Meat traceability: Are U.S. consumers willing to pay for it?

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"There are huge gaps from the farm to the processing plants. No one knows where the cows are coming from. . . Trace forward from the processing plant is supposed to be accurate, but no one knows for sure." – Caroline Smith DeWaal, Food Safety Director for the Center for Science in the Public Interest

ABSTRACT

This article reports the results from a series of laboratory auction markets in which consumers bid on meat characteristics. The characteristics examined include meat traceability (i.e., the ability to trace the retail meat back to the farm or animal of origin), transparency (e.g., knowing that the meat was produced without added growth hormones, or knowing the animal was humanely treated), and extra assurances (e.g., extra meat safety assurances). This laboratory study provides non-hypothetical bid data on consumer preferences for a sample of consumers in Logan, Utah for traceability, transparency, and assurances (TTA) in red meat at a time when the U.S. currently lags other countries in development of TTA meat systems. Results suggest that these consumers would be willing to pay for such TTA meat characteristics, and the magnitude of the consumer bids suggests that a profitable market for development of TTA systems in the United States might exist.

Keywords: Auctions, experiments, red meat, traceability, willingness-to-pay

Introduction

Recent research suggests the U.S. red-meat system is falling behind many of its major competitors and trading partners in terms of traceability, transparency, and other quality assurances (TTA) (Liddell and Bailey). In fact, the U.S. pork system ranks last, according to Liddell and Bailey, when compared against the United Kingdom (UK), Denmark, Canada, Japan, Australia, and New Zealand for TTA. Liddell and Bailey indicate that the U.S. red-meat inspection system is designed principally to control pathogens while some competitors' inspection systems are designed not only to control pathogens but also to trace back meat to its origin and provide information on other "extrinsic"[1] characteristics.

Traceability is sometimes called identity preservation and is defined in Liddell and Bailey as the ability to track the inputs used to make food products backward to their source at different levels of the marketing chain. Transparency refers to the public disclosure and availability of information on all of the rules, procedures, and practices used to produce a food product at each level of the marketing chain (Baines and Davies (1998); Early; Liddell and Bailey).

Quality assurance has three key elements. These elements include 1) managing hygiene to ensure food safety, 2) ensuring quality through grading and other measurements, and 3) providing mechanisms for product recalls (Early; Baines). For example, the processes for ensuring hygiene in the European Union (EU) red-meat system have focused on Hazard Analysis Critical Control Point (HACCP) systems beginning at the farm level.

Ensuring quality in red-meat systems includes measurements of the intrinsic quality of a carcass or product (tenderness, back fat, curing, etc.). Intrinsic quality measurements are common to most government grading systems including the United States, its trading partners, and competitors. However, the EU system also provides measures of the extrinsic qualities of

red meat. An example would be assurances of the absence of genetically modified organisms (GMOs) in a product. TTA is different than typical quality assurances and standardization in its scope (tracing throughout the market chain) and focus (certifies more than just food safety). Because some competitors do include extrinsic quality assurances in their red-meat products and the United States typically does not, we include extrinsic quality characteristics as part of our analysis.

Understanding the evolution of the red-meat inspection system in the EU in recent years is essential to understanding why TTA is an important issue. The emphasis on TTA in the EU evolved in response to the perceived regulatory failure of EU governments to provide adequate information to consumers during the EU *Bovine Spongiform Encephalopathy* (*BSE*)[2] crisis (Baines and Davies (1998)). As a result, the EU has developed systems enhancing the credibility of assurances about certain attributes such as animal welfare and even food safety issues such as *BSE* by filling the perceived information void inherent in standard government grading practices with TTA. The EU demands accountability at all stages of the marketing chain, not only for red meat but also for other products (Jones). However, red meat has probably been the most economically important, or at least the most politically important, application of TTA because of the *BSE* issue.

Although little direct red-meat trade takes place between the EU and the United States, the EU is a competitor in world trade for other markets, especially for pork in Japan (Liddell and Bailey). Perhaps more importantly, the EU system is influencing change in other major competitors such as Canada, Australia, New Zealand, and Uruguay, all of which are developing trace-back, red-meat systems (Liddell and Bailey; Lewis; Early; Baines and Davies (2000); Abbatemarico).

Because TTA systems in the EU were implemented primarily in response to the *BSE* crisis, TTA was not used directly as a value-adding marketing strategy. Consequently, willingness-to- pay (WTP) for characteristics like traceability was not a primary consideration when requirements for providing traceability were imposed on market participants, but rather became a requirement to gain access to markets. Conversely, discussions in the United States about TTA have focused on consumers' WTP. For example, at a recent conference discussing genetically modified crops, sponsored by the Pew Initiative on Food and Biotechnology and the USDA, Economic Research Service, WTP was identified as one of the primary issues involved in identity preservation.

Dr. John Wiemers, the chairman of the U.S. Department of Agriculture's Food Safety and Inspection Service Interagency Committee on Animal Identification, has stated that red-meat traceability systems will only be implemented in the United States if consumers are found to be willing to pay for the additional costs to produce traceable products, suggesting that evidence of consumer WTP for TTA products is essential if TTA systems are to be developed in the United States. However, some TTA products have been developed by private companies in the United States. For example, Farmland Foods and Premium Standard Farms have developed TTA pork products. The fact that a large US firms are developing TTA products provides additional evidence that TTA systems and products are becoming more important in the United States and should be studied.

This article presents initial evidence on U.S. consumers' WTP for TTA characteristics in beef and pork. We report the results from a series of controlled laboratory experiments in which consumers bid in a (theoretically) demand-revealing auction on meat sandwich upgrades. These WTP auctions generate non-hypothetical data on consumer valuation of TTA attributes in meat

and are a first step toward identifying the potential U.S. market(s) for meat produced through a TTA system (Shogren et al. (1994b)).

A limited amount of research has been conducted on characteristics that could be verified using traceability. For example, Lusk, Roosen, and Fox have examined consumer willingness to pay for beef products not treated with growth hormones nor fed genetically modified grain. Lusk and Fox also investigated the effect mandatory labeling of hormone-treated beef or beef that had been produced with genetically modified grains on beef products. Other work by Grannis, Hooker, and Thilmany measured consumer preferences for selected characteristics in beef marketed as being "natural." However, to our knowledge, no study has been completed that directly examines consumer WTP for TTA in the United States.

Because very limited information is available on WTP for red meat with TTA characteristics, our results can help lower the risk of retail trials of TTA meat products. We find consumers are willing to pay significant amounts of money to upgrade a sandwich to an otherwise identical sandwich containing TTA attribute(s) meat. Furthermore, our results suggest the market for TTA beef may be broader than the market for TTA pork, as auction market valuation of the latter is more sensitive to the specific demographic characteristics of the consumers. Part of the focus of our analysis is on what consumers are willing to pay for extrinsic quality assurances because extrinsic characteristics are beyond the typical assurances (food safety and intrinsic qualities) provided by public sector inspection and grading in the United States (Baines and Davies (2000)).

Background on TTA

TTA is obtained through a system of records and certifications that allow a product to be traced and certified back to different points in the food chain. Currently, most U.S. red meat is

traceable from retail back to the distributor or processor but not to the farm or animal level. Establishing TTA prior to processing would require a system that is currently not generally in place in the United States.

Red-meat producers and processors in the United States should be concerned that the U.S. system is lagging other countries in terms of TTA for at least three reasons. First, consumers have become increasingly concerned about the processes (inputs and methods) used to produce food (e.g., Dorey; Nakamoto). Second, if competitors are able to differentiate their red-meat products as being superior to U.S. red-meat products in terms of TTA, the United States may lose market share in its red-meat export markets. For example, recent food safety concerns in Japan, including the recent discovery of *BSE*, could potentially lead to heightened import restrictions and regulations (Nakamoto). Japan is the United State's principal export market for red meat and such concerns could eventually lead to a loss of U.S. market share if competitors such as Canada, Australia, New Zealand, and Denmark are successful in convincing Japanese buyers that their products are "safer" than U.S. products because their system provides more TTA than the U.S. system. Finally, consumers may simply be willing to pay for red-meat products with TTA characteristics and a market opportunity may be lost to U.S. producers if such products are not produced in the United States.

Large investments will be needed to make significant changes are made in the U.S. red-meat system to address TTA concerns.[3] Recapturing these investments will require capturing a significant market share of the red meat market for products featuring TTA characteristics. This will probably require a significant penetration of domestic red-meat markets as well as foreign ones. Consequently, measuring WTP is a critical component of the market potential for TTA products. A large-scale field experiment would be an effective but prohibitively costly way of

conducting such research. As an alternative, the small-scale controlled laboratory experiments described in the next section offer a cost effective way of generating initial data on domestic consumer attitudes about WTP for TTA.

Economic research on issues relating to TTA is quite limited because these systems have been evolving only within the past few years. The economic literature dealing with TTA focuses primarily on the aftermath of the *BSE* crisis in the United Kingdom. For example, Palmer and Loader and Hobbs document the economic devastation to the British beef industry resulting from the *BSE* scare.

Hobbs used transaction costs economics to examine the perceived value of tracing beef cattle from the farm to the packer level (1996a) and between beef suppliers and retail outlets in the UK (1996b). Her findings indicate that traceability is the most important characteristic desired by large, UK beef processors when purchasing cattle from farmers (1996a). Hobbs (1996b) also found that the ease of traceability ranked ahead of prices paid to processors as an important characteristic to consider when supermarkets in the UK purchased meat. Latouch, Rainelli, and Vermersch reported that consumers in the Rennes area of France were willing to pay for traceability. However, their study focused entirely on one issue, *BSE*, and did not deal with more general issues relating to TTA. Verbeke et al. examined the attitudes of Belgian meat consumers about pork and argued that traceability systems would work best when coupled with efforts to improve intrinsic qualities such as leanness, taste, and tenderness and the extrinsic quality of healthiness. None of these studies provide information or data for U.S. consumers and all are narrowly focused and typically deal with only one issue such as *BSE*.

One recent study suggests that improving animal tracking systems in the United States may be economically justified for beef for the added efficiency they would provide in tracking

animal diseases alone (Disney et al.). While the same study found that tracking systems for pork in the U.S. could not be justified solely for their benefit in controlling animal diseases, it suggested that other benefits, such as consumer acceptance, could justify the implementation of tracking systems. This again denotes the importance of information on consumer WTP if TTA systems were to be implemented in the U.S.

Experimental Design

Data on TTA systems in the United States are not publicly available so a laboratory market approach is used here for eliciting individuals' WTP for food traceability and related characteristics. Our experiments follow the design utilized in Shogren et al (1994b) for eliciting bids to "upgrade" a meat sandwich. Subjects in the experiments are given a free lunch, which includes a meat sandwich, along with $15 cash at the beginning of a one-hour experiment. Subjects in the experiment are allowed to bid on what they would be willing to pay to exchange or upgrade their existing sandwich for a sandwich with meat described as having one or more extra verifiable attributes. Subjects are aware that their baseline sandwich meets current standards enforced by the USDA, but does not have the extra verifiable attributes in the upgrade sandwiches.

The upgrades considered are based on each of the elements of TTA. These elements are 1) transparency, which in the experiments is given by extra assurance or information relating to the processes used to produce meat including animal treatment (humane treatment procedures and no added growth hormones used in production of the meat), 2) assurance, which in the experiments is given by extra assurance of food safety (extra tests conducted for *E. coli* or *Salmonella* for beef or pork, respectively), 3) traceability, which in the experiments is stated as the ability to trace the meat back to the farm of origin,[4] and 4) all three upgrades combined. The

respective auction sandwiches are numbered as Sandwich 1, Sandwich 2, Sandwich 3, and Sandwich 4.[5]

While it is apparent that much of the value of a TTA system is likely to be in the attributes of the product that can be verified, and not just the fact that the product can be traced back to the farm or origin, our use of an auction sandwich verifying only traceability is useful for two purposes. First, in valuing traceability by itself we gain initial insights on consumer WTP just for this information *net* of the attributes that can be verified because of the traceability system. Secondly, the comparison of traceability bids to bids on other sandwiches will then gain insights into the perceived value of adding assurances about certain characteristics along with the traceability information.

Subjects were recruited from four different demographic cohorts for the experiments. The subjects were informed at recruitment that either beef or pork would be consumed as part of the free lunch. Each experimental group consisted of 13 or 14 individuals, on the average. Eight experiments were conducted, four experiments using ham sandwiches and four using roast beef sandwiches. Experimental groups were recruited for the ham and beef experiments such that students were one experimental group, faculty were a group, professional staff (e.g., accountants, administrative personnel, etc.) another group, and classified staff (e.g., maintenance workers, buildings and grounds keepers, etc.) as the fourth distinct demographic group. Experiments were conducted in groups of similar individuals for two reasons. First, it is often the case that individuals of similar socio-demographic populations shop in similar locations, and so this approach may help engage subjects in the auction process by lowering socio-economic status barriers in the lab. Secondly, ex post controls for the experimental group can help uncover the

potential importance of consumer demographics in estimating the market potential for traceable food products.

Subjects were recruited from a pool as diverse as possible from within our university population. Subjects were recruited either by classroom visit (students), e-mail advertisement (faculty and professional staff), or flyer (classified staff). Recruitment methods for the various cohort groups reflect the peculiarities of contacting each group for notification of the experiment opportunity. Though classroom visits imply that most subjects in the student experiment came from a small number of classes, advertisement of the faculty and staff experiments reached campus-wide. To the extent that individuals who respond to such recruitment methods may be different from others, our sample is likely not a pure random sample. However, this criticism would equally apply to a field experiment because those responding and participating may be distinct from those who do not participate.

Because the sample consists of individuals all affiliated with the university, some sample statistics from our overall subject pool are provided in Table 1 to demonstrate the sample is representative. In addition to the information in Table 1, the level of education completed by our sample ranges from high school to post graduate degrees (though most had completed at least some college). Finally, 67% of the subjects report that they are personally responsible for making most of the food purchase decisions for their household.

Once the experiment subjects arrived at the experiment site, they were seated with the free lunch in front of them, given the $15 cash and told to await instructions before unwrapping the lunch sandwich. Subjects had written instructions for the experiment, but the instructions also were explained orally (by the exact same experimenter in all experiments), and all clarification questions were answered prior to commencement of the experiment.[6] The auction

format was such that subjects would place an anonymous bid to upgrade their existing sandwich to an auction sandwich, and the auction rules were those of a (theoretically demand-revealing) second-price sealed-bid auction. The sandwiches were constructed to have the same appearance and were visually inspected by each subject during the experimental instruction phase prior to bidding. The instructions clearly explained the different verifiable meat attributes in each auction sandwich.[7]

After all the subjects' questions were answered, bids from each subject were taken first for Sandwich 1, then Sandwich 2, then Sandwich 3, and finally Sandwich 4 (this constituted one round of the auction). Ten total rounds were conducted with each group to allow for bid stabilization (see Hayes et al., Shogren et al (1994b), and Shogren et al. (2001b)). Market price information (i.e., the second highest bid) for each sandwich was announced after each round and prior to eliciting the next round's bid for that sandwich. Subjects were aware that a random draw at the end of the 10^{th} round would determine which of the four simultaneous auctions would be binding.[8] A second random draw determined which of the ten rounds would be binding. Consequently, only one of the auction sandwiches was actually auctioned in each experiment. Subjects were fully aware prior to starting the first round that there was a uniform chance that *any* round for any auction sandwich might be the binding auction, and the subjects reported no confusion regarding understanding these procedures. At the end of the experiment after the binding auction was randomly drawn, the appropriate auction was consummated by the winning subject paying the second highest bid amount to exchange his/her original sandwich for the auction sandwich. Thus, only one auction winner per experimental group consumes an auction sandwich. All subjects were then required to consume their sandwiches prior to leaving the experiment with their experiment cash.

Unlike the auctions in Shogren et al. (1994b), subject bids were not truncated at zero, although we expect that individuals would place positive value on the attributes studied in this experiment. The benefit of this approach is full demand revelation is allowed even if a TTA characteristic is considered a "bad". The drawback is that subjects may submit negative bids strategically rather than to reveal true WTP (or, in such cases, willingness-to-accept). Shogren et al. (2002) study demand revealing properties of the Vickrey auction when both positive and negative values are induced upon subjects and negative bids are allowed. Their results show that, while subject bids are demand revealing on the average, subjects who negatively value an item tend to overbid their true value for the item—that is, they do not fully reveal the extent of their negative valuation of the item. As we will see, negative bidding is rare in our experiments, and is found more often in early rounds—rounds not examined in our later regression analysis.

The auction format used in WTP experiments is an important consideration. While this study is not meant to test auction theory, one would hope that the auction format employed does elicit true valuations from subjects. Some researchers find that Vickrey auctions are demand revealing on the average (e.g., Shogren et al. (2001b)), while others find that bidders engage in strategic bidding (e.g., Knetsch et al.). Some find similarity in bids across auction mechanisms (Shogren et al. (1994a)), while others do not (Rutstrom). To the extent that bidding may be influenced by the particular auction design, there is well-justified concern over the validity of data from any particular study. It is not our intent to resolve this issue in the present study, but we note some useful guidelines in evaluating the data generated.

First, regardless of the particular auction mechanism used, the experiments provide valuable comparative data on WTP for different TTA attributes because the same auction mechanism is used to elicit values for each sandwich type. Therefore, valuable insights may be

gained about the characteristics being tested. For example, the results can indicate whether or not individuals value additional food safety more or less than additional animal treatment guarantees. Secondly, although the current research is an initial investigation of WTP for TTA attributes that is meant to lower the cost of retail trials, others may choose a more in-depth study at the outset. For example, Shogren et al. (1999) generate data from retail, survey and auction markets to examine preferences for irradiated meat—it is noteworthy that their results offer support for the WTP information learned from experimental auctions. Ultimately, researchers are faced with the choice of whether or not to go beyond experimental data generation in the initial research stage, or in latter stages, but what is learned from experimental food auctions appears to be a useful input for the design of broader retail trials. As noted by Hayes et al. the most prudent approach is to view our WTP estimates as upper bounds on any retail WTP.

Results

The main results of average bid behavior for beef and pork are highlighted in Figures 1 and 2, respectively. While the magnitudes of the average bids are important, our main discussions involve comparisons of bids for different attributes of the same type of meat and for the same attribute for different types of meat. The comparisons across meat types are reasonable because the value of the sandwich in both the beef and ham auction is roughly the same. As stated previously, the magnitudes of the average bids are considered more as an upper bound on bids due to the nature of the one-day experiment (Hayes et al.). Nonetheless, it is apparent that the average subject is willing to pay nontrivial amounts of money to upgrade the meat in a sandwich valued at approximately $3.00. Average WTP (averaged across all subjects and all rounds) to upgrade the roast beef sandwich is $0.23 to add basic traceability, $0.50 to add assurances on animal treatment, $0.63 to add extra assurances of food safety, and $1.06 to

upgrade the sandwich to one in which the roast beef contains all three upgrades. For pork, the same respective upgrades were valued on the average at $0.50, $0.53, $0.59, and $1.14.[9]

Although traceability for beef products is valued to some extent; subjects placed an even larger value on specific attributes that might be verified by a traceable meat system (Figure 1). Bids for beef traceability are statistically lower than bids for both animal treatment assurances and bids for increased food safety ($p=.05$ and $p=.01$, respectively, for the two-tailed nonparametric Friedman test).[10] Similarly a comparison between the specific attributes of food safety and animal treatment reveals that bids for food safety are higher than those for animal treatment, although the significance of this comparison is marginal ($p\approx.11$). Subjects are also willing to pay significantly more for beef combining all three of these meat attributes in a single product ($p<.01$ for each comparison except all attributes compared with food safety ($p=.05$)) than they were for the base sandwich. However, the average bid for the "everything" beef sandwich is less than the sum of the bids for individual meat attributes, suggesting subjects display a decreasing marginal WTP for additional attributes.

Figure 2 presents the comparable average bidding data for the ham sandwich upgrade. The bid data for each auction sandwich are not as neatly ordered for ham as they are for beef, but subjects are still willing to pay significantly more for animal treatment and food safety than for traceability ($p=.10$, $p=05$, respectively). As with beef, subjects are willing to pay significantly more for all attributes together in the sandwich meat ($p=.05$, .05, and .01, respectively, for average bid comparisons of Sand1 and Sand4, Sand2 and Sand4, and Sand3 and Sand4) compared to the base ham sandwich, but the average bid for the "everything" ham sandwich upgrade is less than the sum of the individual meat attributes.[11]

Figures 3 and 4 show the average bid frequencies for beef and ham, respectively. While the average subject is willing to pay significant amounts of money for meat with these attributes, Figures 3 and 4 illustrate that a significant number of subjects—anywhere from 15% (food safety) to 55% (traceability) in beef and from 21% (food safety) to 40% (traceability) in pork—place a zero value on some of the individual food attributes. As such, the conditional mean WTP for TTA attributes in ham and beef is even higher than for the overall sample and is a better measure of WTP for the relevant market segment than the overall sample mean. The parametric regression results reported next help highlight whether the positive WTP of certain consumers is general across the demographic groups or specific to one or more demographic group.

Table 2 reports the results of random-effects estimates of average bids for ham and beef attributes. The dependent variable is the average of the final 5 rounds of bids for each sandwich for a given subject (i.e., average subject bids after bid stabilization in the auction trials). This modeling of the data treats each individual as the cross-sectional unit in our panel data (i.e., bids on several sandwich types for each of many individuals). As such, we take into account the potential non-independence of error terms for a given individual's bids across sandwich types. Group-specific effects are also accounted for with group dummy variables for different demographic market groups. Differences in bidding behavior are therefore separated into those resulting from group effects of the subject group and those resulting from the particular meat attribute of the auction sandwich. Each coefficient estimate for a subject group and a TTA characteristic(s) reflects the marginal increase/decrease in bids estimated for that variable, relative to the baseline of bids by professional staff for the traceability sandwich (#3). Because strategic bidding—in a general sense, bidding higher or lower based on market price announcements—may be a concern in any WTP auction (Knetsch et al.), a market feedback

variable, *Market Price*, is also included which measures the average market price for a particular sandwich in the first five rounds of bidding. Note that *Market Price* is predetermined with respect to the dependent variable that measures average bids from the *last* five rounds of bidding.

Both students and faculty made significantly lower bids for ham than professional staff (though the result for students is only significant at the 10% level) while classified employees bid higher for ham than did professional staff (Table 2). For beef, each of the other three subject groups place higher average bids than the professional staff group, though the difference is only statistically significant for the classified employees. These group specific effects could be a function of educational differences present in our cohort groups. Education levels are likely to affect the level of awareness of issues related to TTA such as a *BSE* or *Salmonella* outbreak. Note the classified staff cohort in the experiments—possessing the lowest average education level in the sample—was willing to pay the highest premium for meat attributes in both the ham and beef regressions. This result is not a function of differences in average income levels across cohorts because the student cohort has the lowest average income.

Table 2 also shows that students and faculty bid the lower premiums on meat attributes for ham than classified employees and professional staff but not so for beef, suggesting that some demographic groups respond differently across meat types. Also, the range of the demographic group effects on average bid prices is narrower for beef than for pork in Table 2, implying that WTP for TTA pork may be more influenced by consumer demographics than for beef (assuming that occupation is a key demographic variable). In either case, these results suggest that significant demographic effects likely exist and are larger in magnitude for pork, implying that marketing strategies for TTA characteristics should perhaps not be uniform across meat types.

Subjects in both the ham and beef sandwich experiments would pay significantly more for animal welfare than for traceability alone, and significantly more for extra food safety than for traceability alone. The premiums for both animal welfare and food safety are larger for beef than they are for pork. Subjects are also willing to pay significantly more for a beef or ham sandwich with the combined characteristics (Sandwich 4) than they would for a sandwich with only traceability (see Table 2 and Figures 1 and 2). The higher premiums on TTA attributes for beef compared to ham suggests perhaps a higher degree of concern exists about the procedures used to produce and process beef than those for ham. One could surmise that higher premiums for TTA in beef relative to ham result from more highly publicized food scares in recent years being related to beef than to pork.[12]

Finally, the coefficient on *Market Price* is statistically significant and positive for ham, but insignificant for beef. This implies that there is some market feedback effect in our data for ham, and bids are increased as a result of market-price announcements in the Vickrey auction. Whether or not this is "strategic bidding" is unimportant. However, it is important that this effect be captured to ensure the remaining coefficient estimates remain unbiased in the ham model. The lack of significance of *Market Price* in the beef equation may be due to individuals initially possessing a better notion of their WTP for TTA attributes in beef. More publicized beef food scares in recent years may also explain this phenomenon.

Because average bid levels are also of interest, and not just the marginal effects of distinct groups or TTA characteristics, combinations of coefficients from the random-effects results are presented in Table 3. As an example of how to interpret Table 3, for the Classified Staff-Food Safety cell for Ham the coefficient of 1.095 is the sum of the individual coefficients from Table 2 (.366+.566+.163). Significance is tested using F-tests—the null hypothesis is that

combinations of coefficients are equal to zero. As can be seen in Table 3, the majority of average bid levels for distinct demographic groups and TTA characteristics are also significantly different from zero, though not all are positive. This perspective of the random-effects results reiterates the previous conclusions: A larger bid variance based on subject groups is apparent in the ham relative to the beef experiments, and bid levels are increased for combinations of TTA characteristics for all subject groups in both meat experiments.

How best to effectively communicate these experimental results about TTA or the results of broader studies, if they are conducted later, is an intriguing question. For example, informing consumers that a product has certain verifiable TTA characteristics is quite different than informing them about the methods used to verify the characteristics. Also some consumers may trust different agencies (such as USDA) making assurances about TTA more than others. The purpose here is to obtain an initial measure of WTP for TTA without regard for the process by which it is verified. The best method for verifying and communicating the information needs additional study, including retail trials. Retail trials will be especially critical for the promotion and labeling questions relating to TTA (e.g., how to label additional TTA characteristics and how they are valued given that other information is already on meat labels). The results presented here simply indicate that some positive value is generally placed on these characteristics, and that some TTA characteristics are more valued than others.[13]

Discussion

The experimental results presented here suggest many consumers, though not all, would be willing to pay for TTA characteristics in red-meat products. Average bids for each individual TTA characteristic as well as the combined characteristics were found to be positive in our subject sample. This suggests that a significant marketing opportunity might be exploited if red-

meat producers developed TTA products. Of course these results apply only to the experimental group, but if verified with retail field trials imply that U.S. consumers would be willing to pay for TTA characteristics in red-meat products. If these results are verified through retail trials they would meet the specific criterion suggested by Wiemers for considering the implementation of these systems in the United States.

The implementation of some sort of TTA system for red meat in the United States seems inevitable as our trading partners and competitors move rapidly to develop such systems. While possible TTA systems in the United States are being examined, and in some cases implemented, the USDA and producer groups in the U.S. have sought evidence that TTA systems would produce a net benefit to the industry.

Consumer WTP for TTA characteristics in pork and beef products was elicited in a non-hypothetical setting. The results indicate that the experimental subjects would be willing to pay for TTA characteristics in red meat. The subjects seem to value specific TTA attributes or combinations of attributes more than just traceability in beef and pork, implying that a system of meat traceability alone may not be valued enough by private consumers to justify its creation. Yet traceability itself could be a valuable public good in terms of limiting contamination outbreaks or even limiting the effects of potential terrorism strikes on the American food system. Systems providing traceability can, however, provide additional information on TTA characteristic(s) that consumers value even more than traceability alone, based on the results from our experimental group. The characteristic most valued by subjects in our experiments was food safety. Consequently, safety guarantees are likely an important component of any profitable TTA system.

We also find some distinct results for beef and pork. Specifically, our subjects seem more willing to pay additional money for knowledge about animal treatment and additional food-safety assurances in beef than in pork—this is in addition to what subjects are willing to pay for meat traceability information alone. Therefore, markets for specific and distinct TTA guarantees may be worth exploring more in beef. The subjects are still willing to pay for TTA characteristics in pork, but there is less evidence for a difference in WTP for food safety and animal treatment guarantees versus traceability for pork than for beef. There is also evidence that subjects' occupations, a key indicator of consumer demographics, are less a determinant of WTP for TTA beef than TTA pork. This has important implications for any marketing strategy for TTA meat products since TTA pork may have to be targeted to more specific consumer demographic groups than TTA beef, which may have a broader potential market.

The results reported in this paper are meant to be an initial step toward identifying the willingness-to-pay of U.S. consumers in retail markets for red meat with TTA characteristics. In the absence of such initial insights there is a higher risk of proceeding toward retail field trials of TTA meat products, and so this study endeavors to provide valuable information for such field trials. These results not only need to be confirmed by field trials but they also do not answer the question of how TTA systems would affect the cost structure for producing and processing red meat—the other important ingredient in determining market viability of TTA products. Nonetheless, these findings offer enough evidence to justify continued examination and determination of the most effective ways for implementing TTA in the U.S. red-meat system.

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Table 1. Demographic Characteristics of the United States, Utah, and Sample.

Characteristic	U.S.	Utah	Sample
Weekly Income[a]	$672 (median-males) $511 (median-females)	$544 (mean)	$588
Annual Median Household Income[b]	$42,151	$46,094	$43,369 (mean)
Percent Female[c]	50.1%	49.9%	49%
Size of Household[d]	2.59	3.13	3.00

[a] Source: U.S. Bureau of Labor Statistics and Labor Commission of Utah.
[b] Source: U.S. Census Bureau (2002a).
[c] Source: U.S. Census Bureau (2002b).
[d] Source: U.S. Census Bureau (2002c).

Table 2. Random Effects Estimation Results.[a]
(dependent variable in ham and beef regression is average subject bid in final 5 rounds of auction)

Item/Independent Variable	Ham	Beef
Observations	212	220
R^2	0.4870	0.2601
Intercept	0.366	-0.019
	(0.230)	(0.128)
Market Price	.282	-.0003
	(0.060)**	(0.002)
Demographic Type:[b]		
Students	-.541	0.305
	(0.303)	(0.177)
Faculty	-.925	0.230
	(0.271)**	(0.171)
Classified Employees	0.566	0.345
	(0.275)*	(0.171)*
Meat Characteristic(s):[c]		
Sandwich 1 (Animal Treatment)	0.151	0.265
	(0.072)*	(0.068)**
Sandwich 2 (Food Safety)	0.163	0.383
	(0.069)*	(0.075)**
Sandwich 4 (Combined Characteristics)	0.351	0.803
	(0.097)**	(0.068)**

[a] Standard errors are in parentheses.
[b] Base is professional staff.
[c] Base is Sandwich 3 (traceability).
* Significantly different than zero at the 5% level.
** Significantly different than zero at the 1% level.

Table 3: Random-Effects Results: average bid levels (combined coefficients)

HAM

	Demographic Group			
TTA Characteristic	Students	Faculty	Classified Staff	Professional Staff
Animal Treatment	-.175	-.408*	1.083**	.517*
Food Safety	-.012	-.396	1.095**	.529*
Traceability	-.175	-.559**	.932**	.366
Combined	.176	-.208	1.283**	.717**

BEEF

	Demographic Group			
TTA Characteristic	Students	Faculty	Classified Staff	Professional Staff
Animal Treatment	.551**	.476**	.591**	.246
Food Safety	.669**	.594**	.709**	.364**
Traceability	.286*	.211	.326*	-.019
Combined	1.089**	1.014**	1.129**	.784**

*Significance at the 5% level, results from $F_{(1,204)}$-tests of each linear restriction on combined coefficients

**Significance at the 1% level, results from $F_{(1,204)}$-tests of each linear restriction on combined coefficients

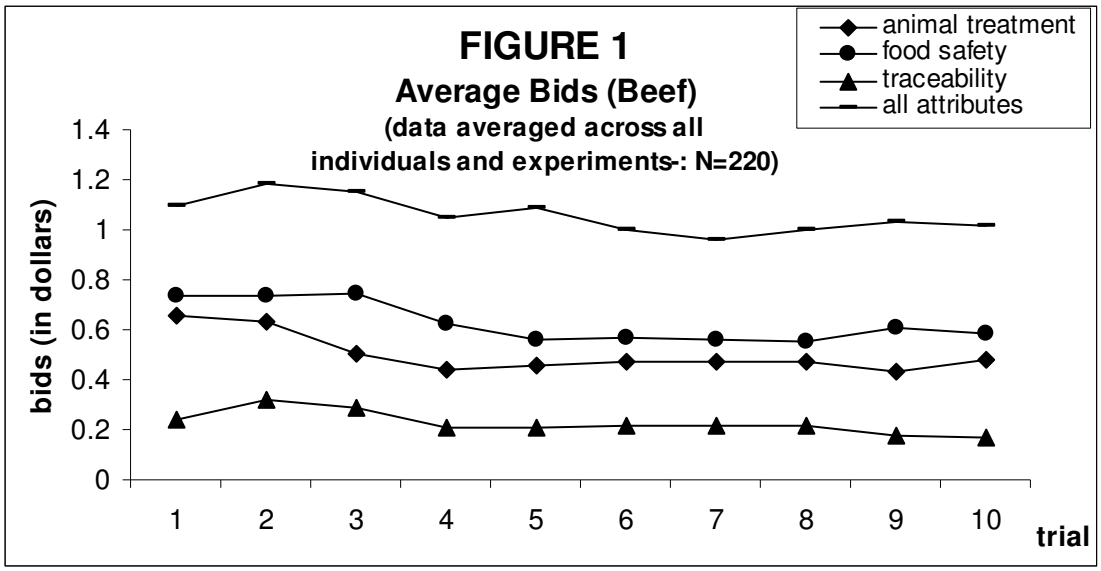
FIGURE 1
Average Bids (Beef)
(data averaged across all individuals and experiments-: N=220)
animal treatment
food safety
traceability
all attributes
bids (in dollars)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1
2
3
4
5
6
7
8
9
10
trial

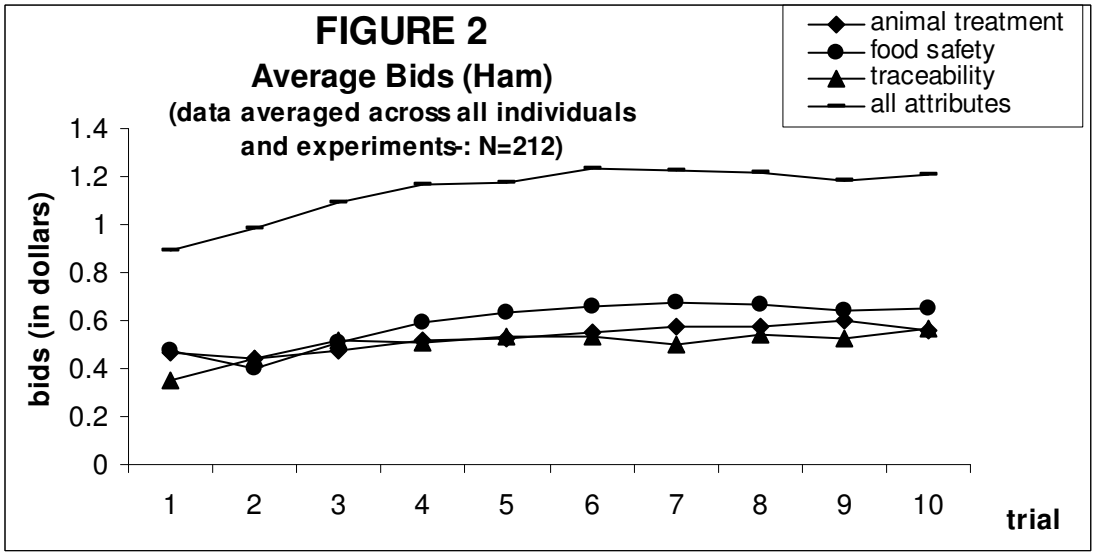
FIGURE 2
Average Bids (Ham)
(data averaged across all individuals and experiments-: N=212)
animal treatment
food safety
traceability
all attributes
bids (in dollars)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1
2
3
4
5
6
7
8
9
10
trial

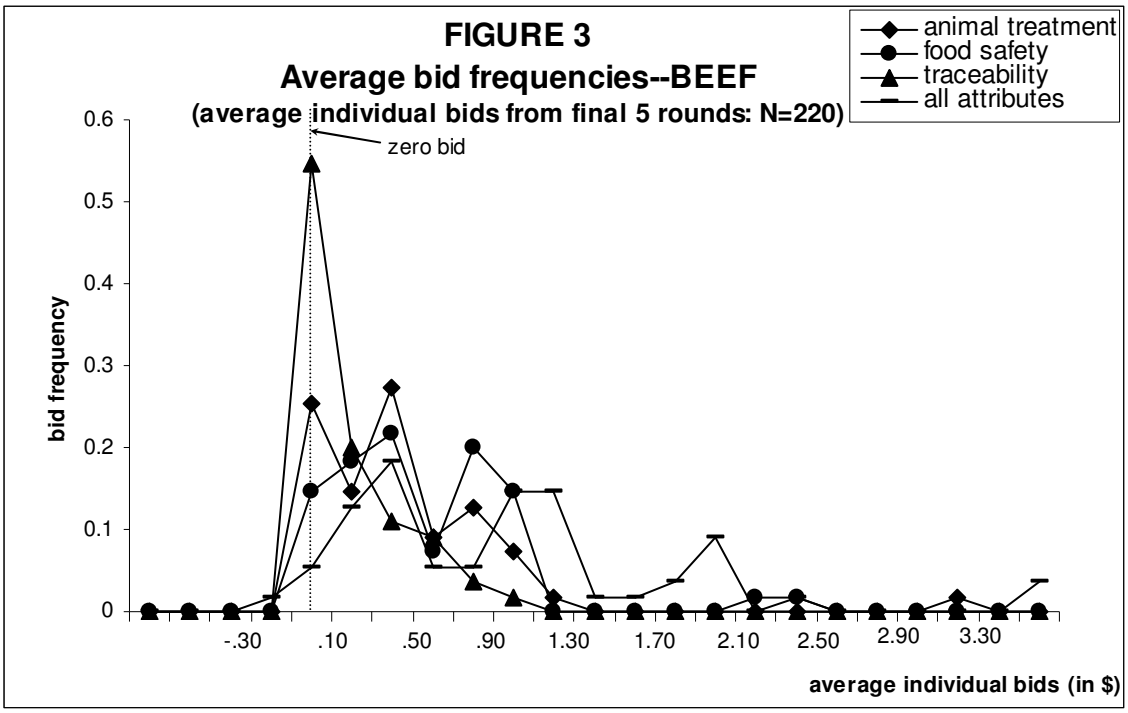
FIGURE 3
Average bid frequencies--BEEF
(average individual bids from final 5 rounds: N=220)
animal treatment
food safety
traceability
all attributes
zero bid
bid frequency
0.6
0.5
0.4
0.3
0.2
0.1
0
-.30
.10
.50
.90
1.30
1.70
2.10
2.50
2.90
3.30
average individual bids (in $)

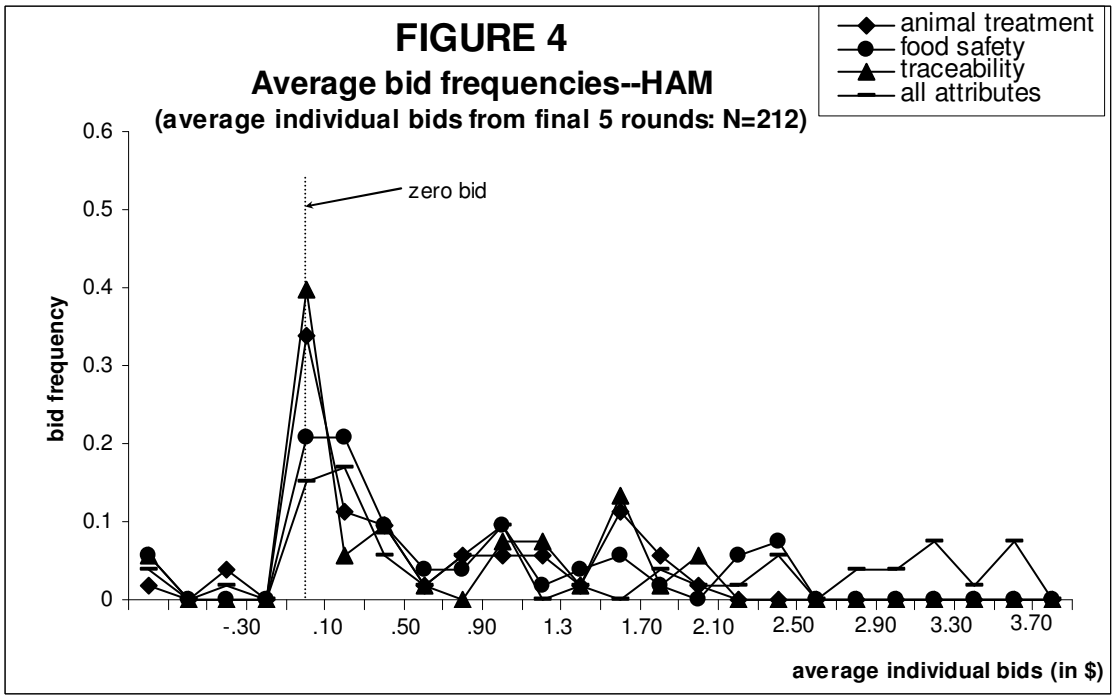
FIGURE 4
Average bid frequencies--HAM
(average individual bids from final 5 rounds: N=212)
animal treatment
food safety
traceability
all attributes
zero bid
bid frequency
0.6
0.5
0.4
0.3
0.2
0.1
0
-.30
.10
.50
.90
1.3
1.70
2.10
2.50
2.90
3.30
3.70
average individual bids (in $)

[1] Extrinsic characteristics refer to meat characteristics that neither affect food safety nor traditional government grading but which are still valued by some consumers. Examples include assurances about animal welfare, social responsibility or environmental responsibility.

[2] Also known as "mad-cow" disease.

[3] Initial estimates suggest that the investment at a single supply chain to implement TTA would be into the millions of dollars depending on the level of TTA desired to be achieved (Buhr; and Coe).

[4] Even though the beef used in the experiment was traceable to the animal level and the ham to the farm level, for consistency the participants were simply told for both ham and beef that Sandwich 3 contained meat traceable to the farm level.

[5] The precise auction sandwich descriptions provided to experiment participants are available from the authors on request.

[6] We chose not to include a pre-test auction with a candy bar (Shogren et al. (1994b)) in our experimental sessions. Two additional experiments were later conducted using a pre-test candy bar auction for three rounds. The sandwich effects we report in this paper are *not* altered by these additional experiments. This shows that the results reported in this paper are *not* an artifact of excluding a pre-test candy auction. The results of the candy pre-test are available from the authors upon request, as are all instructions to the experiment.

[7] The auction sandwiches were truly and verifiably different in the meat they contained. Imported ham from Denmark was used for the traceable (and related characteristics) ham, and one of the Utah State University farms was used to trace the roast beef (as well as to conduct extra safety tests and verify humane animal treatment).

[8] While some may find elicitation of bids on four products at once cumbersome and/or confusing for the subjects, Melton et al. elicit simultaneous bids on eight different pork chops after noting that consumers regularly evaluate from six to eight packages of a particular cut of meat on display at once.

[9] Minor differences in the verifiable food-safety characteristic—e.g., *Salmonella* (ham) versus *E. coli* (beef) safety—imply that the beef/ham results may not be entirely comparable and therefore should be considered separately. These differences are, however, consistent with how extra safety assurances are implemented in existing TTA systems of other countries.

[10] The Friedman (1937) test is conducted using average bids across all rounds and all subjects as the unit of observation. The test assumes that bids across experiment groups are independent, but it also assumes that some ranking can be made for bids across sandwich types (i.e., ranking of WTP in our case). As we show later, the basic results from this nonparametric test are consistent with the parametric regression results shown in Table 2.

[11] We have yet to find a satisfactory explanation for the apparent initial upward trend in ham bidding data versus the initial downward trend in the beef bidding data. The parametric regression results in Table 2 avoid this issue by focusing on the average bid in the fina*l* 5 rounds of the experiment as the dependent variable. Recall also that the purpose of a 10 round auction is to allow for bids to stabilize, which they apparently do in both cases.

[12] Though direct comparisons across meat types may seem risky, sandwiches were used in both experiments such that the base sandwich value would be similar. Caution is still advised in making such comparisons across meats, however, because it is unclear whether subjects' perceived values of a baseline ham/beef sandwich are similar.

[13] Another issue is what the "optimal level" of TTA is. However, this would require information about the marginal cost of providing each TTA characteristic. This information is not yet publicly available. For example, products can be traceable to the farm level or the animal level but costs are quite different for the two different levels.