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Stephanie Schumacher
First United Bank, Amarillo, sschumacher@firstunited.net

Derrell S. Peel
Oklahoma State University, derrell.peel@okstate.edu

Kellie Curry Raper
Oklahoma State University, kellie.raper@okstate.edu

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Stephanie Schumacher (First United Bank, Amarillo),
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ABSTRACT

Though research indicates that many calf management and marketing practices are available to add value for the cow-calf producer, a high percentage of producers are still nonadopters of such practices. Little information identifies nonadopters in the beef cattle industry, limiting efforts to provide educational support. This study uses a binomial logit model and primary survey data to examine the demographic influence on producers' nonadoption of commonly recommended value-added management and marketing practices specific to feeder calves in the cow-calf segment.

KEYWORDS

livestock production, cow-calf, beef management, practice adoption

INTRODUCTION

Research and anecdotal evidence both suggest that preconditioning and other recommended management practices yield market premiums and increased profitability for feeder calves (Bulut & Lawrence, 2007; Dhuyvetter, Bryant, & Blasi, 2005; Zimmerman et al., 2012; Williams et al., 2012). However, many cow-calf producers continue to be nonadopters in spite of the evidence. For example, McKinney (2009) reports that less than 5% of Oklahoma beef calves were formally marketed as "value-added" in 2008. While numerous studies examine practice implementation in agriculture, only a few studies focus on cattle. Little information identifies nonadopters in the beef cattle industry, limiting efforts to provide them with educational support (Gillespie, Kim, & Paudel, 2007).

Multiple studies examine producer adoption of management and production practices in the context of conservation and environmental management or in other segments of the beef supply chain (Johnson et al., 2010; Kim, Gillespie, & Paudel, 2005; Rahelizatovo & Gillespie, 2004). Williams et al. (2013) examined the relationship between cow-calf producers' demographic characteristics and the number of value-added practices implemented. This study builds on that work by examining demographic influences on cow-calf producer decision making regarding implementation of individual practices. While it is true that producers often adopt multiple practices as a bundle to achieve specific marketing purposes, individual practices are also known to add value on their own merit. An increased understanding of the characteristics that influence adoption for specific practices can begin to identify common demographic themes as well as differences among practices that are often bundled. Though we are accustomed to thinking in positive terms of adoption, this study examines nonadoption of commonly recommended value-added management and marketing practices specific to feeder calves in the cow-calf segment. Using data from a survey of Oklahoma cow-calf producers, a binomial logit model is employed to estimate the probability of nonadoption for specific management or marketing practices based on producers' demographics. Focusing on nonadoption does somewhat complicate the flow of the discussion, but specifically examining the demographic influences on nonadoption is a necessary first step in moving toward identification of reasons for nonadoption.

Twelve management and marketing practices are examined here, including castration (healed), dehorning, deworming, 45-day weaning, two rounds of respiratory vaccinations, feed bunk training,

implanting calves, using no antibiotics, age and source verification, recording calves' birth dates, keeping medical treatment records, and individual identification for calves. Practices can be categorized into four groups, including basic, preconditioning, marketing, and record-keeping practices. Basic practices include the low-cost preweaning calf health management practices of castration, dehorning, and deworming. Preconditioning practices consist of 45-day weaning, respiratory vaccinations, and feed bunk training, as these practices bundled with basic practices comprise a typical preconditioning program that improves feeder calf health after marketing beyond the ranch gate. Marketing practices include implanting calves, using no antibiotics in production, and age and source verification. The decision to implement an individual marketing practice is typically made with the intention to market calves to specific programs or buyers to capture market premiums. The fourth category is record keeping, which includes recording calves' birth dates, keeping medical treatment records, and individual calf identification. While record-keeping practices may not directly impact market value individually, they often define the level of success that the operation can expect to achieve.

DEMOGRAPHIC INFLUENCES

Many studies of technology adoption include farm size as a variable and conclude that larger farms are more likely to adopt new practices (e.g., Feder, Just, & Zilberman, 1985; Putler & Zilberman, 1988; Rahelizatovo & Gillespie, 2004). In beef cattle production, this corresponds to cow herd size. Producers with larger cow herds may have incentive to be proactive in practice adoption because they can take advantage of economies of size. On the contrary, Gillespie, Kim, and Paudel (2007) and D'Souza, Cyphers, and Phipps (1993) found no farm size impact on adoption rates. Interestingly, Kebede (1992) discovered that farm size negatively affected implementation of new practices by Ethiopian farmers when opportunities to earn off-farm revenue were present, but the opposite was true when agriculture production was the only means of revenue.

Region may also play a role in adoption of practices. Often the terrain and climate from north to south or east to west sectors of a state can be vastly different, impacting the necessity, effectiveness, or even profitability of practice adoption for specific practices. Eastern Oklahoma receives significantly more rainfall than western Oklahoma. Therefore, eastern producers may be more concerned with internal parasites, increasing the importance of deworming calves. Within the state of Oklahoma, terrain and climate vary dramatically from east to west, while growing season length and first and last freeze dates vary moving from the southeast corner to the northwest corner of the state (http://www.mesonet.org). These differences, along with regional cultural differences, impact available resources and producer management choices.

Practice adoption is often negatively associated with producer age (Ashby, 1982; Coughenour & Chamala, 1989; Heffernan & Green, 1986). Aging producers may be less familiar with more recently established management practices and continue practices that have been established for a longer period of time, even when scientific research suggests change (Gillespie, Kim, & Paudel 2007; Rodriguez et al., 2008). Older producers may resist change because of shortened planning horizons with a perception of insufficient time to realize sufficient gains from practice adoption (Rodriguez et al., 2008). Feder, Just, and Zilberman (1985) found results consistent with this hypothesis when researching conservation adoption and technology adoption. Rahelizatovo and Gillespie (2004) acknowledged similar results among dairy producers in Louisiana.

Years of experience is also expected to influence adoption. Producers with substantial cattle industry experience are more likely to recognize the benefits of basic health management practices, such as castration and weaning. That said, life experiences outside of the cattle industry may help producers be more proactive in researching the benefits and costs of individual practices. For instance, an older producer who is new to the beef cattle industry may seek out information on production and management practices because he is aware of his lack of knowledge.

Producer education level is expected to influence adoption rates (Gould, Saupe, & Klemme, 1989; D'Souza, Cyphers, & Phipps 1993). Gillespie, Kim, and Paudel (2007) found that a bachelor's degree positively impacts adoption of five practices. They also found that producers with a degree were less likely to be unfamiliar with a practice or to say

that it was not applicable. Kebede (1992) found that education had a negative effect on the implementation of new practices by Ethiopian farmers when opportunities to earn off-farm revenue were present and a positive effect when agriculture production was the only means of revenue.

Income is also thought to impact adoption rates. For example, producers with less total income may not adopt practices with higher up-front expenses. On the other hand, producers with higher income levels may not implement value-added practices perceived to have little return per head because they may value time differently than lower-income producers. Income from the cow-calf operation as a percentage of total income may also be influential. If a producer earns a significant share of income from off-farm employment, the off-farm revenue source may be prioritized over income from beef production. Conversely, a producer who depends on cattle production for a majority of income may be more proactive in adopting value-added management and marketing practices (Ward et al., 2008).

Beef extension programming is designed to facilitate improved decision making by producers in their own operations. In previous research, Gillespie, Kim, and Paudel (2007) found that producer contact with the National Resources Conservation Service and the Louisiana Cooperative Extension Service increased the likelihood of favorable attitudes toward practice adoption. Rahelizatovo and Gillespie (2004) found similar results.

DATA

Data are taken from a survey of Oklahoma cow-calf producers' management and marketing practices (OSU IRB AG094, 2010). The U.S. Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS) Oklahoma City office was contracted to implement the mail survey. NASS mailed surveys directly to a sample of the 32,653 cow-calf producers in Oklahoma (U.S. Department of Agriculture, 2009). Extension educators promoted the survey extensively in the press as well as at multiple state, regional, and county meetings both pre- and postmailing.

A total of 1,861 completed surveys were received. Response was similar across region and herd size. Observations with missing data for variables of interest were deleted, leaving 1,453 usable observations. Cow-calf operator demographics are similar between the 2007 and 2012 Census of Agriculture respondents, previously published survey research, and our survey respondents, demonstrating that the data are representative of Oklahoma cow-calf producers.

Producers answered questions about adoption of 12 management and marketing practices identified as potential tools for adding value to calves. These practices include castration (and healing), deworming, feed bunk training, dehorning, a 45-day weaning period, respiratory vaccinations, implanting, birth records, medical treatment records, individual calf identification, age and source verification, and no antibiotic use. Demographic information was also collected in the form of categorical data for cow herd size, age, years of experience in cattle production, household net income, percent of household net income from cattle, level of education, and region of the state where the cow-calf operation is located.

MODEL

A binomial logit model is used to estimate the probability of nonadoption of a specific practice based on producers' demographics. The probability of nonadoption of practice p by producer i can be modeled as follows:

$$Prob\ (\mathrm{N})_{\mathrm{pi}} = \frac{e^{Z}}{1 + e^{Z}}, \tag{1}$$

where the constant e is the base of the natural logarithm, equaling about 2.72. Demographic influences on nonadoption of a specific practice p are modeled as $Z_i = \alpha + \boldsymbol{\beta}\mathbf{X}$ where $\mathbf{X}$ is a vector of demographic characteristics, or, more specifically:

$$\begin{aligned} Z_{ip} = \alpha &+ \sum_{j=1}^{4} \beta_{1j}\, HerdSize + \sum_{j=1}^{4} \beta_{2j}\, Region \\ &+ \sum_{j=1}^{4} \beta_{3j}\, AE + \sum_{j=1}^{4} \beta_{4j}\, Education \\ &+ \sum_{j=1}^{4} \beta_{5j}\, Income + \sum_{j=1}^{4} \beta_{6j}\, FarmIncome \\ &+ \sum_{j=1}^{4} \beta_{7j}\, Training \end{aligned} \tag{2}$$

where Z_i =1 for nonadoption of a specific practice *p* and 0 for adoption, *HerdSize* represents the cow herd size, *Region* is the region of Oklahoma in which the producer resides, *AE* is a categorical variable representing a combination of the producer's age and beef cattle experience, *Education* is the producer's highest level of educational attainment, *Income* is producer's household net income, *FarmIncome* is the percent of a producer's household net income derived from beef cattle production, and *Training* indicates participation in either of two extension programs that promote best practice adoption. Model coefficients are used to calculate the marginal effect of a demographic characteristic (i.e., how the predicted probability of nonadoption changes as the demographic variable changes from the base characteristic). Here, demographic characteristics are defined and estimated as categorical binary independent variables rather than ordinal. The marginal effect is calculated as:

$$Pr(N = 1 \mid \mathbf{X} = \mathbf{0}, x_k = 1) - Pr(N = 1 \mid \mathbf{X}=\mathbf{0}, x_k = 0) \quad (3)$$

where **X=0** is the vector of demographic characteristics set to a base level and x_k is the demographic characteristic of interest.

Previous studies related to practice adoption include either age or experience but rarely include both due to high correlation among the two (Levy & Sharma, 1994). This study uses an age-experience (AE) category in an attempt to capture the notion that it is the combination of age and experience that influences the adoption decision rather than age and experience taken individually. This may be particularly true in the cow/calf segment, where less experienced producers may also be older hobby producers and new to the industry and where younger producers may also have substantial experience earned on their family's farm before becoming independent. Based on the categorical nature of survey questions on age and experience, this study uses the product of the producer's age category (1–5) and experience category (1–4) to create an AE index ranging from 1 to 20, as reported in Table 1. The resulting AE index value is used to sort producers into four AE categories. Generally speaking, the base category contains the youngest producers (<40), the least experienced producers (<5 years), and older producers with little experience. The next category includes middle-age producers with moderate to extensive experience, preretirement producers with moderate experience, and retirement-age producers with less moderate experience. The third category (AE = {13–16}) includes preretirement producers with extensive experience and retirement-age producers with moderate experience. Finally, the fourth category includes retirement-age producers with extensive experience. Table 2 illustrates the distribution of producers among the categories.

RESULTS

Demographic characteristics of survey respondents are summarized in Table 1. A brief look at the demographics of survey respondents indicates that most have fewer than 100 cows, are at least 51 years of age, have 16 or more years of experience, earn 20% or less of their income from the farm, and have not participated in either of two relevant beef management training programs. For respondents with fewer than 100 head of cattle, 44% report fewer than 50 head of cattle, and 33% report between 50 and 99 head of cattle. Ward et al.'s (2008) survey reported that 68% of Oklahoma's commercial producers owned fewer than 100 head, while the 2007 Census of Agriculture reported that 86% of the cow-calf producers in Oklahoma have 100 head of cattle or less (U.S. Department of Agriculture, 2009). The highest percentage of respondents live in the southeastern quadrant of the state (33%), followed by the Northeast (31%), the Southwest (20%), and the Northwest with the panhandle included (16%). The age distribution of respondents clearly supports the well-publicized concern about the aging of agricultural producers, since about 40% of the respondents are 65 or older. Another roughly 40% of respondents are between the ages of 51 and 64. This is similar to the 2007 Census of Agriculture's finding that about 48% of Oklahoma cow-calf producers were over the age of 65 (U.S. Department of Agriculture, 2009). Correspondingly, producers who stated they have over 25 years of experience comprise 68% of the respondents, while only 1% of respondents report less than 5 years of experience.

Table 1. Distribution of Survey Respondents across Demographic Variables

Characteristic	Category	Proportion of Respondents
Herd size	1 to 49 cows	0.44
	50 to 99 cows	0.33
	100 to 499 cows	0.22
	500 + cows	0.01
Region	Southeast	0.33
	Northeast	0.31
	Southwest	0.20
	Northwest and panhandle	0.16
Age	Under 30 years of age	0.00
	31 to 40 years of age	0.04
	41 to 50 years of age	0.13
	51 to 64 years of age	0.40
	65+ years of age	0.42
Experience	Less than 5 years of experience	0.01
	5 to 15 years of experience	0.12
	16 to 25 years of experience	0.19
	Over 25 years of experience	0.68
AE Index	Age x Experience = 1–8	0.12
	Age x Experience = 9–12	0.22
	Age x Experience = 13–16	0.32
	Age x Experience = 17–20	0.34
Education	High school graduate or less	0.39
	Vocational education	0.18
	Bachelor's degree	0.24
	Graduate or professional degree	0.19
Household Net Income	Net income of less than $30,000	0.13
	Net income of $30,000 to $59,999	0.28
	Net income of $60,000 to $89,999	0.27
	Net income of $90,000 to $119,999	0.15
	Net income of $120,000+	0.17
Cattle income percent	0% to 20%	0.59
	21% to 40%	0.22
	41% to 60%	0.11
	61% to 100%	0.07
Training	No Master Cattleman or BQA training	0.91
	Master Cattleman or BQA training	0.09

Table 2. Distribution of Respondents among Age-Experience Categories

	Age	Under 30	31–40	41–50	51–64	>65	Totals
Experience							
Less than 5 years	Frequency	**0**	**1**	**2**	**4**	**5**	**12**
	Percent	0.00	0.08	0.15	0.31	0.39	0.93
	Row pct	0.00	8.33	16.67	33.33	41.67	
	Column pct	0.00	1.89	1.17	0.77	0.92	
5–15 Years	Frequency	**4**	**26**	**29**	**65**	**38**	**162**
	Percent	0.31	2.01	2.24	5.03	2.94	12.53
	Row pct	2.47	16.05	17.90	40.12	23.46	
	Column pct	100.00	49.06	16.96	12.45	7.00	
16–25 Years	Frequency	**0**	**21**	**60**	**103**	**57**	**241**
	Percent	0.00	1.62	4.64	7.97	4.41	18.64
	Row pct	0.00	8.71	24.90	42.74	23.65	
	Column pct	0.00	39.62	35.09	19.73	10.50	
Over 25 Years	Frequency	**0**	**5**	**80**	**350**	**443**	**878**
	Percent	0.00	0.39	6.19	27.07	34.26	67.90
	Row pct	0.00	0.57	9.11	39.86	50.46	
	Column pct	0.00	9.43	46.78	67.05	81.58	
	Total Frequency	4	53	171	522	543	1293
	Total Percent	0.31	4.10	13.23	40.37	42.00	100.00

Nearly 40% of survey respondents have a high school education or less, which may be linked with an age distribution skewed to generally older producers. Full-time agricultural production comprised a larger percentage of employment several decades ago (Dimitri, Effland, & Conklin 2005), when many producers began a career in farming and ranching upon finishing high school or dropped out of school to start an agricultural vocation. That said, 43% of respondents hold a bachelor's, graduate, or professional degree. Regarding household net income, 55% of producers report household net income of $30,000 to $59,000 or $60,000 to $89,999, with respondents nearly equally split between those two categories. Nearly 60% of respondents reported that income from the cow-calf operation is less than 20% of household net income. In contrast, only 7% reported that cattle income was greater than 60% of household net income. This is again similar to Ward et al. (2008), where 76% of cow-calf producers depended on cattle production for less than 40% of their household income. These results correspond with the notion that fewer people are employed in agriculture full-time and that more operations could be described as hobby farms than in the past. In fact, the USDA's Economic Research Service reports that the percent

of U.S. farm households with off-farm employment increased from 54% in 1970 to 93% in 2002 (Dimitri, Effland, & Conklin 2005). Finally, respondents with no Master Cattlemen training or Beef Quality Assurance (BQA) training (91%) far exceed those who have had training (9%).

Rates of nonadoption for individual management and marketing practices are reported in Figure 1. Not surprisingly, nonadoption rates are lowest for the basic management practices of castration (28%) and deworming (37%). The bulk of management practices associated with preconditioning, such as 45-day weaning and feed bunk training for calves, have nonadoption rates ranging from 50% to 64%. About 74% of respondents report that they do not implant calves on the ranch. This is consistent with implant rates found in Asem-Hiablie et al. (2015). Nonadoption rates for record-keeping practices and individual calf identification range from 74% to 79%. Specific practices associated with niche markets, including age and source verification and no antibiotic use, have the highest nonadoption rates at 83% and 88% of respondents, respectively.

The impact of producer demographics on nonadoption is reflected in the binomial logit regression results for individual practices reported in Table 3. Model fit is assessed through examination of the percentage of concordant predictions made. This measure ranges from a low of 58.3% to a high of 69.5% across the 12 practices modeled. The lowest percentages concordant are for the record-keeping practices of medical records, birth date records, and individual calf identification, where the range is from 58.3% to 61.4%. Generally, the percentage of concordant predictions is higher for what could be described as more hands-on practices, such as castration, dehorning, weaning,

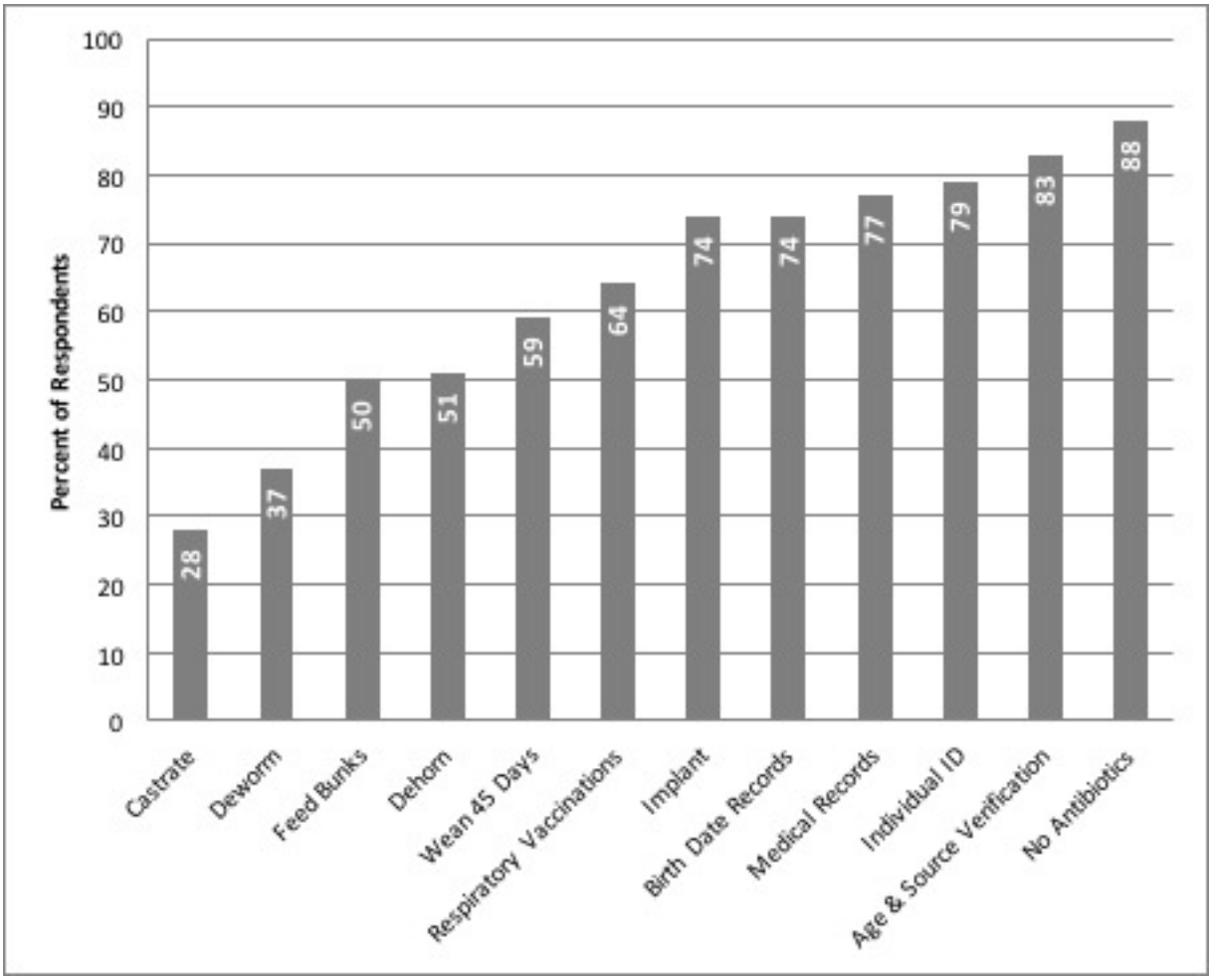

Figure 1. Rate of Nonadoption by Management Practice

Table 3. Binomial Logit Regression Estimates and Marginal Effect of Producer Demographics on Nonadoption by Practice

	PRACTICE	*Castrate*			*Dehorn*			*Deworm*		
	Variable	Coefficient	P-Value	Marginal Effect	Coefficient	P-Value	Marginal Effect	Coefficient	P-Value	Marginal Effect
Base[a]	Intercept	0.459*	0.083	0.613	0.293	0.253	0.573	-0.506*	0.061	0.376
Herd size	50 to 99 cows	-0.211	0.176	-0.051	-0.158	0.289	-0.039	-0.203	0.187	-0.046
	100 to 499 cows	-0.673*	0.003	-0.166	-0.492*	0.020	-0.122	-0.825*	0.000	-0.167
	500+ cows	-0.734	0.508	-0.181	0.024	0.977	0.006	-0.258	0.762	-0.058
Region	Northeast	-0.412*	0.010	-0.101	-0.104	0.500	-0.026	-0.174	0.274	-0.040
	Southwest	-0.481*	0.009	-0.118	-0.433*	0.016	-0.108	-0.410*	0.028	-0.090
	Northwest & panhandle	-1.032*	<.0001	-0.252	-0.560*	0.006	-0.139	-0.269	0.181	-0.061
AE index	AE = {9–12}	-0.216	0.344	-0.052	-0.300	0.169	-0.075	-0.131	0.571	-0.030
	AE = {13–16}	-0.338	0.122	-0.083	-0.275	0.185	-0.068	-0.139	0.529	-0.032
	AE = {17–20}	-0.033	0.879	-0.008	-0.147	0.484	-0.036	0.300	0.172	0.073
Education	Vocational education	-0.045	0.814	-0.011	0.189	0.295	0.045	0.222	0.236	0.053
	Bachelor's degree	-0.182	0.325	-0.044	-0.050	0.774	-0.012	0.108	0.548	0.026
	Grad or prof degree	-0.013	0.947	-0.003	0.161	0.379	0.039	0.294	0.114	0.071
Income	$30,000 to $59,999	-0.437*	0.036	-0.107	-0.300	0.139	-0.075	-0.034	0.875	-0.008
	$60,000 to $89,999	-0.546*	0.012	-0.134	-0.474*	0.024	-0.118	-0.017	0.940	-0.004
	$90,000 to $119,999	-0.832*	0.002	-0.205	-0.488*	0.046	-0.121	-0.226	0.379	-0.051
	$120,000+	-0.497*	0.056	-0.122	-0.615*	0.015	-0.153	-0.062	0.811	-0.014
Cattle income percent	21% to 40%	-0.237	0.173	-0.058	-0.270*	0.102	-0.067	-0.256	0.137	-0.058
	41% to 60%	-0.750*	0.007	-0.185	-0.738*	0.004	-0.182	-0.365	0.147	-0.081
	61% to 100%	-1.067*	0.007	-0.260	-0.904*	0.009	-0.221	-0.503	0.139	-0.109
Training	Master Cattlemen or BQA training	-0.552*	0.053	-0.136	-0.598*	0.025	-0.148	-0.536*	0.053	-0.115
Fit	% concordant	69.5			65.4			64		
	% discordant	30.0			34.0			35.3		

*Asterisk denotes significance of 0.1 or better.

[a] <50 cows, Southeast, AE index < 9, high school education or less, <$30,000 household income, cattle income <20%, no training participation.

[b]AE Classes descriptions: AE = {9–12} contains producers over 40 with at least 5 years' experience; AE={13–16} contains producers of preretirement age with at least 15 years' experience; AE = {17–20} contains producers over age 65 with at least 25 years of experience.

Table 3. Binomial Logit Regression Estimates and Marginal Effect of Producer Demographics on Nonadoption by Practice (*Continued*)

	PRACTICE	*45-Day Weaning Period*			*Respiratory Vaccinations*			*Feed Bunk Training*		
	Variable	Coefficient	P-Value	Marginal Effect	Coefficient	P-Value	Marginal Effect	Coefficient	P-Value	Marginal Effect
Base[a]	Intercept	0.439*	0.077	0.608*	0.342	0.172	0.585	0.017	0.948	0.504
Herd size	50 to 99 cows	-0.084	0.551	-0.020	-0.149	0.296	-0.037	-0.060	0.681	-0.015
	100 to 499 cows	-0.418*	0.024	-0.103*	-0.511*	0.006	-0.127	-0.464*	0.020	-0.114
	500 + cows	0.279	0.693	0.064	-0.988	0.240	-0.241	0.465	0.540	0.114
Region	Northeast	-0.098	0.502	-0.023	-0.143	0.336	-0.035	-0.049	0.747	-0.012
	Southwest	-0.443*	0.008	-0.109*	-0.205	0.220	-0.050	0.152	0.370	0.038
	Northwest & panhandle	-0.588*	0.001	-0.145*	-0.240	0.186	-0.059	-0.252	0.192	-0.063
AE class	AE = {9–12}	-0.087	0.672	-0.021	-0.181	0.389	-0.044	-0.306	0.148	-0.076
	AE = {13–16}	-0.074	0.708	-0.018	-0.090	0.654	-0.022	-0.159	0.427	-0.040
	AE = {17–20}	-0.120	0.550	-0.029	-0.166	0.415	-0.041	-0.369*	0.073	-0.091
Education	Vocational education	0.002	0.989	0.001	0.373*	0.029	0.087	0.032	0.858	0.008
	Bachelor's degree	0.190	0.230	0.044	0.646*	<.0001	0.144	0.148	0.372	0.037
	Grad or prof degree	0.263	0.124	0.061	0.571*	0.001	0.129	0.333*	0.059	0.082
Income	$30,000 to $59,999	0.092	0.642	0.022	0.285	0.151	0.067	-0.069	0.735	-0.017
	$60,000 to $89,999	0.017	0.934	0.004	0.155	0.448	0.037	-0.153	0.465	-0.038
	$90,000 to $119,999	-0.337	0.149	-0.082	-0.178	0.445	-0.044	-0.282	0.244	-0.070
	$120,000 +	-0.176	0.451	-0.043	-0.056	0.813	-0.014	-0.184	0.451	-0.046
Cattle income percent	21% to 40%	-0.291*	0.055	-0.071*	-0.475*	0.002	-0.118	-0.248	0.119	-0.062
	41% to 60%	-0.610*	0.005	-0.151*	-0.800*	0.000	-0.197	-0.661*	0.006	-0.160
	61% to 100%	-0.872*	0.002	-0.215*	-0.541*	0.043	-0.134	-1.122*	0.001	-0.255
Training	Master Cattlemen or BQA training	-0.642*	0.005	-0.159	-0.965*	<.0001	-0.236	-0.830*	0.002	-0.197
Fit	% concordant	64.2			66.7			64.1		
	% discordant	35.2			32.9			35.3		

[a] <50 cows, Southeast, AE index < 9, high school education or less, <$30,000 household income, cattle income <20%, no training participation.
*Asterisk denotes significance of 0.1 or better.
[b]AE classes descriptions: AE = {9–12} contains producers over age 40 with at least 5 years' experience; AE = {13–16} contains producers of preretirement age with at least 15 years' experience; AE = {17–20} contains producers over age 65 with at least 25 years' experience.

Table 3. Binomial Logit Regression Estimates and Marginal Effect of Producer Demographics on Nonadoption by Practice (continued)

		Implant			*No Antibiotic Use*			*Age and Source Verification*		
	Variable	Coefficient	P-Value	Marginal Effect	Coefficient	P-Value	Marginal Effect	Coefficient	P-Value	Marginal Effect
Base[a]	Intercept	0.520*	0.040	0.627	-0.123	0.625	0.469	0.463*	0.074	0.614
Herd size	50 to 99 cows	-0.067	0.647	-0.016	-0.058	0.684	-0.014	-0.154	0.296	-0.037
	100 to 499 cows	-0.244	0.190	-0.059	-0.076	0.683	-0.019	-0.348*	0.065	-0.085
	500 + cows	-0.919	0.282	-0.225	0.246	0.725	0.061	-0.525	0.499	-0.129
Region	Northeast	0.037	0.805	0.009	-0.252*	0.086	-0.062	-0.122	0.418	-0.029
	Southwest	-0.419*	0.012	-0.102	-0.348*	0.037	-0.085	-0.130	0.437	-0.031
	Northwest & panhandle	-0.498*	0.006	-0.122	-0.084	0.638	-0.021	0.093	0.619	0.022
AE class[b]	AE = {9–12}	-0.087	0.686	-0.021	-0.175	0.388	-0.043	-0.018	0.935	-0.004
	AE = {13–16}	-0.412*	0.042	-0.100	-0.544*	0.005	-0.130	-0.224	0.287	-0.054
	AE = {17–20}	-0.351*	0.089	-0.085	-0.568*	0.004	-0.136	-0.672*	0.002	-0.166
Education	Vocational education	0.395*	0.022	0.087	0.096	0.576	0.024	0.341*	0.049	0.077
	Bachelor's degree	0.188	0.237	0.043	0.325*	0.040	0.081	0.350*	0.030	0.079
	Grad or prof degree	0.367*	0.035	0.081	0.607*	0.000	0.149	0.544*	0.002	0.119
Income	$30,000 to $59,999	0.552*	0.006	0.118	0.244	0.232	0.061	0.347*	0.082	0.078
	$60,000 to $89,999	0.474*	0.021	0.103	0.150	0.474	0.037	0.450*	0.030	0.100
	$90,000 to $119,999	0.277	0.235	0.062	0.172	0.465	0.043	0.290	0.217	0.066
	$120,000 +	0.261	0.265	0.059	0.198	0.405	0.049	0.424*	0.075	0.094
Cattle income percent	21% to 40%	-0.418*	0.006	-0.102	-0.073	0.634	-0.018	-0.015	0.921	-0.004
	41% to 60%	-0.620*	0.003	-0.152	-0.315	0.149	-0.077	-0.368*	0.081	-0.090
	61% to 100%	-1.032*	0.000	-0.252	-0.262	0.340	-0.064	0.077	0.771	0.018
Training	Master Cattlemen or BQA training	-0.524*	0.016	-0.128	-0.168	0.435	-0.041	-0.706*	0.001	-0.174
Fit	% concordant	66.1			60.9			63.9		
	% discordant	33.4			38.5			34.0		

[a] <50 cows, Southeast, AE index <9, high school education or less, <$30,000 household income, cattle income <20%, no training participation. *Asterisk denotes significance of 0.1 or better.

[b]AE classes descriptions: AE = {9–12} contains producers over age 40 with at least 5' years experience; AE = {13–16} contains producers of preretirement age with at least 15 years' experience; AE = {17–20} contains producers over age 65 with at least 25 years' experience.

Table 3. Binomial Logit Regression Estimates and Marginal Effect of Producer Demographics on Nonadoption by Practice (*continued*)

		Medical Records			*Birth Records*			*Individually ID Calves*		
	Variable	Coefficient	P-Value	Marginal Effect	Coefficient	P-Value	Marginal Effect	Coefficient	P-Value	Marginal Effect
Base[a]	Intercept	0.097	0.696	0.524	-0.418	0.120	0.397	0.296	0.232	0.573
Herd size	50 to 99 cows	-0.095	0.500	-0.024	-0.167	0.282	-0.039	-0.041	0.770	-0.010
	100 to 499 cows	-0.482*	0.010	-0.119	-0.102	0.612	-0.024	0.090	0.627	0.022
	500 + cows	-0.956	0.259	-0.227	-13.711	0.977	-0.397	-0.364	0.645	-0.090
Region	Northeast	-0.176	0.228	-0.044	-0.032	0.841	-0.008	-0.194	0.181	-0.048
	Southwest	-0.215	0.192	-0.054	-0.185	0.307	-0.043	-0.332*	0.041	-0.082
	Northwest & panhandle	-0.052	0.771	-0.013	0.069	0.718	0.017	-0.231	0.192	-0.057
AE class[b]	AE = {9–12}	0.033	0.873	0.008	-0.369*	0.097	-0.084	-0.214	0.299	-0.053
	AE = {13–16}	-0.256	0.194	-0.064	-0.294	0.160	-0.068	-0.289	0.140	-0.072
	AE = {17–20}	-0.196	0.326	-0.049	-0.413*	0.055	-0.094	-0.301	0.133	-0.075
Education	Vocational education	0.038	0.824	0.009	0.162	0.376	0.039	0.176	0.290	0.042
	Bachelor's degree	0.256	0.106	0.063	0.032	0.854	0.008	0.136	0.385	0.033
	Grad or prof degree	0.157	0.358	0.039	0.340*	0.064	0.083	0.333*	0.050	0.079
Income	$30,000 to $59,999	0.162	0.413	0.040	-0.043	0.842	-0.010	0.213	0.278	0.051
	$60,000 to $89,999	0.097	0.632	0.024	-0.113	0.607	-0.027	0.042	0.833	0.010
	$90,000 to $119,999	0.066	0.774	0.016	-0.101	0.685	-0.024	-0.037	0.871	-0.009
	$120,000+	0.140	0.548	0.035	-0.058	0.820	-0.014	0.135	0.558	0.033
Cattle income percent	21% to 40%	0.096	0.530	0.024	0.040	0.814	0.010	0.063	0.678	0.015
	41% to 60%	-0.468*	0.032	-0.116	-0.236	0.328	-0.055	-0.442*	0.038	-0.110
	61% to 100%	-0.236	0.390	-0.059	0.111	0.700	0.027	-0.153	0.558	-0.038
Training	Master Cattlemen or BQA training	-0.915*	0.000	-0.218	-0.635*	0.016	-0.138	-0.915*	<.0001	-0.224
Fit	% concordant	60.6			58.3			59.1		
	% discordant	38.5			40.6			40.2		

[a] <50 cows, Southeast, AE index < 9, high school education or less, <$30,000 household income, cattle income <20%, no training participation.
*Asterisk denotes significance of 0.1 or better.
[b]AE classes descriptions: AE = {9–12} contains producers over 40 with at least 5 years' experience; AE = {13–16} contains producers of preretirement age with at least 15 years' experience; AE = {17–20} contains producers over age 65 with at least 25 years' experience.

vaccinating, feed bunk training, and implanting. The percentage of concordant predictions for these practices ranged from 64% to 69.5%.

Coefficient estimates are used to calculate the marginal effect of each demographic category. Marginal effects are reported relative to the base producer, defined as a producer with the following characteristics: fewer than 50 cows, Southeast region, AE index less than 9, high school education or less, less than $30,000 income, less than 20% of household income derived from cattle income, and no Master Cattleman or BQA training. Calculated marginal effects represent the change in the probability of practice nonadoption for a specific demographic characteristic compared to the base characteristic. For example, in Table 3, the marginal effect on nonadoption of castration for herd size of 50–99 cows is -0.051. The interpretation is that producers with herd size of 50–99 cows are 5.1 percent less likely to be a nonadopter of castration compared to producers with herd size less than 50 cows, all else equal.

Herd Size

Herd size has often been identified as an important influence on practice adoption, and our results are consistent with those of past research. It appears that as producers move from being small producers (<50 head) to midsize producers (100–499 head), the likelihood of nonadoption for most practices decreases, as is the case for 8 of the 12 practices assessed here. The exceptions are implanting, forgoing antibiotic use, birth records and individual identification of calves, where no significant difference in nonadoption is measured. Interestingly, midsize producers (100–499 head) are the only herd size where significant differences exist in nonadoption from the base of <50 head. This outcome may be attributed to the idea that producers do not see hands-on practices being worthwhile for fewer than 100 head of cattle or for hobby-type producers. Lack of significance for herd size of 500 head or more may be attributable to a small sample size, as herds of this size represent only 1% of the sample. The probability of nonadoption is less than that of the base for producers with a herd size of 100–499 cows for castration (-16.6%), dehorning (-12.2%), weaning 45 days before marketing (-10.3%), and deworming (-16.7%). Producers of this size are also 12.7% less likely to be nonadopters of respiratory vaccinations and 11.4% less likely to be nonadopters of feed bunk training—both practices that are associated with preconditioning calves before marketing. Record keeping appears to be more important for herds of 100–499 head relative to other sizes, as the predicted probability of not keeping medical records is reduced by 11.9%. This suggests that there is a critical size where these management practices become more important.

Region

This study confirms long-held anecdotal beliefs that Oklahoma is a diverse state with respect to cattle production practices. Diversity in production practices is at least partially driven by Oklahoma's diverse ecology combined with multiple cultural influences. Oklahoma has 12 Level III ecoregions—more per square mile than any other state—and 46 Level IV ecoregions. To put this in context, the continental United States contains 104 Level III ecoregions (Woods et al., 2005). Additionally, the cultural influences of the Midwest, Southwest, Great Plains, and South intersect in the center of the state, resulting in four relatively distinct quadrants within the state's borders.

Generally speaking, producers in the southeast region of the state are most likely to be nonadopters across practices, while those in the western regions are least likely to be nonadopters. While little or no regional differences are evident with respect to record-keeping practices in this study, region appears to play a strong role in the likelihood of nonadoption of the basic marketing and management practices of castration, dehorning, and deworming as well as 45-day weaning. Region also influences the marketing decisions of implanting and no antibiotic use. The strongest regional differences are seen in castration. Relative to the base producer in the southeast region, northeast producers and southwest producers are 10.1% and 11.8% less likely, respectively, to be nonadopters of castration. The largest difference, as expected anecdotally, is seen in the northwest region, where producers are 25.2% less likely than those in the southeast region to not castrate bull calves prior to marketing. The east versus west anecdote is reinforced by the results for dehorning,

weaning, and implanting, where the two western regions are about 10% to 14% less likely to be nonadopters relative to the southeast region. Interestingly, producers in the northwest region are not significantly different from those in the southeast with respect to choosing to produce calves using no antibiotics. This practice likely targets calves to natural programs or specific marketing alliances, and based on results here, producers participating in such programs are more likely to be found in the northeast and southwest regions of the state.

AE Index

No significant differences in rates of nonadoption by AE category were measured across the basic practices of castration, dehorning, and deworming or across the preconditioning practices of weaning, respiratory vaccinations, and feed bunk training. The exception is that producers in the highest AE category—oldest and most experienced producers—are about 9% less likely to be nonadopters of feed bunk training relative to the base producer, suggesting that older and more experienced producers are more likely to precondition calves with the next stage of production in mind. AE category does have significant impacts on nonadoption of implanting calves before marketing, where the predicted probabilities for producers in the two highest AE categories are 8.5 to 10 percentage points less than for the base producer. The decision to produce calves without antibiotics is also influenced by AE category, where the two highest AE categories have lower nonadoption probabilities relative to the base by about 10 percentage points. Age and experience also influences the nonadoption rate for keeping birth records on calves. Recall that the base producer is less than 40 years of age or is older but with little experience. Results suggest that producers in category 2 and category 4 of the AE index categories are less likely to be nonadopters of keeping birth records (8.4% and 9.4%, respectively).

Education

Educational attainment does not significantly impact the probability of nonadoption for basic management practices of castration, dehorning, and deworming; 45-day weaning; or record-keeping regarding medical treatment. Education level does have a significant and positive impact on nonadoption of other practices, contrary to results from similar studies. Note that educational attainment was measured without regard to specialty area for degrees beyond a high school diploma. Producers with any education beyond high school are more likely to be nonadopters of respiratory vaccinations than the base producer, ranging from a nearly 9% higher predicted probability for those with some vocational education to 14.4% higher predicted probability of nonadoption for producers with a bachelor's degree. The predicted probability of nonadoption of respiratory vaccinations is 12.9% higher than the base for those with a graduate or professional degree. For the practices of feed bunk training, birth records, and individual calf identification, educational attainment beyond the base producer is only significant for those with graduate or professional degrees. Those producers are about 8% more likely to be nonadopters (8.2%, 8.3%, and 7.9%, respectively). The results indicate that a bachelor's degree or a graduate/professional degree increases the probability of nonadoption (8.1% and 14.9%, respectively) of no antibiotic use and for age and source verification (7.7% and 12%, respectively). Though these results seem counterintuitive, it may be that the model is inadvertently capturing the influence of producers' time resource. Producers with education beyond high school could be more likely to have full-time off-farm jobs and thus have less time to implement various practices.

Net Household Income

Net household income level has a strong impact on both castration and dehorning. In general, as net household income level increases, the probability of not castrating decreases, with decreases of 11%, 13.4%, and 21% for income categories of $30,000–$59,999, $60,000–$89,999, and $90,000–$119,999, respectively. The impact does lessen as net household income rises to $120,000 and above, but it is still strong at 12.2%. Net household income's impact on nonadoption of dehorning follows a similar pattern, beginning with the $60,000 level. The only other practices for which net household income level is a factor are implanting and age and source verification, and

in each case higher levels of net household income indicate higher levels of nonadoption. That said, only the $30,000–$59,999 and $60,000–$89,999 income ranges have significant marginal effects for implanting, at 11.8% and 10.3%, respectively. The impact of net household income on nonadoption of age and source verification is similar, with significant impacts relative to the base for $30,000–$59,999 (7.8%), $60,000–$89,999 (10.0%), and $120,000 or greater (9.4%).

Cattle Income Percentage

The percentage of net household income derived from the cow-calf operation, or cattle income percent (CIP), has an important influence on nonadoption for several marketing and management practices. It is a key influencer for nonadoption of basic recommended practices, including castration and dehorning, with higher CIP decreasing the likelihood of nonadoption. As CIP rises beyond 40%, cow-calf producers are significantly less likely than base producers to leave bull calves uncastrated, with marginal effects of -0.18 for 41–60% CIP and -0.26 for CIP above 60%. Results are similar for dehorning, where the likelihood of producers to leave calves horned decreases as CIP increases. At 21–40% CIP, the likelihood of nonadoption falls nearly 7 percentage points, with even greater decreases for the 41–60% and 61–100% CIP brackets and with marginal effects of -0.18 and -0.22, respectively.

Respiratory vaccinations, 45-day weaning, and feed bunk training are three practices typically bundled with the three basic practices mentioned above in preconditioning programs. The percent of overall income derived from the cattle operation has a significant and negative impact on nonadoption for those preconditioning practices individually. For weaning, the marginal effect for producers with 21–40% CIP is -0.07, indicating that these producers are 7 percentage points less likely to be nonadopters relative to base producers; that is, producers with higher CIP are less likely to market calves without at least a 45-day weaning period prior to marketing. Producers in higher CIP categories of 41–60% and 61–100% have marginal effects for nonadoption of weaning that are increasingly negative, at -0.15 and -0.22, respectively. Producer decisions to not forgo respiratory vaccinations follow a similar pattern, as the decrease in predicted probability of nonadoption for producers beyond 20% CIP ranges from 11.8 (41–60% CIP) to nearly 20 percentage points (61–100% CIP). Results are comparable for feed bunk training. Producers who rely more heavily on income from the cow-calf operation are less likely to skip feed bunk training prior to marketing. Producers with 41–60% CIP are 16% less likely to not adopt feed bunk training, while those in the 61–100% are a notable 25.5% less likely to be nonadopters. CIP has little to no significant impact on the likelihood of nonadoption for deworming or record-keeping practices. However, a higher CIP does decrease the likelihood of nonadoption for calf implants, ranging from a marginal effect of -0.10 for producers with a 41–60% CIP range to -0.25 percentage points for those with a 61–100% CIP.

Training

The demographic characteristic that appears to exert the strongest and most consistent influence on nonadoption across all practices is extension educational programming regarding production and quality management in cow-calf operations. Cow-calf producers who had participated in at least one of two specific programs (Master Cattleman or BQA training) were less likely to be nonadopters for 11 of the 12 marketing and management practices examined. The exception is no antibiotic use, which is ultimately a niche marketing decision rather than a beef quality issue. The impact of educational training on nonadoption is strong and significant for basic management practices such as castration (-13.6%), dehorning (-14.8%), weaning (-15.9%), and deworming (-11.5%). Producers with extension program participation are also less likely to be nonadopters of the preconditioning practices of respiratory vaccinations (-23.6%) and feed bunk training (-19.7%). While few demographic characteristics influenced record-keeping practices in this study, participation in extension educational programming did. Cow-calf producers who had participated in extension educational programming were substantially less likely to be nonadopters of medical records (i.e., more likely to keep medical records, -21.8%), birth date records (-13.8%), and individual calf identification records (-12.4%) than producers who had not

participated in the programming. The strong influence of educational programming continues with implanting and age and source verification, where producers who have participated in that programming are 12.8 percentage points less likely to be nonadopters of implanting calves and 17.4 percentage points less likely to be nonadopters of age and source verification.

Table 4 presents a concise summary of demographic influences on practice nonadoption. Practices are grouped into four categories: basic, preconditioning, marketing, and record keeping. The direction of change in probability of nonadoption is given by a plus (+) or minus (-), relative to the base demographic group. Generally speaking, demographic characteristics that lower the probability of nonadoption for basic practices are herd size, region, income, CIP, and training. For preconditioning practices, herd size, region, CIP, and training are the demographic influences that decrease the probability of nonadoption, while education beyond the high school level actually increases the probability of nonadoption for these practices. Demographic characteristics' influence on practices that reflect marketing choices are mixed. Region, AE class, CIP, and training lessen the likelihood of nonadoption, generally speaking, though region does not influence age and source, nor does CIP influence no antibiotic use. In the case of marketing choices, education beyond high school again increases the probability of nonadoption, as does higher levels of income for implanting and age and source verification. There is little consistency regarding demographic influences across record-keeping functions, with participation in extension training as the exception. Holding a graduate or professional degree increases the likelihood of nonadoption for birth records and individual identification of calves. CIP from 41% to 60% lessens the likelihood of nonadoption of medical record keeping and individual calf identification.

CONCLUSIONS

Oklahoma ranks second in number of beef cows per square mile, behind only Missouri. Production of beef cattle consistently ranks as Oklahoma's leading source of agricultural income, with nearly 48% of the state's total value of agricultural production in 2012 (U.S. Department of Agriculture, 2014). Clearly, it is an important economic enterprise for the state. Yet, many producers do not adopt management and marketing practices that potentially add value to calves. Identifying the demographic characteristics of nonadopters serves to strengthen educational efforts in cow-calf production through more specific targeting of programs.

This study finds that herd size positively influences practice adoption of most practices but also that herds may reach a critical size where adoption is actually deterred, perhaps by labor constraints. For several practices, the likelihood of nonadoption for herds greater than 500 head was not significantly different than for herds of fewer than 100 head, while for herds of 100–499 head nonadoption was less likely in 10 of 12 practices. For smaller herds, producers may not perceive it to be worthwhile to implement health-related practices on a few calves or may be relatively new to the cow-calf industry and unfamiliar with such practices. For the largest herds, their large size may introduce other constraints. Region also plays a role in the likelihood of nonadoption of hands-on practices such as castrating, dehorning, weaning, deworming, and implanting, lending support to commonly held anecdotal beliefs about regional differences within the state. The most outstanding regional effect occurs from the northwest region in castration, which reduces the probability of nonadoption by 25 percentage points. Generally speaking, producers in the eastern half of the state are more likely to be nonadopters of value-adding management and marketing practices than those in the western half of the state.

The AE variable, designed to capture the joint influence of age and experience, is influential only at the highest two levels and then only for selected practices—primarily those related to marketing. Older producers at or near retirement age may not adopt new practices because of impending retirement or herd downsizing. Interestingly, higher levels of education, typically thought to increase adoption rates, are instead shown here to significantly increase nonadoption rates in 8 of the 12 practices and have no impact on the basic practices of castration, dehorning, and deworming. It is likely that those in the highest education category are full-time professionals and part-time cattlemen, so time

Table 4. Direction of Change in Probability of Nonadoption across Demographics for Specific Practices

		Basic			*Preconditioning*			*Marketing*				*Records*		
Demographic Characteristics		Castrate	Dehorn	Deworm	45-Day Weaning	Resp. Vac	Feed Bunk Training	Implant	No Antibiotics	Age & Source	Medical Records	Birth Records	Individually IDed Calves
Herd size	50 to 99 cows												
	100 to 499 cows	-	-	-	-	-	-			-	-		
	500 + cows												
Region	Northeast	-							-				
	Southwest	-	-	-	-			-	-				-
	Northwest & panhandle	-	-		-			-					
AE class	AE = {9–12}											-	
	AE = {13–16}							-	-				
	AE = {17–20}						-	-	-	-		-	
Education	Vocational education					+		+		+			
	Bachelor's degree					+			+	+			
	Grad or prof degree					+	+	+	+	+		+	+
Income	$30,000 to $59,999	-						+		+			
	$60,000 to $89,999	-	-					+		+			
	$90,000 to $119,999	-	-										
	$120,000+	-	-							+			
Cattle income percent	21% to 40%		-		-	-		-					
	41% to 60%	-	-		-	-	-	-		-	-		-
	61% to 100%	-	-		-	-	-	-					
Training	Master Cattlemen or BQA training	-	-	-	-	-	-	-		-	-	-	-

and labor may be constraining factors to adoption. Another finding of interest is that income level does not have widespread influence on practice adoption, and when it is significant, its impacts are not consistent. For example, higher levels of income lessen the likelihood of nonadoption for the basic practices of castration and dehorning yet increase the likelihood of nonadoption for the marketing-related practices of implanting and age and source verification. Practices that have a heightened likelihood of nonadoption based on income stems from the notion that producers are less concerned with added value when overall income is already considered sufficient. Generally speaking and consistent with other studies, greater dependence on cattle income lessens the likelihood of nonadoption for most practices. This is particularly evident for those individual practices that are typically bundled together in preconditioning. A producer's incentive to more aggressively pursue value-adding opportunities may be increased when cow-calf production is a larger contributor to overall income.

The models for record keeping, which consists of medical records, birth date records, and individual calf identification, yield interesting results. Medium-size producers (100–499 head) are less likely to not keep medical records, but herd size has no impact on the likelihood of keeping birth records or individually identifying calves. Ironically, producers with graduate or professional degrees—the highest level of education—are the least likely to keep birth records or individually identify calves. These producers may not realize the value of such record keeping or have the time to document birth dates if earning off-farm income consumes a majority of their time.

Perhaps the most striking finding of the study is the measurable impact that extension education can have on adoption of recommended practices. Participation in either of two extension educational efforts significantly decreased the likelihood of nonadoption in all practices except one, signifying the effectiveness of extension efforts. In fact, for the practices that fall under the record-keeping category, participation in at least one of two extension educational efforts was the only variable that consistently decreased the rate of nonadoption, and its impact is large, relatively speaking. While many cow-calf producers are familiar with traditional extension programming, an increasing number of producers may be less familiar or less interested (e.g., hobby farmers). This study underscores the importance of developing innovative extension programming to reach a diverse audience of cow-calf producers regarding recommended management and marketing practices, along with the need for further research to examine producer decision making regarding adoption of practices as a value-added bundle and to identify specific constraints to practice adoption for cow-calf producers in different demographic groups.

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