Journal of Agricultural and Applied Economics, 40,3(December 2008):851–863

Factors Affecting Adoption of Cow-Calf Production Practices in Oklahoma

Clement E. Ward, Mallory K. Vestal, Damona G. Doye, and David L. Lalman

Most technology adoption research has focused on crops. Primary data were used to determine differences in management practices among two groups of Oklahoma cow-calf producers based on herd size and cattle income dependence. Significant differences were noted between two groups of producers (smaller operations with less dependence on cattle versus larger with more dependence on cattle) in 79% of the management practices examined. Logit models determined factors influencing the probability of adopting 17 recommended practices. Important factors included the firm goal to choose practices that reduce labor, income dependence on cattle, human capital, and size of operation.

Key Words: cattle, cow-calf, livestock, management practices, technology adoption

JEL Classifications: D21, Q12, Q16

Forty percent of U.S. farms had sales of cattle and calves according to the 2002 Census of Agriculture, making it the single most prevalent enterprise on farms nationwide (USDA/NASS). Approximately 80% of farms with beef cows had fewer than 50 cows. The National Animal Health Monitoring System (NAHMS) beef report for 1997 documented management practices in a variety of areas for cow-calf enterprises, including information management, breeding and calving management, production management and disease control, health, and health management (USDA/APHIS). The NAHMS study found the beef herd was the primary source of income on just 14% of all operations included in its survey.

The assumed goal of farm firms is to maximize profit subject to both technical and economic constraints. Previous research has confirmed several production practices can increase cowherd returns either by increasing revenue or by reducing costs (Ramsey et al.). From a producer's standpoint, the expected added benefit from a specific production practice must be compared with the expected added cost of implementation. Economists could argue producers employ this marginal revenue–marginal cost concept both for current production practices and for assessing new technology, whether done implicitly or explicitly.

Overlaid on this partial budgeting approach is the expected utility producers

Clement E. Ward is professor and extension economist, Department of Agricultural Economics, Oklahoma State University, Stillwater, OK. Mallory K. Vestal is instructor, Department of Agricultural Sciences, West Texas A&M University, Canyon, TX. Damona G. Doye is Regents professor and extension economist, Department of Agricultural Economics, Oklahoma State University, Stillwater, OK. David L. Lalman is professor and extension animal scientist, Department of Animal Science, Oklahoma State University, Stillwater, OK.

The authors acknowledge and appreciate financial support for risk management educational programs from the Risk Management Agency, U.S. Department of Agriculture.

associate with current and potential practices. Many recommended management practices require intensive management while others may add value with less intensive management requirements (Fernandez-Cornejo; Fernandez-Cornejo, Hendricks, and Mishra). A producer allocates limited resources, both human and nonhuman, to where those resources maximize expected utility. As a consequence, an individual producer may not necessarily adopt the most innovative, recommended, or best management practice.

This article reports on research conducted with two, sequential objectives. First was to identify production practices of cow-calf producers in Oklahoma and test for differences in practices adopted or used by two specific groups of producers. As hypothesized, significant differences were found in nearly 80% of the management practices examined among two cow-calf producer groups. The second objective was to determine factors affecting the probability of adopting 17 recommended management practices for which differences were found among the two producer groups. Significant factors affecting adoption included farm characteristics, firm goals, and operator demographics. Research reported here contributes to the limited literature on management and technology adoption in livestock operations.

Technology Adoption in Beef Cattle Enterprises

The research reported here falls into the branch of literature Dorfman refers to as empirical studies identifying factors or characteristics associated with adoption decisions. Most such empirical work in the United States pertains to cropping practices and technologies rather than livestock enterprises. However, as noted here, some literature exists on adoption of selected practices or technologies in livestock operations.

One or more of several factors, including human capital (typically measured by education level), off–farm employment and income, farm size, risk perception, borrowing capacity, and farm location characteristics have been found to affect technology adoption in several previous crop enterprise studies (Dorfman; Fernandez-Cornejo; Fernandez-Cornejo, Hendricks, and Mishra). While most studies address adoption for a single technology, Dorfman argued adoption in many cases requires a combination of technologies. Some previous studies have considered management-intensive technology adoption, which may require extensive investment, while some have not distinguished the type of technology being considered for adoption.

Studies related to technology adoption in livestock operations other than beef cattle include swine breeding technologies and swine producer preferences for managerial autonomy and for adoption of best management practices in dairy production (Gillespie, Davis, and Rahelizatovo 2004a,b; Rahelizatovo and Gillespie). Farm size, human capital, diversity of farm operations, risk aversion, and off-farm income affected the adoption of various managerial practices. These studies involved both individual management practices and combinations of practices.

For our study, the question of adoption pertained to individual production practices and not combinations of practices. Adoption of nearly all practices considered here requires only a small capital outlay relative to total production costs, though some were more management/labor intensive than others. It was hypothesized cowherd size, percentage dependence on income from the beef enterprise, extent of off-farm employment, human capital as measured by education and age, and firm goals would significantly affect adoption of specific cow-calf production practices. Previous research found economies of size for cow-calf operations (Langemeier, McGrann, and Parker; Miller et al.; Ramsey et al.; Short). Larger size operators have a greater opportunity cost of not adopting a specific production practice or technology than smaller-size operators (Wozniak). Wozniak studied adoption by cattle feeders of two cattle growth technologies: a growth hormone implant that had been widely adopted since its introduction several years earlier and a feed additive that had been more recently approved for use. Late

or mature adoption referred to the former technology and early adoption to the newer technology. Size of operation, measured by number of head slaughtered, influenced both early and late adoption. Larger operators were found to more likely adopt the growth technology than smaller operators.

Off-farm income and off-farm employment potentially enhance the opportunity for producers to invest in new technology. Jointly, they may provide additional financial resources for outright investment as well as providing enhanced access to borrowed capital. Off-farm employment may provide an incentive to adopt management-saving technology. Wozniak found neither off-farm wages nor extent of debt had a major influence on the likelihood of adopting the two growth technologies. In fact, in the case of wage income, the influence was negative in one model. For the specific technologies he studied, neither required a major investment, only a modest increase in production costs, and neither had a significant effect on management intensity. In contrast, off-farm income has been shown to be much more important for management-saving crop technologies (Fernandez-Cornejo; Fernandez-Cornejo, Hendricks, and Mishra). The relationship between off-farm employment and the importance of specific technology is consistent with findings by Dorfman that greater off-farm employment (i.e., hours worked off farm) reduced the probability of adopting improved irrigation technology.

Income from agricultural enterprises can affect technology adoption also. In one of the few studies of technology adoption in the cow-calf industry, Kim, Gillespie, and Paudel found that income generated from agricultural production had a positive relationship on the probability of adopting specific range management practices.

Human capital has a significant effect on technology adoption in several ways. More formal education was associated with a greater propensity to seek information regarding new technology (Dorfman; Wozniak). However, Popp, Faminow, and Parsch note a key point regarding education. The likelihood of adoption may increase with higher education levels, but better education is also likely to change off-farm employment opportunities. Increasing age can be associated with more years of experience and enhanced human capital, thereby increasing the likelihood of adopting new technology. Again, however, some would argue it could have the opposite effect. Older operators may have a shortened planning horizon, while younger operators may be more innovative and risk taking and thus more apt to adopt new technology (Fernandez-Cornejo). The effect from operator age may be influenced by the type of technology, especially extent of capital required and degree of management intensity required.

Firm goals are expected to affect technology adoption or selection of specific production practices. Two firm goals were hypothesized to influence adoption. One was the importance cow-calf producers placed on choosing technology or practices that reduced labor. Second was the importance of generating enough farm income to avoid off-farm employment.

Standardized performance analysis data show profitability of cow-calf operations varies greatly (Dunn; Ramsey et al.). Economic factors within a ranch manager's control have been found to be important in determining economic performance. Ramsey et al. found that cow-calf cost of production, production output, and profits were influenced by several economic factors, including cowherd size, land investment, machinery and equipment investment, livestock investment, feed fed, calving percentage, death loss, and breeding season. Each of these factors had previously been shown to affect production and production efficiency. Significant factors affecting cost of production included all production and financial management variables along with economies of size. Some production and financial management variables also significantly affected the level of cowherd production. Production rather than financial variables were most important in explaining cow-calf profitability. Together, results indicate the importance of management, in turn suggesting that the goals of manager-proprietors are important.

As noted, little research has focused on technology adoption by cow-calf producers. Popp, Faminow, and Parsch sought to better define and determine those factors that affect the adoption of value-added production in cow-calf operations. Specifically, they focused on the decision by Arkansas cow-calf producers to feed or sell calves at weaning. They hypothesized farm size, human capital, perception of risk and returns, and enterprise diversification would explain the feed-versus-sell decision. Results showed that farm size was significant. Increased acreage for the cow-calf operation increased the likelihood that the production unit would background calves (i.e., feed calves beyond weaning). Producers' perception of risk and profitability also influenced the adoption of the value-added enterprise. If producers believed that the risk associated with feeding calves to heavier weights was less than the expected price premium after backgrounding, producers were more likely to background calves.

A study by Kim, Gillespie, and Paudel focused on economic factors affecting adoption of best management practices related to environmental decisions in cow-calf production. Their major concern was low observed adoption rates despite efforts to educate producers. Primary data were gathered through a statewide survey of cow-calf producers in Louisiana. Results confirmed that firm characteristics and goals were important. More diversified operations were more likely to adopt best management practices. Human capital positively affected the likelihood of adoption, where human capital was measured by increased education. Dependence on the beef enterprise for household income also positively affected the likelihood of adopting best management practices.

Data, Groups, and Differences

The *Oklahoma Beef Cattle Manual*, written by 16 lead authors from six academic disciplines (Lalman and Doye), was distributed through local extension offices, through producer meetings, and by e-mail request from an Oklahoma State University (OSU) website (http://agecon.okstate.edu/cattleman). Producers who received a copy of the manual were asked to complete a lengthy survey documenting current beef production and management practices in several areas of the cow-calf enterprise. Completed surveys numbered 729 and comprised the source data for this research (Vestal).

Sections of the survey were developed with input from OSU faculty who specialize in respective management areas such as animal nutrition, reproduction, genetics, health, forages and pastures, marketing and risk management, and business planning and finance. Questions were structured so as to measure the extent producers adopted or were using practices recommended by animal science, plant science, veterinary medicine, and economic specialists.

Questions covered a broad array of production and management areas of the cow-herd enterprise. Management practices were categorized into seven areas: nutrition and management, forages and introduced pasture, quality assurance and animal health, marketing and risk management, reproduction, genetics, and business planning and management. Questions also were asked regarding demographics and firm characteristics. A brief summary for all respondents is given here:

- 89% were male, 91% were Caucasian, 60% were 50 years old or older, and 80% had completed at least some college courses.
- 70% were employed either full time or part time off the farm or ranch.
- Household income was split nearly equally between those with less than $60,000 per year (51%) and those with more than $60,000 per year (49%).
- 68% had commercial cowherds of less than 100 cows.
- 76% depended on cattle for 40% or less of their total income.

This research was one step in evaluating the Master Cattleman extension program at OSU, which like other similar programs was designed to educate cow-calf producers on recommended management practices. The primary survey data for this study represent

Table 1. Frequency of Producers by Herd Size and Income Dependence

	Household Net Income from Beef Cattle Operation				
Breeding Females in Herd (Head)	1–20%	21–40%	41–60%	61–80%	81–100%
1–49	*189*	*40*	13	5	6
50–99	*49*	*46*	22	9	3
100–249	27	29	**30**	**19**	**10**
250–499	3	3	**4**	**7**	**9**
500–999	0	1	**2**	**2**	**3**
1,000+	0	1	**0**	**0**	**4**

Note: Italic values indicate the "smaller" producer group, and boldface values indicate the "larger" producer group.

a benchmark of management practices prior to receiving educational materials from the program that can be compared with practices adopted x years later following completion of the educational program. Recognizing differences among producers' adoption of recommended practices and understanding factors affecting adoption are important to designing effective educational programs.

Producers supplying primary data were divided into groups based on number of commercial beef cows in the breeding herd and percentage dependency on the beef cow enterprise for household income (Table 1).[1,2] Two groups were of primary interest in this study. The first group (referred to as smaller producers for convenience) consisted of smaller cowherd operations (herds less than 100 breeding females) whose percentage of household income from the beef enterprise in 2003 was 40% or less. The second group (referred to as larger producers) consisted of larger cowherd operations (herds of 100 or more breeding females) whose percentage of household income from the beef enterprise in 2003 was greater than 40%. Producers in these two groups totaled 414 (324 in the group of smaller producers and 90 in the group of larger producers).[3]

Chi-square tests of frequency distributions were conducted to determine differences between the two groups. Some numbered questions had multiple parts and some questions had varying response categories. Some had two response categories (e.g., yes or no), some asked for responses on a 1–7 scale (e.g., 1 = nearly always to 7 = rarely if ever), and some questions could have multiple responses (where answers could be a and c or a, b, and c and so on). Statistically significant differences were found as hypothesized between the two size/dependence groups for 79.2% of all or parts of the 53 questions (Table 2).

Results generally confirmed that larger producers who rely on cattle for a greater percentage of their household income are more apt to adopt or use recommended management practices than smaller producers who are less dependent on cattle for household income. The need for larger producers to generate profit may drive them to adopt recommended practices. This study did not address whether larger producers fell into that group *because* they previously adopted recommended practices that enabled them to earn more profit over time and grow or

[1] While the survey instrument asked for number of commercial and purebred breeding females in separate questions, this research focused on commercial cow-calf producers.

[2] Persons completing surveys consisted of larger cow-calf producers compared with the population of cow-calf producers in Oklahoma. For example, those with less than 50 cows accounted for 47.2% of the total in our data set, compared with 77.3% according to the 2002 Agricultural Census, and those with 500 cows or more accounted for 2.4% of our total compared with 0.4% according to census data.

[3] The authors' primary interest was on the two groups described here in terms of comparing management practices (i.e., the first objective). The other two groups could be described as smaller producers heavily dependent on cattle for household income or larger producers not dependent on cattle for household income.

Table 2. Frequency of Significant Differences in Producer Groups by Management Categories

	Questions and Statistical Difference Between Groups	
Management Category	Number of Questions	Number Significantly Different
Nutrition and management	7	7
Forages and introduced pasture	7	6
Quality assurance and animal health	9	7
Marketing and risk management	11	9
Reproduction	5	4
Genetics	8	3
Business planning and management	6	5
Total	53	42

Note: Some questions contained multiple parts.

expand their operations. Conceptually, smaller producers seeking to grow and expand must consider which management practices are most effective in controlling costs and generating income to increase cowherd profitability.

Factors Affecting Adoption

Differences in adoption of management practices between producer groups raise questions regarding which factors influence producers' propensity to adopt specific practices or technology. Do demographic characteristics of the producer and firm affect adoption of specific practices, or are income and enterprise objectives a better determinant of the probability of adoption? The primary objective of the second phase of this study was to derive a more precise understanding of specific factors that affect the probability of Oklahoma cow-calf producers' adopting recommended management practices.

Specific production practices where differences were found between producer groups were identified for further analysis. Seventeen practices were selected, including implant usage in steers, length of the hay feeding season, soil testing, forage testing of raised and purchased forages, stockpiling grasses and introduced forages, calf vaccination, cow and calf identification, cow and replacement heifer pregnancy exams, bull breeding soundness exams, breeding season length, existence of a long-term plan, record-keeping method, and cash flow planning. Factors hypothesized to influence the probability of a producer adopting recommended practices for these specific management practices were number of breeding females, percent of household net income from the beef operation, operator's age and education, extent of off-farm work, importance of reducing labor use, and importance of generating farm income to avoid off-farm employment.

Researchers have employed alternative methodologies in previous studies, based largely on the research objective. Multivariate probit models were appropriate when producers face multiple adoption decisions (Dorfman; Fernandez-Cornejo; Gillespie, Davis, and Rahelizatovo 2004b). Survey data in which the decision was in degrees of adoption lent support for an ordered probit model by Gillespie, Davis, and Rahelizatovo (2004a). Here, a binomial logit model was specified to estimate the likelihood that given demographic and firm characteristics would affect the probability of producers adopting each specific management practice (Allison). The following equation represents a generalized form of the model for each dependent variable:

$$\text{(1)} \qquad \textit{Prob}(\text{Producer } i \text{ adopts recommended practice}) = \frac{e^{Z}}{1 + e^{Z}},$$

where *Prob*(Producer *i* adopts recommended practice) is the probability of producer *i* adopting each specific recommended practice

Table 3. Logit Model Dependent Variables (Selected Production Practices)

Variable	Definition	Mean
Implant	Frequency of implanting steer calves prior to weaning (0 = nearly always, 1 = rarely, if ever)	0.724 (0.018)
HaySeason	Typical hay feeding season (0 = ≤60 days, 1 = >60 days)	0.897 (0.011)
SoilTest	Frequency of conducting a soil test (0 = at least biannually, 1 = rarely, if ever)	0.621 (0.024)
ForageTestRaised	Frequency of conducting a forage test on raised forages (0 = nearly always, 1 = rarely, if ever)	0.729 (0.020)
ForageTestPurchased	Frequency of conducting a forage test on purchased forages (0 = nearly always, 1 = rarely, if ever)	0.818 (0.016)
GrassStockpile	Stockpiling forage grasses (0 = nearly always, 1 = rarely, if ever)	0.344 (0.024)
IntroducedStockpile	Stockpiling introduced forages (0 = nearly always, 1 = rarely, if ever)	0.399 (0.024)
Vaccinate	Vaccinating calves prior to marketing (0 = vaccinate, 1 = do not vaccinate)	0.299 (0.017)
CowID	Individually identifying cows (0 = individually ID, 1 = do not individually ID)	0.086 (0.010)
CalfID	Individually identifying calves (0 = individually ID, 1 = do not individually ID)	0.210 (0.015)
LongTermPlan	Long-term plan (5 years or more) (0 = yes, 1 = no)	0.573 (0.019)
RecordKeeping	Record-keeping method used (0 = computer usage, 1 = hand method only)	0.629 (0.019)
CashFlow	Cash flow or budget (0 = yes, 1 = no)	0.400 (0.020)
BreedingSeason	Breeding season (0 = defined breeding period, 1 = bulls with cows year-round)	0.452 (0.020)
CowPregExam	Frequency of pregnancy exam on mature cows (0 = nearly always, 1 = rarely, if ever)	0.663 (0.021)
HeiferPregExam	Frequency of pregnancy exam on replacement heifers (0 = nearly always, 1 = rarely, if ever)	0.529 (0.021)
BullSoundness	Frequency of breeding soundness exam on young bulls (≤2 years) (0 = nearly always, 1 = rarely, if ever)	0.403 (0.021)

Note: Numbers in parentheses are standard errors.

or technology. Each respective recommended practice takes on a binomial value. The term e is a mathematical constant, the base of the natural logarithm, that equals approximately 2.718281828, and Z is

$$Z = \alpha + B_1 CowNmbrs + B_2 Income + B_3 Age + B_4 Edu + B_5 OffFarm + B_6 ReduceLabor + B_7 GenFarmIncome \quad (2)$$

The dependent variable is 0 when a producer adopts the recommended practice and 1 when a producer does not implement the management practice. Dependent variables and associated mean values are listed in Table 3. Independent variables in Equation (2) are categorical response variables where *CowNmbrs* is the number of commercial breeding females in the herd from 1 to 6, *Income* is the percentage of household net income from the beef cattle operation from 1 to 5, *Age* is the primary operator's age from 1 to 5, *Edu* is the level of education attained by the primary operator from 1 to 2, *OffFarm* is the extent of off-farm work of the primary operator from 1 to 3, *ReduceLabor* is the operator's perceived importance of choosing practices to reduce labor from 1 to 7, and *GenFarm* is the operator's perceived importance of generating enough farm income to avoid off-farm work from 1 to 7. Independent variable categories are shown in Table 4. For this second research objective, the binary logit

Table 4. Logit Model Independent Variables

Variable	Definition	Mean
CowNmbrs	Number of commercial breeding females in herd (1 = 1–25 head, 2 = 26–75, 3 = 76–175, 4 = 176–225, 5 = 226–700, 6 = 701–1,500)	1.873 (0.042)
Income	Percentage of household net income from beef cattle operation (1 = 1–20%, 2 = 21–40, 3 = 41–60, 4 = 61–80, 5 = 81–100)	1.983 (0.051)
Age	Age of primary operator (1 = less than 30 years, 2 = 30–39, 3 = 40–49, 4 = 50–59, 5 = 60 or more)	3.626 (0.045)
Edu	Dummy variable (1 = no college degree, 2 = college graduate)	1.517 (0.500)
OffFarm	Extent of off-farm employment (1 = none, 2 = part time, 3 = full time)	2.024 (0.034)
ReduceLabor	Importance of choosing practices to reduce labor use, 1–7 scale (1 = extremely important, 7 = extremely unimportant)	1.828 (0.048)
GenFarmIncome	Importance of generating enough farm income to avoid off-farm work, 1–7 scale (1 = extremely important, 7 = extremely unimportant)	2.613 (0.072)

Note: Numbers in parentheses are standard errors.

model was estimated for all completed surveys with Proc Logistic in SAS (SAS Institute).

Logit Results and Discussion

Logit model results indicated all but one independent variable affected the likelihood of adopting specific cow-calf management practices. Table 5 includes significant variables for each practice, their coefficients, odds ratio, number of observations, and the likelihood ratio for each model. Only significant variables are listed to conserve space. Coefficients are difficult to interpret directly, as they show the change in the natural log of the cumulative probability for the dependent variable. However, the sign of the coefficient is important. Positive coefficients indicate the likelihood of the dependent variable being 0 (adopting the recommended practice), while negative coefficients indicate the likelihood of the dependent variable being 1 (not adopting the practice). The odds ratio is a measure of effect size and is the ratio of the probability of a dependent variable being 0 to it being 1. All estimated odds ratios were modest in their effect. They indicated a one-unit increase in the independent variable was never more than two times (1.97) as likely to increase the probability of adopting or not adopting a practice. The likelihood ratio is a statistical test for model fit, and all likelihood ratios were significant at the 0.05 level.

Results are presented two ways. First is a discussion by each independent variable to see the effect from each across several management practices. Second is a discussion by similar management practices to determine similarities that may be related to specific management areas of the cow-calf enterprise.

Results by Independent Variable

Herd size, percent dependence on cattle for household income, off-farm employment, demographic factors, and firm objectives were hypothesized to affect adoption of recommended management practices or technology. The only independent variable not significant in any model was the extent of off-farm employment. However, the percent of income dependence from the beef cattle enterprise was significant in several models, suggesting that the percent dependence variable represented a better indicator of adoption than the categorical variable for extent of off-farm employment. A negative correlation was found between income dependence on cattle and extent of off-farm employment, but the relationship was not as high as might have been expected (−0.36). The percent dependence on cattle for household income declined

Table 5. Factors Affecting Adoption, Logit Results

Dependent Variable	Significant Independent Variables	Coefficient	Odds Ratio	Observations	Likelihood Ratio
Implant (0 = nearly always, 1 = rarely)	*Income*	0.410*** (24.71)	1.51	429	25.37***
HaySeason (0 = <60 days,	*CowNmbrs*	0.002** (7.42)	1.00	507	11.85**
1 = >60 days)	*Edu*	0.646* (4.22)	1.91		
SoilTest (0 = annually or	*Age*	0.225** (4.44)	1.25	289	14.06***
biannually, 1 = rarely)	*ReduceLabor*	0.355*** (8.79)	0.70		
ForageTestRaised (0 = nearly	*Income*	0.334*** (11.52)	1.40	351	15.72***
always, 1 = rarely)	*Edu*	0.507** (4.21)	1.66		
ForageTestPurchased	*CowNmbrs*	0.002** (4.57)	1.00	389	12.81**
(0 = nearly always, 1 = rarely)	*GenFarmIncome*	0.167* (4.13)	.85		
GrassStockpile (0 = nearly	*ReduceLabor*	0.36*** (11.23)	0.70	264	11.97***
always, 1 = rarely)					
IntroducedStockpile (0 = nearly	*CowNmbrs*	0.004** (6.48)	1.00	299	20.60***
always, 1 = rarely)	*ReduceLabor*	0.290** (8.99)	0.75		
Vaccinate (0 = vaccinate prior	*Income*	0.258*** (8.08)	1.29	492	10.27***
to market, 1 = do not	*ReduceLabor*	0.180** (5.46)	0.84		
vaccinate)					
CowID (0 = individually ID,	*ReduceLabor*	0.272*** (6.98)	0.76	509	6.15**
1 = do not individually ID)					
CalfID (0 = individually ID,	*ReduceLabor*	0.188** (5.83)	0.83	509	5.58**
1 = do not individually ID)					
LongTermPlan (0 = do,	*Income*	0.323*** (16.83)	1.38	486	33.37***
1 = do not)	*Age*	−0.352*** (18.38)	0.70		
Recordkeeping (0 =	*CowNmbrs*	0.002** (6.44)	1.00	491	16.07***
computerized, 1 = hand entry)	*ReduceLabor*	0.190** (5.40)	0.82		
CashFlow (0 = do,	*Income*	0.407*** (19.09)	1.50	452	50.54***
1 = do not)	*Age*	−0.245*** (7.40)	0.78		
	ReduceLabor	0.356*** (16.77)	0.70		
BreedingSeason (0 = defined	*Income*	0.247*** (9.71)	1.28	461	8.37***
season, 1 = bull with cows	*Age*	−0.22*** (7.20)	0.80		
year-round)					
CowPregExam (0 = nearly	*Income*	0.321*** (9.71)	1.38	381	51.81***
always, 1 = rarely)	*Age*	−0.432*** (17.48)	0.65		
	Edu	0.678*** (8.01)	1.97		
	GenFarmIncome	0.211*** (7.56)	0.81		
HeiferPregExam (0 = nearly	*Income*	0.504*** (29.27)	1.66	402	54.38***
always, 1 = rarely)	*Age*	−0.293*** (10.08)	0.75		
	ReduceLabor	0.272*** (8.11)	0.76		
BullSoundness (0 = nearly	*CowNmbrs*	0.006** (8.10)	1.01	405	55.11***
always, 1 = rarely)	*Income*	0.313** (7.17)	1.37		
	ReduceLabor	0.302*** (11.19)	0.74		

* Significance levels where $\alpha = 0.1$.
** Significance levels where $\alpha = 0.05$.
*** Significance levels where $\alpha = 0.01$.

as off-farm employment increased from none to full time.

Herd size effects. Herd size was significant in five of the 17 management practice models. Larger herd size increased the probability that cow-calf producers would adopt recommended practices related to forage management (limit the length of their hay feeding season,

forage test purchased forages, and stockpile introduced forages) and one aspect of reproductive management (conduct bull soundness examinations). Producers with larger herd sizes also were more likely to use computerized record-keeping systems. As mentioned earlier, for most of the practices chosen, the capital investment required for implementation was small. Therefore, one could argue, as Wozniak did, that larger operators have a greater opportunity cost associated with not adopting technology. Two of the practices likely require more labor (quality testing purchased forages and conducting bull soundness exams), while two probably involve less labor (shortening the forage feeding season and stockpiling forages).

Dependency on cattle. The percentage of household income from cattle was significant in just over half the models (nine of 17). As the percentage dependency on income from the cow-calf enterprise increased, producers were more likely to implant and vaccinate calves and quality test raised forages. Increased percentage dependency also was positively related to several reproduction practices (i.e., having a defined breeding season, pregnancy checking mature cows and heifers, and conducting bull soundness exams). Producers who were more dependent on cattle for their household income also were more likely to have a long-term business plan and to regularly develop cash flow analyses and enterprise budgets. Nearly all these practices require additional labor and management and additional production expenses, though none by itself requires a large capital expenditure. Economists would argue that if a higher percentage of producer income comes from a specific enterprise, more intensive management of that enterprise is justified.

Human capital. Human capital involves both age and education. Education was significant to adoption for three of 17 practices. Two related to forage management (reducing the hay feeding season and quality testing raised forages), while the other related to reproductive management (pregnancy checking mature cows). Increased education may enable producers to recognize the value from these practices to reducing production costs (limiting the hay feeding season and culling open mature cows) and increasing the efficiency of feeding forages (quality testing raised forages).

Age was a significant factor in adopting six practices but was positive for one and negative for the others. The one positive sign suggests that older producers increased the likelihood of soil testing. This result makes sense if one substitutes experience for age as an indicator of human capital. However, increased age reduced the likelihood that cow-calf producers adopted three reproduction practices (institute a designated breeding season and pregnancy check both mature cows and heifers). These may be related to the increased labor requirement for handling cows and bulls and the increased potential risk of injury for older managers. Also, it may indicate that older cow-calf producers did not adopt these practices at an earlier age and are unwilling to change as they age. Producers were less likely also to have a long-term business plan and to regularly develop cash flow analyses and enterprise budgets as age increased. Negative signs on the age variable are consistent with arguments discussed earlier by Fernandez-Cornejo in terms of older producers having a more limited planning horizon.

Reducing labor. Two firm goals were important for some cow-calf practices. The first goal most often pertained to the importance of choosing practices that reduced labor. As the question was stated in the survey, it cannot be determined whether respondents answered in terms of owned or hired labor and whether they included managerial time with physical labor. The importance of this goal is highlighted by the fact that this variable was significant in more models than any other (10 of 17). While significant and positive, results were sometimes counterintuitive. As the importance of this firm goal increased, producers were more likely to conduct soil tests, vaccinate calves, individually identify both cows and calves, pregnancy check replacement heifers, and conduct bull soundness exams. All are recommended practices, but each requires additional labor at the time they are

completed. With this firm goal, producers also were more likely to use computerized record keeping and to prepare cash flow analyses and enterprise budgets. These, too, may require more management time, but, as mentioned later, the expenditure of time (increased labor) for a certain practice may save labor in the future.

Generating farm income. The second firm goal was important for two cow-calf practices: one related to forage management and one to reproduction management. As the importance of generating farm income to avoid off-farm employment increased, producers were more likely to quality test purchased forages and pregnancy check mature cows. Both may require more labor and a modest outlay of added production cost.

Results by Management Practices

The preceding section identified effects on the probability of adopting management practices for each independent variable hypothesized to be important and included in the models. Here we group practices into similar categories and indicate the independent variables that significantly influenced adoption.

Calf and herd management. Practices in this category included implanting steer calves, vaccinating calves, individually identifying calves, and individually identifying cows. The percent dependency on cow-calf income was important for the first two and the firm goal to reduce labor was important for the last three. The first two conceivably can increase revenue from the cow-calf enterprise by marketing heavier, healthier calves and thus are consistent with a higher dependency on cattle for household income. The goal of wanting to reduce labor can be consistent with vaccinating calves because while vaccinations require more labor initially, less labor is needed to pull and treat sick calves over the ownership period. Individually identifying both cows and calves also requires more, not less, labor. Still, individual identification may indirectly facilitate treating sick animals and culling underperforming cows, thus saving time and labor from a longer-term perspective.

Forage management. Practices included in this category were length of the hay feeding season, soil and forage testing, and stockpiling forages. Herd size was important to reducing the length of the feeding season and stockpiling introduced forages. These seem consistent for larger operators, and the latter is consistent with the goal of reducing labor. Larger operators would likely prefer to reduce the time and labor required to hand-feed during the hay feeding season. Stockpiling forages is an effective means of reducing labor cost, cost of hay harvesting, and shortening the hay feeding season. Percent dependence on the cattle enterprise for income, the goals of reducing labor and generating additional income, and both age and education each were significant for at least one other practice in this group.

Reproduction management. Reproduction practices included having a defined breeding season, pregnancy checking mature cows and replacement heifers, and conducting bull soundness examinations. The likelihood of adopting these practices increased in all cases with an increased dependence on the cow-calf enterprise for household income. Larger operators also were more apt to check for breeding soundness of bulls. All recommended practices make economic sense in terms of contributing to cow-calf profitability. For three of the four, younger producers were more likely to adopt the practice than older producers. Limiting the breeding season, conducting pregnancy exams, and bull soundness exams all may require additional facilities and require additional herd handling. Older cattlemen may be unwilling to make the necessary investment or accept the associated risk of physical injury from handling cows and bulls. Again, too, these practices may not have been stressed as much in their earlier years of being cowherd managers.

Financial management. Financial practices included having a long-term business plan, using a computerized record-keeping system, and developing cash flow analyses and enterprise budgets. Either income dependency on the cattle operation or herd size was significant for these three models. Larger operators

or those with a higher dependence on cattle income may better recognize the value of financial management and business planning. For two practices (long-term business plan and using cash flow analyses or enterprise budgets), younger producers were more apt to use these tools than older producers. This, too, is consistent with arguments presented by Fernandez-Cornejo, especially that of older producers having a shorter planning horizon. The goal to reduce labor was important for two practices (computerized record-keeping and developing a cash flow analysis or enterprise budget). These may require more time to develop but require less labor to maintain on an ongoing basis.

Summary and Implications

Primary surveys completed by Oklahoma cow-calf producers generated data used to satisfy two objectives. First was to document cow-calf production practices adopted by Oklahoma producers and to test for differences among two groups of producers (producers with smaller herds and less dependent on cattle for their household income and producers with larger herds and more dependent on cattle for household income). The second objective was to identify factors affecting adoption of selected production practices.

This study was among the few to focus on adoption of management practices among cow-calf producers and across several production practices. Management practices were categorized into several groups (nutrition and management, forages and introduced pastures, quality assurance and animal health, marketing and risk management, reproduction, genetics, and business planning and management). Producers with larger herds and more dependent on income from cattle consistently managed their cowherds more in line with recommendations by university specialists.

Logit models were estimated to determine factors affecting the adoption of 17 recommended production practices that were found to differ between the two producer groups in the first analysis. Most important factors leading to a higher probability of adoption related to the importance placed on selecting practices that reduce labor and producers' increased dependence on cattle for household income. The next most important was operator age, with younger operators more apt to adopt recommended practices than older operators. Operators with larger herds were also more likely to adopt recommended practices in several models.

Overall, results were generally consistent with literature on technology adoption in commercial agriculture in both crop and livestock operations. Operation size, importance of off-farm income, and human capital were significant factors affecting the probability of adopting several cow-calf production practices. These factors have been found important for adopting various cropping technologies and managerial practices (Dorfman; Fernandez-Cornejo; Fernandez-Cornejo, Hendricks, and Mishra) as well as livestock practices excluding beef cattle (Gillespie, Davis, and Rahelizatovo 2004a,b; Rahelizatovo and Gillespie). Factors found important for adopting selected management practices in Oklahoma cow-calf operations (i.e., operation size, importance of off-farm income, human capital, and firm goals) reinforced findings of other studies involving beef cattle operations (Kim, Gillespie, and Paudel; Popp, Faminow, and Parsch). Adoption of practices selected usually did not entail a major capital investment but did require varying degrees of managerial time and/or labor.

Results of adoption studies lead to suggestions for agricultural extension programming. Human capital consistently is an important factor in technology adoption studies and involves both age and education. Many extension programs may be more effective when targeted toward younger, more educated producers. Farm operation characteristics also are important in several technology adoption studies. This suggests the importance of recognizing producers' resource base and operation size, firm goals, enterprise diversity, and attitude toward risk when developing educational programs. Frequently, extension

programs reach a diverse audience, thus being effective with only a small percentage of the total audience.

The increasing dilemma for extension economists involves how to reach more narrowly defined and targeted groups. While a solution is not given here and likely varies by subject matter, technology adoption research clearly suggests that more effort is needed to target programs in order to increase extension programming effectiveness. The same could be said for classroom instructors. Recognizing differences among agricultural operations and the implications for adoption of recommended management practices may affect how several economic concepts are presented in the classroom.

[Received November 2007; Accepted March 2008.]

References

Allison, P.D. *Logistic Regression Using SAS System: Theory and Application*. Cary, NC: SAS Institute Inc., 1999.

Dorfman, J.H. "Modeling Multiple Adoption Decisions in a Joint Framework." *American Journal of Agricultural Economics* 78,3(August 1996):547–57.

Dunn, B.H. "Characterization and Analysis of the Beef Cow-Calf Enterprise of the Northern Great Plains Using Standardized Performance Analysis." Ph.D. dissertation, South Dakota State University, 2000.

Fernandez-Cornejo, J. *Off-Farm Income, Technology Adoption, and Farm Economic Performance*. Washington DC: U.S. Department of Agriculture, Economic Research Service, ERR-36, February 2007.

Fernandez-Cornejo, J., C. Hendricks, and A. Mishra. "Technology Adoption and Off-Farm Household Income: The Case of Herbicide-Tolerant Soybeans." *Journal of Agricultural and Applied Economics* 37,3(December 2005):549–63.

Gillespie, J.M., C.G. Davis, and N.C. Rahelizatovo. "An Evaluation of U.S. Hog Producer Preferences Toward Autonomy." *Journal of Agricultural and Applied Economics* 36,3(April 2004a):575–90.

———. "Factors Influencing the Adoption of Breeding Technologies in U.S. Hog Production." *Journal of Agricultural and Applied Economics* 36,1(April 2004b):35–47.

Kim, S.A., J.M. Gillespie, and K.P. Paudel. "The Effect of Socioeconomic Factors on the Adoption of Best Management Practices in Beef Cattle Production." *Journal of Soil and Water Conservation* 60,3(May/June 2005):111–20.

Lalman, D., and D. Doye. *Beef Cattle Manual*, 5th ed. Oklahoma State University, Oklahoma Cooperative Extension Service, 2005.

Langemeier, M.R., J.M. McGrann, and J.L. Parker. "Beef Cattle Handbook: Economies of Size in Cow-Calf Production." Texas A&M University, Department of Agricultural Economics, BCH-8100, 1996.

Miller, A.J., D.B. Faulkner, R.K. Knipe, D.R. Strohbehn, D.F. Parrett, and L.L. Berger. "Critical Control Points for Profitability in the Cow-Calf Enterprise." *The Professional Animal Scientist* 17(2001):295–302.

Popp, M.P., M.D. Faminow, and L.D. Parsch. "Factors Affecting the Adoption of Value-Added Production on Cow Calf Farms." *Journal of Agricultural and Applied Economics* 31,1(April 1999):97–108.

Rahelizatovo, N.C., and J.M. Gillespie. "The Adoption of Best-Management Practices by Louisiana Dairy Producers." *Journal of Agricultural and Applied Economics* 36,1(April 2004):229–40.

Ramsey, R., D. Doye, C. Ward, J. McGrann, L. Falconer, and S. Bevers. "Factors Affecting Beef Cow-Herd Costs, Production, and Profits." *Journal of Agricultural and Applied Economics* 37,1(April 2005):91–99.

SAS Institute. SAS™ system under Microsoft Windows. Release 9.1. Cary, NC: SAS Institute Inc., 2002–2003.

Short, S. *Characteristics and Production Costs of U.S. Cow-Calf Operations*. U.S. Department of Agriculture, Statistical Bulletin 974-3, November 2001.

USDA/NASS. *Census of Agriculture: Geographic Area Series*. Washington DC: U.S. Department of Agriculture, National Agricultural Statistics Service, Vol. 1, Part 51, 2002.

USDA/APHIS. *Beef '97, Part 1: Reference of 1997 Beef Cow-Calf Management Practices*. Washington DC: U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Veterinary Services, 1997.

Vestal, M.K. "Production Practices and Management Intensity of Oklahoma Cow-Calf Producers Across Income and Herd Size." M.S. thesis, Oklahoma State University, July 2007.

Wozniak, G.D. "Joint Information Acquisition and New Technology Adoption: Late Versus Early Adoption." *Review of Economics and Statistics* 75,3(1993):438–45.