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Cow Welfare in the U.S. Dairy Industry: Willingness-to-Pay and Willingness-to-Supply

Christopher A. Wolf and Glynn T. Tonsor

Consumers are increasingly scrutinizing the animal welfare implications of modern agricultural production processes. We used surveys to examine both the U.S. public willingness-to-pay for and dairy farmer willingness-to-supply or change on-farm production practices related to dairy cattle welfare and find that the public has a positive WTP for all practices examined, while most dairy farms already supply those practices (with the exceptions of employee training programs, third-party certification, and outdoor access). Implications for practice verification and premiums are discussed in the context of dairy markets and policy.

Key words: animal welfare, consumer demand, dairy farmers, production practices, willingness-to-pay, willingness-to-supply

Introduction

In recent years, public scrutiny of production practices in animal agriculture has increased. U.S. livestock, dairy, and poultry farmers have typically been of the opinion that production practices supported by scientific evidence are justified and should be accepted (Curtis, 1987). However, recent experience suggests that a lack of knowledge and context for production practices in the livestock, dairy, and poultry industries often makes even scientifically defensible practices objectionable to the public (Ellis et al., 2009). Boogaard et al. (2011) described the complicated relationship that society has with modern production animal agriculture, asserting that while the public appreciates the supply of inexpensive and safe food, they have concerns about the size and scale of modern operations (and production practices that accompany these technology sets) that relate to impacts on the environment and animal welfare.

In the United States, undercover videos of poor cattle conditions and abuse on dairy farms have periodically been released, focusing public attention on dairy cattle welfare issues (e.g., Paul, 2015; Miller, 2014; Barret and Bergquist, 2013; Webb, 2010). These videos have spurred conversation as well as market and policy responses. In the United States, industry-wide changes in livestock, dairy, and poultry production practices related to animal welfare have generally occurred through two channels: (i) legislative or ballot initiatives (Videras, 2006; Tonsor, Olynk, and Wolf, 2009) and (ii) retailers requiring suppliers to adopt standards or practices (Mench, 2003; Hudson and Lusk, 2004). Residents of multiple states have determined, through ballot initiatives or legislation, that particular livestock production practices be phased out or banned due to associated undesirable animal welfare impacts (Smithson et al., 2014). For example, tail docking of dairy cattle was banned in California, the largest milk producing state, as of January 1, 2010. Alternatively, many food service establishments, from grocers to restaurants, increasingly purchase their food from sources

Christopher A. Wolf is a professor in the department of Agricultural, Food and Resource Economics at Michigan State University. Glynn T. Tonsor is a professor in the department of Agricultural Economics at Kansas State University.
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that are humanely raised or phasing out specific practices related to animal confinement. While most attention and legal changes to date have focused on other livestock sectors, the U.S. dairy industry is aware that these pressures affect them as well. These methods of change make it clear that the perceptions, opinions, and demands of the public in their roles as both consumers and voters are influential.

A third channel of production practice change has more recently emerged as livestock, dairy and poultry industries take initiative and attempt to lead the discussion and set the direction of animal welfare policy. Because of increased scrutiny of production practices, U.S. dairy farmers need to be aware of public demand. Understanding public perceptions, attitudes, and resulting demand impacts can help dairy farmers make informed decisions about practices while enhancing public trust and maintaining public acceptance and approval for milk production on modern dairy farms. Moreover, enhanced demand insight is central to developing effective product differentiation strategies.

Public acceptance of production practices is unlikely to become less important in the future. Recognizing that social acceptability is critical to long-term industry viability, farm groups have prioritized public relations, education, and industry accountability. Past research has found that messages from farm groups aimed at consumers are often fragmented and uncoordinated (Duffy, Fearne, and Healing, 2005). One response by U.S. farm groups has been public relations programs such as breakfast on the farm and farm tours. These programs expose the public to working farms and, presumably, associated conditions and production practices. However, the effectiveness of these education programs depends on many factors, including participants' willingness to receive the intended message. It is also possible for these programs to result in a stronger aversion to production practices (Cummins et al., 2016).

The agricultural economics literature on farm animal welfare consistently finds that the public has positive willingness-to-pay for what they view as improved practices (Lagerkvist, Carlsson, and Viske, 2006; Carlsson, Frykblom, and Lagerkvist, 2007a,b; Tonsor, Wolf, and Olynk, 2009; Nocella, Hubbard, and Scarpa, 2010). However, few studies have linked these consumer demands for production practices to farmers' willingness to supply them. This research identifies and documents perceived dairy cattle welfare among U.S. dairy producers and the U.S. public. The results indicate that producers are already supplying many practices demanded by consumers. An important exception is third-party verification, for which producers want to receive a premium. The results provide direction as to practices the dairy industry may take to extract premiums and retain public trust in the future.

Dairy Cattle Welfare-Related Practices

In response to the increased scrutiny of dairy farm management practices related to cow welfare, U.S. dairy farm organizations created a voluntary program, Farmers Assuring Responsible Management (FARM), to establish and verify farm practices and to provide assurance to the public at large (National Dairy FARM Program, 2014). This program encourages dairy farms to adopt and verify cattle welfare practices. In addition to this producer program, various animal welfare-related groups have created their own certification and labeling programs (e.g., Certified Humane, 2013).

Farm production and management practices potentially related to dairy cow and calf welfare were compiled from a review of several sources including the FARM program Farm Animal Care Reference Manual (National Milk Producers Federation, 2013), Certified Humane (2013), and expert opinions from animal behavior and welfare specialists. The practices chosen for assessment were informed by recent undercover videos that showed, for example, injured cattle being mishandled and employees striking cattle. The list of potential actions included providing basic requirements critical to cow comfort and productivity, such as clean feed and water as well as dry shelter. The list also included less common practices such as employee animal-welfare training and third-party welfare verification. Table 1 displays the practices as they were presented to survey respondents and the shorter descriptive labels used in the other tables. While we could

Table 1. Dairy Cattle Welfare-Related Practices in Survey

Practice Label	Survey Description
Feed and Water	Provide access to fresh, clean feed and water appropriate for the cow's physiological state
Clean Facilities	Provide adequate comfort by assuring clean, dry, sanitary environmental conditions for cattle
Training	Consistent training program for owner and employees focusing on principles of cow care and handling
Outdoor Access	All cattle must have access to outdoor exercise areas for at least 4 hours per day, weather permitting
Third-Party Verification	Third-party verification that appropriate cow care and facilities are provided on farm
Hoof Health	Maintain hoof health in order to reduce lameness
Treat or Euthanize	Promptly treat or euthanize all injured or sick cows
No Hitting	Sticks and flags may be used as benign handling aids but must not be used for hitting cattle
No Tail Docking	Tail docking (removing bottom part of tail) is prohibited

have examined many potential practices, we limited the list to nine to keep the survey feasible for respondents and mitigate survey fatigue.

Access to fresh, clean feed and water as well as clean, dry, sanitary environmental conditions are basic needs for cows that not only assist with welfare but also enhance productivity and milk quality. While we hypothesized that these basic practices are the default among producers, we did not know *a priori* how the importance of these practices would relate to others, particularly with a U.S. public that is largely uninformed about modern milk production practices.

Consistent training programs for owners and employees on cow care and handling are a staple of all animal welfare programs, whether administered internally by the dairy industry or externally by animal welfare or other third-party groups. Given the increasing use of hired farm labor on larger dairy farms, training employees to consistently treat cattle appropriately is a valuable and important practice.

Some milk production standards (e.g., organic milk production) require outdoor access for cattle. Conventional U.S. dairy farms primarily confine the milking herd in free-stall barns, which generally do not give cattle access to pasture or the outdoors. Past research has demonstrated that a portion of the public find outdoor access desirable (Wolf, Tonsor, and Olynk, 2011).

Third-party verification of production practices is important to build and maintain trust because the public is skeptical of claims that are not independently verified (Olynk, Tonsor, and Wolf, 2010). Research has shown that the threat of inspection can be a great behavioral motivator, even if the number of inspections is relatively small (McCluskey, 2000; Williams et al., 2012).

Lameness, a potentially significant welfare concern, may be caused by diet, facilities, or other management factors (von Keyserlingk et al., 2009). The USDA has estimated that about 15% of cattle on U.S. dairy farms were clinically lame (National Animal Health Monitoring System, 2010).

Undercover dairy farm animal welfare videos in recent years seem to have several factors in common. The cattle in the videos are invariably filthy, sometimes injured, and are often being struck or dragged (e.g., Miller, 2014; Barret and Bergquist, 2013). These videos and the accompanying public outrage motivate the practices of promptly treating or euthanizing injured or sick cows and forbidding the use of sticks or flags to hit cattle. We hypothesized that these practices are important given the outrage accompanying undercover videos.

Finally, tail docking is the practice of removing the bottom portion of the tail, including the switch. Tail docking—estimated to have been practiced historically on a majority of U.S. dairy farms (National Animal Health Monitoring System, 2003; Fulwider et al., 2008)—allegedly improves cow cleanliness, milk quality, udder health, and worker health (Schreiner and Ruegg, 2005; Johnson, 1992), but the accuracy of those alleged benefits has been questioned and many sources find these claims to be unsubstantiated (Federation of Animal Science Societies, 2010; Quaife, 2002). In recent years, tail docking has increasingly been viewed as adversely affecting cow welfare (Humane Society of the United States, 2012), and the practice was banned in California in 2010 by legislative

Table 2. U.S. Public Survey Summary Statistics

Variable	
Gender (% of respondents)	
Male	30
Female	70
Household Size (number of individuals)	
Average Household Size	2.38
Average Number of Adults	1.90
Average Number of Children	0.48
Average Age (years)	51.3
Education Level (% of respondents)	
$\leq$ High School	40.0
> High School	60.0
Household Milk Consumption(% of respondents)	
7 or more times/week	41.8
4–6 times/week	19.1
2–3 times/week	15.1
$\leq$ 1/week	14.1
Never	5.2
Average Household Food Expenditure ($/week)	114.83

process. In 2015, the NMPF announced that their members would end tail docking nationwide on December 31, 2016 (Sjostrom, 2015).

Public Demand for Production Practices

The public and dairy producer surveys were written by a team of Michigan State University and Kansas State University researchers and scrutinized by industry and academic experts.

Survey and Estimation Methodology

A national online survey was administered in April 2014 to collect information about U.S. public milk purchasing habits, perceptions of dairy cow welfare, and demographic characteristics including age, education, gender, household size, and income. This public survey was administered to U.S. households online with participants recruited from a large opt-in panel, which has been used effectively in other research (e.g., Louviere et al., 2008; Tonsor, 2011; Lusk and Tonsor, 2016). The sample was representative of primary U.S. household shoppers based on age, income, and state of residence. The survey focused on primary household food shoppers because we were interested in purchasing and consumption preferences.

A total of 2,001 surveys were completed. The survey asked about participants' concerns about dairy cattle welfare, agreement with statements regarding guiding dairy industry principles, the accuracy of dairy cattle welfare media sources, the ability of groups to influence dairy cattle welfare, and whether they would vote or pay for specific production practices.

Summary statistics of respondent demographics are provided in table 2.[1] Respondents were 70% female (compared to the 51% of Americans who are female, U.S. Census Bureau, 2015). Average

[1] More detailed summary statistics are available in Wolf et al. (2015a).

Table 3. Public Perceptions and WTP for Welfare-Related Production Attributes

Attribute	Most Effective	Most Practical	Mean WTP (95% CI)
	Average Score		$/gallon
Feed and Water	4.10	4.26	1.68 (1.49, 1.87)
Clean Facilities	4.04	4.12	1.92 (1.73, 2.13)
Training	3.89	4.00	1.26 (1.08, 1.43)
Outdoor Access	3.90	4.04	1.24 (1.08, 1.43)
Third-Party Verification	3.81	3.84	1.87 (1.66, 2.04)
Hoof Health	3.83	4.01	0.89 (0.74, 1.04)
Treat or Euthanize	3.97	4.14	1.68 (1.50, 1.88)
No Hitting	3.50	3.79	2.06 (1.85, 2.30)
No Tail Docking	3.34	3.53	0.49 (0.34, 0.66)

Notes: Average scores where 1=Least effective/practical, . . . , 5=Most effective/practical. All WTP estimates are statistically significant at $p<0.05$ using the nonparametric, complete combinatorial approach outlined by Poe, Giraud, and Loomis (2005).

household size was about 2.4 persons (U.S. average was 2.7 individuals per household, U.S. Census Bureau, 2015). The average age of respondents was 51.3 years, with more than half of respondents aged fifty-five years or older. Average education level was similar to the U.S. average, with more than 97% having graduated high school and about 34% holding a bachelor's or higher college degree (compared to 88% having graduated high school and 33% with a bachelor's or higher college degree in the general population, U.S. Census Bureau, 2015).

Over 80% of respondent households had an annual income of less than $75,000, with almost one-third coming from households with annual incomes of $25,000–$50,000. The median U.S. household income in 2014 was $53,046 (U.S. Census Bureau, 2015). Average weekly food expenditure was approximately $115/week. Respondents' geographic dispersion was similar to that reported by the U.S. Census Bureau: 37% in the South, 24% in the West, 21% in the Midwest, and 18% in the Northeast. Eighty-six respondents (4.3%) reported that they were vegetarian or vegan.

In addition to sociodemographic information about each respondent, we collected data about milk consumption habits using a Likert-scale response (1 = least practical or effective, . . . , 5 = most practical or effective) that included questions about which practices were most or least effective and practical for dairy cow welfare. The first two columns of table 3 display the results of the production practice perceptions in the first two columns using means to summarize the Likert-scale responses. The first column displays the average score for the perceived effectiveness of the practice, while the second column displays the average perceived practicality score. Respondents ordered

Milk Attribute	Option A	Option B	Option C
Price ($/gallon)	$3.99	$2.99	*I choose not to purchase either of these products.*
Feed and Water	Yes	No Claim	
Clean Facilities	No Claim	No Claim	
Training Program	Yes	No Claim	
I choose …	☐	☐	☐

Figure 1. Example Choice Scenario

the effectiveness and practically of the practices almost identically. In both cases, providing feed and water and clean cow environment were scored highest. Treating or euthanizing injured or sick cattle and outdoor access were also ranked high. The least effective/practical practices among those examined were not hitting cattle and not docking tails.

Each respondent also completed a choice experiment designed to elicit the amount that he or she was willing to pay for various milk attributes. Choice experiments simulate real-life purchasing situations and permit multiple attributes to be evaluated, which facilitates the estimation of tradeoffs among alternatives (Lusk, Roosen, and Fox, 2003). In this choice experiment, consumers were presented with a series of simulated shopping scenarios, each requiring the participant to choose a preferred alternative from two milk options with a variety of attributes and a third "no purchase" option.

An orthogonal fractional design was used to select scenarios in which milk prices were uncorrelated, and which allowed own-price, cross-price, and alternative specific effects to be identified (Kuhfeld, Tobias, and Garratt, 1994). We used SAS procedures *PLAN* and *OPTEX* to identify an experimental design maximizing D-efficiency (Lusk and Norwood, 2005). The final design consisted of eighteen choice sets divided into three blocks of six to keep the task reasonable for participants (Tonsor et al., 2005; Savage and Waldman, 2008). To mitigate potential ordering impacts, the choice set order was randomized (Loureiro and Umberger, 2007). Figure 1 displays an example choice experiment set.

The choice experiment was hypothetical in that it did not include exchange of actual money or milk. Our instructions included the statement:

> "Experience from previous similar surveys is that people often state a higher willingness to pay than what one actually is willing to pay for the good. It is important that you make your selections like you would if you were actually facing these choices in your retail purchase decisions."

This statement was included as part of a "cheap-talk" strategy to reduce hypothetical bias that has been useful in previous choice experiments (Lusk, 2003; Cummings and Taylor, 1999). Recent research suggests that cheap talk scripts are also effective in online survey applications (Tonsor and Shupp, 2011). Given that our principal interest was to ascertain differences in marginal willingness-to-pay amounts for products (attribute bundles) that were not necessarily available, we were less concerned with the hypothetical nature of our survey (Lusk and Schroeder, 2004). The attributes examined included the welfare-related production practices described in the previous section.

Random utility theory frequently underlies analyses that use choice experiments and assumes that economic agents seek to maximize their expected utility subject to a given choice set. An individual's utility is considered a random variable because researchers have incomplete information. Choice experiments assume that individual i receives utility (U) from selecting option j in choice situation t. Utility is represented by deterministic $[V(x_{ijt})]$ and stochastic (ε_{ijt}) components

and is specified here as

$$U_{ijt} = V(x_{ijt}) + \varepsilon_{ijt}, \tag{1}$$

where x_{ijt} is a vector of milk attributes and ε_{ijt} is the stochastic error component that is *i.i.d.* over all individuals, alternatives, and choice situations (Revelt and Train, 1998). Alfnes (2004) notes that this describes a panel data model where the cross-sectional element is individual i and the time-series component is the t choice situations. That is, the data are treated as a panel because each respondent answered six choice sets. Consequently, our model estimation procedures use the panel data specification procedure in NLOGIT 4.0 (Greene, 2002).

Our estimated consumer choice models specify the systematic portion of the utility function as

$$V_{ijt} = \alpha' P_{ijt} + \beta_i \boldsymbol{x}_{jt} \; \forall \; j = A, B, \tag{2}$$

$$V_{ijt} = \delta \; \forall \; j = C, \tag{3}$$

where P_{ijt} is price and $\boldsymbol{x}_{jt}$ is a vector of milk production attributes (including the nine animal welfare-related practices in table 1), which enter the equation as dummy variables. A and B refer to the two milk choices, while C indicates a choice to purchase neither. The remaining terms—α, β_i, and δ—are parameter vectors to be estimated and represent cost, attributes, and opt-out, respectively.

We estimated both multinomial logit models (MNL) that presume consumers hold homogeneous preferences and random parameters logit (RPL) models reflecting preference heterogeneity (Revelt and Train, 1998). Likelihood ratio tests failed to reject the MNL model in favor of the RPL model, allowing all nonprice attributes to vary normally.[2] Mean WTP estimates are calculated as the negative ratio of the estimated coefficient on the verified attribute to the price coefficient. The coefficient on attribute k is multiplied by 2 in the WTP ratio in this analysis because of effects coding (Lusk, Roosen, and Fox, 2003). The WTP for production attribute k in this analysis was calculated as

$$WTP_k = -\left(\frac{2 \times \beta_k}{\beta_c}\right), \tag{4}$$

where β_k is the coefficient on the attribute and β_c is the coefficient on price. Confidence intervals for mean WTP values were simulated following Krinsky and Robb (1986). Subsequently, we used the nonparametric, complete combinatorial approach outlined by Poe, Giraud, and Loomis (2005) to test for statistical difference in mean WTP estimates.

WTP Results

Table 3 displays the mean WTP (in dollars per gallon of milk purchased) for the production practices. All practices had positive, statistically significant mean WTP values. While caution is warranted given possible hypothetical bias concerns, Lusk and Schroeder (2004) support our focus on marginal WTP estimates. The highest WTP premiums would be paid for not hitting cattle followed by providing clean, sanitary living conditions. Both of these practices are repeatedly violated in undercover videos released by animal welfare groups (e.g., Miller, 2014; Barret and Bergquist, 2013; Webb, 2010), which may explain the high WTP. The third highest WTP was for third-party verification of production practices, which was not common at the time of the survey. The lowest WTP, although still significant, was for hoof care to avoid lameness and not docking tails. Respondents may not have been as familiar with these practices; the welfare effects may not be as obvious as some of the other practices.

[2] In other settings where preference heterogeneity is of central focus, further examination using latent class logits or alternative mixed logit approaches may be warranted. While we focused on preference heterogeneity, it is possible that scale variation exists in these data.

Table 4. U.S. Dairy Farmer Survey Summary Statistics

Variable	Mean	St. Dev.
Milk cows (head)	346	946
Milk/cow (lb)	24,478	8,489
Operator age (years)	51.9	12.8
Operator experience (years)	31.4	15.3
Operator Education (% respondents)		
$\leq$ High School	59.1	
> High School	40.9	

Given that the average price of milk in 2014 was $3.82/gallon (Statista, 2016) and WTP for these practices varied from $0.49 to $2.06/gallon, one might conclude that these WTP values were quite high. However, past research has suggested that hypothetical WTP values should be treated as an upper bound because meta-analyses have found that respondents overstate WTP by 35% (Murphy et al., 2005) to 200% (List and Gallet, 2001). Several strategies can mitigate hypothetical bias, including calibrating (e.g., divide estimated values by two) estimates to be closer to actual WTP (Loomis, 2014). Nonetheless, the fact that these values were significant and positive reflects demand for these welfare-related dairy cattle production practices, and the relative rankings reflect preference ordering.

Dairy Farmer Supply of Practices

The U.S. dairy producer survey was administered by mail in March and April 2014. Dairy producers were randomly drawn from producer lists acquired from Departments of Agriculture in seven states, including California, Florida, Indiana, Michigan, New Mexico, Vermont, and Wisconsin. Together, these states accounted for 47% of U.S. milk production in 2014 (96.9 billion of 206 billion pounds) (U.S. Department of Agriculture, National Agricultural Statistics Service, 2015) and are located in major milk-producing regions across the country, including the Upper Midwest (WI, MI, IN), the Northeast (VT), Southeast (FL), Southwest (NM), and Pacific (CA). Following the Tailored Design Method, the initial survey was sent, a reminder card followed three weeks later, and a second survey was sent three weeks after the reminder card (Dillman, Smyth, and Christian, 2009). Of 2,500 names and addresses initially drawn, 2,414 surveys were sent out and 692 responses received, for a 28.7% effective response rate (after accounting for 86 "bad" or outdated addresses).

Table 4 displays summary statistics of dairy farmer respondents.[3] On average, herds had 346 milk cows, larger than the average U.S. milk cow operation but reflective of typical commercial dairy farm operations (U.S. Department of Agriculture, National Agricultural Statistics Service, 2015). Annual milk production per cow was 24,478 lb., higher than the average U.S. milk cow, which produced 22,258 lb. in 2014 (U.S. Department of Agriculture, National Agricultural Statistics Service, 2015). Average primary dairy farm operator age was 51.9 years, identical to the average primary dairy farm operator age from the most recent agricultural census (U.S. Department of Agriculture, National Agricultural Statistics Service, 2012). About 40% of operators had at least some college education, and most operations derived at least 75% of farm revenue from the dairy enterprise. Producers were asked what welfare-related practices they currently provided, what they believed to be the most desirable change from the consumer perspective, and the most costly practices to provide. Table 5 displays the results of these questions for the nine practices examined. Virtually all farms stated that they provided access to fresh, clean feed and water and adequate

[3] More detailed summary statistics are available in Wolf et al. (2015b).

Table 5. Dairy Farmer Welfare-Related Production Attributes and Perceptions

	U.S. Dairy Farmers (% of Respondents)		
Practice	**Currently Practice**	**Believe Consumers Want**	**Most Expensive**
Feed and Water	98.8	38.3	13.3
Clean Facilities	97.7	41.5	15.5
Training	56.0	16.9	20.0
Outdoor Access	62.0	24.5	42.7
Third-Party Verification	43.8	28.4	28.7
Hoof Health	88.6	21.6	11.3
Treat or Euthanize	94.1	25.2	7.0
No Hitting	54.1	14.0	3.8
No Tail Docking	52.1	17.7	4.6

Notes: Respondents could check more than one practice, so responses total to more than 100%.

comfort by assuring a clean, dry, sanitary environment. Since response to all questions was voluntary, a small minority of respondents skipped individual questions. Thus, we do not know whether the small number of respondents who did not state they were currently supplying these basic practices were being brutally honest about lack of basic cow care or were too insulted to answer the question.

Most operations also provided prompt treatment or euthanasia for injured or sick cattle and maintained cow hoof health to reduce lameness. About half of respondents provided cow care and handling training programs for owners and employees, refrained from hitting cattle, and did not dock tails. The least common practice currently provided was third-party verification of cow care and facilities.

Dairy farmer respondents believed that consumers were most likely to want fresh feed and water and clean conditions for cattle. The most expensive practices to provide were outdoor access—which might be prohibitively expensive if current facilities were strictly confinement based—and third-party verification. Few dairy farmer respondents believed that it would be expensive to eliminate tail docking or refrain from striking cattle.

Estimation Methods

Following Schulz and Tonsor (2010), we use the term willingness-to-change (WTC) or willingness-to-supply (WTS) to generally capture both willingness-to-pay (WTP) and willingness-to-accept (WTA) terms from the literature. Thus, the estimation captures both the possibility of either a premium or a discount. WTP identifies the premiums producers would pay to provide a practice while WTA identifies how much producers would require to provide that practice. WTC is allowed to be positive, indicating a premium would be required, or negative, suggesting that producers value the practice and would have to face discounts or penalties to dis-adopt. WTS is censored at zero.

We followed an interval approach to estimate WTC or WTS welfare-related dairy cow production practices. First, survey participants were asked to indicate all of the practices that they currently provided (from the list of nine examined) without premium or subsidy. Second, respondents were asked which practices they would supply for \$0.50 per hundredweight (denoted cwt, a premium of approximately \$0.04 per gallon), including those that they currently provided. Third, respondents were asked which practices they would provide for \$1.00/cwt ($\sim$ \$0.08/gallon). This sequence of questions identifies producers' WTC or WTS that practice. There are four possible outcomes to these questions:

1. "Yes" to the first question, meaning that they currently provided the practice (WTC $\leq$ \$0/cwt);
2. "No" followed by "yes," meaning they would provide the practice for for \$0.50/cwt (\$0 < WTC $\leq$ \$0.50/cwt = \$0.04/gal);

3. "No" followed by "no" and then "yes," meaning they would provide for \$1/cwt (\$0.50 = \$0.04/gal < WTC $\leq$ \$1cwt = \$0.08/gal); and

4. "No" to all three questions, meaning it would take a premium larger than \$1.00/cwt = \$0.08/gal of milk sold to provide that practice (WTC > \$1/cwt = \$0.08/gal).

This isolated the range containing each individual respondent's WTC from the four general possibilities. This range information can be used in interval-censored models following Cameron (1988). We assumed producer i has true WTC for practice j:

$$WTC_{ij}^{*} = \boldsymbol{X}_i \boldsymbol{B}_j + e_{ij}, \tag{5}$$

where $\boldsymbol{X}_i$ is a vector of explanatory variables pertaining to respondent i, $\boldsymbol{B}_j$ is a conformable vector of coefficients, and e_{ij} is an *i.i.d.* normal error with standard deviation μ_i. The log-likelihood function can be written as

$$LLF = LN\left[\phi\left(\frac{\$0.08 - X_i B_j}{\mu_i}\right) - \phi\left(\frac{\$0.04 - X_i B_j}{\mu_i}\right)\right], \tag{6}$$

where ϕ is the cumulative standard normal distribution function. When estimated only with a constant term, the constant is an estimate of mean WTP (Cameron and Quiggin, 1994). Equation (5) was estimated using the standard logistic distribution.

We defined WTS practices to be similar to WTC, except that the base interval was censored at zero. This adjustment assures that values have strictly positive point estimates. Thus, we constrained the market to supply these production attributes with potential premiums but did not consider the potential for discounts or fines, which are possible with negative values.

Finally, like WTS, conditional willingness-to-supply (CWTS) was censored at zero, but CWTS values were derived solely for producers who had not currently implemented a practice. Accordingly, CWTS reflect only a subset of the full dataset. These WTS values are conditional in that they reflect the values needed to get the typical nonuser to change and implement.

Farmer Results

Table 6 displays the results of the producer WTC, WTS, and CWTS estimates. When payments were allowed to be negative (as in the case of WTC), all mean WTC estimated were either negative or not statistically different than zero, except for third-party verification. These negative values reflect that the overwhelming majority of dairy farms already provided most of the practices and realized the value of those practices without requiring additional payment or premiums. The second column displays WTS with premiums censored at zero. This indicates, for example, that it would take \$0 for a randomly drawn producer to implement clean feed and water. WTS indicates small positive premiums for most practices. The final column of table 6 displays CWTS for producers who indicated they were not currently providing a practice. Thus, these are the premiums required to assure the entire dairy industry implements the practice in question.

With respect to relative ranking of potential premiums, the only positive WTC premium was for third-party verification. In descending order, training programs, no hitting, feed and water, hoof health, and treat or euthanize had significant WTC premiums. The order differed for WTS, with outdoor access requiring the largest premium (\$0.05/gal) followed by third-party verification, no hitting, no tail docking, training, clean facilities, treat or euthanize, and hoof health. When only those producers who did not provide the practices were considered, CWTS premiums were largest for treat or euthanize (\$0.12/gal), followed by a set of practices that included third-party verification, hoof health, training, and outdoor access.

Table 6. Willingness to Change or Supply Results

	WTC	WTS	Conditional WTS
Practice	**$/gallon (95% confidence interval)**		
Feed and Water	−0.31*	< 0.001	0.04*
	(−0.55, −0.06)	(−0.001, 0.001)	(0.02, 0.07)
Clean Facilities	< 0.001	0.002*	0.12
	(#)	(0.001, 0.003)	(#)
Training	−0.02*	0.03*	0.08*
	(−0.04, −0.01)	(0.027, 0.034)	(0.07, 0.09)
Outdoor Access	< 0.001	0.05*	0.12
	(#)	(0.042, 0.053)	(#)
Third-Party Verification	0.01*	0.04*	0.08*
	(0.003, 0.02)	(0.036, 0.044)	(0.07, 0.09)
Hoof Health	−.30*	0.008*	0.09*
	(−0.41, −0.19)	(0.007, 0.01)	(0.07, 0.11)
Treat or Euthanize	−0.78*	0.005*	0.12*
	(−1.24, −0.32)	(0.003, 0.006)	(0.08, 0.16)
No Hitting	−0.02*	0.04*	0.11*
	(−0.04, −0.003)	(0.033, 0.042)	(0.09, 0.12)
No Tail Docking	−0.01	0.04*	0.09*
	(−0.02, 0.01)	(0.034, 0.043)	(0.08, 0.10)

Notes: Willingness to change (WTC) allows interval to be negative. Willingness to supply (WTS) censors WTC interval at zero. Conditional WTS calculated only for operations not already providing that practice. U.S. dairy farmers are paid in dollars per hundred pounds of milk sold (hundredweight). One hundred pounds of milk is 11.628 gallons. Single asterisk (*) indicates significance at p<0.05. Pound sign (#) indicates confidence intervals omitted due to imprecise model estimation.

Market and Policy Implications

The results of this analysis have many implications for the production and marketing of milk as well as animal welfare policy in the United States. First, most producers believe they are providing many or even all of the welfare-related practices examined here, with the least common practice being third-party verification. The FARM program, which requires inspection and verification, may help fill this void. That then raises the question whether the public will view these inspections as truly independent third-party inspections. Past research has examined verification of credence attributes in agriculture and found that consumers preferred the U.S. Department of Agriculture (USDA) over industry as the verifying entity (Olynk, Tonsor, and Wolf, 2010). This might mean that seeking and receiving USDA process verification and the associated credibility would add significant value to the program.

Another finding is that consumers' WTP was much larger than producers' WTC.[4] For example, consumer WTP for *No Tail Docking* was estimated to be $0.49/gal (table 3) while producer WTS was estimated to be $0.04/gal (table 6), suggesting that possible "market solutions" to current debates around animal welfare may be achievable. Of course, this difference also in part reflects the fact that

[4] As noted by a reviewer, the pragmatic selection to employ different elicitation mechanisms for consumers and producers may impact conclusions from directly comparing relationships of consumer WTP and producer WTC.

consumers purchase relatively few gallons of milk annually, while producers sell thousands or even millions of gallons per year. U.S. residents consume about twenty gallons of fluid milk per year, so a family of four purchases about eighty gallons annually (Statista, 2016), or $39.20 annually at $0.49/gal. Meanwhile, a typical herd with 350 milking cows producing an average of about 2,560 gallons per cow yields approximately 896,000 gallons of milk, or $35,840 at $0.04/gal premium. Coupled with that disparity in magnitude is the fact that many of these practices have other potential production and efficiency benefits; it seems likely that it would not take a large incentive on a per gallon basis to change farmer behavior. It may not even require premiums to change behavior if retailers, processors, cooperatives, or other actors in the dairy food chain require or mandate these practices, including third-party verification, for market access purposes.

This research only considered demand for these dairy cattle practices with respect to fluid milk demand, which is considered quite inelastic. While per capita consumption has been declining in the long run, many consumers prefer milk over alternative substitutes when it comes to, for example, coffee and cereal. However, only about one-fourth of all milk consumption in the U.S. is as a beverage (Statista, 2016). Cheese consumption accounts for the most milk and yogurt has been another consumption success story in recent years. Past research has demonstrated that consumers' WTP for production attributes related to these products can differ compared to beverage milk (Olynk Widmar and Ortega, 2014). Even if premiums were differentiated by product, dairy farmers would either provide the practice or not.

The current milk marketing system does not generally lend itself to segregating farm-level production by final product type. If farm-level premiums are required to encourage practice adoption and only beverage milk could collect a premium, the required premium on beverage milk at the farm level would necessarily be larger than if all final dairy products could realize a premium (Saitone, Sexton, and Sumner, 2015). However, if the dairy industry moves to widespread participation in FARM or a similar program for market access it seems likely that farms not implementing these practices are likely to experience a discount or even lose market access rather than farms that do implement them gaining a premium.

Conclusions

Supply and demand forces for farm-animal welfare are becoming more complicated and signaled through increasingly diverse channels. The economic impacts of these developments require examination. The implications of the public putting pressure on supply chains to document practices they may be already providing and the economic impacts of producers resisting such requests from the public warrant assessment.

This research surveyed the U.S. public and dairy farmers to assess demand for and supply of animal welfare-related production practices. The U.S, public had a positive WTP for all nine of the practices examined. Dairy farmers were already providing most of these practices, reflecting the value these practices have to milk production and profitability. The most common exception was third-party verification of animal welfare-related practices.

The National Milk Producers Federation FARM program is an attempt by dairy farmers to get ahead of animal-welfare groups and maintain a positive relationship with the U.S. public. Recent cow welfare actions by member cooperatives have been to first encourage participation and then, in some cases, to require participation. It remains to be seen whether voluntary industry programs without government oversight can be viewed as credible. When undercover videos of cow abuse on dairy farms are in the news, the negative publicity and resulting demand impact damages the entire industry. Thus, all dairy farmers have an interest in participating in a program with credible verification and real consequences for violators.

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