [0.44, 0.62]	0.48 [0.38, 0.60]	0.52 [0.41, 0.66]	***	***	***	***
Retailer certification	−1.41 [−1.98, −0.94]	−1.03 [−1.35, −0.72]	−1.09 [−1.47, −0.73]	−1.09 [−1.49, −0.70]	−0.57 [−0.79, −0.38]	−0.37 [−0.47, −0.28]	−0.44 [−0.57, −0.32]	−0.49 [−0.66, −0.35]				

[a] A complete combinatorial test was performed on the attribute WTP relative to the average price of each product ($4.49 for ice cream and $0.75 for yogurt).
[b] Asterisks, *, **, and *** indicate statistically significant differences in WTP for attributes between products at the 10%, 5%, and 1% level, respectively.
Notes: Simulated 95% confidence intervals (identified using 1000 Krinsky-Robb simulations) are presented in brackets. ANA, attribute nonattendance; COV, coefficient of variation.

Table 9. Mean Willingness to Pay (WTP; $) Estimates and 95% Confidence Intervals (CIs) for Smoked Ham and Ham Lunchmeat

	Smoked Ham Mean WTP ($/lb) Estimates [95% CI]				Ham Lunchmeat Mean WTP ($/lb) Estimates [95% CI]				Statistical Evidence of Differences between WTP among Products[a,b]			
										Coefficient of Variation > __		
	Not Accounting for ANA	CoV >1	CoV >2	CoV >3	Not Accounting for ANA	CoV >1	CoV >2	CoV >3	Not Accounting for ANA	1	2	3
Opt out (do not buy)	−14.07 [−16.32, −12.02]	−12.25 [−14.15, −10.50]	−13.85 [−15.96, −11.90]	−13.67 [−16.20, −11.48]	−13.44 [−15.56, −11.49]	−12.11 [−14.33, −9.94]	−12.98 [−15.06, −11.19]	−14.06 [−16.07, −12.22]	**	*	**	*
Pasture access	2.23 [1.73, 2.77]	1.61 [1.25, 2.00]	2.07 [1.62, 2.52]	2.23 [1.75, 2.74]	1.96 [1.50, 2.43]	1.78 [1.44, 2.12]	1.87 [1.50, 2.29]	1.98 [1.58, 2.47]				
Antibiotic use	2.18 [1.55, 2.87]	2.80 [2.21, 3.45]	2.92 [2.24, 3.69]	2.68 [1.96, 3.45]	1.59 [1.06, 2.15]	1.95 [1.45, 2.49]	1.78 [1.27, 2.32]	1.82 [1.27, 2.38]				
Individual crate/stall	0.89 [0.39, 1.39]	0.97 [0.60, 1.37]	0.97 [0.50, 1.43]	1.04 [0.54, 1.52]	0.92 [0.48, 1.37]	0.97 [0.56, 1.41]	1.02 [0.60, 1.50]	1.09 [0.66, 1.58]				
USDA-PVP	4.13 [3.20, 4.99]	3.93 [3.25, 4.66]	4.19 [3.39, 5.06]	4.32 [3.43, 5.28]	2.95 [2.23, 3.67]	2.78 [2.24, 3.39]	2.98 [2.39, 3.63]	3.04 [2.46, 3.71]				
Pork Industry certification	−2.70 [−3.69, −1.83]	−1.94 [−2.61, −1.30]	−2.49 [−3.28, −1.70]	−2.64 [−3.58, −1.80]	−1.62 [−2.42, −0.90]	−1.59 [−2.22, −1.02]	−1.86 [−2.55, −1.18]	−1.86 [−2.60, −1.17]	**	*	**	

[a] A complete combinatorial test was performed on the attribute WTP relative to the average price of each product ($5.79 for smoked ham and $6.74 for lunchmeat).
[b] Asterisks, *, **, and *** indicate statistically significant differences in WTP for attributes between products at the 10%, 5%, and 1% level, respectively.
Notes: Simulated 95% confidence intervals (identified using 1000 Krinsky-Robb simulations) are presented in brackets. ANA, attribute nonattendance; COV, coefficient of variation.

and Pork Industry certification. For ham lunchmeat, mean WTPs were lower, although not statistically different for pasture access and Pork Industry certification, and higher for opting out, antibiotic use, individual crates/stalls, and USDA-PVP certification. In contrast to the findings for dairy products, ham and ham lunchmeat were not found to have statistically different mean estimates of WTP for the majority of attributes and verifying entities examined. Only opting out and Pork Industry certification yielded differences in WTP across the different models investigated. McKendree et al. (2013) examined verified attributes, or interactions between attributes and verifying entities, and found no evidence of statistically different WTP across smoked ham and ham lunchmeat. Interestingly, Pork Industry certification when examined in this model was found to elicit a different consumer WTP in smoked ham versus ham lunchmeat, except in the model in which ANA was accounted for using a coefficient of variation threshold of three.

Across all four products evaluated, there are inconsistencies in whether mean WTP increases or decreases when accounting for ANA; this holds true when looking at a single coefficient of variation threshold. By examining overlap in 95% confidence intervals, mean WTP values did not vary significantly among the models investigated. Thus, it cannot be concluded that ANA, as measured in our analysis, consistently led to increased or decreased mean WTP estimates. Rather, impacts were relatively small and induced insignificant upward or downward movement on estimates.

Conclusion

Four livestock products were investigated to determine mean consumer WTP for production process attributes, namely ice cream, yogurt, smoked ham, and ham lunchmeat. This study relied on an inferred method of ANA proposed by Hess and Hensher (2010) that uses the coefficient of variation on individual specific parameter estimates to measure the degree of noise-to-signal ratio on the variability of preference intensity for a given attribute. Of particular interest was the coefficient of variation

threshold value used to infer ANA. Although the issue of identifying an optimal threshold value when using this method is of interest and would be valuable in future work, it is beyond the scope of this study and is left as an area of future research. Determination of a truly optimal threshold requires some agreement as to the true level of ANA in a data set, which may be influenced by data collection methods, subject matter, timing, and other factors. We do note, however, that our findings are robust to a wide range of threshold values.

Accounting for ANA did not alter the overarching findings of the original research studies. Consumer preferences for attributes in ice cream and yogurt differed significantly across products, whereas ham products did not. The effects of ANA at all thresholds investigated were relatively small and led to upward or downward impacts on estimates. These inconsistent and insignificant effects can provide some reassurance of the continued use of previously drawn conclusions. Although it would be premature to draw overarching and definitive conclusions based on this study, continued work is needed to investigate the effects ANA on related consumer demand work regarding livestock species and products. Although we find that the incorporation of inferred ANA based on the coefficient of variation does not change the overall conclusions and implications of prior work on dairy and ham products, the evaluation of additional measures and modeling techniques of ANA (both inferred and stated) are important areas of future study.

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Appendix A. Ice Cream and Yogurt Attributes and Attribute Levels Evaluated in Choice Experiments

Product Attribute	Ice Cream Attribute Levels	Yogurt Attribute Levels
Price	$1.99/pint	$0.30/6 oz
	$4.49/pint	$0.75/6 oz
	$6.99/pint	$1.20/6 oz
Pasture access	Required	
	Not required	
Antibiotic use	Not permitted	
	Permitted	
rbST/rbGH use	Not permitted	
	Permitted	
Certifying entity	USDA-PVP	
	Dairy Industry certification	
	Retailer	

Appendix B. Smoked Ham and Ham Lunchmeat Attributes and Attribute Levels Evaluated in Choice Experiments

Product Attribute	Smoked Ham Attribute Levels	Ham Lunchmeat Attribute Levels
Price	$1.69/lb	$2.49/lb
	$5.79/lb	$6.74/lb
	$9.89/lb	$10.99/lb
Individual crates/stalls	Not permitted	
	Permitted	
Pasture access	Not required	
	Required	
Antibiotic use	Not permitted	
	Permitted	
Certification entity	USDA-PVP	
	Retailer certification	
	Industry certification	

Appendix C. Example Choice Set Scenario for Ice Cream and Yogurt

Example ice cream purchasing scenario:			
Attribute	Option A	Option B	Option C
Price ($/pint)	$1.99	$4.49	I choose not to purchase either product
rbST use	Not permitted	Permitted	
Pasture access	Not required	Required	
Antibiotic use	Not permitted	Not permitted	
Certification entity	Dairy Industry certification	USDA-PVP	
I choose:	—	—	—

Example yogurt purchasing scenario:			
Attribute	Option A	Option B	Option C
Price ($/6-oz container)	$1.20	$0.75	I choose not to purchase either product
rbST use	Not permitted	Not permitted	
Pasture access	Not required	Required	
Antibiotic use	Permitted	Permitted	
Certification entity	Retailer certification	USDA-PVP	
I choose:	—	—	—

Appendix D. Example Choice Set Scenario for Smoked Ham and Ham Lunchmeat

Example smoked ham purchasing scenario:			
Attribute	Option A	Option B	Option C
Price ($/lb.)	$9.89	$5.79	I choose not to purchase either product
Individual crates/stalls	Not permitted	Not permitted	
Pasture access	Required	Not required	
Antibiotic use	Not permitted	Not permitted	
Certification entity	Pork Industry	Retailer certification	
I choose:	—	—	—

Example ham lunchmeat purchasing scenario:			
Attribute	Option A	Option B	Option C
Price ($/lb.)	$6.74	$2.49	I choose not to purchase either product
Individual crates/stalls	Permitted	Not permitted	
Pasture access	Not required	Not required	
Antibiotic use	Not permitted	Not permitted	
Certification entity	USDA-PVP	USDA-PVP	
I choose:	—	—	—