Similarities and Differences of Animal Welfare Perceptions between U.S. Cow-Calf Producers and the Public

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Abstract: The U.S. livestock industry is increasingly faced with pressure to adjust practices in response to societal concerns. A specific area of growing concern surrounds how production practices impact the welfare of farm animals. The objective of this analysis is to use best-worst scaling (maximum difference) to determine which practices the U.S. public and cow-calf producers view as the most effective and most practical practices to improve the welfare of beef cattle in the U.S. In meeting this objective, we determine similarities and differences in the public and producer views. Random parameters logit and latent class models are used to better understand heterogeneity within and across both the public and producers. Results indicate that both the U.S. public and cow-calf producers viewed providing access to fresh, clean feed and water appropriate for the animal's physiological state, and providing adequate comfort through the use of shade, windbreaks, and ventilation assuring clean, dry, sanitary environmental conditions for cattle as both the most effective and most practical practices to improve the welfare of beef cattle. The practices which were viewed as the least effective and least practical were to castrate male calves either within the first three months of age or with pain control, and dehorn/disbud calves either before horn tissue adheres to the skull or with pain control. Implications for future research, possible verification programs, and related debates regarding beef cattle welfare are provided.

Keywords: animal welfare, beef, best-worst scaling, cattle, demand, economics, supply

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The U.S. livestock industry is increasingly faced with pressure to adjust practices in response to societal concerns. A specific area of growing concern surrounds how production practices impact the welfare of farm animals. For example, in May 2015 Walmart announced their new position on farm animal welfare and antibiotic use (Walmart, 2015). In their release, Kathleen McLaughlin, president of the Walmart Foundation and senior vice president of Walmart sustainability stated, "We have listened to our customers, and are asking our suppliers to engage in improved reporting standards and transparency measures regarding the treatment of farm animals" (Walmart, 2015). Examples of other major U.S. companies which recently announced changes in animal welfare polices such as antibiotic use, housing and use of pain control include McDonald's (Storm, 2015), Tyson (Kissel, 2015), and Aramark (Aramark, 2015).

Although consumers' concerns and attention to animal welfare have increased recently, corresponding research and outreach efforts have not kept pace. The limited existing work has focused on gestation crates/stalls in the swine industry or alternative uses to laying hen cages in the poultry industry because these have been the focus of ballot initiatives and legislation. However, Tonsor and Olynk (2011) suggest that all livestock industries have experienced negative meat demand impacts from increasing media attention to animal welfare. Additionally, several of the recent corporate animal welfare announcements involved policies relating to all species of livestock (e.g., Aramark, 2015). Therefore, it is important to understand the economic implications for the beef industry of animal welfare concerns. This understanding starts with a benchmarking of existing awareness and perceptions of both producers and the public.

This study aims to provide exactly this benchmarking information by identifying the U.S. public and cow-calf producer perceptions of animal welfare in the beef industry. A unique contribution of this study is the comparison of the U.S. public's perceptions to those of cow-calf producers. This comparison sheds new light on possible market opportunities (e.g., aligning producer and consumer interest) and identifies potential threats (e.g., noting existing perception gaps that may result in calls for production changes). Stated differently, this comparison will help document potential actions to better align desires of the U.S. public with practices of beef producers. The objective of this analysis is to use maximum difference scaling to determine which practices the U.S. public views as the most effective and most practical to improve the welfare of beef cattle in the U.S., which practices U.S. cow-calf producers view as the most effective and most practical practices to improve the welfare of beef cattle in the U.S., and to determine similarities and differences in the public and producer views.

Research Methodology

Maximum difference (best-worst, most-least, etc.) scaling is a methodology that presents individual survey respondents (either public member or producer in this analysis) with multiple answer options (production practices in our application) and asks them to select one option as "most" and one option as "least" of the multiple choices presented (at least three). Through multiple choice scenarios, a cardinal ranking of the presented practices can be developed. Best-worst scaling questions are preferred to simple ranking or Likert-scale questions because individuals are required to make tradeoffs instead of simply rating the importance of each practice independently (Lusk and Briggeman, 2009; Wolf and Tonsor, 2013). This combats the issue of respondents marking all practices as most practical, for example. Additionally, most-

least scaling nullifies the scale subjectivity of ranking questions. For example, what is considered a "4" to one individual might be a "5" on another individual's scale (Lusk and Briggeman, 2009; Lusk and Parker, 2009; Wolf and Tonsor, 2013). Outside of the agricultural economics field, maximum difference scaling has been used in health care preferences (e.g., Flynn et al., 2007) and epidemiology (e.g. Cross, Rigby, and Edwards-Jones, 2012). In agricultural economics, maximum difference has been used to evaluate consumer preferences for food values (Lusk and Briggeman, 2009) and dairy producer preferences for policies (Wolf and Tonsor, 2013). However, to the authors' knowledge, no study has employed maximum difference scaling to compare public and producer perceptions of food production issues including welfare of beef cattle.

The data collection portion of this project was three-fold. A nationally representative U.S public survey (n=1992, N=2000) was completed in December 2013.[1] Collaborating with BEEF magazine using surveys very similar to those provided to the public sample, U.S. cow-calf producers were surveyed using mail surveys, response rate of 28.87% (n=433, N=1500), and online surveys, response rate of 1.91% (n=290, N=15,202), in December 2013 through January 2014. However, of the 723 producer responses, only 374 properly completed the maximum difference questions (one answer as most and one answer as least for all choice scenarios shown) and are used in this analysis. Of the 374 usable responses, 91 were mail surveys and 283 were internet surveys. In addition to maximum difference questions, questions were asked to elicit public and producer demographic information, perceptions of animal welfare in the beef industry, and for the public sample their ground beef and beef steak purchasing behaviors.

[1] Representative of U.S. population across age, gender, income, education, and state of residence.

Given multiple dimensions of possible changes in animal care provision it is important to consider the feasibility of implementing changes (practicality) as well as to examine corresponding impacts on realized animal welfare (effectiveness). The issue of feasibility is inherently linked to practicality of on-farm adjustments and hence production costs and supply-side economics. Similarly, prospects for demand maintenance or changes are tied to perceptions regarding effectiveness. By examining both effectiveness and practicality we gain a much more complete picture of underlying economic issues tied to beef cattle welfare.

Accordingly, in this analysis, a split sample approach was used where one half of respondents were randomly assigned to assess practicality while the other half assessed effectiveness. That is, the "best" options were presented as "most effective" or "most practical" while the "worst" options were "least effective" and "least practical."

The design used in both the public and producer best-worst analysis was the same. To investigate the nine production practices in table 1, a total of 12 choice scenarios with six production practices each were needed for both the practical and effective scales.[2] To mitigate respondent fatigue, the 12 choice scenarios were randomly allocated to one of two blocks such that a given respondent only received six scenarios. An example most-least choice scenario from this study using the effective scale is shown in figure 1.

The nine production practices investigated (table 1) were selected following a multi-stage process. Narrowly, a longer list of production practices was identified from existing literature and current animal welfare protocols embedded in verification programs. Additional practices were considered following focus group discussions with livestock producers in related Extension

[2] Specifically, %MktBIBD in SAS 9.2 was used to identify a balanced, incomplete block design that was balanced with each production practice being included in eight scenarios and appeared in five scenarios with each of the other eight production practices.

meetings. Ultimately this longer list was shared by the authors with animal behavior and veterinarian experts to further refine the list to a set manageable for feasible investigation in our surveys.

Multinomial Logit, Random Parameters Logit and Latent Class Models

According to Louviere (1993), an assumption of maximum difference scaling is the participant evaluates all possible pairs of items within the choices shown, and then will choose the pair that maximizes the difference (in either effectiveness or practicality in our application). If there are *J* items (or production practices in this analysis, 6 in each scenario), then *J(J-1)* most-least combinations will be possible (for this analysis, 6*5=30). The most-least pair chosen represents the choice which maximizes the difference in effectiveness (practicality). Following Lusk and Briggeman (2009) and Wolf and Tonsor (2013), let λ_j represent the location of j on the scale of effectiveness (practicality), and let the true or latent unobservable level of effectiveness (practicality) for individual i be given by $I_{ij} = \lambda_j + \varepsilon_{ij}$ where ε_{ij} is the random error term. The probability that the pair j, k is chosen with production practice j being the most and production practice k being the least out of a choice set with J production practices, is the probability that the difference between j and k is larger than all the $J(J-1)-1$ other possible differences in the choice set. If the error terms are i.i.d. type I extreme value, then the probability described takes the multinomial logit (MNL) form:

$$Prob_i(j \text{ is chosen as most and } k \text{ as least}) = \frac{e^{\lambda_j - \lambda_k}}{\sum_{l=1}^{J}\sum_{m=1}^{J} e^{\lambda_l - \lambda_m - J}}. \qquad (1)$$

Based on the probability statement in equation (1), the λ_j parameters can be estimated by maximizing the log-likelihood function. Here, the dependent variable is 1 if the most-least pair is chosen by the individual, and 0 for the $J(J-1)-1$ other pairs of production practices. The

λ_j estimated represents the effectiveness (practicality) of production practice j relative to some other production practice that is normalized to 0 to prevent the dummy variable trap.

The MNL assumes that individuals have homogeneous views of the production practices investigated. Given the likely diverse views on animal welfare broadly and individual production practices more narrowly, it seems likely that perceived effectiveness and practicality could vary across respondents. Accordingly, to allow for respondent heterogeneity random parameters logit (RPL) models (Train, 1998) and latent class models (LCM) (Boxall and Adamowicz, 2002) were also estimated. Likelihood ratio tests reject the MNL model in favor of RPL models allowing perceptions for all practices to vary normally, thus rejecting homogeneity restrictions.

Following Boxall and Adamowicz (2002), under latent class modeling, individuals (i) are sorted into segments or classes, s ($s = 1, \dots, S$). The views of individuals in the same class are homogeneous, while views across the S classes are heterogeneous. In LCM, individuals are assigned into latent classes probabilistically simultaneously with perception parameters of each latent class being estimated (Tonsor, Olynk, and Wolf, 2009).

Coefficient estimates from MNL models, RPL models and LCM are not intuitive for direct interpretation. Fortunately, a "share of effectiveness (practicality)" for each practice can be created that provides an interpretable estimate. These shares are the forecasted probability that each production practice is chosen as the most effective (practical):

$$share\ of\ effectiveness\ (practicality)\ for\ production\ practice\ j = \frac{e^{\widehat{\lambda_j}}}{\sum_{k=1}^{J} e^{\widehat{\lambda_j}}}. \qquad (2)$$

The shares must sum to one across all nine production practices investigated. The value calculated in equation (2) represents the effectiveness or practicality of production practice j on a

ratio scale. For example, if one production practice has an effectiveness share that is twice that of the other, then the former is viewed as twice as effective as the latter. This share represents the probability that a production practice is more effective (or practical) than another production practice.

Using responses to the sets of best-worst scaling questions, both ordinal and cardinal rankings of the practices can be developed and compared across the producer and public groups. The resulting survey responses can be used to compare similarities between perceived effectiveness (e.g., improvement on welfare; potential demand side benefits) and practicality (e.g., feasibility of implementation; supply side impacts) that are critical to understanding economic implications of possible changes in production practices.

Results

Tables 2 and 3 present the summary statistics of the U.S. public sample and U.S. cow-calf producer sample. Extensive details of the survey responses and descriptive statistics are available in McKendree et al. (2015 a, b). Of the U.S. public members surveyed, over half were female and the average age was 47 (table 2). One-third of the U.S. public sample had received at least a Bachelor's degree. Over half of the sample had household incomes of less than $50,000. About three-fourths of the sample considered themselves white, while the other quarter considered themselves Black, Asian, Mexican or Latino, American Indian and other races. The U.S. public participants were geographically diverse.

The majority, 88%, of the cow-calf producers surveyed were male and the average age was 42 (table 3). Approximately half of producers surveyed earned at least a Bachelor's degree. Half of the producer sample reported household incomes of less $100,000 with most having 50%

or less of their household income coming from their beef cattle operation. The majority of the sample was from the Midwest and South regions of the U.S. The majority of the producers surveyed had raised beef cattle for over 20 years and most expected their operation to continue raising cattle for more than 20 years in the future.

The results of the estimated RPL models and LCMs for both the U.S. public and U.S. cow-calf producers' maximum difference responses are presented below. The shares of relative effectiveness or practicality have a more useful interpretation than coefficient estimates. Accordingly, the shares of effectiveness and practicality are shows in tables 4 -9, while underlying coefficient estimates of each model are reported in Appendix A.

U.S. Public

Table 4 presents the RPL results of the U.S. public's relative views on the effectiveness and practicality of the nine examined practices to improve the welfare of beef cattle in the U.S., respectively. Tables 5 and 6 present the parallel results for the LCM. For both effectiveness and practicality, likelihood ratio tests reject the MNL homogeneity restrictions in favor of the uncorrelated RPL model and thus indicate heterogeneity in the public's views. In all of the models, the effectiveness and practicality of each production practice were estimated relative to provide access to fresh, clean feed and water appropriate for the animal's physiological state (referred to as fresh, clean feed and water).

The shares presented in table 4 suggest that the U.S. public views fresh, clean feed and water as both the most effective (0.25) and most practical (0.16) production practice to improve the welfare of U.S. beef cattle. Further, provide adequate comfort through the use of shade, windbreaks, and ventilation assuring clean, dry, sanitary environmental conditions for cattle (referred to as shade, windbreaks, and ventilation) (0.19, 0.16), and promptly treat or euthanize

all injured or sick animals (referred to as promptly treating or euthanizing) (0.13, 0.14) have the second and third highest probabilities of being viewed as most effective or most practical. Combined, the three practices of fresh, clean feed and water, shade, windbreaks, and ventilation, and promptly treating or euthanizing capture roughly one-half of the total effectiveness and practicality offered by all nine practices. The two production practices which had the lowest shares of effectiveness and practicality were castrate male calves either within the first three months of age or with pain control (referred to as castrate with pain control) (0.05, 0.06) and dehorn/disbud calves either before horn tissue adhere to skull or with pain control (referred to as dehorning/disbudding with pain control) (0.04, 0.04). Actual share numbers varied across effectiveness and practicality for production practices ranked in the middle including develop a herd health program with the help of a veterinarian (referred to as develop herd health plan), consistent training program for owner and employees focusing on principles of animal care and handling (referred to as consistent training program), restrict use of antibiotics to disease treatment (referred to as restrict antibiotic use), and third party verification that appropriate animal care and facilities are provided on farm (referred to as third party verification). Because the shares give relative rankings, fresh, clean feed and water was viewed by the public as at least two or three times more effective or practical than most of the other practices for improving the welfare of beef cattle in the U.S.

Another way to explore heterogeneity in the U.S. public's views of effectiveness and practicality of the selected production practices to improve cattle welfare is through use of LCMs. Using Akaike Information Criterion (AIC) (Boxall and Adamowicz, 2002) and adjusted Bayesian Information Criterion (BIC) criterion (Dziak et al., 2012),[3] a LCM with three classes

[3] More details in Appendix A

(or segments) was selected for both the effectiveness and practicality models. Demographic variables were explored as class membership covariates, but failed to improve the models statistical performance.[4] Tonsor, Olynk and Wolf (2009), and Nilsson, Foster and Lusk (2006) also found that consumer characteristics were not good indicators of class membership when studying consumer food preferences. The shares for effectiveness of all three classes are in Table 5 and the shares of practicality of all three classes are in Table 6.

First looking at the three class model for effectiveness, 11.3% of the sample composed class 1, 18.0% class 2, and the majority 70.7% class 3 (table 5). Across all three classes, fresh, clean feed and water was viewed as the most effective practice, but those in class 1 viewed fresh, clean feed and water was relatively more effective than the other two class with a share of 0.39, compared to 0.27 in class 2 and 0.22 in class three. Additionally, all three classes viewed dehorning/disbudding with pain control as the least effective practice to improve the welfare of U.S. beef cattle. Heterogeneity across classes was prominent in the intermediate, second to eighth, rankings. Class 1 perceived consistent training program as the second most effective practice while it was ranked fourth by class 3 and fifth by class 2. Additionally, third party verification was ranked as the second most effective practice by class 2, seventh by class 3 and eighth by class 1. Furthermore, looking at the third party verification shares, class 2 perceived third party verification as more than twice as effective as class 3 and six times more effective than class 1.

The public's heterogeneity in perceptions of practicality is also evident in Table 6. Class 1 was composed on 14.5% of the sample, class 2 4.4 %, and class 3 81.1%. Again, across all three classes, fresh, clean feed and water was viewed as one of the top two most practical

[4] Specifically, gender, college education, income, age, weekly food expenditure, race, frequency of ground beef consumption, geographic region, and number of adults and children in the household were explored.

practices to improve the welfare of beef cattle. However, the relative share for class 1 (0.40) was nearly double that of class 2 (0.24) and class 3 (0.23). For class 2, develop herd health plan was viewed as the most practical practice, yet develop herd health plan ranked as the seventh most practical in classes 1 and 3. Additionally, shade, windbreaks, and ventilation was viewed as the second most practical practice by classes 1 and 3, but the sixth most practical practice by class 2. The three classes generally agreed on the practicality of promptly treating or euthanizing, third party verification and castrating with pain control.

U.S. Cow-Calf Producer

Overall the results from U.S. cow-calf producers were similar to the general public results, but notable differences exist. For effectiveness, LR tests rejected the MNL homogeneity restrictions in favor of the uncorrelated RPL and thus indicated heterogeneity in perceptions. Furthermore, for practicality, LR tests rejected the restrictions in the MNL and uncorrelated RPL in favor of the correlated RPL model. In all of the models, the effectiveness and practicality were estimated relative to fresh, clean feed and water.

Looking at the RPL model shares in Table 7, the surveyed producers' relative rankings for practicality and effectiveness were very comparable. Producers overwhelming viewed fresh, clean feed and water as the most effective (0.37) and practical (0.48) practice to improve the welfare of beef cattle in the U.S. Fresh, clean feed and water was viewed as nearly twice as effective as shade, windbreaks, and ventilation (0.19) and more than three times as practical as shade, windbreaks, and ventilation to improve welfare (0.15). Three practices, develop herd health plan, promptly treating or euthanizing, and consistent training program had effectiveness shares between 0.15 and 0.09. On the other hand, develop herd health plan and promptly treating

or euthanizing had practicality shares around 0.11. Further, castrate with pain control, restrict antibiotic use, dehorning/disbudding with pain control and third party verification were low ranking both in terms of effectiveness and practicality.

To further explain heterogeneity, LCMs for producers' views of effectiveness and practicality are presented in Tables 8 and 9, respectively. Again, using AIC and adjusted BIC criterion three class models were chosen. Producer characteristics were investigated as membership covariates.[5] For the producer practical model, having a Bachelor's degree or higher educational attainment decreased your probability of belonging to class 1 or 2. No significant membership covariates were found for the producer effective model. More information on these models can be found in Appendix A.

For effectiveness, the three classes were composed of 77.1%, 15.2%, and 7.7% of the producers sampled, respectively (Table 8). Both classes 1 and 2 viewed fresh, clean feed and water as the most effective practice to improve the welfare of beef cattle, while fresh, clean feed and water ranked second for class 3. Looking deeper into heterogeneity of views across the classes, shade, windbreaks, and ventilation, develop herd health plan and restrict antibiotic use are the three practices where the most disagreement seems to occur. Class 3 viewed develop herd health plan as the most effective practice while it ranked third and sixth for classes 1 and 2, respectively. Moreover, restrict antibiotic use ranked as the second most effective practice for class 2, third for class 3 and eighth for class 1, although the share for class 3 was higher than class 2. Shade, windbreaks, and ventilation was viewed as the second, third and sixth most

[5] Specifically, gender, college education, income, age, years in industry, years expected for operation to remain raising beef cattle, percent of household income from outside of operation, geographic region and cattle sold were investigated.

effective practice by classes 1, 2, and 3, respectively. All three groups generally viewed third party verification and dehorning/disbudding with pain control as not very effective practices.

In terms of practicality, the LCM exhibit some, but not as much, heterogeneity as the effective models. Membership for the three classes was more evenly dispersed with 29.4% of the sample belonging to class 1, 22.0% to class 2, and 48.6% belonging to class 3. All three classes viewed fresh, clean feed and water as the most practical practice, however, class 1 has a share of 0.67, class 2 0.24 and class 3 0.46. All three classes also viewed third party verification and dehorning/disbudding with pain control as the least practical approach with shares ranging from near zero to 0.03.

Discussion and Implications

Figure 2 plots both producer and public shares from the RPL models in a 2x2 effectiveness and practicality space to further highlight similarities and differences in views held by the two groups. The scale is normalized, meaning that the zero coordinate corresponds with all the practices being viewed as equally effective or practical (0.111 share each). The measures in the upper right-hand (or first quadrant) represent those practices which were viewed as above average in both effectiveness and practicality terms. Conversely, those practices in the lower left-hand quadrant (or third quadrant) were viewed as low in terms of both effectiveness and practicality. The relationship between effectiveness and practicality is nearly linear for both the public and producers. Although the reason for this linearity are not known, potentially, the U.S. public and producers do not distinguish between practicality and effectiveness. Furthermore, the correlation coefficient between effective and practical shares was 0.98 for the public and 0.97 for producers.

The consensus among producers and the public suggested by the RPL models is noteworthy. Both producers and the public viewed fresh, clean feed and water, and shade, windbreaks, and ventilation as the most effective and practical methods to increase the welfare of U.S. beef cattle. There was not as much agreement on other practices, but neither seemed to view dehorning/disbudding with pain control or castrate with pain control as effective or practical practices to increase the welfare of beef cattle.

Comparing the LCMs across the public and producers is a useful exercise for matching potential groups of consumers with suppliers. As an example, to compare the views on effectiveness of the largest classes compare class 3 from the effective public sample (table 5) to effective class 1 of producers (table 8). Both classes viewed fresh, clean feed and water and shade, windbreaks, and ventilation as the most effective practices, however, producers viewed fresh, clean feed and water as more effective than the public (0.31 for producers vs 0.22 for the public). Additionally, both groups had small shares for dehorn/disbud with pain control (0.04., 0.03). Since the public and producers held similar views on fresh, clean feed and water, shade, windbreaks, and ventilation, and dehorning/disbudding with pain control, these practices could make for viable areas of agreement in future discussions on verifying animal welfare on-farm. For the other six practices, views between the public and producers were somewhat different. For example, producer class 1 viewed develop herd health plan as a somewhat effective practice with a share of 0.17 while the public class 3's share was only 0.09. Furthermore, the public share for restricting antibiotic use was 0.10, but the producer share was only 0.02. Therefore, producers and the public from these two majority classes seemed to disagree about the effectiveness of develop herd health plan and restricting antibiotic use suggesting discussions around these practices are more likely to be difficult. Comparing other minority groups across

the public and producers shows potential extreme views in the market that could lead to heightened friction or controversy. For example, public class 1's effectiveness share for fresh, clean feed and water was almost twice that of producer class 3's. Additionally, producer class 3's effectiveness share for develop herd health plan was six times that of public class 1. Similar exercises can be completed for all combinations of classes across the two models where similarities and differences in perceptions can be found.

Repeating this exercise for practicality, compare the largest classes, class 3 for both the public and producers, from tables 6 and 9. Although both classes viewed fresh, clean feed and water as the most practical production practice to improve cattle welfare, the producer class 3's share was double that of the public (0.46 vs 0.23). Both classes viewed shade, windbreaks, and ventilation as the second most practical practice. Share magnitudes for promptly treating or euthanizing are similar, but producer class 3 viewed develop herd health plan as more practical than promptly treating or euthanizing. Accordingly, fresh, clean feed and water, shade, windbreaks, and ventilation, and promptly treating or euthanizing are common areas of agreement between the public and producers, potentially lending these practices as foundations on which to begin animal welfare discussions. The public class 3 viewed restrict antibiotic use (0.11 vs 0.02) and dehorning/disbudding with pain control (0.10 and 0.02) as five times more practical than producer class 3. Therefore, potentially restricting antibiotic use and dehorning/disbuding with pain control could be areas for debate in future animal welfare policy discussions. Other comparisons across classes from the public and producers can also be made. For example, public practical class 2 and producer practical class 1 seemed to be at odds. Producer practical class 2 viewed fresh, clean feed and water (0.67) as nearly three times more effective than public practical class 2 (0.24). Additionally, public practical class 2 viewed

develop herd health plan (0.27) as almost four times as practical as producer practical class 1 (0.07). One could envision productive conversations regarding animal welfare to be difficult between these two groups.

Thus, heterogeneity is present both within the public and producers and also across the two broad groups. LCM models allow further exploration and identification of groups of the public whose views on effectiveness and practicality are similar to groups of producers, but also identify groups with disagreements. Combined this may suggest fresh, clean feed and water and shade, windbreaks, and ventilation would be given high priority, with reasonable chance of producer acceptance, in designing animal welfare programs and protocols such as those mentioned in the introduction. Likewise, these combined results indicate inclusion of dehorning/disbudding with pain control or castrate with pain control may be less successful or potentially require higher premiums for producer adoption.

Conclusions

This analysis used the method of maximum difference scaling to determine views on the effectiveness and practicality of production practices to improve welfare of U.S. beef cattle. Both U.S. public members and cow-calf producers were surveyed. Effectiveness and practicality scales were developed from RPL models and LCM. Heterogeneity was found both within the public and cow-calf producers and across the two groups. Using the RPL framework, fresh, clean feed and water, and shade, windbreaks, and ventilation were viewed as both the most effective and practical practices to increase the welfare of beef cattle in the U.S. by the public and producers. However, dehorning/disbudding with pain control and castrate with pain control were viewed as the least effective and practical practices. Additionally, little distinction between

practicality and effectiveness was found and should be investigated further in the future. Heterogeneity was further investigated by LCM. Here groups with similar and opposing views were identified. Again, fresh, clean feed and water was viewed by most groups as both effective and practical. Based on the LCM results, while some similarities were found, gaps in perceptions between the public and producers were notable. These results can be used to inform future areas of agreement and disagreement in discussions on certification underlying an animal welfare assured label, corporate or public policy, or by industry in responding to increasing calls from supply chain customers. By identifying heterogeneity across and within U.S. cow-calf producers and the public, niche markets can be identified. This will assist in aligning those in the marketplace who are concerned about beef animal welfare and are willing to pay a premium for products with desired attributes with producers who are willing to change their production practices to those sought after by said groups of consumers. These maximum difference results could also be compared with data collected from producers regarding current production practices in place to assess gaps from on-the-ground practices. This will highlight the extent to which "real world change" may be required to alleviate growing public concern.

The practices identified as both most effective and most practical, fresh, clean feed and water and shade, windbreaks, and ventilation, could be candidates for practices in animal welfare certification programs, policy promotions, or industry recommendations. These practices are likely already widely implemented in the beef industry and thus may require less on the ground changes. Instead, more documentation and verification of these attributes could be warranted and communicated as holding value to the public.

One surprising finding was the heterogeneity and lower shares of effectiveness and practicality of antibiotic use given the large attention to antibiotic use recently. Many

corporations, such as Walmart (Walmart, 2015) and McDonald's (McDonald's 2015), are requiring or voluntarily asking their suppliers to limit antibiotic use. However, in this study antibiotic use was not one of the top practices mentioned for effectiveness or practicality. Potentially, antibiotic use is not viewed as an animal welfare issue. Potentially, the public is concerned about antibiotic use for other reasons such as human health and medical concerns.

Perhaps media announcements such as those by Aramark, Walmart and McDonald's are the result of pressure from the minority of the U.S. public consistent with alternative perceptions held by the smaller classes identified in our LCMs. If indeed this is true, future work would be well served to identify the aggregate economic welfare impacts of required changes in production practices (or documentation thereof) being initiated by calls for change by the minority of the public.

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Table 1. Cow-calf production practices investigated using best-worst scaling to improve welfare of U.S. beef cattle

Cow-calf production practice	Abbreviation
1. Provide access to fresh, clean feed and water appropriate for the animal's physiological state	FCW
2. Provide adequate comfort through the use of shade, windbreaks, and ventilation assuring clean, dry, sanitary environmental conditions for cattle	SWV
3. Promptly treat or euthanize all injured or sick animals	PTE
4. Develop a herd health plan with the help of a veterinarian	VET
5. Consistent training program for owner and employees focusing on principles of animal care and handling	CTP
6. Restrict use of antibiotics to only disease treatment	ADT
7. Castrate male calves either within the first three months of age or with pain control	C3M
8. Dehorn/disbud calves either before horn tissue adheres to skull or with pain control	DDC
9. Third party verification that appropriate animal care and facilities are provided on farm	TPV

Table 2. Summary statistics of the U.S. public sample (n=1992)

Demographic Variable	Frequency	Percent
Gender		
Male	890	45%
Female	1102	55%
Household Size		
Average Number of Adults		2.1
Average Number of Children		0.6
Age		
18-24	177	9%
25-34	388	19%
35-44	347	17%
45-54	397	20%
55 and over	683	34%
Average Age (years)		46.6
Earned a Bachelor's (B.S. or B.A.) College Degree or higher	662	33%
Annual Household Income		
Less than $25,000	447	22%
$25,000-$49,999	656	33%
$50,000-$74,999	430	22%
$75,000-$99,999	223	11%
$100,000-$124,999	108	5%
$125,000-$149,999	58	3%
$150,000-$174,999	36	2%
$175,000 or more	34	2%
Race		
White or Caucasian	1508	76%
Black or African American	232	12%
Asian or Pacific Islander	106	5%
Mexican or Latino	103	5%
American Indian	14	1%
Other	29	1%
Geographic Region		
South	691	35%
West	485	24%
Midwest	465	23%
Northeast	351	18%
Average Weekly Food Expenditure		$126.53

Table 3. Summary statistic of the U.S. cow-calf producer sample (n=374)

Demographic Variable	Frequency	Percent
Gender		
Male	330	88%
Female	42	11%
Did not answer	2	1%
Average Age (Years)		42
Earned a Bachelor's (B.S. or B.A.) College Degree or higher	192	51%
Region		
Northeast	5	1%
Midwest	155	41%
South	137	37%
West	64	17%
No Answer	13	3%
Income		
Less than $49,999	64	17%
$50,000-$99,999	137	37%
More than $100,000	140	37%
No Answer	33	9%
Portion of household income from beef cattle operation		
Less than 25%	140	37%
26% to 50%	102	27%
51% to 75%	50	13%
Over 75%	68	18%
No answer	14	4%
Years raising beef cattle		
Less than 10 years	41	11%
11-20 years	48	13%
21-30 years	54	14%
Over 30 years	227	61%
No Answer	4	1%
Years expected for operation to be raising beef cattle		
Less than 10 years	59	16%
11-20 years	107	29%
21-30 years	59	16%
Over 30 years	145	39%
No Answer	4	1%
Beef Cows on operation Jan 1st, 2013		
None	26	7%
Less than 100	147	39%
100 to 500	160	43%
More than 500	35	9%
No Answer	6	2%

Table 4. Random Parameters Logit shares and rankings for the U.S. public's view of the effectiveness and practicality of selected production practices to improve cattle welfare

	Effective Uncorrelated RPL		Practical Uncorrelated RPL	
Production Practice	**Share**	**Rank**	**Share**	**Rank**
Provide access to fresh, clean feed and water appropriate for the animal's physiological state (base case)	0.24	1	0.25	1
Provide adequate comfort through the use of shade, windbreaks, and ventilation assuring clean, dry, sanitary environmental conditions for cattle	0.18	2	0.16	2
Promptly treat or euthanize all injured or sick animals	0.13	3	0.14	3
Consistent training program for owner and employees focusing on principles of animal care and handling	0.11	4	0.10	4
Third party verification that appropriate animal care and facilities are provided on farm	0.09	5	0.10	5
Develop a herd health plan with the help of a veterinarian	0.08	6	0.09	6
Restrict use of antibiotics to only disease treatment	0.08	7	0.06	7
Castrate male calves either within the first three months of age or with pain control	0.05	8	0.06	8
Dehorn/disbud calves either before horn tissue adheres to skull or with pain control	0.04	9	0.04	9

Table 5. Latent Class Modeling shares and rankings for the U.S. public's view of the effectiveness of selected production practices to improve cattle welfare

Class name	Public Effective Class 1		Public Effective Class 2		Public Effective Class 3	
% of sample in class	11.3%		18.0%		70.7%	
Production Practice	Share	Rank	Share	Rank	Share	Rank
Provide access to fresh, clean feed and water appropriate for the animal's physiological state (base case)	0.39	1	0.27	1	0.22	1
Provide adequate comfort through the use of shade, windbreaks, and ventilation assuring clean, dry, sanitary environmental conditions for cattle	0.14	3	0.17	3	0.18	2
Promptly treat or euthanize all injured or sick animals	0.10	4	0.12	4	0.14	3
Consistent training program for owner and employees focusing on principles of animal care and handling	0.21	2	0.09	5	0.10	4
Third party verification that appropriate animal care and facilities are provided on farm	0.03	8	0.18	2	0.08	7
Develop a herd health plan with the help of a veterinarian	0.06	5	0.05	6	0.09	6
Restrict use of antibiotics to only disease treatment	0.05	6	0.05	7	0.10	5
Castrate male calves either within the first three months of age or with pain control	0.04	7	0.04	8	0.05	8
Dehorn/disbud calves either before horn tissue adheres to skull or with pain control	0.02	9	0.04	9	0.04	9

Table 6. Latent Class Modeling shares and rankings for the U.S. public's view of the practicality of selected production practices to improve cattle welfare

Class name	Public Practical Class 1		Public Practical Class 2		Public Practical Class 3	
% of sample in class	14.5%		4.4%		81.1%	
Production Practice	Share	Rank	Share	Rank	Share	Rank
Provide access to fresh, clean feed and water appropriate for the animal's physiological state (base case)	0.40	1	0.24	2	0.23	1
Provide adequate comfort through the use of shade, windbreaks, and ventilation assuring clean, dry, sanitary environmental conditions for cattle	0.22	2	0.06	6	0.16	2
Promptly treat or euthanize all injured or sick animals	0.12	3	0.13	3	0.14	3
Consistent training program for owner and employees focusing on principles of animal care and handling	0.09	4	0.04	9	0.10	5
Third party verification that appropriate animal care and facilities are provided on farm	0.03	9	0.05	8	0.04	9
Develop a herd health plan with the help of a veterinarian	0.04	7	0.27	1	0.06	7
Restrict use of antibiotics to only disease treatment	0.05	5	0.07	5	0.11	4
Castrate male calves either within the first three months of age or with pain control	0.05	6	0.05	7	0.06	8
Dehorn/disbud calves either before horn tissue adheres to skull or with pain control	0.04	8	0.09	4	0.10	6

Table 7. Random Parameters Logit shares and rankings for U.S. cow-calf producers' views of the effectiveness and practicality of selected production practices to improve cattle welfare

	Effective Uncorrelated RPL		Practical Correlated RPL	
Production Practice	**Share**	**Rank**	**Share**	**Rank**
Provide access to fresh, clean feed and water appropriate for the animal's physiological state (base case)	0.37	1	0.48	1
Provide adequate comfort through the use of shade, windbreaks, and ventilation assuring clean, dry, sanitary environmental conditions for cattle	0.19	2	0.15	2
Promptly treat or euthanize all injured or sick animals	0.12	4	0.11	4
Consistent training program for owner and employees focusing on principles of animal care and handling	0.09	5	0.04	5
Third party verification that appropriate animal care and facilities are provided on farm	0.01	9	0.01	9
Develop a herd health plan with the help of a veterinarian	0.15	3	0.11	3
Restrict use of antibiotics to only disease treatment	0.03	7	0.03	6
Castrate male calves either within the first three months of age or with pain control	0.03	6	0.03	7
Dehorn/disbud calves either before horn tissue adheres to skull or with pain control	0.03	8	0.03	8

Table 8. Latent Class Modeling shares and rankings for U.S. cow-calf producers' views of the effectiveness of selected production practices to improve cattle welfare

Class name	Producer Effective Class 1		Producer Effective Class 2		Producer Effective Class 3	
% of sample in class	77.1%		15.2%		7.7%	
Production Practice	Share	Rank	Share	Rank	Share	Rank
Provide access to fresh, clean feed and water appropriate for the animal's physiological state (base case)	0.31	1	0.31	1	0.25	2
Provide adequate comfort through the use of shade, windbreaks, and ventilation assuring clean, dry, sanitary environmental conditions for cattle	0.20	2	0.07	3	0.07	6
Promptly treat or euthanize all injured or sick animals	0.12	4	0.05	4	0.08	4
Consistent training program for owner and employees focusing on principles of animal care and handling	0.10	5	0.02	5	0.07	5
Third party verification that appropriate animal care and facilities are provided on farm	0.01	9	0.01	9	0.01	8
Develop a herd health plan with the help of a veterinarian	0.17	3	0.01	6	0.36	1
Restrict use of antibiotics to only disease treatment	0.02	8	0.08	2	0.14	3
Castrate male calves either within the first three months of age or with pain control	0.04	6	0.01	7	0.01	7
Dehorn/disbud calves either before horn tissue adheres to skull or with pain control	0.03	7	0.01	8	0.01	9

Table 9. Latent Class Modeling shares and rankings for U.S. cow-calf producers' view of the practicality of selected production practices to improve cattle welfare

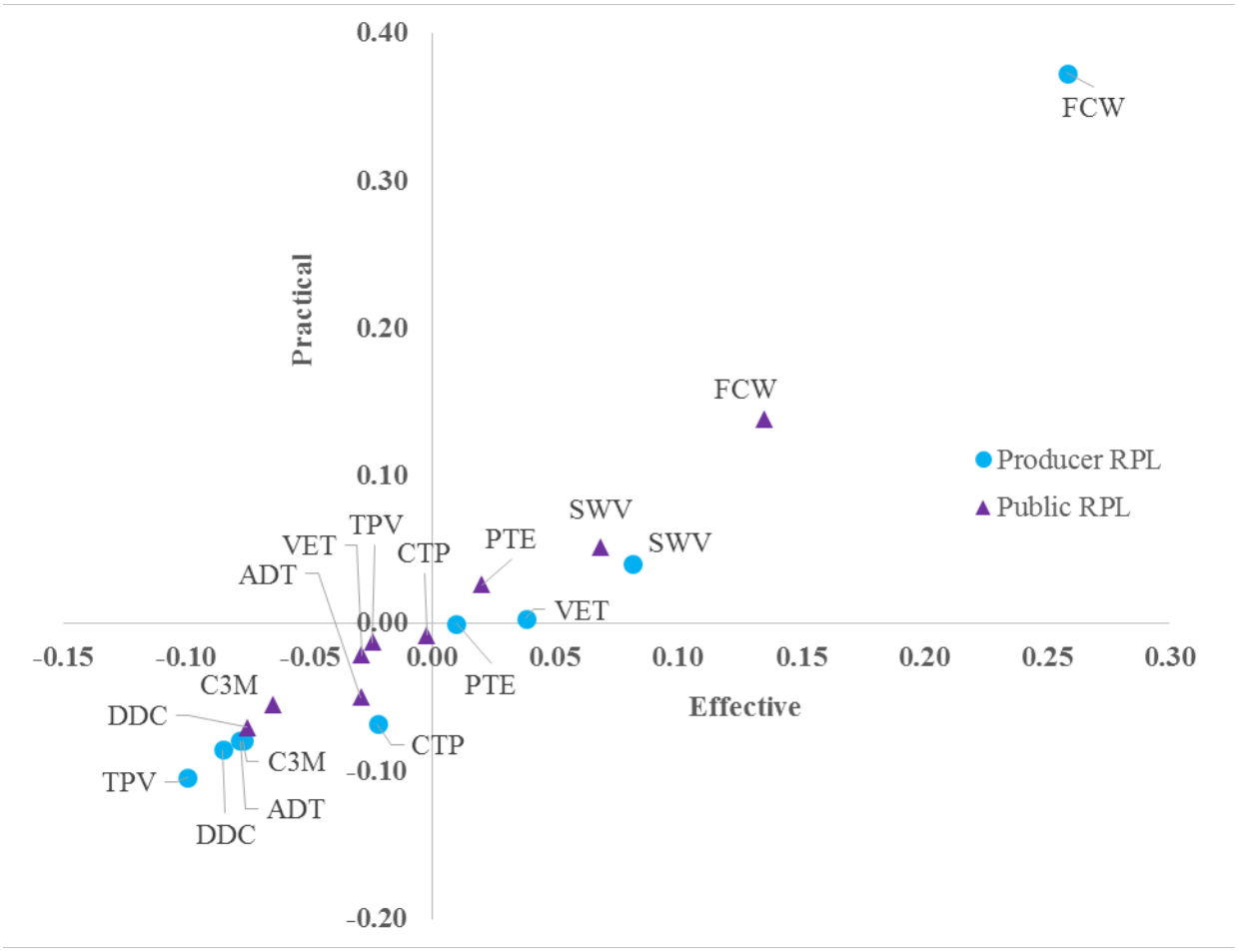
Class name	Producer Practical Class 1		Producer Practical Class 2		Producer Practical Class 3	
% of sample in class	29.4%		22.0%		48.6%	
Production Practice	Share	Rank	Share	Rank	Share	Rank
Provide access to fresh, clean feed and water appropriate for the animal's physiological state (base case)	0.67	1	0.24	1	0.46	1
Provide adequate comfort through the use of shade, windbreaks, and ventilation assuring clean, dry, sanitary environmental conditions for cattle	0.08	2	0.16	3	0.19	2
Promptly treat or euthanize all injured or sick animals	0.07	4	0.19	2	0.10	4
Consistent training program for owner and employees focusing on principles of animal care and handling	0.03	6	0.07	6	0.04	5
Third party verification that appropriate animal care and facilities are provided on farm	0.00	9	0.03	9	0.01	9
Develop a herd health plan with the help of a veterinarian	0.07	3	0.13	4	0.13	3
Restrict use of antibiotics to only disease treatment	0.05	5	0.06	7	0.02	8
Castrate male calves either within the first three months of age or with pain control	0.01	8	0.07	5	0.04	6
Dehorn/disbud calves either before horn tissue adheres to skull or with pain control	0.02	7	0.04	8	0.02	7

Figure 1. Example of a most-least scaling question in the effectiveness survey version

Which of the following actions, if implemented throughout the entire U.S. beef industry, is the most effective and which is the least effective to improve the welfare of beef cattle?
(Check only one issue as the most and only one as the least effective)

Most Effective	Action	Least Effective
	Restrict use of antibiotics to only disease treatment.	
	Castrate male calves either within the first three months of age or with pain control.	
	Dehorn (remove horns)/disbud calves either before horn tissue adheres to skull or with pain control.	
	Develop a herd health plan with the help of a veterinarian.	
	Provide adequate comfort through the use of shade, windbreaks, and ventilation assuring clean, dry, sanitary environmental conditions (housing, pasture, or dry lots) for cattle.	
	Third party verification that appropriate animal care and facilities are provided on farm.	

Figure 2. Zero-centered (where zero indicates all practices are equally effective and equally practical) mean effectiveness and practicality scores from RPL model for the production practices investigated



APPENDIX A: Coefficient Estimates

Table A.1. U.S. public effective model coefficient estimates

		Uncorrelated	LCM		
Production Practice	MNL	RPL	Class 1	Class 2	Class 3
Provide access to fresh, clean feed and water appropriate for the animal's physiological state (base case)	0.00	0.00	0.000	0.000	0.000
Provide adequate comfort through the use of shade, windbreaks, and ventilation assuring clean, dry, sanitary environmental conditions for cattle	-.308*** (0.037) [0.00]	-.315*** (0.038) [0.133]	-1.053*** (0.256)	-.491*** (0.175)	-.164** (0.068)
Promptly treat or euthanize all injured or sick animals	-.613*** (0.038) [0.00]	-.628*** (0.039) [0.0325]	-1.408*** (0.264)	-.865*** (0.1812)	-.457*** (0.067)
Consistent training program for owner and employees focusing on principles of animal care and handling	-.793*** (0.038) [0.00]	-.815*** (0.041) [.321***]	-.636*** (0.184)	-1.154*** (0.233)	0.000 (0.079)
Third party verification that appropriate animal care and facilities are provided on farm	-1.027*** (0.039) [0.00]	-1.0427*** (0.043) [.468***]	-2.731*** (0.36)	-.430** (0.189)	-.967*** (0.086)
Develop a herd health plan with the help of a veterinarian	-1.064*** (0.039) [0.00]	-1.096*** (0.042) [.3012***]	-1.945*** (0.349)	-1.642*** (0.233)	-.836*** (0.085)
Restrict use of antibiotics to only disease treatment	-1.066*** (0.039) [0.00]	0.041 (0.041) [.3012***]	-1.990*** (0.323)	-1.763*** (0.238)	-.806*** (0.082)
Castrate male calves either within the first three months of age or with pain control	-1.626*** (0.04) [0.00]	-1.668*** (0.041) [0.007]	-2.373*** (0.243)	-1.844*** (0.18)	-1.525*** (0.066)
Dehorn/disbud calves either before horn tissue adheres to skull or with pain control	-1.882*** (0.04) [0.00]	-1.928*** (0.041) [0.015]	-2.869*** (0.312)	-2.011*** (0.184)	-1.771*** (0.071)
N individuals	995	995			
Log Likelihood	-18501.51	-18470.701		-18458.13	
Membership Percent			11.30%	18.00%	70.70%
AIC/BIC				36968.26 / 37013.145	

Table A.1 notes: The MNL models assume that all individuals have homogeneous views for the effectiveness/practicality of the production practices investigated. RPL allows the views for each production practice to vary normally. Standard errors are shown in () and standard deviations are shown in [ ]. LCM assume that views are homogeneous within a group, but heterogeneous across the groups.

Table A.2. U.S. public practical model coefficient estimates

		Uncorrelated	LCM		
Production Practice	MNL	RPL	Class 1	Class 2	Class 3
Provide access to fresh, clean feed and water appropriate for the animal's physiological state (base case)	0.00	0.00	0.000	0.000	0.000
Provide adequate comfort through the use of shade, windbreaks, and ventilation assuring clean, dry, sanitary environmental conditions for cattle	-.420*** (0.037) [0.00]	-.427*** (0.039) [.261***]	-.587*** (0.171)	-1.356*** (0.398)	-.349*** (0.052)
Promptly treat or euthanize all injured or sick animals	-.591*** (0.038) [0.00]	-.599*** (0.038) [0.078]	-1.219*** (0.215)	-.599* (0.319)	-.496*** (0.058)
Consistent training program for owner and employees focusing on principles of animal care and handling	-.920*** (0.038) [0.00]	-.934*** (0.04) [.245***]	-1.503*** (0.265)	-1.754*** (0.357)	0.000 (0.067)
Third party verification that appropriate animal care and facilities are provided on farm	-1.387*** (0.039) [0.00]	-1.408*** (0.042) [.374***]	-2.340*** (0.34)	0.109 (0.281)	-1.335*** (0.067)
Develop a herd health plan with the help of a veterinarian	-1.004*** (0.039) [0.00]	-1.024*** (0.041) [.273***]	-2.360*** (0.357)	-.979** (0.46)	-.809*** (0.079)
Restrict use of antibiotics to only disease treatment	-.873*** (0.038) [0.00]	0.04 (0.04) [.273***]	-2.046*** (0.34)	-1.185*** (0.31)	-.692*** (0.072)
Castrate male calves either within the first three months of age or with pain control	-1.462*** (0.039) [0.00]	-1.490*** (0.04) [0.006]	-2.140*** (0.229)	-1.606*** (0.29)	-1.376*** (0.059)
Dehorn/disbud calves either before horn tissue adheres to skull or with pain control	-1.778*** (0.039) [0.00]	-1.810*** (0.04) [0.006]	-2.531*** (0.238)	-1.628*** (0.336)	-1.701*** (0.061)
N individuals	997	997			
Log Likelihood	-18737.38	-18719.42		-18695.95	
Membership Percent			14.50%	4.40%	81.10%
AIC/BIC				37443.899 / 37488.846	

Table A.2 notes: The MNL models assume that all individuals have homogeneous views for the effectiveness/practicality of the production practices investigated. RPL allows the views for each production practice to vary normally. Standard errors are shown in () and standard deviations are shown in [ ]. LCM assume that views are homogeneous within a group, but heterogeneous across the groups.

Table A.3. Producer effective model coefficients

		Uncorrelated	LCM		
Production Practice	MNL	RPL	Class 1	Class 2	Class 3
Provide access to fresh, clean feed and water appropriate for the animal's physiological state (base case)	0.00	0.00	0.000	0.000	0.000
Provide adequate comfort through the use of shade, windbreaks, and ventilation assuring clean, dry, sanitary environmental conditions for cattle	-.624*** (0.094) [0.00]	-.651*** (0.099) [0.208]	-.439*** (0.121)	-1.440*** (0.331)	-1.333** (0.611)
Promptly treat or euthanize all injured or sick animals	-1.064*** (0.101) [0.00]	-1.117*** (0.106) [0.005]	-.966*** (0.127)	-1.816*** (0.339)	-1.093** (0.487)
Consistent training program for owner and employees focusing on principles of animal care and handling	-1.325*** (0.105) [0.00]	-1.425*** (0.12) [.522***]	-1.091*** (0.134)	-3.001*** (0.461)	0.000 (0.645)
Third party verification that appropriate animal care and facilities are provided on farm	-3.316*** (0.112) [0.00]	-3.4617*** (0.128) [.412***]	-3.418*** (0.143)	-4.040*** (0.525)	-2.981*** (0.623)
Develop a herd health plan with the help of a veterinarian	-.829*** (0.095) [0.00]	-.907*** (0.11) [.517***]	-.620*** (0.123)	-3.106*** (0.552)	0.360 (0.624)
Restrict use of antibiotics to only disease treatment	-2.337*** (0.111) [0.00]	0.13 (0.13) [.517***]	-2.646*** (0.141)	-1.940*** (0.406)	-0.599 (0.471)
Castrate male calves either within the first three months of age or with pain control	-2.237*** (0.111) [0.00]	-2.376*** (0.123) [0.082]	-2.117*** (0.142)	-3.540*** (0.414)	-2.911*** (0.655)
Dehorn/disbud calves either before horn tissue adheres to skull or with pain control	-2.537*** (0.112) [0.00]	-2.654*** (0.123) [.331*]	-2.329*** (0.147)	-3.934*** (0.438)	-3.683*** (0.572)
N individuals	168	168			
Log Likelihood	-2681.739	-18719.42		-2638.53	
Membership Percent			77.1%	15.2%	7.7%
AIC/BIC				5329.051 / 5373.997	

Table A.3 notes: The MNL models assume that all individuals have homogeneous views for the effectiveness/practicality of the production practices investigated. RPL allows the views for each production practice to vary normally. Standard errors are shown in () and standard deviations are shown in [ ]. LCM assume that views are homogeneous within a group, but heterogeneous across the groups.

Table A.4. Producer practical model coefficients

Production Practice	MNL	Correlated RPL	LCM Class 1	LCM Class 2	LCM Class 3
Provide access to fresh, clean feed and water appropriate for the animal's physiological state (base case)	0.00	0.00	0.000	0.000	0.000
Provide adequate comfort through the use of shade, windbreaks, and ventilation assuring clean, dry, sanitary environmental conditions for cattle	-1.029*** (0.088) [0.00]	-1.162*** (0.122) [0.180]	-2.092*** (0.473)	-0.369 (0.248)	-.899*** (0.19)
Promptly treat or euthanize all injured or sick animals	-1.332*** (0.089) [0.00]	-1.471*** (0.124) [0.026]	-2.265*** (0.351)	-0.220 (0.248)	-1.498*** (0.259)
Consistent training program for owner and employees focusing on principles of animal care and handling	-2.190*** (0.098) [0.00]	-2.419*** (0.134) [0.196]	-3.268*** (0.391)	-1.204*** (0.244)	0.000 (0.255)
Third party verification that appropriate animal care and facilities are provided on farm	-3.839*** (0.103) [0.00]	-4.233** (0.161) [0.051]	-5.532*** (0.591)	-1.978*** (0.313)	-4.285*** (0.327)
Develop a herd health plan with the help of a veterinarian	-1.301*** (0.093) [0.00]	-1.441*** (0.125) [0.259]	-2.260*** (0.409)	-.612** (0.24)	-1.252*** (0.26)
Restrict use of antibiotics to only disease treatment	-2.467*** (0.105) [0.00]	0.147 (0.147) [0.259]	-2.636*** (0.393)	-1.302*** (0.313)	-3.249*** (0.286)
Castrate male calves either within the first three months of age or with pain control	-2.492*** (0.101) [0.00]	-2.730*** (0.136) [.807***]	-3.895*** (0.433)	-1.166*** (0.29)	-2.541*** (0.307)
Dehorn/disbud calves either before horn tissue adheres to skull or with pain control	-2.685*** (0.103) [0.00]	-2.942*** (0.136) [0.011]	-3.420*** (0.336)	-1.690*** (0.289)	-3.120*** (0.234)
N individuals	206	206			
Log Likelihood	-3161.887	-3116.20		-3113.84	
Membership Percent			29.40%	22.00%	48.60%
AIC/BIC				6283.671 / 6332.019	

Table A.4 notes: The MNL models assume that all individuals have homogeneous views for the effectiveness/practicality of the production practices investigated. RPL allows the views for each production practice to vary normally, note this is a correlated RPL model with lower triangular Cholesky matrix shown in Table A.5. Standard errors are shown in ( ) and standard deviations are shown in [ ]. LCM assume that views are homogeneous within a group, but heterogeneous across the groups. This LCM is with college as a class membership covariate (see table A.6)

Table A.6. Lower triangular Cholesky matrix for the producer practical correlated RPL model

	ADT	C3M	DDC	VET	SWV	TPV	CTP	PTE
ADT	.88064***							
C3M	-.67503***	1.11317***						
DDC	-.64847***	0.39903	.76442***					
VET	-.44478**	0.00256	.46885**	.74378***				
SWV	-.41356**	0.08246	.41168**	.51942**	.82061***			
TPV	-1.10374***	0.49064	1.03838***	.93239***	.93094***	1.42795***		
CTP	-.54844***	0.01084	.57401***	.57005**	.59622**	1.20406***	.95467***	
PTE	-.63370***	0.10313	.64294***	.65608***	.58710***	1.25381***	.75933***	.91924***

Table A.7. Membership covariates from producer practical LCM model

	Coefficient	St. Err
Class 1		
Constant	0.226	0.904
College	-1.474**	0.721
Class 2		
Constant	0.123	0.650
College	-2.214**	1.013
Class 3		
Constant	.....(Fixed	Parameter).....
College	.....(Fixed	Parameter).....