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Willingness to pay estimates informing agribusiness decision making: a cautionary tale

RESEARCH ARTICLE

Courtney Bir[Ⓐ], Ann M. Cummins^ᵇ, Nicole Olynk Widmar^ᶜ, and Christopher A. Wolf^ᵈ

^ᵃPhD Candidate, ^ᵇMasters Student, and ^ᶜProfessor, Department of Agricultural Economics, Purdue University, 403 West State Street, Lafayette, IN 47909, USA

^ᵈProfessor, Department of Agricultural, Food, and Resource Economics, Michigan State University, 446 W. Circle Dr., Rm 307, Justin S Morrill Hall of Agriculture, East Lansing, MI 48824-1039, USA

Abstract

Multiple methods to improve reliability of results when using willingness-to-pay (WTP) to evaluate consumer preferences have been developed. This study compared methods of accounting for attribute non-attendance (ANA) in WTP for food product attributes. Both inferred and stated ANA were studied and estimates of WTP for pork chop and bacon attributes were compared. A larger number of significant differences were found between stated or inferred ANA corrected models than between corrected and uncorrected models. Significant correlations between inferred and stated ANA were not present and WTP estimates from correcting for inferred ANA (IANA) or stated ANA were statistically different from one another. Exploring WTP estimates across ANA corrected models is imperative for improving models to provide insight into consumer preferences. These insights can be used in making production decisions in order to meet consumer demands and inconsistent results can lead to conflicting business decisions.

Keywords: attribute non-attendance, consumer preference, willingness-to-pay

JEL code: C9, C5, D1

[Ⓐ]Corresponding author: birc@purdue.edu

1. Introduction

You may have to chop your expectations of bringing home the bacon when using willingness-to-pay (WTP) to evaluate consumer preferences. Economic theory assumes that producers maximize profit, defined as price times output less the cost of production (Mas-Colell, 1995). Producers can make implementable decisions about entering and competing in the marketplace when the good is established and the price is observable. What happens if they are considering producing a new good, or an established good with novel attributes? If those attributes are credence attributes and consumers rely on labeling for information, does the certifying entity matter? Hypothetical choice experiments to inform modeling activities, such as WTP estimation, are a method that can be used to determine consumers' preferences and the dollar amount they are willing to pay for a new product or attribute. Estimates of WTP have been used to study credence attributes such as production methods that may improve animal welfare (Carlsson *et al.*, 2007; Napolitano, 2008; Olynk *et al.*, 2010). Producers may not be willing to implement these production changes without information regarding how much a consumer is willing to pay for that change in production. Using information from hypothetical choice experiments can be the first step in analyzing a business decision. However, what if those results are inconsistent across models or estimation techniques?

There are many challenges in estimating consumer WTP for products or attributes, particularly for a hypothetical product. In order to capture consumer preferences, it is often necessary to include several attributes in a choice experiment. However, it can be difficult for a person to make decisions from many attributes, and they may simplify these choices (Alemu *et al.*, 2013; Scarpa *et al.*, 2012). A primary concern in simplifying choices occurs if the respondent ignores an attribute in order to simplify a choice task. This attribute non-attendance (ANA) may affect the marginal effects of attribute changes because choice experiments are based on random utility theory (Scarpa *et al.*, 2012). Although we can correct for ANA, it is unknown if the correction results in a more or less reliable estimate, better representing the consumer's true preferences. An important first step is to determine if correction methods result in statistically similar results. This research contributes to the literature by examining two methods used to address the challenge in determining WTP of respondents ignoring attributes in the choice experiment, ANA, and utilizing a choice experiment (CE) on pork products as an example.

1.1 Attribute non-attendance

When using CEs, information about a set of attributes is presented to respondents who are asked to make choices, which are then used to determine their preferences for the attributes included. Generally, the estimation of models utilizing data from discrete CEs assumes respondents consider all the information and attributes presented. However, evidence of the use of decision rules, in which the respondent may ignore information or attributes in order to simplify choice tasks, has been documented in CE literature (Hensher and Greene, 2010; Hole, 2011; Scarpa *et al.*, 2012). In cases where attributes and levels are ignored, the estimation of utility coefficients may not accurately reflect consumer preferences and leads to biased results. In this case, these results may lead to misguided decisions by producers or marketers. Therefore, methods that correct for ANA have recently become an area of research focus.

Hole (2011) identified three commonly used approaches to address or account for ANA using modeling techniques, by identifying which respondents are not attending to which specific attributes. In the first approach, referred to as stated ANA (SANA), participants are asked in follow-up questions to state which attributes they did not consider while making decisions (Hole, 2011). In the second approach the interviewer asks participants to 'think aloud' while making choices, and attribute attendance, or ANA, that is verbalized is recorded by the interviewer (Hole, 2011). The third approach uses a modeling technique to estimate when the respondent did not pay attention to a particular attribute, called inferred ANA (IANA) (Hole, 2011). Beyond these approaches to discerning ANA in specific respondents' choices, there are a variety of techniques within each approach to analyze ANA, some of which require significant costs or changes to the data collection structure.

Hess and Hensher (2010) proposed an IANA approach based on the coefficient of variation of random parameter estimates (inferring that ANA is present when the absolute value of the coefficient of variation is greater than two). Olynk Widmar and Ortega (2014) analyzed the impacts of accounting for IANA following Hess and Hensher (2010), but used cutoffs for the coefficient of variation (one, two, or three) and found inconsistent and insignificant effects.

Modeling techniques such as endogenous attribute attendance models (EAA), mixed logit models, standard logit models and others can also be employed to address ANA. Hole (2011) examined methods of accounting for IANA by comparing standard logit models with EAA and latent class models and found that WTP estimates derived from EAA models and latent class models were lower than those provided by the standard logit model, suggesting that not accounting for ANA resulted in biased WTP estimates. Lagarde (2013) studied ANA using latent class models and found that more than 97% of respondents did not consider all CE attributes shown, and that accounting for ANA improved goodness-of-fit for the models as well as having statistically different WTP estimates (than when not accounting for ANA). Comparisons between methods of SANA and IANA have also been completed. For example, Scarpa *et al.* (2012) assessed two methods accounting for IANA against SANA, and concluded that neither of their two IANA approaches was preferred to SANA.

Ideally, accounting for ANA should make the estimates more accurately reflect true consumer WTP. If the various methods to identify ANA are inconsistent, the resulting corrections employed in modeling preferences or demand could be impacted in various ways. The participant not attending to an attribute should be consistently identified across methods (Scarpa *et al.*, 2012). This analysis compares the effect of SANA and IANA on the estimated WTP. Additionally, it examines whether the participants exhibiting IANA and having SANA were the same for each attribute. Identifying IANA and SANA in participants and across the same attributes determines whether the methods identify ANA consistently and whether the results of ANA corrected models are impacted consistently and/or significantly.

1.2 Example products: willingness-to-pay for pork production processes

Livestock production process attributes are credence attributes that are unknown by simply looking at the product, and are of increasing interest to the consumer (Olynk *et al.*, 2010). Therefore, the marketing of meat and milk products increasingly includes both product-specific information and livestock production process attributes, which provide insight into how the animals were raised. Economic theory suggests that consumers will purchase the bundle of goods (within some constraint such as budget) that, to the best of the consumer's ability to determine, provides them with the greatest utility (Caswell, 1998). Consumers have the potential to influence livestock production practices via their purchases, and various methods have been used to estimate consumer demand and consumer preferences for livestock products, including willingness-to-pay, direct ranking, and best-worst scaling (Carlsson *et al.*, 2007; Igo *et al.*, 2013; Lagerkvist, 2013; Napolitano, 2008; Olynk *et al.*, 2010). Recently there has been much attention on production practices in the pork industry including specific concern over antibiotic use, health and safety (particularly regarding the Porcine Epidemic Diarrhea Virus), and housing practices (Barton, 2014; Chapinal, 2010; Wang *et al.*, 2014).

Consumer perceptions of swine rearing practices have the potential to influence demand for pork products and have been the topic of several WTP studies. Lusk, Norwood, and Pruitt (2006) examined U.S. consumer WTP for pork production where sub-therapeutic antibiotic use is not permitted. They found that on average consumers preferred the pork chop where sub-therapeutic antibiotic use was not allowed. Tonsor *et al.* (2009a) examined Michigan consumer perceptions of the use of gestation crates and other pork production practices alongside preferences for country of origin and pig farm size in the form of consumers' WTP. They found that Michigan consumers had statistically significant and negative WTP for pork from large farms (vs medium sized farms) and positive WTP for pork produced without the use of gestation crates (Tonsor *et al.*, 2009a). Similarly in a nationally representative survey, Tonsor *et al.* (2009b) found that respondents believed gestation crates were less likely to be used by 'family' or 'small' farms when compared to 'corporate' farms. Those respondents were also willing to pay \$230/year to implement a ban on the use of gestation crates (Tonsor

et al., 2009a). Farm size is thus a production attribute that has potential linkages, for some consumers, to animal treatment and environmental impacts, and scale of farming operations often has ties to the social acceptability of livestock farming. The value U.S. consumers placed on additional verified credence attributes such as individual crates/stalls, pasture access, antibiotic use, and certified trucking/transportation for the production of pork chops were studied utilizing a choice experiment by Olynk *et al.* (2010).

This analysis focuses on determining consumer WTP for production processes for bacon and pork chops. The attributes studied are relevant to today's swine industry, including use of individual crates/stalls, antibiotic use, and farm size. These attributes are verified by either USDA-Process Verified Program (PVP), Pork Industry, or Retailer in the CE employed. Bacon and pork chops are utilized because they are both pork products, but have distinctions from one another in terms of eating occasion and health associations. Bacon, in particular, is of interest given the lack of substitutes available in the marketplace.¹ If producers consider changing their production in order to meet consumer demand for certain credence attributes, it is important that they are using the most accurate willingness-to-pay information available to make their decisions. By focusing on two methods of correcting for ANA, we can demonstrate the consistency, or lack of consistency, between correction methods.

The objective of this analysis was to analyze the impacts of correcting for ANA via two methods (SANA and IANA) compared to uncorrected models. These WTP comparisons were based on the same set of individual consumer choices within a statistically designed CE evaluated once without correcting for ANA, a second time accounting for IANA, and a third time to account for SANA.

2. Materials and methods

An online survey of U.S. residents was conducted July 23 through August 6, 2014.² The sample was targeted, through the use of respondent quotas, to be representative of U.S. households in terms of gender, age, income, and region of residency. Information collected in the survey included demographic and household information, knowledge and perceptions of pork production and pig farm size, and preferences for pork products (through the use of a CE).

2.1 Choice experiment

Hypothetical CEs, or simulated shopping, without the exchange of goods or money were designed to elicit WTP for bacon and pork chop verified production process attributes. Respondents were randomly assigned to a CE for either bacon or pork chops. Bacon and pork chops were offered at three different price levels: \$3.39/lb, \$5.69/lb, and \$7.99/lb or \$2.29/lb, 4.39/lb, and \$6.49/lb, respectively.³ In addition to the price level, respondents were also given information on production practice attributes including: use of individual crates/stalls permitted or not, antibiotic use, and farm size (small=less than 50 pigs, medium=50 to 500 pigs, or large=greater than 500 pigs). The verification entity included: USDA-PVP, Pork Industry, or Retailer. A brief description of each attribute and attribute level in the experiment was provided to participants immediately before beginning the CE (Supplementary materials S1).

The CE design was created using SAS OPTEX procedure (SAS Institute Inc., Cary, NC, USA), and resulted in a main effect plus two-way interaction design following Lusk and Norwood (2005) which had a maximized

¹ Newman *et al.* (2001) provide support of the uniqueness of bacon in the market place in their study of Irish consumers, where bacon was found to have one of the lowest income elasticities across seven meat categories, and expenditure on bacon was found not to be influenced by other meat purchases.

² The survey used was designed, programmed, and housed at Purdue University, while Lightspeed GMI provided the panel of respondents. Participants were required to be at least eighteen years old. The survey was conducted under Purdue University Institutional Review Board approved protocol number 1406014912.

³ While retail prices for these products vary greatly, the mean price was set to be comparable to the retail price at the time the survey was distributed in 2014. Mean prices were obtained from the Bureau of Labor Statistics "Average retail food and energy prices, U.S. city average and Midwest Region" information.

Past research suggests that models that account for heterogeneous preferences, such as the random parameters logit (RPL), are appropriate, given likely distribution of consumer preferences (Alfnes, 2004; Lusk *et al.*, 2003; McKendree *et al.*, 2013; Olynk *et al.*, 2010, 2014; Schulz and Tonsor, 2010; Tonsor *et al.*, 2005)⁶. The RPL model was used to estimate parameters associated with the verified attributes while accounting for heterogeneity in consumer preferences. Thus, utility for individual n selecting alternative i in situation t is equal to the systematic portion of utility (v_{nit}) plus the sum of the error term distributed normally over individuals and attributes but not choice sets (u_{ni}) and the I.I.D. stochastic error term ε_{nit} (distributed over individuals, attributes, and choice sets) which is written as:

$$U_{nit} = v_{nit} + [u_{ni} + \varepsilon_{nit}] \quad (5)$$

The model for the systematic portion of utility (v_{it}) is of the form

$$\begin{aligned} v_{it} = & \beta_1 price_{it} + \beta_2 USDA_SmFarm_{it} + \beta_3 Retailer_SmFarm_{it} + \beta_4 Indusrty_SmFarm_{it} \\ & + \beta_5 USDA_LargeFarm_{it} + \beta_6 Retailer_LargeFarm_{it} + \beta_7 Indusrty_LargeFarm_{it} \\ & + \beta_8 USDA_Anti_{it} + \beta_9 Retailer_Anti_{it} + \beta_{10} Indusrty_Anti_{it} + \beta_{11} USDA_IndivCrate_{it} \\ & + \beta_{12} Retailer_IndivCrate_{it} + \beta_{13} Indusrty_IndivCrate_{it} + \beta_{14} OptOut_t \end{aligned} \quad (6)$$

where $\beta_1 price_{it}$ was the price of the product (bacon or pork chops) and $USDA_SmFarm$, $Retailer_SmFarm$, and $Industry_SmFarm$ are the effects coded interaction terms between the verification entities and small farm size (farm size of less than 50 pigs).⁷ $USDA_LargeFarm$, $Retailer_LargeFarm$, and $Industry_LargeFarm$ are the effects coded interaction terms between the verification entities and large pig farms (farm size of more than 500 pigs). $USDA_Anti$, $Retailer_Anti$, and $Industry_Anti$ are the effects coded interaction terms between antibiotic use being not permitted and verification entity. $USDA_IndivCrate$, $Retailer_IndivCrate$, and $Industry_IndivCrate$ are the effects coded interaction terms between individual crates being not permitted and verification entity. $OptOut$ is a constant used to designate the disutility of not having the pork product in the choice set. The model is specified such that the β 's (except for those associated with price) vary normally across consumers in order to allow WTP estimates to be either positive or negative (Lusk *et al.*, 2003).

Correlated taste parameters are possible with RPL models since they do not exhibit the independence from irrelevant alternatives as standard logit models do (Revelt and Train, 1998). Following Revelt and Train (1998) the standard Cholesky matrix was estimated. If estimates of the Cholesky matrix show statistical significance, there is support for dependence in tastes and the model allows for increased understanding of correlations in preferences amongst verified attributes (Scarpa and Del Giudice, 2004).

Since the coefficients of the estimated model have little interpretation value on their own mean WTP estimates are calculated as follows:

$$WTP_k = - \left(\frac{2 \times \beta_k}{\beta_1} \right) \quad (7)$$

where β_1 is the coefficient estimate of price and β_k is the coefficient estimate of a verified attribute.⁸ There are several commonly used methods to estimate confidence intervals and statistic variability for the WTP estimates, including the delta method, Krinsky and Robb, Fieller, or other bootstrapping methods. According to Hole (2007), these methods all provide reasonably accurate results which are similar to each other, implying that any one method used is sufficient and no one particular method is preferred. This analysis employed the Krinsky and Robb (1986) method to construct 95% confidence intervals for the WTP estimates. The complete

⁶ The most common and simple model employed for CE data is often the multinomial logit (MNL), although the MNL model assumes homogenous preferences for product attributes across consumers and performs poorly if consumers possess heterogeneous preferences.

⁷ Due to the experimental design, it is impossible for an attribute level to be chosen without having a verification entity to verify the attribute level was present in the selected product. Following Olynk *et al.* (2010) and McKendree *et al.* (2013) a single verification entity was interacted with each of the attributes to produce a verified attribute.

⁸ Effects coding of the verified attribute, k , necessitates multiplication of the WTP ratio by 2 (Lusk *et al.*, 2003).

combinatorial method by Poe *et al.* (2005) was used to evaluate statistical differences for certified attributes between two WTP series.⁹ The complete combinatorial method test was completed using the ratio of WTP for each certified attribute divided by the mean product price (\$5.69 for bacon and \$4.39 for pork chops).

2.3 Attribute non-attendance

To quantify IANA this analysis follows the technique outlined by Hess and Hensher (2010). Although it may be tempting to allocate respondents based on their conditional distribution, that method is likely to result in people with low sensitivity to an attribute being labeled as ignoring the attribute. Therefore, the ratio between the standard deviation and the mean of the conditional distribution, or coefficient of variation, is used to determine if the conditional mean is indistinguishable from zero. First, the coefficient of variation was calculated using the standard deviation coefficient estimates and the individual specific coefficient estimates. Then, if the absolute value of the coefficient of variation was greater than two, that particular attribute was considered to be non-attended by the individual. The value of two was chosen following Hess and Hensher (2010) as they indicated it was a conservative threshold. A high coefficient of variation indicates a very low conditional mean. Following Greene (2012) the attributes that respondents did not attend to while making their decisions were coded to be omitted deliberately in the model. All RPL models were estimated in Nlogit 5.0 (Econometric Software Inc., Plainview, NY, USA).

To quantify SANA, each respondent was directly asked immediately following the CE which attributes they did not consider or ignored. Following Greene (2012) attributes that respondents reported they did not attend to (or ignored) while making their decisions were coded to be omitted deliberately in the model. The RPL model for each product was estimated three times, once uncorrected, once corrected for IANA following Hess and Hensher (2010), and once corrected for SANA following Greene (2012).

3. Results

A total of 1,004 completed surveys were collected. Table 1 summarizes respondent demographics and provides U.S. Census Bureau statistics for comparison. 85% of respondents indicated they had purchased pork products in the previous year and only 7 and 10% of respondents indicated they had never purchased bacon or pork chops, respectively. A total of 4% of respondents indicated they were vegetarian and 2% identified as vegan.

The log likelihood ratio test was used to assess whether the observations from respondents who did and did not receive the information on pig farm size should be pooled. Consumers who responded to the bacon CE were insensitive to the information treatment, and the null hypothesis of equal parameters failed to be rejected. Consumers who responded to the pork chop CE were sensitive to the information treatment. Therefore, analyses are presented for three groups of individuals: those who completed the bacon CE, pork chop CE with the information treatment, and pork chop CE without the information treatment.

The standard deviations for all parameters in the three models (with the exception of three parameters in the pork chop with information treatment group) were statistically significant. In all three models there existed random parameters with elements in the Cholesky matrix that were statistically significant, indicating support for dependence in tastes.¹⁰ Thus, the RPL model with correlated errors provides better understanding of correlations in preferences across attributes (Scarpa and Del Giudice, 2004). WTP for the verified attributes are displayed, along with 95% confidence intervals, in Table 2. The WTP estimate for example, for retailer verified individual crates/stalls should be interpreted as the dollars per pound of product that consumers are WTP above or below the mean marginal price for a retailer to certify the animal was raised on an operation that did not confine animals in individual crates or stalls.

⁹ Testing between WTP series included WTP for differing products as well as testing between uncorrected, IANA, and SANA models.

¹⁰ The coefficient estimates, standard errors, and standard deviations of the parameters from the RPL models for all models run are displayed in Supplementary results S1. Cholesky matrices available from authors upon request.

Table 1 Summary statistics for survey respondent demographic information.

Variable description	Respondents completing bacon CE ¹ frequency (%)	Respondents completing pork chop CE frequency (%)	Census Bureau comparison statistic
Male	55	48	49% (2010 Census, revised 2014)
Age			
18 to 24 years	8	8	70% of the U.S. population over the age of 18 was 25-64 years old (2010 Census, Revised 2014)
25 to 44 years	37	41	
45 to 64 years	37	35	
65 years and over	18	16	
Household income			
Less than \$25,000	22	22	Mean household pre-tax income \$73,034 (U.S. Census Bureau, 2008-2012)
\$25,000-\$34,999	10	13	
\$35,000-\$49,999	16	14	
\$50,000-\$74,999	21	18	
\$75,000-\$99,999	13	14	
\$100,000-\$149,999	13	13	
\$150,000 or more	5	6	
Region of residency			
Northeast	24	25	18% (2010 Census, revised 2013)
South	34	39	38% (2010 Census, revised 2013)
Midwest	23	17	22% (2010 Census, revised 2013)
West	19	19	22% (2010 Census, revised 2013)
Education			
Did not graduate from high school	1	2	86.9% of U.S. citizens older than the age of twenty-five had graduated from high school and that 30.1% had completed at minimum four years of college (U.S. Census Bureau, 2014)
Graduated from high school	18	19	
Attended college, no degree earned	23	21	
Attended college, associate or trade degree earned	16	12	
Attended college, bachelor's (B.S. or B.A.) degree earned	26	31	
Graduate or advanced degree (M.S., Ph.D., law school)	16	15	
Other	0	0	
Vegetarian	3	5	
Vegan	3	4	
Purchased pork in last year	83	84	

¹ CE = choice experiment.

Results from this analysis show consumers generally had a positive WTP for verified antibiotic use and individual crates/stalls regardless of the certification entity for each of the three models. There was one exception as the estimated WTP was not statistically different from zero for retailer verified individual crates/stalls for pork chops in the group without the information treatment. There was an estimated WTP of \$1.29/lb. for bacon that was USDA-PVP verified and from a farm with less than 50 pigs. The estimated WTP for bacon (-\$1.22/lb.) and pork chops for the group who had an information treatment (-\$1.75/lb) were negative for farm size greater than 500 pigs verified by a retailer.

The confidence intervals for all three models, and each attribute level were visually inspected for overlapping confidence intervals. If the confidence intervals do not overlap it indicates that the mean WTPs are statistically

Table 2. Mean willingness-to-pay (WTP) estimates and 95% confidence intervals for bacon and pork chops.¹

Variable	Bacon (n=506)		Pork chops with information treatment (n=252)		Pork chops with NO information treatment (n=246)		P-value comparing WTP between bacon and pork chops with information treatment	P-value comparing WTP between bacon and pork chops with NO information treatment	P-value comparing WTP between pork chops with and without an information treatment
	Mean WTP estimates (\$)	WTP 95% confidence interval estimates	Mean WTP estimates (\$)	WTP 95% confidence interval estimates	Mean WTP estimates (\$)	WTP 95% confidence interval estimates			
USDA-verified farm size less than 50 pigs	1.29**	[0.63, 1.93]	0.85	[-0.08, 1.81]	0.01	[-1.13, 1.09]	0.6312	0.9606	0.8904
Retailer-verified farm size less than 50 pigs	0.56	[-0.02, 1.18]	-0.11	[-0.95, 0.73]	-0.37	[-1.46, 0.74]	0.8633	0.8895	0.6288
Pork industry-verified farm size less than 50 pigs	0.01	[-0.92, 0.86]	-0.36	[-2.03, 1.24]	-0.35	[-2.08, 1.41]	0.6752	0.6429	0.4914
USDA-verified farm size greater than 500 pigs	-0.14	[-0.93, 0.64]	-0.52	[-1.97, 0.84]	0.41	[-0.91, 1.58]	0.6828	0.2348	0.1770
Retailer-verified farm size greater than 500 pigs	-1.22	[-2.25, -0.32]	-1.75	[-2.96, -0.61]	-1.30	[-2.79, 0.13]	0.8789	0.6720	0.3069
Pork industry-verified farm size greater than 500 pigs	-0.29	[-1.15, 0.53]	-0.93	[-2.09, 0.16]	-1.20	[-2.65, 0.08]	0.8689	0.8936	0.6003
USDA-verified antibiotic use	2.67**	[1.87, 3.40]	2.18**	[1.06, 3.42]	1.40**	[0.41, 2.37]	0.4464	0.8674	0.8352
Retailer-verified antibiotic use	1.63**	[0.83, 2.46]	1.25**	[0.17, 2.31]	2.10**	[0.88, 3.35]	0.5429	0.1366	0.1603
Pork industry-verified antibiotic use	3.24**	[2.43, 4.05]	1.89**	[0.75, 3.04]	2.34**	[1.02, 3.68]	0.8003	0.5952	0.3300
USDA-verified individual crates/stalls	1.4**	[0.70, 2.15]	1.80**	[0.69, 2.91]	2.63**	[1.54, 3.79]	0.1157	0.0082	0.1516
Retailer-verified individual crates/stalls	0.98**	[0.22, 1.74]	1.68**	[0.40, 2.85]	0.46	[-0.93, 1.78]	0.0770	0.6721	0.9229
Pork industry-verified individual crates/stalls	1.15**	[0.31, 1.97]	1.58**	[0.09, 2.94]	2.10**	[0.45, 3.78]	0.1587	0.0884	0.1561
Opt out	-10.09	[-11.41, -8.88]	-8.78	[-10.56, -7.09]	-7.87	[-9.93, -5.62]			

¹ 95% confidence intervals were found using the Krinsky and Robb (1986) method. A complete combinatorial test was completed for the ratio (mean WTP estimate/average price of each product) using \$5.69 for bacon and \$4.39 for pork chops. Interpretation is such that a *P*-value of less than 0.05 indicates statistical significance at the 5% level. Following Olynk *et al.* (2010) statistical significance at the 5% level is indicated by ** 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.

different from each other.¹¹ For example, when looking at the confidence intervals for the bacon model in Table 2, the confidence intervals for USDA-verified antibiotic use and retailer-verified antibiotic use do not overlap, so they are not statistically different from one-another. To test for differences in WTP for certified attributes across products, and information treatment in the case of pork chops, the complete combinatorial method was used and *P*-values are displayed in Table 2 (Poe *et al.*, 2005). Considering the pairwise tests for the three models, the estimated WTP between bacon and pork chops without an information treatment for USDA_PVP verified individual crates/stalls was statistically different. This finding differs from that of McKendree *et al.* (2013) who found no variation between consumer WTP for smoked ham and ham lunchmeat. These findings are also in contrast to Olynk and Ortega (2013) who found statistical differences for all but one of their distributions of WTP for verified dairy production attributes. These findings suggest the degree of difference between products, even when from the same livestock species, increases the difference in distribution of WTP.

3.1 Attribute non-attendance

A summary of the percentage of individuals who revealed SANA and IANA using Hess and Hensher (2010) is displayed in Figure 1. When determining individuals who inferred attribute non-attendance for farm size and certification entities, IANA was first determined for each level following Hess and Hensher (2010). Then they were combined to determine individuals who had been identified as having IANA for farm size (regardless of the level) and individuals who had IANA for certification entity (regardless of the level) so that comparisons between SANA and IANA rates could be made. Inferred and stated ANA from each particular individual should agree (Scarpa *et al.*, 2012). Thus, to explore relationships between SANA and IANA within our data, correlations between incidences of SANA and IANA were assessed (Table 3). SANA for farm size was positively correlated with IANA for small and large farm size. Similarly, SANA for individual crates/stalls was positively correlated with IANA for individual crates/stalls. Price, antibiotic use, and certification entity did not have statistically significant correlations between SANA and IANA for the same attribute.

Each of the three models (bacon, pork chops with an information treatment, and pork chops without an information treatment) were re-evaluated twice (once to account for IANA and once to account for SANA). This resulted in a total of nine RPL models (three uncorrected models and six models corrected for ANA) with estimates for consumers' WTP for verified pork attributes. The mean parameter coefficient estimates, associated standard errors, and standard deviation estimates are displayed in Supplementary results S1 for the pork products evaluated. The parameter coefficient estimates from the IANA and SANA corrected models were used to calculate mean WTP estimates. The results are displayed in Tables 4-6 along with estimates from the uncorrected model. Mean WTP estimates between uncorrected and corrected models were compared using overlapping 95% confidence intervals and there were few statistical differences.

¹¹ The visual comparison of confidence intervals is more conservative than the standard method of testing statistical differences when the null hypothesis is true. When the null hypothesis is false, comparison of the 95% confidence intervals falsely fails to reject the null hypothesis more frequently than standard methods (Schenker and Gentleman, 2001).

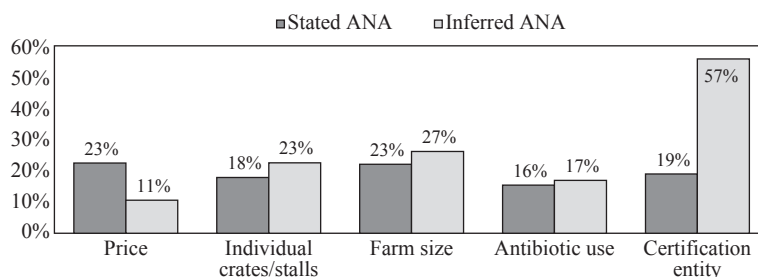


Figure 1. Rates of stated attribute non-attendance (SANA) and inferred attribute non-attendance (IANA).

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Table 3. Spearman correlations between SANA and IANA (n=1,004).¹

Values	SANA for attributes						IANA for attributes						
	Price	Individual crates/ stalls	Farm size	Antibiotic use	Certification entity	None	Price	Individual crates/ stalls	Farm size less than 50 pigs	Farm size greater than 500 pigs	Antibiotic use	USDA-PVP certification	Pork industry certification
SANA for attributes													
Price	1												
Individual crates/stalls	0.105**	1											
Farm size	0.109**	0.382**	1										
Antibiotic use	0.122**	0.327**	0.284**	1									
Certification entity	-0.003	0.239**	0.280**	0.253**	1								
None	-0.475**	-0.409**	-0.479**	-0.359**	-0.426**	1							
IANA for attributes													
Price	-0.029	-0.056	-0.010	-0.009	-0.023	0.011	1						
Individual crates/stalls	-0.016	0.073*	0.119**	0.069*	0.056	-0.078*	-0.068*	1					
Farm size less than 50 pigs	-0.041	0.064*	0.090**	0.050	-0.006	-0.007	-0.055	0.045	1				
Farm size greater than 500 pigs	-0.046	0.068*	0.139**	0.092**	0.085**	-0.059	-0.040	0.282**	0.333**	1			
Antibiotic use	-0.023	0.072*	-0.006	0.027	-0.063*	0.019	-0.014	0.095**	0.121**	0.169**	1		
USDA-PVP certification	0.024	-0.019	-0.033	0.019	0.008	-0.057	-0.101**	0.008	0.020	0.043	-0.039	1	
Pork industry certification	-0.013	0.041	-0.011	0.012	0.030	-0.036	0.007	0.025	0.101**	0.050	0.049	0.022	1

¹ **, * = statistically significant at the 1 and 5%, respectively; SANA = stated attribute non-attendance; IANA = inferred attribute non-attendance.

The complete combinatorial test was used to determine statistical differences in WTP between uncorrected, corrected for SANA, and corrected for IANA for each of the three models (Tables 4-6). For each product, the complete combinatorial test revealed there were more statistical differences in the estimated WTP between the corrected for IANA and corrected for SANA, than there were between the uncorrected and either SANA or IANA. Very few significant differences were found between corrected and uncorrected models. For bacon (Table 4), significant differences were found between IANA corrected models and SANA corrected models for retailer and pork industry verified farm size. The WTP estimates for pork chops with the information treatment (Table 5) were different between uncorrected models and those corrected for IANA for USDA and retailer verified antibiotic use but did not differ between uncorrected and SANA corrected models for any attributes studied. Estimates for WTP between IANA and SANA corrected models differed for pork chops with pork industry verified farm size and USDA and retailer verified antibiotic use. Without the information treatment, WTP for pork chops (Table 6) differed significantly between IANA and SANA corrected models for retailer verified farm size, antibiotic use by all verifiers, and pork industry verified individual crates/stalls.

4. Discussion

The estimated WTP between bacon and pork chops without an information treatment for USDA_PVP verified individual crates/stalls was statistically different according to the complete combinatorial test. Price, antibiotic use, and certification entity did not have statistically significant correlations between SANA and IANA for the same attribute. The lack of statistically significant correlations between IANA and SANA is concerning because it implies the two methods of accounting for ANA tended to not identify ANA for the same attributes in the same individuals. The lack of correlation between SANA and IANA between attributes led to examining further correlations between key demographics and SANA and IANA. The majority of significant correlations between demographics and SANA and IANA were inconsistent across ANA methods. The demographic age category 25-44 years old was the only demographic category where statistically significant correlations between SANA and IANA existed for the same attribute (antibiotic use). These findings are concerning in that they suggest the presence of SANA and IANA was not correlated for the same person, or more generally, with key demographic characteristics.

For each product the complete combinatorial test revealed there were more statistical differences in the estimated WTP between the corrected for IANA and corrected for SANA, than there were between the uncorrected and either SANA or IANA. Very few significant differences were found between corrected and uncorrected models. These findings cannot answer whether accounting for SANA or IANA provides better consumer WTP information, and thus it cannot be determined that a particular method for addressing ANA is superior. However, it can be concluded that correcting for SANA versus IANA can yield statistically different WTP results. These findings generate concern in that the purpose of correcting for ANA is to reduce errors in the WTP estimate results. Further studies could find the optimal threshold, as mentioned by Hess and Hensher (2010), instead of simply using the value of two for the threshold of the coefficient of variation for the IANA correction. Corrections for SANA or IANA in this case were more different from one another than they were from the uncorrected model. Further, the individuals identified as SANA or IANA for an attribute often were not the same, but were instead dependent on the method of identification.

5. Conclusions and implications

Consumer WTP for bacon and pork chops verified attributes were estimated using models that were uncorrected for ANA, as well as corrected for IANA and SANA. Respondents who were shown the information treatment had statistically different responses to farm size when choosing pork chops, and thus were evaluated separately. With respect to bacon, respondents were insensitive to the farm size information treatment. Mean WTP estimates were determined for each of the three models and revealed that consumers were willing to pay a positive amount for verified attributes antibiotic use and individual crates/stalls regardless of the verification entity. The complete combinatorial test was used to determine differences for the WTP for each of the verified attributes between the uncorrected and corrected for ANA models. Most statistical differences in WTP for

Table 4. Mean willingness-to-pay (WTP) estimates and 95% confidence intervals for bacon.¹

Variable	Uncorrected		IANA		SANA		P-value comparing WTP between uncorrected and corrected for IANA	P-value comparing WTP between uncorrected and corrected for SANA	P-value comparing WTP between corrected for IANA versus SANA
	Mean WTP estimates (\$)	WTP 95% confidence interval estimates	Mean WTP estimates (\$)	WTP 95% confidence interval estimates	Mean WTP estimates (\$)	WTP 95% confidence interval estimates			
USDA-verified farm size less than 50 pigs	1.29**	[0.63, 1.93]	1.09**	[0.39, 1.75]	1.16**	[0.46, 1.88]	0.6591	0.6040	0.4464
Retailer-verified farm size less than 50 pigs	0.56	[-0.02, 1.18]	-0.78	[-1.50, -0.06]	0.55	[-0.10, 1.26]	0.9978	0.5018	0.0037
Pork industry-verified farm size less than 50 pigs	0.01	[-0.92, 0.86]	\$0.10	[-0.69, 0.90]	1.17**	[0.27, 2.04]	0.4461	0.0353	0.0403
USDA-verified farm size greater than 500 pigs	-0.14	[-0.93, 0.64]	-0.31	[-1.25, 0.62]	-1.13	[-2.07, -0.17]	0.6138	0.9408	0.8904
Retailer-verified farm size greater than 500 pigs	-1.22	[-2.25, -0.32]	-2.07	[-3.00, -1.10]	-0.99	[-1.89, -0.07]	0.8901	0.3675	0.0553
Pork industry-verified farm size greater than 500 pigs	-0.29	[-1.15, 0.53]	-0.22	[-1.09, 0.62]	0.08	[-0.81, 0.98]	0.4583	0.2758	0.3162
USDA-verified antibiotic use	2.67**	[1.87, 3.40]	1.29**	[0.58, 2.03]	1.96**	[1.15, 2.73]	0.9929	0.8982	0.1156
Retailer-verified antibiotic use	1.63**	[0.83, 2.46]	0.41	[-0.52, 1.36]	0.41	[-0.33, 1.13]	0.9739	0.9864	0.4976
Pork industry-verified antibiotic use	3.24**	[2.43, 4.05]	1.37**	[0.63, 2.11]	1.28**	[0.62, 1.93]	0.9998	0.9999	0.5744
USDA-verified individual crates/stalls	1.41**	[0.70, 2.15]	0.85**	[0.08, 1.64]	1.00**	[0.41, 1.60]	0.8506	0.8038	0.3814
Retailer-verified individual crates/stalls	0.98**	[0.22, 1.74]	0.00	[-0.84, 0.83]	0.28	[-0.45, 1.00]	0.9547	0.9014	0.3163
Pork industry-verified individual crates/stalls	1.15**	[0.31, 1.97]	0.08	[-0.80, 0.92]	0.10	[-0.74, 0.87]	0.9593	0.9612	0.4895
Opt out	-10.09	[-11.41, -8.88]	-6.66	[-7.5, -5.81]	-7.27	[-8.15, -6.32]			

¹ IANA = inferred attribute non-attendance; SANA = stated attribute non-attendance; 95% confidence intervals were found using the Krinsky and Robb (1986) method. A complete combinatorial test was completed for the ratio (mean WTP estimate/average price of each product) using \$5.69 for bacon. Interpretation is such that a *P*-value of less than 0.05 indicates statistical significance at the 5% level. Following Olynk *et al.* (2010) statistical significance at the 5% level is indicated by ** 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.

Table 5. Mean willingness-to-pay (WTP) estimates and 95% confidence intervals for pork chops with an information treatment.¹

Variable	Uncorrected		IANA		SANA		P-value comparing WTP between uncorrected and corrected for IANA	P-value comparing WTP between uncorrected and corrected for SANA	P-value comparing WTP between corrected for IANA versus SANA
	Mean WTP estimates (\$)	WTP 95% confidence interval estimates	Mean WTP estimates (\$)	WTP 95% confidence interval estimates	Mean WTP estimates (\$)	WTP 95% confidence interval estimates			
USDA-verified farm size less than 50 pigs	0.85	[-0.08, 1.81]	0.90	[-0.01, 1.77]	1.27**	[0.47, 2.08]	0.5367	0.7489	0.2752
Retailer-verified farm size less than 50 pigs	-0.11	[-0.95, 0.73]	0.07	[-1.06, 1.20]	0.50	[-0.25, 1.24]	0.6001	0.8598	0.2636
Pork industry-verified farm size less than 50 pigs	-0.37	[-2.03, 1.24]	-0.49	[-1.66, 0.69]	1.13**	[0.18, 2.05]	0.4515	0.9426	0.0165
USDA-verified farm size greater than 500 pigs	-0.52	[-1.97, 0.84]	-0.42	[-1.35, 0.54]	-0.32	[-1.17, 0.57]	0.5399	0.5851	0.4423
Retailer-verified farm size greater than 500 pigs	-1.75	[-2.96, -0.61]	-2.12	[-3.80, -0.35]	-0.93	[-1.99, 0.18]	0.3596	0.8431	0.1247
Pork industry-verified farm size greater than 500 pigs	-0.93	[-2.09, 0.16]	-0.39	[-1.54, 0.68]	0.96**	[0.06, 1.92]	0.7462	0.9942	0.0345
USDA-verified antibiotic use	2.19**	[1.06, 3.42]	1.16**	[0.31, 2.07]	2.44**	[1.65, 3.23]	0.0843	0.6353	0.0180
Retailer-verified antibiotic use	1.25**	[0.17, 2.31]	-0.54	[-2.07, 0.94]	1.28**	[0.47, 2.17]	0.0306	0.5089	0.0208
Pork industry-verified antibiotic use	1.89**	[0.75, 3.04]	1.09**	[0.23, 1.99]	1.89**	[1.07, 2.75]	0.1386	0.4952	0.1018
USDA-verified individual crates/stalls	1.80**	[0.69, 2.91]	1.69**	[0.81, 2.52]	2.25**	[1.40, 3.15]	0.4327	0.7386	0.1753
Retailer-verified individual crates/stalls	1.68**	[0.40, 2.85]	1.64**	[0.38, 2.96]	1.26**	[0.33, 2.19]	0.4737	0.2893	0.6764
Pork industry-verified individual crates/stalls	1.58**	[0.09, 2.94]	0.95	[-0.01, 1.93]	1.65**	[0.77, 2.64]	0.2288	0.5241	0.1512
Opt out	-8.78	[-10.56, -7.1]	-4.82	[-5.69, -3.98]	-6.46	[-7.69, -5.32]			

¹ IANA = inferred attribute non-attendance; SANA = stated attribute non-attendance; 95% confidence intervals were found using the Krinsky and Robb (1986) method. A complete combinatorial test was completed for the ratio (mean WTP estimate/average price of each product) using \$4.39 for pork chops. Interpretation is such that a *P*-value of less than 0.05 indicates statistical significance at the 5% level. Following Olynk *et al.* (2010) statistical significance at the 5% level is indicated by ** 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.

Table 6. Mean willingness-to-pay (WTP) estimates and 95% confidence intervals for pork chops without the information treatment.¹

Variable	Uncorrected		IANA		SANA		P-value comparing WTP between uncorrected and corrected for IANA	P-value comparing WTP between uncorrected and corrected for SANA	P-value comparing WTP between corrected for IANA versus SANA
	Mean WTP estimates (\$)	WTP 95% confidence interval estimates	Mean WTP estimates (\$)	WTP 95% confidence interval estimates	Mean WTP estimates (\$)	WTP 95% confidence interval estimates			
USDA-verified farm size less than 50 pigs	0.01	[-1.13, 1.09]	0.22	[-0.78, 1.23]	0.59	[-0.35, 1.47]	0.3972	0.2125	0.2968
Retailer-verified farm size less than 50 pigs	-0.37	[-1.46, 0.74]	-2.09	[-3.45, -0.77]	0.25	[-0.65, 1.13]	0.9757	0.1891	0.0012
Pork industry-verified farm size less than 50 pigs	-0.35	[-2.08, 1.41]	-0.43	[-2.17, 1.22]	0.47	[-0.64, 1.59]	0.5247	0.2237	0.1845
USDA-verified farm size greater than 500 pigs	0.41	[-0.91, 1.58]	-0.10	[-1.55, 1.28]	-0.87	[-1.94, 0.13]	0.7059	0.9404	0.8081
Retailer-verified farm size greater than 500 pigs	-1.30	[-2.80, 0.13]	-2.76	[-4.32, -1.22]	-1.93	[-3.10, -0.86]	0.9153	0.7546	0.1971
Pork industry-verified farm size greater than 500 pigs	-1.20	[-2.65, 0.08]	-0.76	[-2.03, 0.44]	-0.81	[-1.99, 0.37]	0.3200	0.3357	0.5258
USDA-verified antibiotic use	1.41**	[0.41, 2.37]	0.81	[-0.47, 2.17]	2.60**	[1.43, 3.83]	0.7653	0.0625	0.0261
Retailer-verified antibiotic use	2.10**	[0.88, 3.35]	-1.40	[-3.07, 0.23]	0.98	[-0.10, 1.99]	0.9994	0.9157	0.0089
Pork industry-verified antibiotic use	2.34**	[1.02, 3.68]	0.21	[-1.11, 1.60]	1.75**	[0.80, 2.79]	0.9851	0.7566	0.0390
USDA-verified individual crates/stalls	2.63**	[1.54, 3.79]	2.62**	[1.63, 3.64]	1.66**	[0.80, 2.60]	0.5055	0.9098	0.9158
Retailer-verified individual crates/stalls	0.46	[-0.93, 1.78]	0.64	[-0.94, 2.17]	1.26**	[0.35, 2.17]	0.4339	0.1669	0.2495
Pork industry-verified individual crates/stalls	2.10**	[0.45, 3.78]	-0.05	[-1.52, 1.43]	1.57**	[0.58, 2.61]	0.9736	0.7113	0.0363
Opt out	-7.88	[-9.93, -5.62]	-5.00	[-6.16, -3.80]	-6.96	[-8.22, -5.86]			

¹ IANA = inferred attribute non-attendance; SANA = stated attribute non-attendance; 95% confidence intervals were found using the Krinsky and Robb (1986) method. A complete combinatorial test was completed for the ratio (mean WTP estimate/average price of each product) using \$4.39 for pork chops. Interpretation is such that a *P*-value of less than 0.05 indicates statistical significance at the 5% level. Following Olynk *et al.* (2010) statistical significance at the 5% level is indicated by ** 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.

each product were between the corrected models, which implied that correction for ANA by SANA versus IANA can yield statistically different results. The WTP estimates resulting from correcting for IANA or SANA were statistically different from one another and significant correlations between incidences of SANA and IANA were missing. Thus, differing methods of correction for ANA appear to have the potential to introduce significant differences to estimated values. If businesses are using estimated WTP values to make production, pricing, or marketing decisions, these significant differences across corrected models may be problematic.

Supplementary material

Supplementary material can be found online at <https://doi.org/10.22434/IFAMR2017.0115>.

Materials S1. Choice experiment definitions.

Results S1. Parameter estimates.

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