Journal of Agricultural and Applied Economics, 42,1(February 2010):15–30

Factors Affecting Adoption of Recommended Management Practices in Stocker Cattle Production

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Binary logit regression models were used to estimate factors affecting adoption of recommended management practices. Variables analyzed include aspects of farm structure, human capital, farm objectives, and production system employed by the producer. Results reveal that operation size and dependency upon income from the stocker operation, in particular, influence the adoption of recommended practices. Older producers and those pursuing a year-round production strategy were found to lag in adoption.

Key Words: beef production, logit, management practices, stocker cattle

JEL Classifications: Q12, Q16

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Three phases typically comprise U.S. beef production: cow-calf, growing, and finishing. Most calves go through a postweaning growing program, although specific programs vary in structure, type, and nomenclature. Weaned calves intended for sale as commercial feeder cattle, but not yet placed in the feedlot, are commonly referred to as stocker cattle. Stocker calves, typically weighing from 300 to 800 pounds, represent an important segment of the beef production and marketing chain. Stocker cattle inventory in a specific geographic area at a point in time is not easily captured in U.S. Department of Agriculture's (USDA) data collection system. However, the National Agricultural Statistic Service (NASS) national cattle inventory reports reveal that 1.75 million stocker calves were grazing small grain pastures in Kansas, Oklahoma, and Texas as of January 1, 2008 (USDA, NASS, 2008). Stocker cattle represent an economically viable enterprise characterized by inexpensive weight gain relative to cow-calf and finishing phases of production (Peel, 2003). A cow-calf producer may retain ownership of weaned calves for growing as a preliminary phase before cattle feeding. Alternatively, beef cattle producers may

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The views expressed here are those of the authors, and may not be attributed to the Economic Research Service or the U.S. Department of Agriculture.

choose to engage in stocker cattle production as an independent commercial enterprise.

In the stocker phase, emphasis is placed on animal growth versus fattening and on the use of forage/grazing-based systems versus concentrate feeds. Some stockers are grazed throughout the summer (season-long), while others may be double-stocked and removed from summer pasture in midsummer (early intensive strategy). Winter production systems typically employ either annual cool season forage, such as small grains pasture, or perennial cool season forages. Stockers may also be completely confined and fed harvested forages. Mineral, protein, and/or energy supplementation is generally practiced, depending on forage conditions (Peel, 2003).

Core components of stocker production include nutrition, pasture management, quality assurance and animal health, marketing and risk management, genetics, and business management. Each management area offers opportunities to add value to the product and/or reduce costs of production. Numerous technologies and management practices are available and often recommended by extension educators to improve biological and economic efficiency of stocker operations. Examples include anabolic implanting, setting proper stocking rates, correctly administering intramuscular (IM) injections, marketing cattle in uniform lots, using risk management tools, and drafting a long-term business plan (Avent, Ward, and Lalman, 2004; Dexter et al., 1994; Doye, 2005; Hart et al., 1988; Reuter, Highfill, and Lalman, 2005; Schmitz, Moss, and Schmitz, 2003; USDA, Animal and Plant Health Inspection Services, 2000).

Previous research has identified the adoption of management practices within the cow-calf and feeder industries (Gillespie, Kim, and Paudel, 2007; Popp, Faminow, and Parsch, 1999; Ward et al., 2008). However, factors affecting adoption of specific management practices within the stocker industry have not yet been empirically identified. This article contributes to the literature by diminishing this information gap. Determining the factors affecting producer adoption of recommended management practices (RMPs)[1] is of interest. Why are recommended production and management practices not implemented in certain cases? Is there a definable category of producers who are not adopting new information and technology to whom educational programs could be targeted? The objective of this research is to identify factors that influence adoption of RMPs in Oklahoma stocker cattle operations. Findings will facilitate directing, or redirecting, research and educational programs by researchers and extension staff to achieve the goal of high adoption levels of RMPs within various production systems.

Stocker Cattle Recommended Management Practices

Research has shown that anabolic implants are one of the most cost-effective technologies available to cattle producers as producers can expect a 10–15% improvement in average daily gain over nonimplanted controls (Reuter, Highfill, and Lalman, 2005). Implants increase the rate of growth measured by average daily gain as well as the metabolic and economic efficiency of growth. Implanting calves provides the capacity to increase weight gains by 8–20% during the grazing season with adjusted stocking rates (Selk, Reuter, and Kuhl, 2006).

Since forage utilization represents a critical cost factor in stocker production, knowing how to set a proper stocking rate is key to stocker profitability. Proper stocking rates and grazing duration ensures that plants will recover from grazing during the growing season, the quality of the available forage will be maintained, and animal performance will be optimized (Hart et al., 1988).

Injection site lesions arise from the administration of intramuscular injections. Blemishes in top sirloin beef occur in approximately 11% of carcasses and result in substantial losses to

[1] Best management practices are often associated with natural and environmental resource management practices. This study analyzes management practices recommended by extension educators and researchers; thus the term recommended management practices (RMPs) is used.

the beef industry (Dexter et al., 1994). Blemishes result in visual defects and require further processing, resulting in a less tender end product and an undesirable consumer eating experience. State and national industry leaders and educators have worked to inform beef producers of ideal injection practices, namely administering intramuscular and subcutaneous injections in the animal's neck region. Injection site blemishes are thought to primarily originate from the cow-calf and stocker levels, or early in the finishing period (USDA, Animal and Plant Health Inspection Services, 2000).

Production and feeding efficiency increase with larger, more uniform lots of cattle and cattle sold in uniform lots often command a market premium (Avent, Ward, and Lalman, 2004). Uniform lots consist of cattle with similar frame, muscling, weight, and breeding. Jones et al. (1992) and Schroeder et al. (1988) found feeder cattle transaction price differentials significantly differ between uniform and mixed cattle lots. Using 2001–2003 data, Ward, Ratcliff, and Lalman (2004) found that average sale price increased $1.91/per hundred weight (cwt) for cattle sold in uniform lots.

Feeder cattle prices are difficult to predict due to a constantly changing demand for slaughter cattle attributed to changing feed prices and shifting demand in both domestic and international markets. Futures and options contracts are risk management strategies available to producers when marketing cattle. Selective hedging strategies in live cattle markets can decrease volatility of returns while increasing profitability (Noussinov and Leuthold, 1999).

The stocker enterprise is a margin business with highly variable input and output prices, primarily reflected in stocker calf purchasing prices and feeder cattle market fluctuations. Business planning for a stocker operation is particularly important, yet often neglected by producers. A business plan defines the operation's goals, identifies limitations, and includes financial plans. Livestock are realistically matched to land resources, appropriate markets are targeted, and financial resources are identified. A business plan can be especially useful for stocker operators since it can serve as an important reference for producers seeking financing. The ultimate goal of business planning is to direct the enterprise through a feasible operational/ financial plan so that a producer's goals and objectives will be fulfilled (Doye, 2005).

Literature Review

Examining the factors affecting technology adoption has long been a focus of agricultural economics research. Griliches (1957) was one of the first economists to analyze adoption and diffusion of technological innovations. He found profitability to be the largest determinant of adoption in the case of hybrid corn. Rogers (1983) examined how various characteristics, either real or perceived, of a certain technology affected its adoption. He included profitability as one component of adoption with relative advantage, compatibility, complexity, trialability, and observability positively influencing adoption.

Farm size has frequently been identified as a positive factor in adoption of agricultural innovations (Banerjee et al., 2008; Diederen et al., 2003; Gillespie, Basarir, and Schupp, 2004; Just and Zilberman, 1983; Popp, Faminow, and Parsch, 1999; Rahelizatovo and Gillespie, 2004; Ward et al., 2008). Popp, Faminow, and Parsch (1999) found farm size was a significant factor for adopting value-added production, but the producer's perceptions of risk and profitability were also important.

Caswell et al. (2001) examined how technology adoption can be driven by unquantifiable factors, finding that the amount of off-farm work undertaken by producers was significantly related to the adoption of technologies that economized on managerial time. Operators of large farms, more dependent upon on-farm revenues and pursuing off-farm work to a lesser extent, were more likely to adopt managerially intensive technologies such as precision agriculture. Daberkow and McBride (2003) also noted a positive relationship between full-time farming and adoption of precision farming technologies.

Technology adoption has also been found to be contingent upon the degree to which a producer's net household income is generated from the operation (Banerjee et al., 2008). Nonadopters of recommended practices tend to be less dependent upon the operation as a generator of household income (Gillespie, Kim, and Paudel, 2007; Vestal, 2005). Gillespie, Kim, and Paudel (2007) found most frequently adopted best management practices (BMPs) were those that resulted in immediate economic benefits; nonapplicability and unfamiliarity were the most commonly cited reasons for lack of BMP adoption.

Specialization has been found to affect technology adoption and the likelihood of a farmer being a top performer in the dairy industry (El-Osta and Morehart, 2000). However, diversification in both beef and dairy production has also been shown to influence technology adoption (Gillespie, Basarir, and Schupp, 2004; Gillespie, Kim, and Paudel, 2007).

Human capital characteristics, such as age, education, and experience, represent other frequently identified factors influencing technology adoption (Banerjee et al., 2008; Caswell et al., 2001; Daberkow and McBride, 2003; Diederen et al., 2003; Gillespie, Basarir, and Schupp, 2004; Gillespie, Kim, and Paudel, 2007; Rahelizatovo and Gillespie, 2004; Traoré, Landry, and Amara, 1998; Vestal, 2005). Education, in particular, was often demonstrated to have a strong positive effect on the adoption of information-intensive technologies.

Age had a negative effect on adoption of precision farming technologies in a study by Daberkow and McBride (2003). However, Banerjee et al. (2008) found adoption of other precision farming technologies had a larger impact on adoption probabilities than age and education variables. Paudel et al. (2008) found visits between producers and the U.S. Department of Agriculture Natural Resource Conservation Service increased BMP adoption probabilities in Louisiana dairy producers. In addition to operation size and income dependency, Ward et al. (2008) found age, education, and farm objectives positively impacted adoption.

Fernandez-Cornejo (2007) and Caswell et al. (2001) note the entire farm production system must be considered since profitability of various technologies can be influenced between varying production locations. Heterogeneity of the resource base has also been shown to influence technology adoption and profitability (Green et al., 1996; Thrikawala et al., 1999).

Studies thus far have not investigated the implementation of specific management practices in the stocker industry. Furthermore, and of notable importance, RMPs have not been evaluated in specific stocker production systems. This is important because of the diversity in production methods, seasons, and forage bases plus the variety of tools for managing risks within the stocker industry.

Theoretical Framework

Adoption of specific technologies in stocker cattle operations is an individual producer's decision. A producer's utility from adopting a technology may be modeled as a linear function of the producer's characteristics and the attributes of the technology. The probability that a producer will choose to adopt a particular technology alternative is given by the probability that the utility of the alternative is greater than the utility that the producer would gain from any other given alternative. With the decision to adopt or to not adopt, the producer is choosing the alternative that maximizes utility (Kennedy, 1998).

Following Judge et al. (1985), a random utility model is used to depict a producer's decision to adopt a technology. When the i^{th} producer has j technology choices, the utility of adopting technology j is

$$(1)\quad U_{ij} = x'_{ij}\beta_i + \varepsilon_{ij} \quad \text{where } i = 1, \ldots, I, \text{and } j = 1, \ldots, J,$$

and where $\beta_i = \overline{\beta} + \nu i$ is a vector of preference parameters specific to the i^{th} producer, $\overline{\beta}$ is the mean preference parameter, and ν_i is a vector of random elements that represent the i^{th} producer's deviation from the mean. Since ν_i is unobservable, the resulting model is

$$(2)\quad U_{ij} = x'_{ij}\overline{\beta} + (x'_{ij}\nu_i + \varepsilon_{ij}).$$

The random parameters β_i and random errors ε_{ij} are assumed to be multivariate normal and independent of one another with Weibull distribution. With the i^{th} producer's adoption of technology j, the utility of the technology, U_{ij}, is maximized. The probability that producer i adopts technology j is

$$\begin{aligned} P_i(j) &= \Pr[U_{ij} > U_{ik}] \\ &= \Pr[x'_{ij}\beta_i + (x'_{ij}\nu_i + \varepsilon_{ij})] \geq [x'_{ik}\beta_i + (x'_{ik}\nu_i + \varepsilon_{ik})] \\ &= \Pr[(x'_{ik}\nu_i + \varepsilon_{ik}) - (x'_{ij}\nu_i + \varepsilon_{ij}) \leq (x'_{ij}\beta_i - x'_{ik}\beta_i)] \end{aligned} \tag{3}$$

for all other $k \neq j$, $k \in R_i$, where R_i is the alternative set for producer i [$R_i = \{j, k\} = \{$Adopt, Do not adopt$\}$].

As shown by Greene (1990), the i^{th} producer's adoption of technology j is given by

$$P_i(j) = e^{x'_{ij}\beta_i} \Big/ \sum_{k \in R_i} e^{x'_{ik}\beta_i} \tag{4}$$

Empirical Applications and Data

The decision to adopt each of the designated management practices is estimated using the binary logit model. Binomial logistic and cumulative normal (probit) models are similar in the midrange sections of the respective distributions of error terms. Logit models tend to have heavier tails than probit distributions (Amemiya, 1981). Given that all of the explanatory variables used in the regression are dummy variables bounded by 0 and 1, data are yielded that more readily represents an underlying equal distribution (large tails) and the binary logit model is found to be most appropriate. RMP adoption is modeled with the logit equation as follows:

$$\begin{aligned} P_i(j) &= F(Z_i) = e^{zi}/(1 + e^{zi}) \\ &= 1/(1 + e^{-zi}), \text{ where } Z_i = \sum_{j=1}^{k} X'_{ij}\beta_j \end{aligned} \tag{5}$$

where P_i is the probability that the i^{th} producer adopts the management practice and is regressed against the explanatory variables (X_i). X_i is the i^{th} row of the $n \times k$ matrix of explanatory variables, β_j is the $k \times 1$ vector of parameter coefficients, n is the number of observations, and k is the number of coefficients. The coefficient measures a one unit change in the explanatory variable based on the logarithm of the probability ratio, or $\text{Ln}[P_i/1 - P_i)]$, of the producer choosing to adopt the management practice ($j = 1$), and measures the likelihood of adoption (Cox, 1958). The marginal change in probability of the i^{th} producer adopting a certain management practice results from a change in the k^{th} explanatory variable and following Greene (2002) is computed as

$$\Delta_{ik} = P_{ik}(X_k = 1) - P_{ik}(X_k = 0). \tag{6}$$

Independent variables used to measure the likelihood of management practice adoption were socioeconomic and structural characteristics of the stocker producer and stocker operation (Table 1). The explanatory variables included operation size (MEDIUM and LARGE), dependency upon operation income (DEPINCOME), producer age (AGE2), education (EDU2, EDU3, and EDU4), extent of off-farm work (PART and FULL), and value placed on operation objectives by producers such as generating income to reduce off-farm work (INCOMELOW and INCOMEHIGH) and choosing labor reducing management practices (LABORLOW and LABORHIGH). Production system type was incorporated through variables that categorize grazing time periods (WINTERSP and YRROUND) and forage bases (WSGRASSES and CSGRASSES). Independent variables were identified with dummy variables (either 0 or 1). Based on the literature review, most variables were hypothesized to have positive signs on their estimated coefficients. However, assigning low importance to generating income to reduce off-farm work or to choosing management practices to reduce labor was hypothesized to have negative signs as was increasing producer age. Detailed definitions of the independent variables are provided in Table 1.

The empirical model used for the analysis was:

$$\begin{aligned} \text{Recommended Management Practice} &= \beta_0 \\ &+ \beta_1\text{MEDIUM} + \beta_2\text{LARGE} + \beta_3\text{DEPINCOME} \\ &+ \beta_4\text{AGE2} + \beta_5\text{EDU2} + \beta_6\text{EDU3} + \beta_7\text{EDU4} \\ &+ \beta_8\text{PART} + \beta_9\text{FULL} + \beta_{10}\text{INCOMELOW} \\ &+ \beta_{11}\text{INCOMEHIGH} + \beta_{12}\text{LABORLOW} \\ &+ \beta_{13}\text{LABORHIGH} + \beta_{14}\text{WINTERSP} \\ &+ \beta_{15}\text{YRROUND} + \beta_{16}\text{WSGRASSES} \\ &+ \beta_{17}\text{CSGRASSES} + \varepsilon_t \end{aligned} \tag{7}$$

Two categories were created for the dependent variables, or RMPs, to represent the dichotomous choice in qualitative response.

Table 1. Summary of Variables Used in Logit Models[a,b]

Category/Variable	Description	Mean
Dependent Variable		
	Production	
Implanting	Steers are implanted. (1 = nearly always, 0 = rarely, if ever)	0.362
	Forages	
Stocking Rate	The producer has knowledge of setting and monitoring a proper stocking rate. (1 = yes, 0 = no, or not sure)	0.483
	Quality Assurance and Animal Health	
IM Injections	Intramuscular injections are administered in the neck. (1 = nearly always, 0 = rarely, if ever)	0.111
	Marketing and Risk Management	
Marketing Type	Lot type used for marketing cattle. (1 = uniform lots, 0 = mixed lots)	0.257
Risk Management Tools	Feeder cattle futures, options, and/or cash contracts are used to lock in expected fixed prices. (1 = nearly always, 0 = rarely, if ever)	0.105
	Business Planning	
Business Plan	The producer has a long-term business plan. (1 = yes, 0 = no)	0.497
Explanatory Variable[c]		
	Farm Structure	
SMALL	Number of stocker/feeder cattle managed each year. (1 = less than 100 head, 0 = otherwise)	0.359
MEDIUM	Number of stocker/feeder cattle managed each year. (1 = 100–500 head, 0 = otherwise)	0.301
LARGE	Number of stocker/feeder cattle managed each year. (1 = greater than 500 head, 0 = otherwise)	0.280
NONINCOME	Percent of net household income generated from the beef cattle operation. (1 = 1–40%, 0 = otherwise)	0.582
DEPINCOME	Percentage of net household income generated from the beef cattle operation. (1 = 41–100%, 0 = otherwise)	0.349
	Human Capital	
AGE1	Producer age. (1 = less than 50 years, 0 = otherwise)	0.449
AGE2	Producer age. (1 = greater than or equal to 50 years, 0 = otherwise)	0.502
EDU1	Highest level of education attained by the producer. (1 = high school, 0 = otherwise)	0.174
EDU2	Highest level of education attained by the producer. (1 = some college, 0 = otherwise)	0.280
EDU3	Highest level of education attained by the producer. (1 = college graduate, 0 = otherwise)	0.322
EDU4	Highest level of education attained by the producer. (1 = some post graduate work or graduate/professional degree, 0 = otherwise)	0.185

Table 1. Continued.

Category/Variable	Description	Mean
NOOFF	Extent of producer off-farm work. (1 = no off-farm work, 0 = otherwise)	0.465
PART	Extent of producer off-farm work. (1 = part-time, 0 = otherwise)	0.179
FULL	Extent of producer off-farm work. (1 = full-time, 0 = otherwise)	0.317
	Farm Objectives	
INCOMELOW	Importance of generating enough farm income so that off-farm work is not necessary. (1 = very unimportant, 0 = otherwise)	0.089
INCOMEMED	Importance of generating enough farm income so that off-farm work is not necessary. (1 = medium importance, 0 = otherwise)	0.211
INCOMEHIGH	Importance of generating enough farm income so that off-farm work is not necessary. (1 = very important, 0 = otherwise)	0.661
LABORLOW	Importance of choosing practices to reduce labor use. (1 = very unimportant, 0 = otherwise)	0.063
LABORMED	Importance of choosing practices to reduce labor use. (1 = medium importance, 0 = otherwise)	0.195
LABORHIGH	Importance of choosing practices to reduce labor use. (1 = very important, 0 = otherwise)	0.719
	Production System	
WINTERSP	Primary time period cattle are grazed. (1 = winter, spring, or both, 0 = otherwise)	0.587
SUMMER	Primary time period cattle are grazed. (1 = summer, 0 = otherwise)	0.412
YRROUND	Primary time period cattle are grazed. (1 = year round, 0 = otherwise)	0.407
SMGRAINS	Primary forage base used for grazing cattle. (1 = small grains pasture, 0 = otherwise)	0.566
WSGRASSES	Primary forage base used for grazing cattle. (1 = warm season grasses: Bermuda, Old World bluestem, weeping lovegrass, or native range, 0 = otherwise)	0.857
CSGRASSES	Primary forage base used for grazing cattle. (1 = cool season grasses: fescue or smooth brome, 0 = otherwise)	0.624

[a] Data were collected using the "Beef Cattle Management Practice Assessment" distributed to Oklahoma stocker cattle producers who received an Oklahoma Beef Cattle Manual, March 2004–July 2006.

[b] Total number of observations, $n = 186$.

[c] Variables in bold are omitted from the analysis to avoid perfect collinearity and serve as the reference point.

Dummy variables were created referring to each RMP with 1 = adopt (or nearly always) and 0 = not adopt (or rarely, if ever). Specific management practices were chosen pertaining to each stocker management area including production, forages, quality assurance and animal health, marketing and risk management, and business planning management. RMPs analyzed were implants, maintenance of a proper stocking rate, administration of IM injections, marketing lot type, use of risk management tools, and presence of a long-term business plan for the stocker operation. RMPs, or dependent variables, are further identified and defined in Table 1.

To eliminate potential endogeneity problems in variables such as size of operation, income dependency, and RMP adoption variables, Asteriou and Hall's (2007) two-stage least squares regression was performed. Each right hand side potentially endogenous variable was regressed against other endogenous variables. Fitted values from the first stage were then used as instruments in each of the six RMP logit regressions. To address potential heteroscedasticity, variance equations were estimated and used in the maximum likelihood estimation procedure.

The Oklahoma Beef Cattle Manual (Lalman and Doye, 2005) was distributed through local extension offices, producer meetings, and by e-mail request from an Oklahoma State University website (http://agecon.okstate.edu/cattleman/). Educators who distributed manuals from March 2004 through July 2006 were instructed to ask producers who received a copy to complete a "Beef Cattle Management Practices Assessment." No control mechanism existed to ensure this request was followed and no follow-up with individual producers was possible. Approximately 5,500 manuals were distributed; however, the number of surveys distributed is unknown. One of two surveys was issued: one for beef producers with only stockers and a second for those who also had a cow-calf operation. Producers were asked to document their current practices. For this study, completed surveys from 186 beef producers specializing in stocker production were the focus.

The survey documented current management practices of Oklahoma stocker producers in the areas of production, forage and introduced pasture, quality assurance and animal health, marketing and risk, genetics, and business planning management. The survey asked 54 questions with the majority presented in 1–7 Likert scale format, including those regarding implanting practices, administration site of IM injections, and use of risk management tools in marketing cattle including futures, options, and cash contracts.[2] Other questions asked respondents to report percentages and numerical values. Producers were questioned regarding operational characteristics, importance of specific farm objectives, extent of off-farm work, dependency upon income generated from the stocker operation, aspects of human capital, and other demographic characteristics. Producer questions concerning knowledge in setting proper stocking rates were presented as "yes" or "no" and were self-assessments. The producer was asked to choose between "mixed lots" or "uniform lots" in indicating the way the majority of cattle were typically marketed. Finally, the producer was asked if a long-term business plan was present in the management of the operation and response options were "yes" or "no."

Table 1 identifies the demographic groups analyzed. Questions concerning farm structure and human capital were self-assessed, including the extent of off-farm work pursued by the producer with no off-farm work, part-time off-farm work, and full-time off-farm work as choices. Operation size and income dependency data breaks were based on a consensus from state specialists involved in the project. Questions concerning operational objectives and production systems were converted from Likert scale format. Responses of 1 or 2 classified an objective as "very important," with 3, 4, or 5 indicating "medium importance," and 6 or 7 identifying the objective as being "very unimportant." Similarly, producers are grouped into time of grazing and primary forage base groups based on Likert scale responses. A response of 1 or 2 (nearly always regarding period of time cattle are grazed or forages used for grazing) categorized the producer into the designated time of grazing and forage base groups identified in Table 1.

Sample means indicate that 36.2% of producers nearly always implant cattle. Nearly half of producers have knowledge of setting proper stocking rates and have a long-term business plan. Only 11.1% of producers administer IM injections in the animal's neck region and 25.7% of producers market cattle in uniform lots. Only 10.5% of producers use either futures, options, and/or cash contracts as risk management tools at least some of the time in marketing cattle.

[2] An example of a question presented in Likert scale where the respondent was instructed to circle the best answer is as follows, with 1 being "nearly always" and 7 being "rarely, if ever.": Do you implant steers? 1 2 3 4 5 6 7

Results

Estimated coefficients from the logit analysis and percentage changes in probability for each RMP are presented in Table 2. Standard errors of the changes in probability for RMP adoption were estimated using the Delta method (Greene, 2002). Statistics suggest a strong relationship between the decision to adopt the RMP and the explanatory variables. McFadden R-squares for implanting, marketing lot type, risk management tools, and long-term business plan were 0.19, 0.38, 0.36, and 0.24, respectively. Hensher and Johnson (1981) consider values between the range of 0.20 and 0.40 to be a good fit. McFadden R-squares for stocking rate and IM injections were only slightly above this range at 0.44 and 0.41. Mean values of the explanatory variables, or the proportion of producers taking on the particular qualitative attribute, were used in the logit equation to calculate the changes in probability.

Implanting

Operation size and higher education positively impacted the probability that cattle are implanted (Table 2). Large operations were 10.4% more likely to implant cattle. As noted earlier, implanting calves increases growth rates and the economic efficiency of growth; furthermore, past research confirms that profitability is a factor driving technology adoption by larger operators. Additional cattle weight gain from implanting likely equates to greater absolute profits. In addition, the probability of implanting increased by

Table 2a. Results of Logit Models for Selected Recommended Practices

	Implanting				Stocking Rate			
Category/ Variables	Coefficient	Standard Error	Change in Probability	Standard Error	Coefficient	Standard Error	Change in Probability	Standard Error
Intercept	−3.67	2.2009	—	—	4.8605	1.8724	—	—
Farm Structure								
MEDIUM	1.1371	1.0851	8.43%	0.1182	0.0901**	0.0401	4.71%	0.0184
LARGE	1.1031**	1.0422	10.36%	0.1623	0.0930**	0.0377	4.85%	0.0187
DEPINCOME	−0.7626	0.5813	−5.44%	0.4652	1.9394***	0.7336	10.24%	0.1484
Human Capital								
AGE2	−0.3305	0.1529	−2.36%	0.0618	−0.6459	0.4809	−13.72%	0.2047
EDU2	−0.1756	1.1799	−1.25%	0.0848	−0.5625	0.4954	−2.36%	0.3119
EDU3	2.9933**	1.3778	7.38%	0.1106	−0.8646	0.5106	−0.45%	0.2651
EDU4	5.4764**	2.2197	9.12%	0.1673	0.1116	0.5157	5.83%	0.2657
PART	−0.6414	1.6691	−0.45%	0.1193	2.6212**	1.0493	13.68%	0.3244
FULL	−0.9711	1.3757	−6.93%	0.1017	2.8910**	1.1542	15.09%	0.2437
Farm Objectives								
INCOMELOW	−13.4892	1.6819	−16.78%	0.3494	5.1734	2.9603	2.88%	1.1955
INCOMEHIGH	1.8013	1.6158	12.86%	0.1182	−2.8539	1.1609	−14.89%	0.4278
LABORLOW	−2.7869	2.3736	−19.91%	0.1662	1.7595	0.9287	19.32%	0.2438
LABORHIGH	0.1091	1.1763	0.77%	0.0844	0.3702	0.4223	19.18%	0.2492
Production System								
WINTERSP	0.9938	1.0478	7.10%	0.0844	−0.5213	0.4027	−2.72%	0.2051
YRROUND	0.0059	1.0621	0.04%	0.0758	−1.1801**	0.5632	−16.60%	0.1298
WSGRASSES	−2.4121*	1.3371	−17.32%	0.1033	−0.8756***	0.5501	−25.71%	0.1029
CSGRASSES	−2.2426	1.6034	−16.02%	0.1126	0.18821	0.4749	9.82%	0.2546

Note: McFadden R^2 for implanting = 0.19 and stocking rate = 0.44.
***, **, and * indicates significance at the 1%, 5%, and 10% levels, respectively. Total number of observations, n = 186.

Table 2b. Results of Logit Models for Selected Recommended Practices

	Intramuscular Injections				Marketing Lot Type			
Category/ Variables	Coefficient	Standard Error	Change in Probability	Standard Error	Coefficient	Standard Error	Change in Probability	Standard Error
Intercept	4.8865	1.8052	—	—	4.6921	2.1235	—	—
Farm Structure								
MEDIUM	1.1123**	0.8867	4.89%	0.0071	0.1305**	0.0564	1.65%	0.2044
LARGE	0.0747	0.8561	1.23%	0.0047	0.0535**	0.0388	0.68%	0.0062
DEPINCOME	2.1302	0.7253	3.22%	0.1062	2.2384***	0.7949	12.82%	0.0772
Human Capital								
AGE2	−0.5211*	0.4589	−4.71%	0.0736	−2.7417**	1.1795	−14.43%	0.1471
EDU2	−0.3213	0.9315	−2.95%	0.1405	0.3653	1.0581	0.46%	0.1367
EDU3	−1.1078	0.8393	−5.06%	0.1396	0.3108	0.9808	0.39%	0.1258
EDU4	−0.3421	0.6671	−0.07%	0.0944	1.8381	1.2541	2.31%	0.1537
PART	2.1042	1.2478	1.89%	0.1539	5.912	2.4167	5.43%	0.2078
FULL	1.912	1.1355	1.57%	0.1381	4.1432	1.4307	3.28%	0.1804
Farm Objectives								
INCOMELOW	3.6738	1.6801	0.91%	1.3041	−2.163	1.0552	−2.69%	0.6241
INCOMEHIGH	2.7223	0.9131	4.87%	0.1642	0.7746	1.7131	0.95%	0.1648
LABORLOW	2.8884	0.9531	3.98%	0.1771	−0.1955	1.1561	−2.34%	0.2136
LABORHIGH	2.0093	0.6756	2.48%	0.0945	4.3345	2.3904	1.22%	0.1475
Production System								
WINTERSP	0.64131	0.4671	11.70%	0.8662	1.8905**	0.9401	19.65%	0.1023
YRROUND	−0.1009	0.5012	−3.62%	0.8903	−2.9851**	1.2286	−13.76%	0.1014
WSGRASSES	−1.8312**	0.8021	−22.80%	0.1007	1.7871***	0.8521	22.57%	0.1063
CSGRASSES	−1.0419	0.7165	−19.75%	0.1258	−0.2727	1.0033	−3.44%	0.1253

Note: McFadden R^2 for intramuscular injections = 0.41 and marketing lot type = 0.38.
***, **, and * indicates significance at the 1%, 5%, and 10% levels, respectively. Total number of observations, n = 186.

7.3% and 9.1% for producers indicating some postgraduate work and a graduate or professional degree, respectively.

Warm season grass production systems had statistically significant negative impacts on the probability that cattle are implanted. Producers who primarily graze cattle on warm season grasses were 17.3% less likely to implant cattle. Due to heat stress and other weather risks, weight gains in summer stockers are often lower, providing less profit potential for implant programs. Using the same dataset, Johnson (2008) determined that a greater number of small stocker operators were pursuing production systems based on warm and cool season grasses, a factor which might diminish the likelihood that warm season stocker producers implant cattle. Additionally, a small grain based production system would typically be more management intensive than a summer pasture based system.

Stocking Rate

Operation size, income dependency, off-farm work, and year-round and warm season grass production systems significantly affected the likelihood that a producer knew how to set stocking rates (Table 2). Producers dependent upon income generated from the stocker cattle operation were 10.2% more likely to know how to set accurate stocking rates. These results were consistent with earlier findings that producers were more likely to adopt technologies with immediate economic benefits, such as grazing management practices, and that producers dependent upon stocker income were

Table 2c. Results of Logit Models for Selected Recommended Practices

Category/ Variables	Risk Management Tools				Business Plan			
	Coefficient	Standard Error	Change in Probability	Standard Error	Coefficient	Standard Error	Change in Probability	Standard Error
Intercept	3.9986	1.4121	—	—	3.6428	1.4044	—	—
Farm Structure								
MEDIUM	0.11525***	0.0311	1.60%	0.0051	0.1107	0.0403	2.65%	0.0071
LARGE	0.0459**	0.5193	0.64%	0.0049	0.0824	0.0309	1.97%	0.0057
DEPINCOME	1.8463***	0.0944	7.65%	0.0655	1.5921***	0.5071	8.16%	0.0811
Human Capital								
AGE2	−2.6061	0.9541	−6.32%	0.1033	−1.6187***	0.5953	−18.80%	0.1058
EDU2	−0.1042**	0.9395	−1.45%	0.1324	1.0721*	0.6563	5.70%	0.1419
EDU3	−0.2704**	1.0288	−3.04%	0.1295	−0.4961	0.6472	−1.89%	0.1511
EDU4	−1.5645	1.5247	−2.17%	0.1359	0.9183	0.7551	12.01%	0.1729
PART	4.5030***	1.2289	6.25%	0.1841	2.7911	1.0476	16.91%	0.1938
FULL	3.3336	3.0136	4.63%	0.1585	2.9621***	1.0533	17.00%	0.1835
Farm Objectives								
INCOMELOW	2.6329	0.9023	0.07%	0.2848	5.2847	1.4553	1.54%	0.2342
INCOMEHIGH	−1.4735	1.3351	−0.20%	0.1352	−2.0864	0.7806	−1.01%	0.1688
LABORLOW	0.8391	0.9776	0.12%	0.1865	2.3234	0.1817	3.70%	0.2524
LABORHIGH	−0.777	0.6485	−1.07%	0.1352	0.6589	0.5757	1.69%	0.1308
Production System								
WINTERSP	1.5312**	0.6485	12.26%	0.0895	−0.6599	0.4789	−15.82%	0.1069
YRROUND	−2.1156***	0.7552	−21.92%	0.9732	−0.4757	0.4619	−11.39%	0.1068
WSGRASSES	1.5784**	0.7449	11.92%	0.0915	0.0856	0.4682	20.53%	0.1111
CSGRASSES	−0.3487	0.8344	−4.84%	0.1156	0.6766	0.6864	16.21%	0.1572

Note: McFadden R^2 for risk management tools = 0.36 and business plan = 0.24
***, **, and * indicates significance at the 1%, 5%, and 10% levels, respectively. Total number of observations, n = 186.

implementing management practices which reduce costs and/or increase profitability. Medium and large operations were also 4.7% and 4.8%, respectively, more likely to know how to set proper stocking rates. Due to economies of size, the economic benefits realized from increased plant and animal efficiency will be greater for larger operations. Full and part-time off-farm work increased the probability by 15.1% and 13.7%, respectively, that the producer knew how to set accurate stocking rates. Warm season production, however, negatively impacted this likelihood by 25.7%. Year-round production also decreased the probability by 16.6%. Producers pursuing the wheat-stocker enterprise face complex decisions when producing both grain and beef gains from forage. Thus, producers grazing cattle on warm season grasses do not perceive setting accurate stocking rates as critically as do producers with dual purpose wheat or, because of differences in weather risks and management intensity, these producers stock at lower rates rather than risk having insufficient pasture.

Intramuscular Injections

Medium size operations were 4.9% more likely to correctly administer IM injections in the neck region (Table 2). Interestingly, Hoag, Ascough, and Frasier (1999) identified midsized producers as most likely to adopt specific management practices, resulting in an inverted U-shaped adoption pattern, as is the case with IM injections here. Producer age and production systems based on warm season grasses diminished the probability that IM injections were administered correctly. Producers over age 50 were 4.7% less likely to inject the animal in the neck region. Despite perhaps greater years of experience, older producers were often reluctant to adopt new technologies and practices (Gillespie, Basarir, and Schupp, 2004). Producers grazing cattle on warm season grasses were 22.8% less likely to correctly administer IM injections, demonstrating a relative decrease in management intensity for summer based grazing systems as compared with winter/spring stocker producers. Since IM injection sites on an animal are not realized until slaughter, direct incentives for the stocker producer to adopt the RMP are lacking, which explains large and income dependent producers' failure to adopt this practice.

Marketing Lot Type

Operation size, income dependency, producer age, and production systems based on grazing winter or spring small grains pasture and warm season forage, as well as year-round production affected marketing lot types (Table 2). Producer age and year-round grazing were the only statistically significant factors that negatively impacted the probability that cattle were marketed in uniform lots. Producers above age 50 were 14.4% less likely to market cattle in uniform lots. Such findings corroborate the results of Gillespie, Basarir, and Schupp (2004) where younger producers utilized a greater variety of alternative marketing arrangements. Medium sized operations were 1.65% more likely to market cattle in uniform lot types. The probability was increased by 12.8% for producers dependent upon income generated from the stocker operation. Considering the additional and immediate economic gains that can be realized from marketing cattle in uniform lots, such results were not surprising.

Production systems based both on small grains pasture and warm season grasses, the two most common seasonal approaches to stocker production, positively impacted the adoption of this marketing management practice. Producers engaged in production during the winter or spring and producers grazing cattle on warm season grasses were 9.8% and 20.3%, respectively, more likely to pool cattle together into uniform lots at time of sale. Seasonal stocker producers had greater total herd numbers at specific points of the year and generally marketed cattle during a designated time frame; thus, seasonal producers had an increased herd stock to assemble uniform lots and appear to do so in a concerted effort when marketing cattle.

Risk Management Tools

Operation size, income dependency, part-time off-farm work, and seasonal production systems positively affected the use of risk management tools such as futures, options, and/or cash contracts (Table 2). Medium and large operations were 1.6% and 0.6% more likely to use risk management tools, respectively. Income dependent producers were 7.6% more likely to use risk management tools. Interestingly, higher education levels significantly reduced the probability that a producer used futures, options, and/or cash contracts in managing risk. Producers with some college were 1.4% less likely to use risk management tools. The likelihood also decreased by 3.0% for college graduates. The field of study or degree attained by the producer was not captured in the data set; thus, education levels may not specifically relate to areas of agricultural study. Additional variables capturing agricultural related education and/or participation in extension educational programs would have perhaps explained such counter-intuitive results.

Part-time off-farm work positively influenced the use of risk management tools by 6.2%. Harwood et al. (1999) found the riskiness of farm income positively related to working off the farm; thus, producers working off the farm may be more risk averse, and more attentive to risk management tools. Producers grazing cattle seasonally were significantly more likely to use risk management tools, 12.2% for producers grazing cattle during winter and spring and 11.9% for producers grazing cattle on warm season grasses. This likelihood decreased by 21.9% for producers grazing cattle year-round. Year-round producers may market cattle more frequently, but with smaller numbers have less ability and/or incentive to manage risk with contracts.

Business Plan

Numerous statistically significant factors were identified regarding producers' probability of having a long-term business plan for their operation (Table 2). Income dependency, some college education, and full-time off-farm work positively impacted this probability, while producer age had a negative impact. Producers dependent upon income generated from the stocker operation were 8.2% more likely to have a long-term business plan. Vestal (2005) also found income dependent cow-calf producers to be more likely to have a business plan. Such results were not surprising as producers who derive a greater percentage of net income from their cattle operation have a greater incentive to maximize profit. Furthermore, the business plan aids in efficiently allocating financial resources to achieve operational objectives. Producers who indicated they had at least some college education were 5.7% more likely to have a business plan. The probability increased by 17.0% for producers engaged in full-time off-farm work. This is similar to Caswell et al.'s (2001) findings where a strong relationship between off-farm work and the adoption of technologies that economized on managerial time was found. Producers over age 50 were 18.8% less likely to have a long-term business plan, demonstrating that older producers may be less concerned with expanding and improving the operation. The same trend was also noted by Vestal (2005) regarding long-term business planning and cow-calf producers.[3]

[3] Joint hypothesis tests for operation size, income dependency, age, education, and off-farm work were conducted for each RMP. Test results are reported at the 5% level. For implanting, operation size and education were statistically significant with F-values of 3.62 and 4.06, respectively. For stocking rate, income dependency was statistically significant with F-value of 3.62. For both intramuscular injections and risk management tools, operation size was the only statistically significant group with F-values of 3.12 and 12.01, respectively. For marketing lot type and business planning, only age was statistically significant with F-values of 5.82 and 4.09, respectively.

Conclusions and Implications

Few studies have analyzed technology and recommended management practice adoption in the stocker cattle industry. We analyzed the probability of adoption of six recommended management practices, specifically, implanting, stocking rates, IM injections site, marketing lot type, use of risk management tools, and long-term business planning. Binomial logit models were used to model adoption behavior using variables relating to farm structure, human capital, producer evaluation of certain farm objectives, and production system.

Results demonstrated a clear disparity between producer groups regarding management practice adoption. Operational characteristics had the most impact upon adoption probabilities. Operation size was significant in five of six management practices modeled and positively affected adoption of each practice analyzed. Income dependency was also statistically significant in four of the six practices analyzed. The propensity for large and income dependent operations, in particular, to adopt RMPs corroborates previous research findings.

Extension educational programs, such as the Oklahoma State University Master Cattleman program, seek to enhance the profitability of beef cattle operations and the quality of life of beef cattle producers through education. Our research results suggest that if large and small, income dependent and nonincome dependent producer groups become increasingly differentiated with growing disparity between rates of adoption, such programs will become increasingly advantageous to the small producer. Results also suggest that when educational resources are limited, efforts could be targeted to groups with the highest return on investment.

Education levels did not always have a positive impact on adoption probabilities, contrary to previous research findings. Interestingly, education levels beyond a high school education negatively influenced the use of futures, options, and/or cash contracts. Future research which differentiates between fields of education related to agriculture as opposed to nonrelated fields and which accounts for extension education might yield informative results. Likewise, knowledge about producer attitudes toward risk would be helpful.

Similar to previous studies, a common finding was the negative impact of producer age on adoption rates. Younger producers have a longer time horizon over which to recoup costs of technology adoption. If age is consistently identified as negatively impacting technology adoption beneficial to society, incentive programs for older producers may prove useful.

Educational programs can encourage technology adoption and high levels of adoption in the stocker sector have the potential for sizable economic impacts in the beef industry. Until this study, technology adoption by stocker producers had not been examined in detail, nor had differing production systems been considered. Results revealed that seasonal stocker producers, primarily producers engaged in the wheat-stocker enterprise, were more likely to adopt recommended practices while year-round and often warm season producers lagged behind in adoption. A better understanding of producer groups and their characteristics should enable extension educators to identify producer groups that would benefit from educational programs. While conferences targeted to wheat-stocker producers are routinely held (at least in Oklahoma), producers using other stocker systems could benefit from similar opportunities.

Limitations of this research should be mentioned. Data generated from the survey instrument does not represent a random sample. Many producers who requested or received the Beef Cattle Management Practice Assessment were interested in becoming part of the Master Cattleman program. Therefore, findings may not be extrapolated to the stocker producer population unconditionally. A larger sample size would facilitate more detailed analysis.

The recent National Stocker Survey conducted by Elanco and Beef Magazine in conjunction with Kansas State University might provide interesting comparisons. Economic impacts resulting from disparity in adoption probabilities between producer groups could also be analyzed, as could cost-benefit analysis for certain practices and for particular groups of producers. Considering the beef industry's importance not only to the Southern Plains states, but also to the United States, an analysis of this scope would have regional and national implications.

[Received September 2008; Accepted September 2009.]

References

Amemiya, T. "Qualitative Response Models: A Survey." *Journal of Economic Literature* 19,1(1981):1483–536.

Asteriou, D., and S.G. Hall. *Applied Econometrics*. New York: Palgrave Macmillan, 2007.

Avent, R.K., C.E. Ward, and D.L. Lalman. "Market Valuation of Preconditioning Feeder Calves." *Journal of Agricultural and Applied Economics* 36,1(2004):173–83.

Banerjee, S., S.W. Martin, R.K. Roberts, S.L. Larkin, J.A. Larson, K.W. Paxton, B.C. English, M.C. Marra, and J.M. Reeves. "A Binary Logit Estimation of Factors Affecting Adoption of GPS Guidance Systems by Cotton Producers." *Journal of Agricultural and Applied Economics* 40,1(2008):345–55.

Caswell, M., K. Fuglie, C. Ingram, S. Jans, and C. Kascak. "Adoption of Agricultural Production Practices: Lessons Learned from the U.S. Department of Agriculture Area Studies Project." Agricultural Economic Report No. 792. Washington, DC: U.S. Department of Agriculture, Economic Research Service, 2001.

Cox, D.R. "The Regression Analysis of Binary Sequences." *Journal of the Royal Statistical Society* 20,2(1958):215–42.

Daberkow, S.G., and W.D. McBride. "Farm and Operator Characteristics Affecting the Awareness and Adoption of Precision Agriculture Technologies in the U.S." *Precision Agriculture* 4,2(2003):163–77.

Dexter, D.R., G.L. Cowman, J.B. Morgan, R.P. Clayton, J.D. Tatum, J.N. Sofos, G.R. Schmidt, R.D. Glock, and G.C. Smith. "Incidence of Injection-Site Blemishes in Beef Top Sirloin Butts." *Journal of Animal Science* 72,4(1994): 824–27.

Diederen, P., H. van Meijl, A. Wolters, and K. Bijak. "Innovation Adoption in Agriculture: Innovators, Early Adopters and Laggards." *Cahiers d'Economie et Sociologie Rurales* 67,2(2003):29–50.

Doye, D. "Ranch Business Planning and Management." *Beef Cattle Manual*. D. Lalman and D. Doye, eds. 5th Ed. Stillwater, OK: Oklahoma Cooperative Extension Service, Oklahoma State University, 2005.

El-Osta, H.S., and M.J. Morehart. "Technology Adoption and Its Impact on Production Performance of Dairy Operations." *Review of Agricultural Economics* 22,2(2000):477–98.

Fernandez-Cornejo, J. "Off-Farm Income, Technology Adoption, and Farm Economic Performance." Agricultural Economic Report No. 36. Washington, DC: U.S. Department of Agriculture, Economic Research Service, 2007.

Gillespie, J., A. Basarir, and A. Schupp. "Beef Producer Choice in Cattle Marketing." *Journal of Agribusiness* 22,2(2004):149–61.

Gillespie, J., S. Kim, and K. Paudel. "Why Don't Producers Adopt Best Management Practices? An Analysis of the Beef Cattle Industry." *Agricultural Economics* 36,1(2007):89–102.

Green, G., D. Sunding, D. Zilberman, and D. Parker. "Explaining Irrigation Technology Choices: A Microparameter Approach." *American Journal of Agricultural Economics* 78,4(1996):1064–72.

Greene, W.H. *Econometric Analysis*. Upper Saddle River, NJ: Macmillan, Inc., 1990.

———. *Econometric Analysis*. Upper Saddle River, NJ: Prentice Hall, 2002.

Griliches, Z. "Hybrid Corn: An Explanation in the Economics of Technological Change." *Econometrica* 25,4(1957):501–22.

Hart, R.H., M.J. Samuel, P.S. Test, and M.A. Smith. "Cattle, Vegetation, and Economic Responses to Grazing Systems and Grazing Pressure." *Journal of Range Management* 41,4(1988):282–86.

Harwood, J., R. Heifner, K. Coble, J. Perry, and A. Somwaru. "Managing Risk in Farming: Concepts, Research, Analysis." Agricultural Economic Report No. 774. Washington, DC: U.S. Department of Agriculture, Economic Research Service, 1999.

Hensher, D.A., and L.W. Johnson. *Applied Discrete Choice Modeling*. London: Croom Helm, 1981.

Hoag, D.L., J.C. Ascough, and W.M. Frasier. "Farm Computer Adoption in the Great Plains." *Journal of Agricultural and Applied Economics* 31,1(1999):57–67.

Johnson, R.J. "Adoption of Recommended Management Practices in Stocker Cattle Production." Master's Thesis. Department of Agricultural Economics, Oklahoma State University, 2008.

Jones, R., T. Schroeder, J. Mintert, and F. Brazle. "The Impacts of Quality on Cash Fed Cattle Prices." *Southern Journal of Agricultural Economics* 24,2(1992):149–62.

Judge, G.G., W.E. Griffiths, R. Carter Hill, H. Lutkepohl, and T.C. Lee. *The Theory and Practice of Econometrics*. New York: John Wiley and Sons, 1985.

Just, R.E., and D. Zilberman. "Stochastic Structure, Farm Size, and Technology Adoption in Developing Agriculture." *Oxford Economic Papers* 35(1983):307–28.

Kennedy, P. *A Guide to Econometrics*. 4th Ed. Cambridge: The MIT Press, 1998.

Lalman, D., and D. Doye. *Beef Cattle Manual*. 5th Ed. Stillwater, OK: Oklahoma Cooperative Extension Service, Oklahoma State University, 2005.

Noussinov, M.A., and R.M. Leuthold. "Optimal Hedging Strategies for the U.S. Cattle Feeder." *Journal of Agribusiness* 17,1(1999):1–19.

Paudel, K., W. Gauthier, J. Westra, and L. Hall. "Factors Influencing and Steps Leading to the Adoption of Best Management Practices by Louisiana Dairy Farmers." *Journal of Agricultural and Applied Economics* 40,1(2008):203–22.

Peel, D.S. "Beef Cattle Growing and Backgrounding Programs." *The Veterinary Clinics: Food Animal Practice* 19,2(2003):365–85.

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(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(2004):229–40.

Reuter, R., G. Highfill, and D. Lalman. "Implants and Their Use in Beef Cattle Production." *Beef Cattle Manual*. D. Lalman and D. Doye, eds. 5th Ed. Stillwater, OK: Oklahoma Cooperative Extension Service, Oklahoma State University, 2005.

Rogers, E. *Diffusion of Innovations*. 3rd Ed. New York: Free Press, 1983.

Schmitz, T.G., C.B. Moss, and A. Schmitz. "Marketing Channels Compete for U.S. Stocker Cattle." *Journal of Agribusiness* 21,2(2003):131–48.

Schroeder, T.C., J. Minert, F. Brazle, and O. Grunewald. "Factors Affecting Feeder Cattle Price Differentials." *Western Journal of Agricultural Economics* 13,1(1988):71–81.

Selk, G.E., R.R. Reuter, and G.L. Kuhl. "Using Growth Promoting Implants in Stocker Cattle." *The Veterinary Clinics of North America. Food Animal Practice* 22,2(2006):435–49.

Thrikawala, S., A. Weersink, G. Kachanoski, and G. Fox. "Economic Feasibility of Variable-Rate Technology for Nitrogen on Corn." *American Journal of Agricultural Economics* 81(1999):914–92.

Traoré, N., R. Landry, and N. Amara. "On-Farm Adoption of Conservation Practices: The Role of Farm and Farmer Characteristics, Perceptions, and Health Hazards." *Land Economics* 74,1(1998):114–27.

U.S. Department of Agriculture, Animal and Plant Health Inspection Services. *Injection Practices in U.S. Feedlots*. 2000. Internet site: http://nahms.aphis.usda.gov/feedlot/. (Accessed July 2008).

U.S. Department of Agriculture, National Agricultural Statistics Service. *Cattle*. Internet site: http://usda.mannlib.cornell.edu/usda/nass/Catt//2000s/2008/Catt-02-01-2008.pdf. (Accessed July 2008).

Vestal, M.K. "Production Practices and Management Intensity of Oklahoma Cow-Calf Producers Across Income and Herd Size." Master's Thesis. Department of Agricultural Economics, Oklahoma State University, 2005.

Ward, C.E., M. Vestal, D. Doye, and D. Lalman. "Factors Affecting Adoption of Cow-Calf Production Practices in Oklahoma." *Journal of Agricultural and Applied Economics* 40,3(2008): 851–63.

Ward, C.E., C.D. Ratcliff, and D.L. Lalman. *"Buyer Preferences for Feeder Calf Traits." Division of Agricultural Sciences and Natural Resources. AGEC-602*. Stillwater, OK: Oklahoma Cooperative Exptension Service Fact Sheet, Oklahoma State University, 2004.