ANALYSES OF RETAINED OWNERSHIP AND VALUE-ADDED MANAGEMENT PRACTICES BY COW-CALF PRODUCERS

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CHAPTER I

REAL OPTION VALUE OF RETAINING WEANED CALVES

Introduction

Cow-calf producers can choose to sell calves at weaning or retain ownership through additional stages of production, including preconditioning, wheat or pasture grazing, and feedlot. After each stage of production, producers then choose to sell the calves or keep them through the next stage. We assume the decision to sell is irreversible, creating the possibility that retaining calves beyond weaning creates a real option with potentially significant value.[1] Since the expected profitability of each decision varies by year, no single selling point is optimal every year.

Dixit (1992) describes three requirements for an investment to have an option value: a sunk cost to investment is involved, an ongoing uncertainty in which information is acquired as time progresses, and a decision of when and whether to invest must be made. These three conditions are met in cow-calf production, but the literature has not considered the option value of retaining calves past weaning. The sunk costs for retaining calves would include costs such as transportation, feed, and labor. Price uncertainty exists in both the cattle and feed grain markets and prices become more certain as time progresses. A decision is made to sell or retain calves after each stage of production, meeting the third condition.

[1] The irreversibility is economic. A producer could sell and then rebuy similar cattle, but such an action would generate two sales commissions, two transportation charges, stress on the cattle, and a loss of information about the genetics and history of the cattle.

Some past research on real options assume that the decision to exercise the option is reversible (Lence et al. 1993; Tronstad and Taylor 1991), but similar to Fackler and Livingston's (2002) assumption on grain marketing, we assume the decision to sell is irreversible. However, unlike Fackler and Livingston the nature of cow-calf production does not allow us to present expected returns as continuous in time. This research presents the decision to retain ownership of beef calves in a discrete-time real-option framework.

While prior research investigates the profitability of retaining ownership in a beef cattle operation, researchers typically focus on single stages of production such as preconditioning or the feedlot. Others examine optimal selling points over multiple stages of production, but do not investigate the real option value associated with retained ownership.

Each of the production systems in this paper includes a preconditioning stage of production. Many researchers have also considered preconditioning. Among the research on the preconditioning stage of production, Roeber and Umberger (2002), Avent et al. (2004), King and Seeger (2004), Zimmerman et al (2012), and Williams et al. (2012) investigate the premiums associated with preconditioning calves. Gardner et al. (1996), Cravey (1996), and Gardner et al. (1999) examine the impact of preconditioning on feedlot profitability. Dhuyvetter (2006) estimates the profitability of preconditioning.

Similar to the retained ownership decision considered here, Lambert (1989), Schroeder and Featherstone (1990), VanTassell et al. (1997), and Reisenauer et al. (2001) analyze profitability at multiple stages of production. Reisenauer et al. (2001) use biological production simulation models to compare three selling points for spring, summer, and fall born calves. Lambert (1989), VanTassell et al. (1997), Schroder and Featherstone (1990) employ discrete stochastic programming (DSP) to model retained ownership, assuming decisions are made at several points in the production process. In Lambert's model, each decision relies on current and expected market conditions and forage availability to find the optimal rate of gain and marketing strategy. Schroeder and Featherstone (1990) determine the expected utility maximizing retention rates at weaning and at one year of age as well as marketing calves using cash prices, options, or hedging. VanTassell et al. (1997) also determines the expected utility maximizing selling point in a DSP model under different risk aversion levels and production levels.

While useful in determining an *a priori* optimal retained ownership plan, DSP does not consider the sequential decision process of producers because it does not re-optimize decisions as states of nature are realized. Stochastic dynamic programming (SDP) explicitly re-optimizes decisions as information uncertainties are resolved. SDP accounts for the real option value of retaining the calves by utilizing market-based information, such as spot and futures prices, to predict the value of retained ownership. The previous research using discrete stochastic programming maximizes net present value. As Fackler and Livingston (2002) suggest, such models are sub-optimal because the cost of exercising an irreversible option cannot be considered. Excluding the real option value can lead to selling cattle earlier than optimal. Our stochastic dynamic programming model considers all possible outcomes up to and including the terminal stage, incorporates information as uncertainties are resolved, and determines an optimal decision that considers the maximum expected returns associated with the option of future production. The value of this option for future production is known as the real option value (Carmichael et al. 2011).

The sequential decision process faced by producers can be modeled utilizing a stochastic dynamic program with a market-based signal. The market-based signal indicates whether retained ownership is or is not expected to be profitable. Two calving seasons common in U.S. Southern Plains, spring and fall, are considered. The stages of production for spring calving producers considered here are preconditioning, wheat pasture, and feedlot. The stages of production considered for fall calving producers are preconditioning, grass pasture, and feedlot. In each of the production systems considered, calves are preconditioned before being placed on pasture. Preconditioning is a period of time, generally seven to 45 days, in which calves are weaned, vaccinated, and prepared for the next stage of production. When calves go on wheat pasture, they graze wheat over the winter from November until March. If they are placed on grass, fall-born calves are grazed on grass pasture for a three-month period in the summer and fall.

Methods

Research on retained ownership has traditionally chosen a single selling point that maximizes expected returns. However, the optimal selling point actually depends on uncertain futures market prices. If calves are sold at weaning, producers eliminate the option to use new market information to decide whether to sell or retain calves through later stages.

Producers are assumed to maximize expected economic returns to cow-calf expenses and retention by choosing the sale point of weaned calves. This expectation is updated as more information becomes available at the next decision node. As time progresses, additional information becomes available that is used to make decisions about continued retention. Because of the updating of the information set, the optimal strategy is continually adjusted until the calves are sold. Following Dixit and Pindyck (1994), the value functions can be defined as:

$$F_1(\boldsymbol{D},\boldsymbol{\Omega_1}) = \max_{\boldsymbol{D}}\{\pi_1(\boldsymbol{D},\boldsymbol{\Omega_1}) + \gamma E[F_2(\boldsymbol{D},\boldsymbol{\Omega_1})]\}$$
$$F_2(\boldsymbol{D},\boldsymbol{\Omega_2}) = \max_{\boldsymbol{D}}\{\pi_2(\boldsymbol{D},\boldsymbol{\Omega_2}) + \gamma E[F_3(\boldsymbol{D})|\boldsymbol{\Omega_2})]\} \quad (1.1)$$

where $\pi_1(\boldsymbol{D},\boldsymbol{\Omega_1})$ is the profit from selling in stage one and is zero when cattle are not sold in stage 1, $\boldsymbol{D}$ is a matrix of binary decision variables for all stages and states of nature, $\boldsymbol{\Omega_s}$ is the information set available at stage *s* including cattle futures and feed prices, $F_1(\boldsymbol{D},\boldsymbol{\Omega_1})$ is the maximized expected profits over all stages as observed in stage one, $F_2(\boldsymbol{D},\boldsymbol{\Omega_2})$ is the maximized expected profits over all future stages as observed in stage two, $F_3(\boldsymbol{D})$ is the maximized expected profit in the final stage, and γ is a discount factor. Information available at each decision point includes cattle futures prices and feed prices.

The Bellman's equation associated with (1.1) is:

$$F(\pi) = \max\{\pi_1, \gamma E[\pi_2|\boldsymbol{\Omega_1}] + \gamma^2 E[F_3(\boldsymbol{D}|\boldsymbol{\Omega_2})]\} \quad (1.2)$$

where $F(\pi)$ is the maximized expected profit associated with the optimal solution. Any optimal plan must satisfy the condition in (1.2). From (1.2) and similar to Dixit and Pindyck (1994), calves are optimally retained beyond weaning if and only if:

$$\gamma\, E[\pi_2|\boldsymbol{\Omega_1}] + \gamma^2 E[F_3(\boldsymbol{D}|\boldsymbol{\Omega_2})] \geq \pi_1; \quad (1.3)$$

otherwise, calves are sold at weaning.

Conceptually similar to Fackler and Livingston's (2002) optimal grain storage model, cow-calf producers are essentially storing calves for future sale. The calves incur storage costs in the form of feed, rent, labor, and opportunity cost. There are two major differences between Fackler and Livingston's model and our model. The first difference is that we not only have price uncertainty, but also an increase in the quantity being sold as time progresses. The second is that the profit function is not continuous in time. As shown in Figure I-1, as time progresses the expected profits of each stage increases. At the end of each stage, a decision must be made to retain the calves or sell them. If calves are retained at each decision point, the expected profits will drop at the beginning of the next stage. This drop is associated with transportation costs, weight loss due to stress, and other initial inputs to prepare calves for the next stage. These costs are offset as a calf gains weight and value over the course of each stage, and the expected profits again increase as time progresses. In Figure I-1, expected returns to cow-calf expenses are not continuous in time. This makes the maximization problem difficult to solve analytically. So, it must be solved numerically with a programming model.

One of the more common methods of calculating the real-option value is known as the Black-Scholes method. Based on Black and Scholes (1973), the real option value can be defined as:

$$ROV = N(\pi_3)X_0 - N(\pi_1)We^{-rT} \tag{1.4}$$

where ROV is the real option value, π_3 is the maximized net return across all stages of production, π_1 is the net return from selling at weaning, $N(\pi_3)X_0$ is the expected present value if the option is exercised (calves are retained), X_0 is the maximized value of retained ownership, $N(\pi_1)We^{-rT}$ is the discounted expected cost of exercising the option, $N(\pi_3)$ is the probability that the expected returns from retaining are greater than the cost of exercising the option, $N(\pi_3)$ is the probability that the option will be exercised, r is the interest rate, and T is the length of time calves are retained (Black and Scholes 1973.) In this research, the cost of exercising the option is the opportunity cost of retention, or the returns from selling at weaning. While the Black-Scholes method assumes a continuous distribution, we assume a discrete distribution. Assuming a discrete distribution and that producers exercise the option to retain each time the expected returns are greater than the cost of exercising the option, $N(\pi_3)$ and $N(\pi_1)$ are equal. Using an adaptation of the Black and Scholes model proposed by Carmichael et al. (2011), we rewrite the real option value as

$$ROV = (E[F_3(\boldsymbol{d})] - E[\pi_1]), \quad (1.5)$$

where $F_3(\boldsymbol{d})$is the maximized return from the real option model, and π_1 is the return from selling at weaning. $E[\pi_1]$ is assumed to be the opportunity cost of retaining ownership in (1.5). Equation (1.5) is used below to calculate the real option value of retaining ownership.

<u>Estimation of the Stochastic Process for Expected Profit</u>

We develop a stochastic dynamic programming model of the sequential decision process confronting cow-calf producers. The model is solved using backward recursion in GAMS (GAMS Development Corp. 2012). The DSP model determines the optimal retention strategy and the value of the real option to retain calves beyond weaning. Because, as shown in Figure I-1, there is uncertainty in projected returns, each selling point has a distribution of expected profits associated with it. At weaning, returns to cow-calf production are known with certainty if the calves are sold. The distribution of expected returns from retaining one additional stage (preconditioning or grazing) is known and is conditional on the information available at weaning. However, the distribution of expected returns from finishing in a feedlot is not known at weaning. Rather, there is a distribution of distributions characterizing the expected returns from finishing. If calves are retained, uncertainty regarding the distribution of expected returns from finishing is resolved. Conditioned on the stage of nature, i.e., future prices and input prices, the distribution of returns to finishing is known post-preconditioning or post-grazing and prior to the decision to place the calves in a feedlot.

At each decision point, the decision maker observes information indicating the distribution or distributions of future returns. In some states of nature, information suggests that future returns from retention will be positive. By delaying selling, uncertainty regarding the distribution of continued retention is resolved. This creates value to the decision maker. That value however is only realized by delaying selling past weaning. At the beginning of each stage, an expectation on what the mean returns will be at the end of the stage is formed. However, because market conditions are likely to change from the beginning of the stage to the end of the stage, this expectation has uncertainty around it, as demonstrated in Figure I-1.

This uncertainty is characterized using a stochastic process that includes the projected returns, $\tilde{\pi}_{si}$, and a normally distributed error term at each point in time. The equation of motion is then defined as:

$$\begin{gathered}\tilde{\pi}_{si} = \rho\tilde{\pi}_{s,i-1} + \varepsilon_{si};\\ \boldsymbol{\varepsilon_{si}} \sim N(0, \sigma_s^2)\\ \forall\, \boldsymbol{s} \in \{1,2\}\\ \forall\, \boldsymbol{i} \leq \boldsymbol{s}\end{gathered} \tag{1.6}$$

where ε_{si} is a normally distributed error term for stage s, $\tilde{\pi}_{si}$ is the calculated expected return for stage *s* observed in time i, ρ is the correlation between expected returns from stage *s* formed at time *i* and *i*-1, and $\tilde{\pi}_{s,i-1}$ are the calculated expected returns for stage *s* as observed in time i-1. Expected profits are calculated using fed and feeder cattle futures with basis adjustment[2] and feed prices observed at i-1. In particular, we are concerned with the uncertainty of feedlot returns. At weaning, the distribution of feedlot return is not known. After one stage of retained ownership (preconditioning or grazing), the distribution of feedlot return is known. The stochastic process specified in (1.6) characterizes the change in the distribution of return to finishing as time progresses.

The net returns to cow-calf expenses and current state of nature, i.e., expected returns to retention with current futures prices, are known at weaning. At each decision point, expected returns from additional retention must be computed. The expected return from future retention varies with the current set of futures price information. To compute these returns, current future prices for feeder cattle, basis, and feed costs are utilized at each decision. Thirty years of historical expected net returns calculated at weaning for the feedlot stage are ranked from low to high and assigned to one of three groups of ten observations each. Each conditional mean is assigned a probability of 1/3. Table I-1 demonstrates this process for the spring stocker fed production system in column two.

The corresponding expected returns formed post preconditioning/grazing from the feedlot stage are also reported in Table I-1 for the spring stocker production system. The expected returns formed post preconditioning or grazing are sorted into three intervals:

[2] The basis adjustment is a three-year moving average observed at Oklahoma City.

low, medium, and high expected returns. The sorted data and conditional means are reported in column seven of Table I-1.

To estimate the Markov transition probability matrix associated with (1.6), historical expected returns to feedlot computed post precondition or grazing are sorted to correspond by year (see column four of Table I-1) to the ranked expected returns at weaning (column three). The direction of change, if any, between the two expectations of feedlot returns is noted in column five of Table I-1. A note of "no change" indicates that the expected returns to finishing as computed after preconditioning/grazing stay in the same interval (i.e, low, medium, or high) as the corresponding return computed post weaning. The number of times (historically) out of ten years that the expected returns to finishing increased (decreased) one or two intervals is then used to estimate the Markov transition probabilities. In the case of the Spring stocker fed system reported in Table I-1, given that the initial expectation that expected feedlot return is low, the probability that the expected feedlot return after grazing will be in the low interval is 90%, in the medium interval is 10%, and in the high interval is 0%. Given that initial expectation is in the medium interval, the probability that expected feedlot return will be in the low interval after grazing is 10%, in the medium interval is 80%, and in the high interval is 10%. Similarly, at a high initial expectation, the probabilities are 0%, 10% and 90% for the low, medium, and high intervals for expected feedlot return calculated after grazing.

The conditional means (i.e., expected payoffs) for each stage are summarized in Table I-2. The associated Markov transition probability matrices are summarize in Table I-3. In general, the Markov transition probabilities indicate there is only a small chance that expectations will change between weaning and post preconditioning/grazing. Shorter time intervals, such as with 45-day preconditioning, resolve less uncertainty and so are expected to have lower real option values. In the extreme case, the Markov transition matrix is an identity matrix, as is the case with the spring calf fed production system.

Production Systems

Four production systems, each with two decision nodes, are included. The spring calving production systems are shown in Figure I-2 and the fall calving production systems are shown in Figure I-3. The spring stocker production system has decision points at weaning and after wheat pasture. The spring calf fed production system has decision points after weaning and after preconditioning. The fall stocker production system has decision points after weaning and on October 1 after the grass pasture stage. The fall stocker production system has decision points after weaning and after the wheat pasture stage of production. If retained through the feedlot stage, cattle are harvested in all strategies. In each of the production systems, if a calf is retained until the next decision point, it will go through all stages of production described in Figures I-2 and I-3 preceding the decision point.

At weaning, a producer either sells the calves or retains them one more stage. For example in the spring stocker system shown in Figure I-4, if the producer chooses to retain through preconditioning, there is a distribution of returns for the preconditioning stage and distributions for the wheat pasture and feedlot stages. The producer will not know what distribution of returns he/she will face for wheat pasture and feedlot stages until the start of each respective stage. Based on the given information, the producer must decide to retain or sell. If the producer retains, the distribution of returns for the wheat pasture stage and feedlot stage is updated using current futures prices. This process continues until either the producer sells or reaches the terminal stage. As the process continues, a producer will make the decision that maximizes expected returns to cow-calf production and retention as shown in (1.1).

Alternative Models

Four additional models called naïve, myopic, perfect foresight, and always sell at weaning are compared to the real option model described above. The naïve model represents a producer's decision if they were to choose the strategy that is historically most profitable without taking into account current market conditions. In this model, the average historical returns to cow-calf expenses for each stage of each production system are calculated. This model uses the single selling point that yields the highest average net returns over the thirty-year period.

In the myopic model, futures prices are used to find the expected returns from the next stage of production. If forecasted returns of retaining in the next stage are greater than returns from selling, the calves are retained one more stage. This process is repeated until calves are sold. Mathematically, the maximization of the myopic model is:

$$\max_{d_s} E(R) = \sum_{s=1}^{S} d_s \, E[P_s Y_s - C(Y_s)] \, \gamma^{s-1}$$

subject to

$$d_s \in \{0,1\}$$

$$\sum_{s} d_s = 1 \qquad (1.7)$$

$$Y_s = f(Y_{s-1}, \boldsymbol{X_s})$$

where R is the return to cow-calf expenses and retention, P_s (dollars per cwt) is the price of output in stage s, Y_s (cwt) is the quantity of output in stage s, C is the cumulative cost of producing up to stage s, V_s are input prices for stage s, $\boldsymbol{X_s}$ is a vector of inputs (including feed, veterinary, and days-on-feed), d_s is a binary dummy variable that is one if calves are sold in stage s and zero otherwise and calves can only be sold once. The expected return $E[P_s Y_s - C(Y_s, V_s)]$ is a function of the information available at the end of the previous stage. Specifically, futures prices of calves less basis and cash prices for inputs are used to computed expected return. Calves are given the same quantity of feed, vaccinations, and other inputs each year. Average daily gain and days on feed within a stage also remain constant each year. If calves are sold in stage s-1, then production in subsequent stages is zero. The decision to sell is a discrete choice: sell ($d_s = 1$) or retain ($d_s = 0$). The output Y_s (pounds of calf) in each stage is determined by a function $f(.)$ of the ending weight in the prior stage Y_{s-1} and the inputs used in the current stage X_s. This relationship is expressed in the last line in (1.7). The projected net return to cow-calf expenses and retained ownership, $E[P_s Y_s - C_t(Y_s)]$, is forecasted using information available at the beginning of each stage.

The real option, naïve, and myopic models are compared to the returns from always selling at weaning and a fourth model called the perfect foresight model. The perfect foresight model assumes the producer can predict the future perfectly and choose the *ex post* profit-maximizing strategy each year. Always selling at weaning is considered the benchmark that each model is compared to while the perfect foresight model represents the upper envelop of returns.

Data

Retention strategies and associated rations were developed following growth rates and strategies similar to Winterholler et al. (2008) and with the expert opinion of Lalman (2010) and Krehbiel (2010). Lalman and Krehbiel also assisted in estimating the physical characteristics of the animals such as growth, starting weights, and ending weights through each stage of production.

Oklahoma City feeder cattle prices, CME feeder cattle futures, Oklahoma fed cattle prices, fed cattle futures from 1980-2009, Texas Triangle corn prices, and monthly Nebraska dried distiller's grain prices from 2001-2008 were taken from the Livestock Marketing Information Center (2011). Corn and soybean meal futures and fed cattle futures from 1978-1980 were obtained from the Great Pacific Trading Company (2011). Alfalfa prices, grazing rates, Oklahoma wheat prices, wheat seed prices, and national nitrogen prices paid by producers were taken from the United States Department of Agriculture's National Agricultural Statistics Service (2011). Wheat and wheat seed prices as well as the nitrogen prices reported by NASS are used to estimate the wheat grazing rates. Supplement, grass hay, and soybean meal prices are obtained from Oklahoma Agricultural Statistics (1979-2010).

The wheat pasture grazing rental rate is calculated as:

$$Wheat\ Pasture = 1.25(30P_{Nitrogen} + P_{Seed} + 7 * P_{Wheat}) \tag{1.8}$$

where per-acre wheat grazing rates are calculated as 125 percent of the additional input costs of producing wheat if it is used for grazing (Peel 2010), $P_{Nitrogen}$ is the price of nitrogen, P_{Seed} is the price of a bushel of wheat seed, and P_{Wheat} is the price of a bushel of wheat. The cost of grazing wheat pasture is calculated assuming that grazed wheat requires an additional 30 pounds of nitrogen per acre, an additional bushel of seed per acre is planted, and yields are decreased by about seven bushels per acre as a result of early planting (Doye et al. 2008).

Producers make the decision to keep or sell their calves before each stage of production and if calves are retained they purchase (or hedge) all feed necessary for production up to the next decision point. This eliminates complications associated with varying costs within stages. In addition, feed is not hedged beyond the current stage as future production decisions may change after each stage. Producers will not purchase or hedge feed they are uncertain will be used. Oklahoma City spot cattle prices are used to calculate realized returns while cattle futures with a three-year moving average basis are used to calculate projected returns.

Thirty years of historical price data are used to develop partial budgets for each stage of the retained ownership strategies. Three stages with two potential decision nodes are considered in each of the four production systems. Three partial budgets are developed for the feedlot stage, one using realized prices, one using futures prices observed at weaning, and one using futures prices observed after the preconditioning or grass/wheat pasture stage. Two partial budgets are created for the preconditioning or grass/wheat pasture stage. One partial budget uses realized prices and one uses futures prices observed at weaning.

Empirical Model

In the fall grass stocker production system, fall born calves are weaned in July at a weight of 650 pounds. Next, calves are preconditioned in a drylot for seven days. Calves are then placed on grass pasture until October 1 at which point they can be sold or put in a feedlot. In the feedlot, calves are fed for 147 days to a finishing weight of 1375 pounds.

In the fall fed production system, fall born calves are again weaned in July at a weight of 650 pounds. If retained, calves are preconditioned in a drylot for seven days. Calves are then placed on grass 38 days to complete the 45-day preconditioning period at which point they can be sold or placed in a feedlot. In the feedlot, calves are fed for 147 days to a finishing weight of 1308 pounds. The two fall calving production systems are illustrated in Figure I-2.

In the spring calf fed production system, the calves are weaned in early October at a weight of 450 pounds. If calves are retained, they go through 45 days of preconditioning. After preconditioning, calves are either sold or finished in a feedlot to a weight of 1164 pounds over 171 days.

In the spring wheat stocker production system, calves are weaned in early October at a weight of 450 pounds. The calves then go through a 21-day preconditioning period and 110 days on wheat pasture. After wheat pasture, calves are sold or placed in a feedlot. In the feedlot, they are fed to a finishing weight of about 1283 pounds over 130 days and are sold in June. The spring calving production systems are illustrated in Figure I-3.

During the spring preconditioning period calves receive a ration consisting of corn, soybean meal, grass hay, alfalfa hay, Synergy (a high energy feed additive), and a protein supplement. During the seven-day fall preconditioning period, calves receive a ration of grass hay and supplement and will receive one pound of supplement per day while on grass. While in the feedlot, the steers receive a ration of corn, soybean meal, sorghum silage, alfalfa, and a supplement from 1979 until 2000. The ration is changed in 2001 to account for the increased availability and use of distiller's grain. From 2001 to

2008, the ration includes dried distiller's grains, supplement, and alfalfa (Winterholler et al. 2008).

Thirty years of price data are collected and used in a partial budget from DeVuyst et al. (2009) to calculate returns to cow-calf expenses and retention each year. An example budget for the spring stocker production system can be found in Table I-3. This budget assumes a 45-day preconditioning period if the calves are sold and a 21-day preconditioning period if calves are retained. Budgets for other retention paths are similar to the spring stocker production system. Table I-4 provides the calculations used to determine the feedlot feed costs in the spring stocker production system. Partial budgets for the other strategies are found in the appendix.

Projected returns and realized average returns are calculated for each of the models and compared to a baseline of always selling at weaning and the maximum possible outcome from the perfect foresight model. The projected returns for the naïve model are a 30-year average of calculated returns that producers expect to receive from selling in a stage given the futures price information available at the beginning of that stage. The projected returns for the myopic and real option model utilize the conditional interval means and probabilities reported in Tables I-2 and I-3. Each model employs projected returns calculated at some point in time. For the naïve model, returns are projected before any information has been obtained. The projected returns for each stage in the naïve model are computed as the 30-year historical average return from selling in that stage. For the myopic model and the real option model, projected returns are calculated at the start of each stage.

Results

A summary of the returns from always selling at weaning, the perfect foresight model, the naïve model, the myopic model, and the real option model are each shown in Table I-6. The projected returns to cow-calf expenses from always selling at weaning under both spring-calving production systems is $406.25/head and the projected returns to cow-calf expenses is $540.70/head for the fall-calving production systems. The goal of any retained ownership strategy is to improve on these benchmark values.

Perfect Foresight Model

The 30-year average return to cow-calf expenses using the perfect foresight model ranges from $415.43/head for the spring calf fed production system to $600.93/head for the fall stocker production system. These returns are the maximum possible returns for each production system and represent another benchmark for comparing alternative retention strategies. As shown in Table I-6, the perfect foresight model has a potential improvement in realized returns of $60.23/head in the fall stocker production system, $43.54/head in the fall calf fed production system, and $72.87/head in the spring stocker production system. The perfect foresight model improves the realized returns from the spring calf fed production system by $9.18/head.

Naïve Model

The first step in the naïve model is to calculate the historical net returns for each stage. The historical average net returns for each stage are used to determine the optimal retention strategy. Each stage in the fall calf fed and the fall stocker production system has positive average historical net returns as shown in Table I-7. Utilizing information at weaning, fall born calves have projected net returns for each stage ranging from a loss of $3.65/head to $39.76/head. The only fall stage that has a negative projected net return is the preconditioning stage in the fall stocker production system. As a result, it is optimal with the naïve model to sell after the feedlot stage in both fall calving production systems.

Profits from spring calving production systems are reported in Table I-8. The spring calf fed production system will on average lose $20.97/head in projected net returns in the preconditioning stage and $14.25/head in the feedlot stage, while both wheat pasture and the subsequent feedlot stage are profitable in the spring stocker production system. Based upon these results, the naïve model will always sell after the feedlot stage in the spring stocker production system and always sell at weaning in the spring calf fed production system.

The naïve model improves projected returns in the spring stocker production system by $58.35/head over always selling at weaning. Similarly, the naïve model in the fall stocker production system improves mean projected returns by $53.16/head over always selling at weaning, moving to within $7.07/head of the maximum potential of the perfect foresight model. The naïve model improves projected returns in the fall calf fed production system by $28.78/head over always selling at weaning. The naïve model always sells calves at weaning in the spring calf fed production system, so the difference in projected returns between the always selling at weaning and the naïve model is $0/head. In the spring and fall stocker production systems and the fall calf fed production system, the naïve model suggests always selling after the feedlot stage of production.

Myopic Model

The myopic model has lower average projected returns than the naïve model in all four retention production systems. This is likely because the myopic model only looks one stage forward and makes decisions without considering potential returns in subsequent stages. In the spring stocker production system, the myopic model improves projected return by $58.35/head over always selling at weaning. The projected returns for the myopic model are equal to the returns from always selling at weaning in the spring calf fed, fall calf fed, and fall stocker production systems.

Real Option Model

The real option model has projected returns that are greater than or equal to the naïve model and the myopic model all four production systems. The projected net return for the fall calf fed production system is $572.52/head and the projected net return for the spring stocker production system is $464.60/head. The projected return of $598.19/head for the fall stocker production system are less than the perfect foresight model's return by $2.74/head.

In comparison to always selling at weaning, the real option model improves projected return by $58.35/head in the spring stocker production system, $31.82/head in the fall calf fed production system, and by $57.49/head in the fall stocker production system. In each of these three production systems, the real option model has an improvement in realized returns over selling at weaning that are equal to or greater than both the myopic and the naïve models. In the spring calf fed production system, the projected returns in the real option model are equal to the returns for selling at weaning. In other words, the real option model always sells at weaning in the spring calf fed production system.

The real option value of retaining calves past weaning is calculated using equation (1.5). In the spring stocker production system, the real option value is $58.35/head. In the spring calf fed production system, calves are always sold at weaning and the real option value is zero. The second stage of the spring calf fed production system is 45 days long, so little uncertainty is resolved during that time period. The fall calf fed production system has a real option value of $31.82/head while the fall stocker production system has a real option value of $57.49/head.

Conclusions

Previous research employs discrete stochastic programming models to analyze optimal beef cattle retention strategies. This paper explicitly models the real option value associated with retained ownership. A real option model considers the decision to sell as irreversible. Additional calves cannot be produced in a marketing year and since our focus is on retaining calves produced on-farm, we rule out the purchase of calves for production in future stages. This option to delay selling when the decision is irreversible adds a real option value to calves and could lead to producers holding calves longer than previous models have suggested. Because of the real option value, producers may be willing to lose small amounts of money in one stage of production so that they can have an opportunity to realize larger profits in later stages of production.

This research compares four models of four beef cattle production systems to determine if there is a real option value for retaining beef cattle past weaning. Budgets are used to calculate projected returns based on historical cattle, feed, and futures price data. The resulting returns for each stage of each production system are used to calculate mean conditional returns for a Markov process and Markov transition probability matrices. The Markov process is a fundamental component to the real option stochastic dynamic programming model that determines the optimal retention strategy for each of the past 30 years. Results from the real option model are used to find the real option value of retaining calves past weaning.

The results show that the real option model has equal or higher projected returns than each of the other two models all four production systems. This result demonstrates that there is a value of holding onto calves to conserve the option of future production in three of the four production systems modeled here. Results from this research have important implications for producers and Extension Specialists. Market information that is readily available to producers and Extension Specialists can be utilized to make decisions on when it is profitable to retain past weaning.

The stochastic dynamic programming framework has not been commonly used in previous literature on beef cattle production. This research fills the gap in the literature by using stochastic dynamic programming to model the real option value of retaining ownership. This research also has significant implications for cattle producers. Results indicate that on average, producers can increase their returns to cow-calf production by utilizing available market information to make decisions on retaining ownership. The myopic model in which decisions are made looking one stage forward, the real option model accounting for the value of future production, and the naïve model in which calves are sold at the point with the highest average net returns from 1979 to 2008 each increase the mean projected returns that producers would have received over the last 30 years. This presents an opportunity for the development of signals to help producers make future retention decisions that could increase their returns.

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Table I-1. Historical Returns for the Feedlot Stage of the Spring Stocker Production System

Interval	Year	Returns Observed at Weaning Ranked from Low to High	Returns Observed after Grazing	Change in Interval[a]	Year After Ranking	Observed after Grazing (Ranked from Low to High)
low expected return	1982	252.09	214.16	no change	1995	214.16
	1981	268.06	271.16	no change	1996	271.16
	1998	294.07	339.03	no change	1985	309.2
	1995	309.60	390.62	no change	1986	339.03
	1983	337.53	365.58	no change	1981	342.88
	1986	363.85	309.20	no change	1997	356.11
	1996	369.70	369.43	no change	1998	365.58
	1985	376.07	430.33	up one	1994	369.43
	1987	392.53	342.88	no change	1982	390.62
	1997	396.24	356.11	no change	1980	423.78
Conditional mean		**335.97**	**338.85**			**338.20**
medium expected return	1980	413.63	433.59	no change	1999	424.76
	1999	414.61	424.76	down one	1983	430.33
	2001	428.07	463.01	no change	2000	433.59
	1984	446.90	451.52	no change	2003	435.74
	2000	458.06	460.28	no change	2002	451.52
	1994	490.41	525.72	no change	1984	460.28
	1979	491.63	473.78	no change	1987	463.01
	2002	502.23	505.08	no change	1993	473.78
	1988	504.44	497.88	no change	1991	497.88
	1991	525.34	435.74	up one	2001	505.08
Conditional mean		**467.53**	**467.14**			**457.60**
high expected return	1989	541.25	552.49	down one	2008	519.52
	1993	558.95	519.93	no change	1989	519.93
	1992	559.79	423.78	no change	1992	525.72
	2003	560.76	535.90	no change	1988	535.9
	1990	580.93	542.44	no change	1979	542.44
	2008	633.43	519.52	no change	1990	552.49
	2006	634.23	731.59	no change	2007	603.2
	2004	635.73	603.20	no change	2004	709.85
	2007	721.04	709.85	no change	2006	731.59
	2005	745.16	739.40	no change	2005	739.4
Conditional mean		**617.13**	**587.81**			**598.00**

[a]Indicates the change in the interval of the unsorted expected net returns for the feedlot stage observed after grazing after they are resorted from low to high.

Table I-2. Mean Conditional Returns by Stage for Markov Process

	State at Weaning	Feedlot Returns at Weaning Ranked from Low to High	Feedlot Returns After Precon/Grazing	Returns From Selling After Precon/Grazing Stage	Returns From Selling at Weaning
Fall Calf Fed	Low	412.90	421.37	430.48	429.77
	Medium	542.85	554.18	546.33	549.24
	High	730.26	732.91	634.35	643.10
Fall Stocker	Low	426.96	461.43	486.30	465.39
	Medium	567.53	580.58	516.60	512.16
	High	763.05	739.59	673.54	644.55
Spring Calf Fed	Low	272.86	274.47	290.86	318.09
	Medium	369.65	368.06	377.42	396.62
	High	481.19	490.85	487.55	504.04
Spring Stocker	Low	335.97	338.85	345.45	315.52
	Medium	467.53	467.14	460.76	417.35
	High	617.13	587.81	541.75	485.88

Table I-3. Markov Transition Probability Matrices

Production System	State at Weaning	State After Preconditioning or Grazing: Low	Medium	High
Fall Calf Fed	Low	1	0	0
	Medium	0	1	0
	High	0	0	1
Fall Stocker	Low	0.9	0.1	0
	Medium	0.1	0.8	0.1
	High	0	0.1	0.9
Spring Calf Fed	Low	0.9	0.1	0
	Medium	0.1	0.8	0.1
	High	0	0.1	0.9
Spring Stocker	Low	0.9	0.1	0
	Medium	0.1	0.8	0.1
	High	0	0.1	0.9

Table I-4. Example Budget by Stage of Production for the Spring Stocker Production System Using 2007 Prices

	Weaning	Preconditioning	Wheat Pasture	Feedlot
Ending weight (lbs)	450.00	482.00	752.00	1,283.00
Weight net of shrink (lbs)	436.50	472.36	736.65	1,231.34
Sale price ($/cwt)	$127.04	$124.74	$105.59	$93.45
Revenue	$554.53	$582.75	$773.16	$1,147.80
Commission and transportation if sold	$9.00	$10.00	$5.00	
Transportation from previous stage			$1.80	$3.00
Beef checkoff	$1.00	$1.00	$1.00	
Death loss (1%, 0.6%, and 0.25%)		$0.48	$0.72	$1.04
Feed expense		$34.00	$0.58	$338.11[a]
Grazing rate ($/lb of gain)			$0.38	
Grazing cost/head			$104.46	
Veterinary costs		$8.00	$2.00	$7.50
Labor		$1.50	$0.25	
Yardage (includes labor and other expenses)				$45.50
Other expenses		$2.50		
Interest and opportunity cost (6.5% annual)		$2.12	$12.29	$22.36
Expenses from prior stages			$50.70	$171.13
Total expenses	$10.00	$49.80	$177.00	$588.64
Net returns	$544.53	$523.15	$596.16	$559.16

Note: Values are in $/head unless otherwise specified.

[a] Feedlot feed expense calculations are shown in Table I-4.

Table I-5. Feed Cost Calculations for the Feedlot Stage of Production using a Ration with DDG[a] in the Spring Stocker Production System Using 2007 Prices

Feedstuff	Proportion of Ration	% Dry Matter (DM)	Feed Price	DM[b] price/unit	Feed Units	DM Price/lb	($/lb DM) Proportion
Corn	0.676	88	$5.24	$5.95	bushel	0.10636	$0.072
DDG	0.157	90	$163.50	$181.67	ton	0.09083	$0.014
Alfalfa	0.060	88	$117.00	$132.95	ton	0.06648	$0.004
Supplement	0.107	90	$382.00	$424.44	ton	0.21222	$0.023
					Total ($/lb)		$0.113
					lbs of feed/day		23
					Days on Feed		130
					Total Feed Cost		$337.43

[a] Dried Distillers Grain.

[b] Dry Matter

Table I-6. Per-Calf Projected[a] Net Returns Under Four Production Systems Using Three Models for Retained Ownership Compared to Perfect Foresight and Always Selling at Weaning

	Spring Stocker	Spring Calf Fed	Fall Calf Fed	Fall Stocker
Always sell at weaning	406.25	406.25	540.70	540.70
Naïve model	464.60	406.25	569.48	593.86
Myopic model	464.60	406.25	540.70	540.70
Real option model	464.60	406.25	572.52	598.19
Perfect foresight	479.12	415.43	584.25	600.93

[a]Projected returns are a 30-year average of forecasted returns to cow-calf expenses that producers expect to receive given the futures price information available at the beginning of each stage.

Table I-7. Mean Projected[a] Returns by Stage of Production for Fall Calving Production Systems ($/Head)

Stage of Production	Mean	Standard Deviation
Grass until October 1	18.11	32.61
Feedlot on October 1	39.76	85.51
Preconditioning	-3.65	21.77
Calf Fed Feedlot	21.13	77.76

[a]Projected returns are a 30-year average of calculated returns that producers expect to receive from selling in a stage given the futures price information available at the beginning of each stage.

Table I-8. Mean Projected[a] Returns by Stage of Production for Spring Calving Production Systems ($/Head)

Stage of Production	Mean	Standard Deviation
Preconditioning	-20.97	23.35
Wheat Pasture	43.07	28.14
Calf Fed Feedlot	-14.25	40.58
Feedlot after Wheat	29.07	74.72

[a]Projected returns are a 30-year average of calculated returns to cow-calf expenses that producers expect to receive from producing in a stage given the futures price information available at the beginning of each stage.

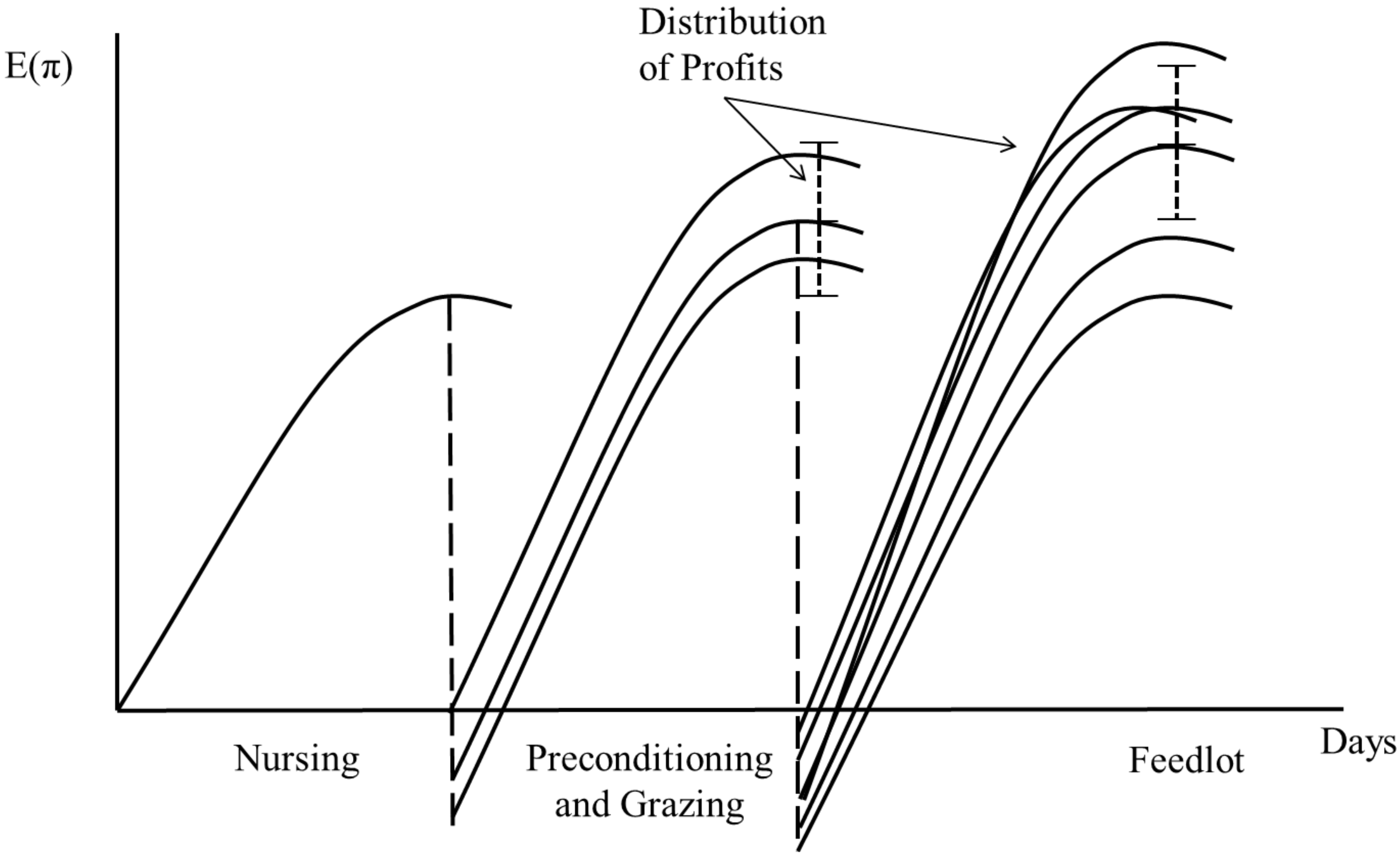

Figure I-1. Expected Returns to Cow-Calf Production over Time

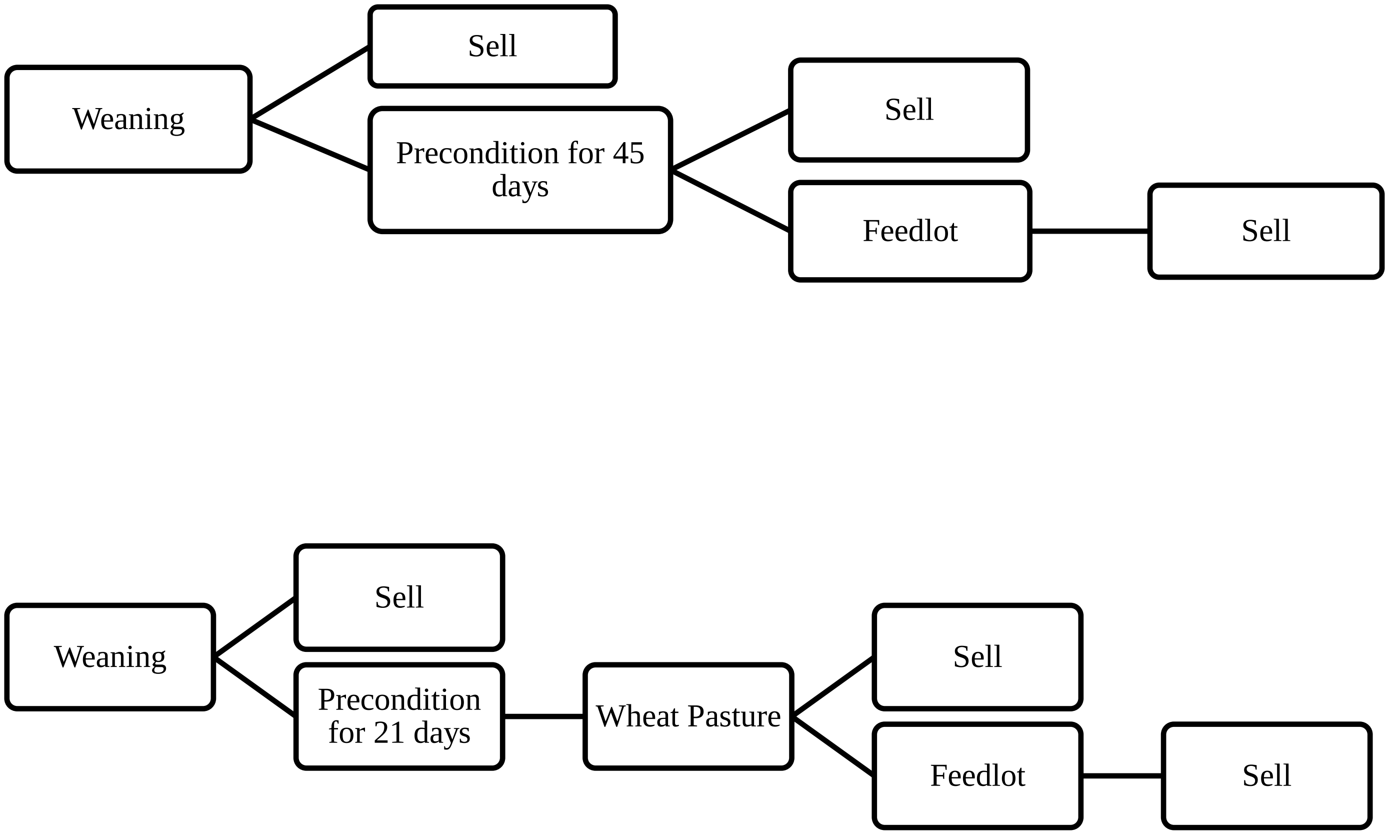

Figure I-2. Possible Production Systems for Spring-Calving Producers

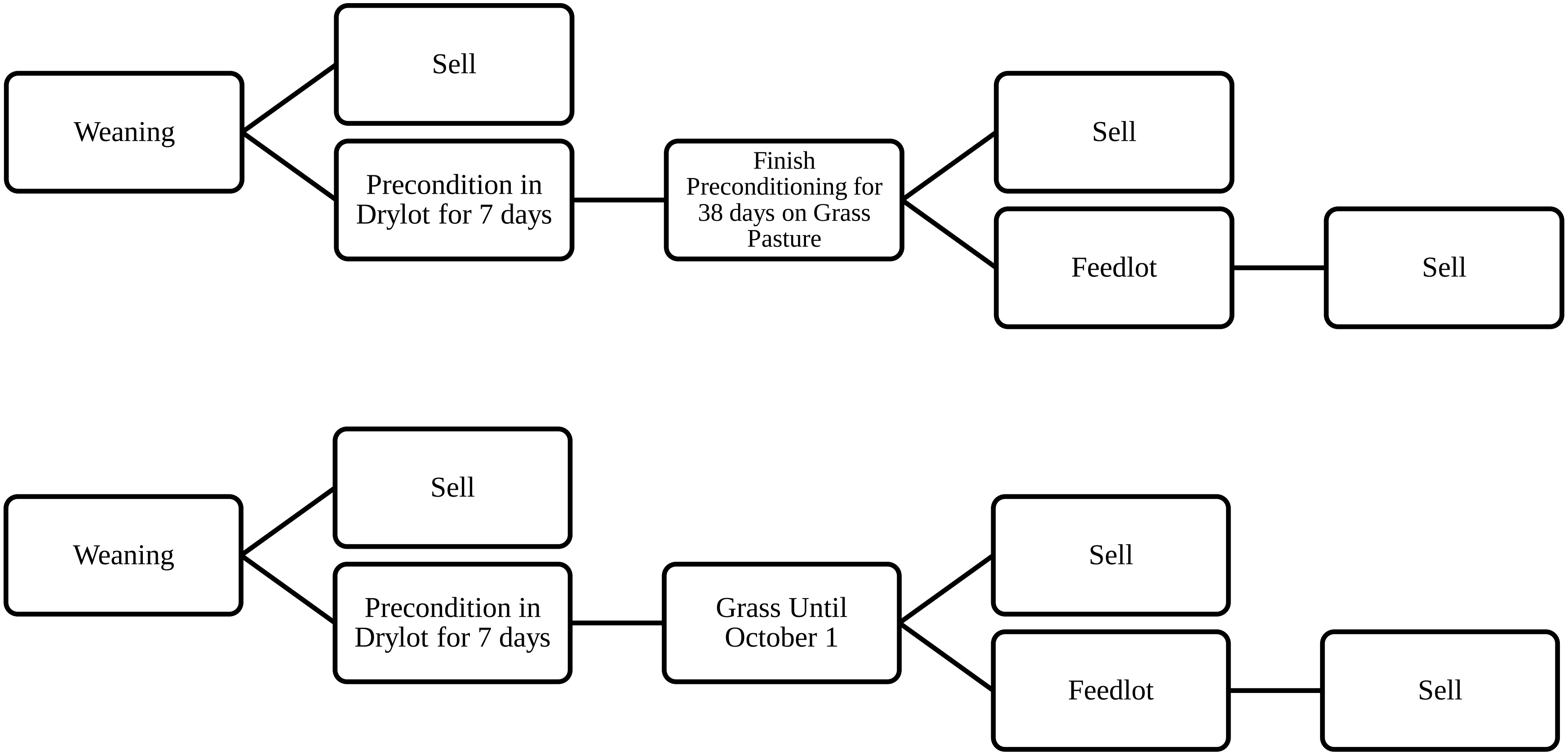

Figure I-3. Production Systems for Fall-Calving Producers.

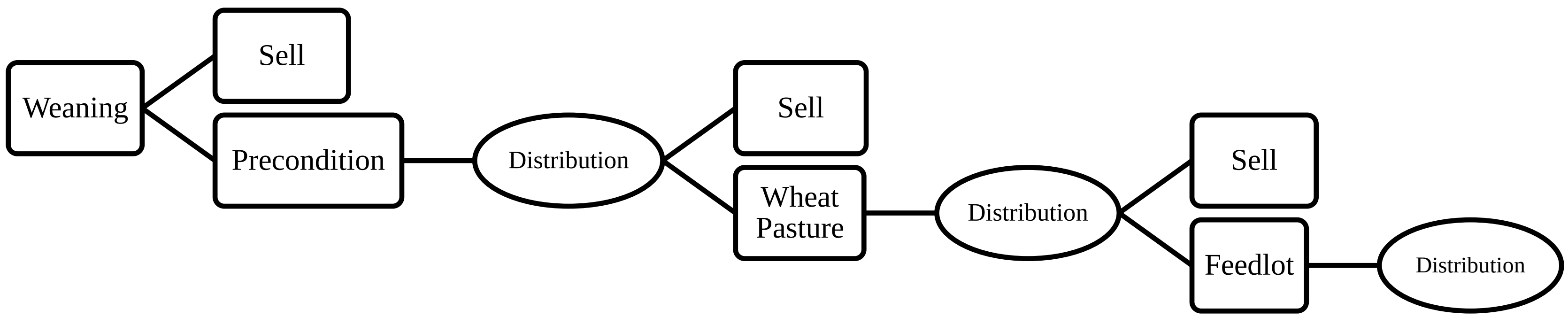

Figure I-4. Stochastic Dynamic Programming Model for the Spring Calving Stocker Production System

CHAPTER II

ACCOUNTING FOR SELF-SELECTION BIAS IN FEEDER CATTLE PREMIUM ESTIMATES USING MATCHED SAMPLING

Introduction

Each year thousands of Southern Plains cow-calf producers sell feeder cattle at local auction barns. As the calves pass through the sale ring, buyers quickly assess the relative value of each lot. Some information can be quickly observed visually, such as hide color, horns, weight, number of head, gender, and general health. Additional information can occasionally be obtained from the auctioneer, including vaccinations, weaned, preconditioned, and the seller's name. Williams et al. (2012a) show that weaned, vaccinated, and preconditioned calves sell for a premium over calves straight from their dams' sides ("bawlers" in the jargon of the sale barn). These premiums provide incentives to represent calves as value-added even if they are not. In economics jargon, producers providing false information are said to be "masquerading."

Given the potential of masquerading producers, third-party verification of value-added practices may improve the credibility of seller claims regarding credence attributes, improving sale prices for their calves. Oklahoma Quality Beef Network

(OQBN) is a third-party verification program. The third party, Oklahoma Cooperative Extension Service, has no vested interest in cattle sold in this program and so lends credence to value-added producers' claims of management practices completed. Schumacher et al. (2012) find that feedlots are willing to pay an additional $0.85/cwt for third party certification and an additional $2.37/cwt for USDA certification that calves have been weaned and vaccinated.

Previous research concerned with the marginal value of various characteristics in calves generally employs hedonic pricing models. Schroeder et al. (1988) is one of the first to utilize a hedonic model to investigate the impact of animal health, body condition, fill, and muscling on feeder cattle prices. Coatney et al. (1996) implement a system of hedonic equations to estimate the values of cattle characteristics. Other research uses hedonic pricing models to examine the contribution of value-added practices such as preconditioning, weaning, and vaccinating. Lalman and Smith (2001) and Dhuyvetter et al. (2005) examine the premium received for preconditioning calves and compare the added revenue to the cost of preconditioning.

Several researchers have used data from video auctions. For example, Bailey et al. (1991) compare video auction prices to market prices. King et al. (2006) and Zimmerman et al. (2012) use hedonic modeling to estimate premiums at Superior Livestock auctions for a variety of factors including vaccinations, horns, and breed. Blank et al. (2009) estimate a hedonic pricing model to look at premiums for various management practices using data from Western Video Market. Blank et al. (2009) include premiums for preconditioning, but not for third party certification. Similarly, Turner et al. (1991) estimate premiums for cattle characteristics in teleauctions.

Others have estimated hedonic pricing models utilizing data from conventional auctions. Lawrence and Yeboah (2002) estimate the value of age and source verification. Bulut and Lawrence (2006) and Avent et al. (2004) estimate the value of calves that are certified, weaned, and vaccinated, but do not report the value of certification. Similarly, Williams et al. (2012a) employ hedonic pricing models to determine the marginal value of vaccinations, weaning, certification, and other value-added characteristics at OQBN and non-OQBN sales in Oklahoma.

Hedonic pricing models, including those used by Zimmerman et al. (2012) and Williams et al. (2012a), require restrictive assumptions and impose a functional form. Regression models also introduce potential selection bias in their estimates (Tauer 2009). Lots of cattle cannot be treated and untreated at the same time. Rather, producers must self-select into a treatment group, potentially causing biased estimates.

To reduce potential selection bias, a multivariate matched sampling methodology without the restrictions and assumptions necessary in regression models is employed on data collected at Oklahoma feeder calf auctions in fall 2010. Matching value-added lots with similar non-value-added lots imitates the random placement of lots of feeder cattle into treatment and control groups and resembles a controlled experiment (Tauer 2009; Gillespie 2012). If placement into the treatment group is random, the treatment is considered independent of covariates (Sekhon 2011) and selection bias is reduced. Using the matching samples method, we can compute 1) the premiums received by adopters of value-added practices, 2) the premiums foregone by non-adopters, and 3) the average premium available to or received by all producers. Using matched methods, lots of calves that are similar except for one characteristic (or a set of characteristics) are matched.

Treatment lots, possessing some trait, are then directly compared to matching control lots lacking the trait under consideration. This direct comparison allows for the estimation of treatment effects as if a controlled experiment had been conducted, whereas a hedonic pricing model groups all observations together and parameter estimates are estimated by minimizing error across the entire dataset.

Producers who would receive the highest premiums for adopting a value-added management practice are expected to select into the treatment group. As a result, lots of cattle in the treatment group are expected to receive higher premiums for adoption than the premiums foregone by non-adoption by those in the control group.

Methods

The focus of this paper is to find the premiums associated with the management practices required for cattle to be OQBN certified while accounting for potential presence bias resulting from self-selection and misspecification found in hedonic pricing models. To qualify for OQBN certification, calves must be dehorned, weaned a minimum of 45 days, vaccinated, dewormed, and bull calves must be castrated (OQBN 2012). Using the matched samples approach calves with a trait are assigned to the treatment group (T_i = 1) and calves without the trait are assigned to the control (T_i = 0). Then, the basis for lot *i* is defined as $Y_i(T_i)$, where

$$Y_i(T_i) = \begin{cases} Y_i(0) \text{if } T_i = 0; \\ Y_i(1) \text{if } T_i = 1. \end{cases} \quad (2.1)$$

The basis for each lot is calculated as the difference between the sale price of the lot of calves and the weekly Oklahoma City price for a 750lb steer (USDA-AMS 2010.)

Several matching methods have been proposed in past literature. Exact matching occurs when treatments and controls are matched exactly on ***X*** where ***X*** is a vector of traits shared by both control and treatment observations. However, two types of exact matching can occur: complete and incomplete matching on $\boldsymbol{X}$ (Rosenbaum and Rubin 1985a). Complete matching occurs when all treated lots are matched with a control lot with exactly the same values for $\boldsymbol{X}$, while incomplete matching occurs when a subset of the treatments are matched with controls and the remainder of the observations are discarded (Rosenbaum and Rubin 1985a). Rosenbaum and Rubin (1985a) show that omitting observations in incomplete exact matching introduces severe bias in estimating treatment effects. Unfortunately, exact matches do not exist for all treatment lots, eliminating the possibility of using an exact matching method. To correct for these problems, Rosenbaum and Rubin (1983), propose a propensity score that increases the balance (the similarity between the distribution of $\boldsymbol{X}$ in the control and treatment groups) by estimating a propensity score for each observation and then matching on that propensity score. Most propensity scores are found using a logistic regression where T is the dependent variable and $\boldsymbol{X}$ are independent variables. The propensity score is calculated as:

$$P(T = 1|\boldsymbol{X}) = \frac{e^{F(\boldsymbol{X})}}{1 - e^{F(\boldsymbol{X})}} \tag{2.2}$$

where the propensity score $P(T = 1|\boldsymbol{X})$ is the probability that T equals one given $\boldsymbol{X}$ and $F(\boldsymbol{X})$ is a function of the explanatory variables such as the observable traits of feeder cattle. In our model,

$$F(\boldsymbol{X}) = \beta_0 + \beta_1 head + \beta_2 head^2 + \beta_3 avgwt + \beta_4 avgwt^2 + \beta_5 wean$$
$$+ \beta_6 vac + \sum_{i=1}^{7} \beta_{6+i}\, color_i + \beta_{13} Brahman$$
$$+ \sum_{j=1}^{2} \beta_{13+j}\, flesh_j + \sum_{k=1}^{2} \beta_{15+k}\, gender_k + \beta_{18} horns \tag{2.3}$$
$$+ \sum_{l=1}^{2} \beta_{18+l}\, fill_l + \beta_{21}\, Health\,.$$

This model is derived from Williams et al. (2012a). The difference is that Williams et al. (2012a) use the equation on the right-hand-side of (2.3) to directly estimate feeder cattle basis. Here, $F(\boldsymbol{X})$ is a logit model of the probability that a given lot is in the treatment group. In (2.3), *head* is the number of head in the lot (the observational unit), *avgwt* is the average weight of calves in the lot, *wean* is a binary variable equal to one if calves are weaned and zero otherwise, *vac* is a binary variable equal to one if calves are vaccinated and zero otherwise, *Brahman* is a binary variable equal to one if calves have Brahman influence and zero otherwise, $flesh_j$ are binary variables indicating calves' average condition score, $gender_k$ are binary variables indicating calves' gender , *horns* is a binary variable equal to one if horns are present and zero otherwise, $fill_l$ are binary variables indicating average gut fill, and *health* is a binary variable equal to one if healthy and zero otherwise. Our model follows Williams et al. (2012a) closely to enable direct comparison to their hedonic model results.

One of the more common methods of matching in the statistics field is the nearest-neighbor method. The nearest-neighbor method minimizes

$$C(i) = \min_j \|p_i - p_j\| \tag{2.4}$$

where $C(i)$ is the set of controls matched to treated lot i, p_i is the propensity score for treated lot i, and p_j is the propensity score for control lot *j* (Becker and Ichino 2002). The matches are found using the statistical program Stata (Statacorp 2009).

To estimate the treatment effects, assignment to the treatment group is assumed to be unconfounded. That is,

$$\{Y(0), Y(1) \perp T\}|\boldsymbol{X}. \tag{2.5}$$

In other words, selection into the treatment and control group is random given observable covariates $\boldsymbol{X}$. Because the treatment of each lot is independent of $\boldsymbol{X}$, the estimated treatment effects are unbiased.

The matched pairs are used to find the treatment effect of the management practice. Following Sekhon (2011), the average treatment effect (ATE) is

$$\text{ATE} = E(Y_i(1)|T_i = 1) - E(Y_i(0)|T_i = 0) \tag{2.6}$$

where $E(Y_i(1)|T_i = 1)$ is the expected premium for observation *i* given that the feeder calves in that lot have the characteristic of interest and $E(Y_i(0)|T_i = 0)$ is the expected premium for observation *i* given that the feeder calves in that lot lack the characteristic of interest.

Equivalent to the marginal effect in a hedonic model, the ATE is the treatment effect for all observations. However, because of the possibility of self-selection by producers into a certification program or other treatment, the outcome may differ between those in treatment and control groups (Sekhon 2011). The average treatment effect for the treated (ATT) yields the premium received by producers who adopt a management practice (or the discount if they had not implemented the practice.) The average treatment effect for the control (ATC) is the premium non-adopters would have received had they adopted a management practice. To find the treatment effect for each group, ATT is calculated as:

$$\text{ATT} = E(Y_i(1)|T_i = 1) - E(Y_i(0)|T_i = 1) \quad (2.7)$$

and ATC is:

$$\text{ATC} = E(Y_i(1)|T_i = 0) - E(Y_i(0)|T_i = 0) \quad (2.8)$$

where $E(Y_i(0)|T_i = 1)$ is the expected premium for those in the control group given that the feeder calves in that lot lack the characteristic of interest and $E(Y_i(1)|T_i = 0)$ is the expected premium for those in the treatment group given that the feeder calves in that lot have the characteristic of interest. However, $E(Y_i(0)|T_i = 1)$ and $E(Y_i(1)|T_i = 0)$ are not observed in the data and equations (2.7) and (2.8) cannot be directly estimated (Sekhon 2011).

Heckman et al. (1998) describe an alternative way of calculating ATT that is conditional on the characteristics, $\boldsymbol{X}$. Assuming that (2.5) holds, Heckman et al. (1998) rewrite (2.7) as:

$$\text{ATT} = E(Y_i(1)|\boldsymbol{X}, T_i = 1) - E(Y_i(0)|\boldsymbol{X}, T_i = 1) \quad (2.9)$$

where $E(Y_i(1)|\boldsymbol{X}, T_i = 1)$ is the expected premium for those in the treatment group given a set of characteristics **X** and treatment T=1 and $E(Y_i(0)|\boldsymbol{X}, T_i = 1)$ is the expected premium for those in the control group given a set of characteristics $\boldsymbol{X}$ and treatment T=1.

Following Heckman et al. (1998), ATC can be rewritten as:

$$\text{ATC} = E(Y_i(1)|\boldsymbol{X}, T_i = 0) - E(Y_i(0)|\boldsymbol{X}, T_i = 0) \quad (2.10)$$

where $E(Y_i(1)|\boldsymbol{X}, T_i = 0)$is the expected premium for those in the treatment group given a set of characteristics $\boldsymbol{X}$ and treatment T=0 and $E(Y_i(0)|\boldsymbol{X}, T_i = 0)$ is the expected premium for those in the control group given a set of characteristics $\boldsymbol{X}$ and treatment T=0.

Imperfect matches can result in a biased estimated treatment effect. For example, research has shown that buyers will pay a premium for larger lots holding everything else constant. If a lot of 2 calves is matched with a lot of 20 calves, the resulting treatment effect will be biased. Bias is removed using a regression adjustment as proposed by Rubin (1979). Following Tauer (2009), we define the regression function for bias adjustment as:

$$\hat{\mu}_T(\boldsymbol{X}) = \hat{\alpha}_{T0} + \hat{\alpha}_{T1}\boldsymbol{X} \tag{2.11}$$

where $\hat{\mu}_T(\boldsymbol{X})$ is the estimated basis for treatment T given characteristics $\boldsymbol{X}$, and $\hat{\alpha}_{T0}$ and $\hat{\boldsymbol{\alpha}}_{\boldsymbol{T1}}$ are the parameters estimated from the least squares regression. Equation (2.11) is then used to predict the estimated outcome as:

$$\tilde{Y}_i(0) = \begin{cases} Y_i & \text{if } T_i = 0; \\ \dfrac{1}{N}\sum_{j \in N} Y_j + \hat{\mu}_0(\boldsymbol{X_i}) - \hat{\mu}_0(\boldsymbol{X_j}) & \text{if } T_i = 1 \end{cases} \tag{2.12}$$

and

$$\tilde{Y}_i(1) = \begin{cases} \dfrac{1}{N}\sum_{j \in N} Y_j + \hat{\mu}_1(\boldsymbol{X_i}) - \hat{\mu}_1(\boldsymbol{X_j}) & \text{if } T_i = 0; \\ Y_i & \text{if } T_i = 1 \end{cases} \tag{2.13}$$

where $\tilde{Y}_i(0)$ is the estimated basis for lots in the control group, $\tilde{Y}_i(1)$ is the estimated basis for lots in the treatment group, $\hat{\mu}_1(\boldsymbol{X})$ is the estimated premium for the treatment group given characteristics $\boldsymbol{X}$**,** $\hat{\mu}_0(\boldsymbol{X})$ is the estimated basis for the control group given characteristics $\boldsymbol{X}$**,** N is the total number of matches, Y_j is the reported basis for observation

j, and observation j is a subset of observations only in the control group in (2.13) and only in the treatment group in (2.12.)

The estimated outcomes from (2.12) and (2.13) are then used to rewrite the estimator for ATE as

$$\text{ATE} = E\big(\tilde{Y}_i(1)\big|T_i = 1\big) - E\big(\tilde{Y}_i(0)\big|T_i = 0\big). \quad (2.14)$$

The regression adjusted estimator for ATT is

$$\text{ATT} = E\big(\tilde{Y}_i(1)\big|\boldsymbol{X}, T_i = 1\big) - E\big(\tilde{Y}_i(0)\big|\boldsymbol{X}, T_i = 1\big) \quad (2.15)$$

and the regression adjusted estimator for ATC is

$$\text{ATC} = E\big(\tilde{Y}_i(1)\big|\boldsymbol{X}, T_i = 0\big) - E\big(\tilde{Y}_i(0)\big|\boldsymbol{X}, T_i = 0\big). \quad (2.16)$$

After calculating the ATE, ATT, and ATC, a bootstrap is used to estimate the standard errors and p-values.

Data

Data were collected at 16 feeder cattle auctions from October through December 2010. The data include 2,973 lots consisting of 22,363 head of cattle (Williams et al. 2012a). Eight auctions included OQBN cattle, with two comprised entirely of OQBN cattle (Williams et al. 2012a). The OQBN certification program certifies that calves have participated in a preconditioning program in which calves are vaccinated, dehorned, and castrated, in addition to being weaned for a minimum of 45 days. Information on price, lot size, management practices, and phenotype was collected for each lot of cattle. Phenotypic (physically observable) characteristics include per-animal weight, hide color, fleshiness, gender, frame score, uniformity, health, horns, muscling, and fill (Williams et al. 2012a). Management practices such as vaccinations, weaning, certification from a preconditioning program, and age and source verification were also collected. Additional data collected include sale location and time, and whether seller identification is announced. To maintain consistency, all data were collected by five individuals trained by United States Department of Agriculture (USDA) Agriculture Marketing Service (AMS) professionals (Williams et al. 2012a). To account for cattle price variation over time, a basis is calculated as the difference between the sale price of each lot and the weekly average Oklahoma City price for a 750-pound steer (USDA-AMS 2010).

Observations with a mean lot weight of less than 300 pounds or greater than 800 pounds are removed. Observations that have missing data or recording errors are also removed from the dataset. The final dataset consists of 2,762 observations, including 816 OQBN certified lots and 1,946 uncertified lots.

The summary statistics for all lots, OQBN certified lots only, and non-certified lots only are shown in Table II-1. The characteristics between groups have only a few minor differences. The mean lot size is slightly larger in OQBN certified lots with nearly nine head compared to 7.48 in uncertified lots. All calves in certified lots are weaned, vaccinated, and dehorned while 51 percent are weaned and 20 percent are vaccinated in uncertified lots.

Lots containing calves with at least some black make up 77 percent of the certified lots while 69 percent of uncertified lots have at least some black calves in them. The distribution of other hide colors is similar between groups. Calves in the certified group tend to have higher body condition scores than those in the uncertified group. One percent of calves in the certified group are classified as thin compared to three percent of calves in the uncertified group. Conversely, 36 percent of calves in the certified group are classified as fleshy compared to 27 percent in the uncertified group.

Data from one of the sale barns creates a modeling challenge. In one sale barn, OQBN calves are comingled. That is, OQBN calves from two or more producers are sorted into relatively homogeneous, in terms of size and breed, lots of cattle. This is the only sale barn with comingled sales. The modeling challenge is that there is no set of matching cattle for this barn. Specifically, there are no non-OQBN calves at that sale barn that are comingled. So, if a comingled variable is included, there are no matches for the OQBN calves from that barn. Since comingling reduces the value of lots of calves, this has the effect of biasing downward the estimated value of OQBN calves for our data. The alternative, omitting these calves from the data, results in the loss of valuable information. We chose to use the observations, ignoring comingling effects, and note that our results conservatively estimate the value of certification in the OQBN program.

Results

Results for the logistic regression used to calculate the propensity score are presented in Table II-2. When OQBN certification is the dependent variable, few parameter estimates are statistically significant, although the number of head and its square are both statistically significant. The parameter estimate for Brahman influence and the indicator variable for calves that appear to be full are also statistically significant. All other parameters are not statistically significant. The nearest-neighbor matching method uses the propensity to create matches between the treatment group and the control group.

Table II-3 presents the average treatment effects from the matching procedure. The average treatment effect (ATE) of certification is \$5.25/cwt ($p \leq 0.001$). This greater than the range of -\$0.52/cwt for 650lb calves to \$2.81/cwt for 350lb calves found by

Williams et al. (2012a), toward the high end of the range for certification premiums of $1.51/cwt to $5.89/cwt found by Ward et al. (2003) and higher than the range of $1.47 to $4.32 found by Zimmerman et al. (2012). The average treatment effect for the treated (ATT) when the treatment is certification is $5.38/cwt ($p \leq 0.001$). Conversely, the average treatment effect for controls (ATC) (calves that are not certified) is $5.17 and is statistically significant ($p \leq 0.001$). In other words, producers who do not have a third party certify their calves would gain $3.00/cwt more by certifying their calves in the OQBN program, assuming they have already met all of the qualifications. This provides evidence supporting our hypothesis that producers who receive the highest premiums self-select into the OQBN certification program.

The ATE for weaning calves is $5.23/cwt ($p \leq 0.001$). This is greater than the statistically significant premium found by Williams et al. (2012a) of $2.05/cwt and the $4.50/cwt premium for weaning found by Zimmerman et al. (2012). The ATT for weaning is $4.93/cwt ($p \leq 0.001$) and the ATC for weaning is $5.804/cwt ($p \leq 0.001$). The treatment effects for weaning indicate that producers who do not currently wean their calves would receive the highest premium if they had chosen to wean.

The ATE for vaccinating calves is $6.785 ($p \leq 0.001$), the ATT for vaccinating calves is $5.40/cwt ($p \leq 0.001$), and the ATC for vaccinating calves is $8.02/cwt ($p=0.001$). Each of these premiums is greater than the premium of $1.44/cwt ($p=0.05$) for vaccinating reported by Williams et al. (2012a) and $1.68/cwt ($p=0.10$) for one vaccination reported by Zimmerman et al. (2012). The ATE for calves that have been dehorned is $5.26/cwt ($p=0.001$), greater than the premium of $3.15/cwt ($p \leq 0.001$) reported by Williams et al. (2012a), $1.70 found by Bulut and Lawrence (2006) and

$0.04 to $1.61 found by Zimmerman et al. (2012). The ATT for dehorning is $5.36/cwt (p=0.02) and the ATC for dehorning is $3.77/cwt (p=0.037).

Conclusions

Hedonic pricing models are a common method for investigating the contribution of various characteristics to the price of a product. However, hedonic models do not account for selection bias and are subject to misspecification. We utilize an alternative method that is not subject to misspecification and reduces selection bias. A matched sampling method is employed to find the premium for OQBN certifying, weaning, vaccinating, dehorning, and castrating calves. Observations from the treatment group are matched with observations from the control group using a nearest-neighbor matching method. The average treatment effect (ATE), average treatment effect for the treated (ATT), and the average treatment effect for the control (ATC) are each calculated from the matches and are corrected for bias using a linear regression. To compare to previous research, ATE is directly comparable to marginal effects from hedonic models.

Results show a certification premium of $5.25/cwt for ATE, $5.38/cwt for ATT, and $5.17/cwt for ATC. The ATE is higher than the range of -$0.52/cwt to $2.81/cwt reported by Williams et al. (2012a) and within the range of $1.47 to $4.32 found by Zimmerman et al. (2012). The large discrepancy between the results in this paper and results reported by Williams et al. (2012a) despite using the same dataset suggests that bias may exist. It appears that OQBN program participants have predetermined whether or not they will receive premiums for weaning and respond accordingly to market incentives.

An ATE of $5.23/cwt for weaning suggests that buyers value weaned calves more than previous research has indicated. For example, Zimmerman et al. (2012) reports a value of $3.47/cwt and Williams et al. (2012a) report a value of $2.05/cwt. The ATT for weaning is $4.93/cwt and the ATC for weaning is $5.80/cwt. While inconsistent with our expectations, the difference between the ATT and the ATC for weaning suggests that although they would receive a higher premium, the opportunity cost outweighs the benefits of weaning for producers in the control group. For example, some producers may have an off-farm income source that increases the opportunity cost of time. Rather than allocate additional time, hay, or pasture to weaning calves, it may be more profitable to allocate those resources to a larger herd. Another reason producers in the control group might elect to forgo additional premium is that they may have crops as well. Crops are typically planted in Oklahoma in September and October, which is the same time many producers choose to wean calves. The high opportunity cost of delaying planting may cause producers with both cattle and crops to sell calves without weaning them.

Estimates for ATE of $6.79/cwt for vaccinating is larger than the $1.44/cwt found by Williams et al. (2012a) and $1.68/cwt found by Zimmerman et al. (2012). We find an ATE of $5.26/cwt for dehorning calves, higher than the premium of $3.15/cwt found by Williams et al. (2012a). The ATT for vaccinating calves is $5.40/cwt and the ATC for vaccinating calves is $8.02/cwt. The ATT and ATC for vaccinating are inconsistent with our expectation that adopters will receive higher premiums. Similar to the premiums to weaning, this inconsistency is likely explained by the opportunity cost. For spring born calves, vaccinations are typically applied in September or October, falling during Oklahoma's planting season. The ATT for dehorning is $5.36/cwt and the ATC for dehorning is $3.77/cwt while Bulut and Lawrence (2006) estimate a premium of $1.70/cwt. The ATT and ATC for dehorning are consistent with expectations that producers have predetermined their premiums and self-select in to the treatment group. Both these practices are confirmed to add value to calves marketed through sale barns, however the premiums are higher in this research than in previous research. Higher estimates for vaccinating and weaning suggest that estimates from hedonic models may be biased downward.

We find that in general, producers who do not wean and/or vaccinate their calves are those who would benefit the most by changing their management practices. While producers who currently implement these practices receive a premium for each practice implemented, the premium is not as high as the potential premium received by non-adopters and sometimes not as high as previous research suggests. One explanation for this difference is that producers who wean and/or vaccinate their calves may already have a reputation that is not measured in the data. Producers who have already developed a reputation are more likely to have adopted many of the value-added management practices and are already receiving a premium.

This research not only estimates value-added premiums for all producers, but also estimates premiums for two sub-groups of producers: adopters and non-adopters. Our results suggest that cow-calf producers from all groups gain additional revenue by participating in the OQBN certification program. With a $5.17/cwt certification premium for non-adopters and an average weight of 525 pounds, uncertified producers would gain an extra $27.14 per head in revenue just by certifying their calves in the OQBN certification program. This is in addition to the premiums for weaning, vaccinating, and castrating as part of the requirement for OQBN certification. One reason for non-adoption is that the opportunity cost of certification outweighs the benefit. Some producers have off-farm jobs or other activities and simply do not have the time to invest in certifying cattle. Others may have crops that need planting at the same time value-added management practices should be adopted. Scarce resources may instead be allocated toward increasing herd size. Each of these potentially increases the opportunity cost of adoption. This presents an opportunity for Extension personnel to design ways to reduce the opportunity cost of certification and increase the adoption rates of value-added practices. Increasing adoption rates of value-added practices increases revenue for cow-calf producers and ensures a larger supply of cattle with characteristics that buyers prefer, resulting in a beneficial outcome for both buyers and sellers.

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Table II-1. Summary Statistics

Variable	All Lots Mean	All Lots Standard Deviation	Certified Lots Only Mean	Certified Lots Only Standard Deviation	Uncertified Lots Only Mean	Uncertified Lots Only Standard Deviation
Lot size	7.89	13.84	8.88	11.87	7.48	14.57
Average weight (cwt)	5.31	1.17	5.44	1.15	5.25	1.18
Certified	0.30	0.46	1.00	0.00	0.00	0.00
Weaned	0.66	0.48	1.00	0.00	0.51	0.50
Vaccinated	0.44	0.50	1.00	0.00	0.20	0.40
Dehorned	0.94	0.24	1.00	0.00	0.91	0.29
Brahman influence	0.07	0.25	0.09	0.28	0.06	0.24
Healthy	0.99	0.09	0.99	0.08	0.99	0.09
Color						
Black	0.72	0.45	0.77	0.42	0.69	0.46
Mixed	0.06	0.25	0.06	0.24	0.07	0.25
Red	0.08	0.27	0.06	0.25	0.08	0.27
Red mixed	0.02	0.15	0.02	0.15	0.02	0.15
Hereford	0.02	0.13	0.01	0.12	0.02	0.14
Dairy	0.01	0.11	0.00	0.06	0.02	0.13
White	0.08	0.27	0.06	0.23	0.09	0.29
Other	0.01	0.09	0.00	0.06	0.01	0.10
Flesh						
Average	0.68	0.47	0.63	0.48	0.70	0.46
Thin	0.02	0.15	0.01	0.09	0.03	0.17
Fleshy	0.30	0.46	0.36	0.48	0.27	0.44
Steers	0.51	0.50	0.58	0.49	0.48	0.50
Heifers	0.44	0.50	0.42	0.49	0.45	0.50
Bulls and/or Mixed	0.04	0.21	0.00	0.00	0.06	0.24
Fill						
Average	0.81	0.39	0.82	0.38	0.81	0.39
Gaunt	0.01	0.09	0.00	0.05	0.01	0.10
Full	0.18	0.38	0.18	0.38	0.18	0.38

Table II-2. Logistic Regression Results for Determining the Propensity Score Where Certification is the Dependent Variable

Variable	Parameter Estimate	Standard Error	p-value
Intercept	88.04	2880.00	0.98
Lot size	0.05	0.01	≤0.01
Lot size squared	0.00	0.00	0.04
Average weight	-0.82	0.56	0.14
Average weight squared	0.09	0.05	0.08
Weaned	16.75	740.30	0.98
Vaccinated	33.31	770.70	0.97
Dehorned	10.97	1744.00	0.99
Brahman Influence	1.45	0.41	≤0.01
Healthy	1.27	0.79	0.11
Color			
Black	1.33	0.95	0.16
Mixed	0.97	0.98	0.32
Red	0.64	0.97	0.51
Red Mixed	0.79	1.02	0.44
Hereford	0.17	620.10	0.98
Dairy	0.17	1103.00	0.99
White	0.67	0.98	0.49
Flesh			
Thin	0.26	0.84	0.76
Fleshy	0.14	0.17	0.40
Steers	18.86	2027.00	0.99
Heifers	18.80	2027.00	0.99
Fill			
Gaunt	14.46	935.50	0.99
Full	-0.42	0.19	0.03

Table II-3. Impact of Various Practices on Premiums Received by Producers Using a Nearest-Neighbor Matching Method ($/cwt)

	Average Treatment Effect[a]		Average Treatment Effect for Treated[b]		Average Treatment Effect for the Control[c]	
Treatment	Premium	p-value	Premium	p-value	Premium	p-value
OQBN Certification	5.248	≤0.001	5.379	≤0.001	5.168	≤0.001
Weaned Calves	5.234	≤0.001	4.925	≤0.001	5.804	≤0.001
Vaccinated Calves	6.785	≤0.001	5.400	≤0.001	8.024	≤0.001
Dehorned	5.262	0.001	5.362	0.020	3.773	0.037

[a] The ATE is the treatment effect for all observations and is equivalent to the marginal effect in a hedonic model.
[b] The average treatment effect for the treated (ATT) yields the premium received by producers who adopt a management practice (or the discount if they had not implemented the practice.) .
[c] The average treatment effect for the control (ATC) is the premium non-adopters would have received had they adopted a management practice.

CHAPTER III

THE LIKELIHOOD OF POSITIVE RETURNS FROM VALUE-ADDED CALF MANAGEMENT PRACTICES

Introduction

For several years, Extension faculty have been educating cow-calf producers about value-added calf management programs and the premiums available at auction from these management practices. However, adoption rates remain low. McKinney (2009) reports that 12 percent of Oklahoma producers participate in formal value-added production and marketing practices such as age and source verification. Williams et al. (2012a) report that 41% of Oklahoma producers are weaning calves, 35% are vaccinating calves, and 14% enroll their calves in a certified vac-45 program[3]. Anecdotally, producers express doubts regarding the likelihood of premiums and the profitability of each practice as each practice has some producer-incurred cost associated with it. Researchers and Extension faculty have typically taken two approaches to educate cow-calf producers about value-added marketing opportunities: reporting sale premiums and developing partial budgets. Schroeder et al. (1988) are among the first to estimate sale premiums for cattle characteristics such as health, body condition, fill, and muscling using a hedonic pricing model. Similarly, Coatney et al. (1996) implement a system of hedonic equations to

[3] A certified vac-45 program requires calves to be weaned a minimum of 45 days, vaccinated, dehorned, wormed, and bull calves must be castrated.

estimate the value of cattle characteristics. However, many of the characteristics reported by Schroeder et al. (1988) and Coatney et al. (1996) involve an animal's current state of health or are influenced by long-term management decisions such as frame size, muscling, and breed.

More recently, researchers have evaluated sale premiums for value-added management practices. For example, Avent et al. (2004) estimate the value of calves that are certified, weaned, and vaccinated, but do not report the individual premium for certification. Hedonic price modeling is the favored approach to estimating the marginal price impacts of individual value-added practices. For example, King et al. (2006) estimate a hedonic model using data from Superior Livestock Auctions from 1995 to 2005 to evaluate the value of preconditioning programs, vaccinations, and other characteristics. Blank et al. (2009) also estimate a hedonic pricing model to determine premiums for various management practices using data from Western Video Market. More recently, Zimmerman et al. (2012) and Williams et al. (2012c) employ hedonic pricing models. Zimmerman et al. (2012) investigate the value of vaccinations, presence of horns, and breed using data from the years 2001-2010 at Superior Livestock auctions. Similarly, Williams et al. (2012c) consider the marginal value of vaccinations, weaning, certification, and other value-added characteristics at value-added and traditional auctions in Oklahoma using a hedonic pricing model. Finally, Williams et al. (2012b) estimate value-added premiums for both adopters and non-adopters utilizing a matching-pairs methodology. Williams et al. (2012b) explain that latent variables such as producer education, management ability, or off-farm income may bias results of hedonic pricing models. Williams et al. (2012b) propose a matched-pairs method to correct for selection bias. A matched-pairs estimation technique results in three estimates: an average treatment effects for all producers, (ATE), for adopters of the value added management practices, (ATT), and for non-adopters, (ATC).

Other researchers have weighed the premiums received for preconditioning and other value-added management practices against the costs of implementing these practices using a partial budgeting approach. Bulut and Lawrence (2006) estimate the value of calves that are certified, weaned for 30 days, and vaccinated and compare the added revenue to the costs. Lalman and Smith (2001), Dhuyvetter et al. (2005), and Dhuyvetter (2010) all compare the premium received for preconditioning calves to the added revenue to the cost of preconditioning. Lalman and Smith (2001), Dhuyvetter et al. (2005), Bulut and Lawrence (2006), and Dhuyvetter (2010) each focus on the net returns of a preconditioning program, but do not examine the profitability of individual practices or bundles of practices.

This past research demonstrates that cow-calf producers have an abundance of opportunities to add value to their calves. However, despite the efforts of Extension faculty, few producers participate in value-added production practices. Cow-calf producers are typically risk averse (Fausti and Gillespie 2006). Pope et al. (2011) find that as risk aversion increases, producers are less likely to retain calves past weaning. One explanation for this behavior is that cow-calf producers commonly reduce risk by practicing low-cost production methods (Hall et al. 2003). In other words, producers are willing to forgo additional profits in favor of lowering production costs.

With the abundance of opportunities available for cow-calf producers to increase revenues, research that goes beyond the traditional approach of reporting premiums and budgeted profits is needed to encourage risk-averse producers to adopt value-added management practices. Risk-averse cow-calf producers often question how many of their peers receive premiums for value-added practices and how often they would at least break-even by implementing a set of management practices. This paper investigates the likelihood of profit generation using individual value-added practices and bundles of practices.

Methods and Data

The probability of receiving a positive return from a value-added management practice is one minus the cumulative density function (CDF) of net return evaluated at zero. Assuming return is normally distributed, the probability of receiving a positive return from adopting a practice is defined as:

$$P(Return_i \geq 0) = 1 - F(x_i) \quad (3.1)$$

where $F(x_i)$ is the cumulative density function of the premium or net return for implementing the value-added management practice or bundle of practices *i*. Expected or average net return is calculated using a partial budget for each management practice or bundle of practices and the marginal price impact of each value-added practice or bundle of practices The marginal price impact of each value-added practice or bundle of practices is re-estimated using matching sample methods similar to Williams et al. (2012b). These values are used to generate point (mean) estimates of the per head net returns from individual value-added practices.

Additionally, the impacts of bundles of practices on the distributions of net returns are considered. The model from Williams et al. (2012b) is reformulated to estimate the marginal impacts of simultaneously adopting two or more practices.

Parameter estimates and their standard errors for each value-added management practice/bundle as estimated by Williams et al. (2012b) are estimates for the average treatment effect over all producers rather than for individual producers. For this reason, any probability calculated using equation (3.1) results in the probability that the mean return for adoption over all individuals is greater than zero. Rather, the focus of this paper is to estimate the probability that an individual producer will receive positive net returns. This is done using a nonparametric method.

Partial budgets are developed for individual pairs matched using methods described by Williams et al. (2012b). Three sets of matched-pairs are used: matches used for calculating the average treatment effect for all producers (ATE), matches used for calculating the average treatment effect for adopters (ATT), and matches used for calculating the average treatment effect for non-adopters (ATC). The mean net return is calculated as the average over all producers in each group. To estimate the cumulative density functions of returns and premiums for each practice (or bundle of practices), a non-parametric approach is employed. For each match pair of lots, the model adds up the number of times that the value-added lot received a higher price than its non-value-added matched lot. Similarly, the returns to cow-calf expenses of the two matched lots are compared.

The probability of an individual producer receiving a positive is then calculated as

$$\frac{\#\ recieving\ positive\ net\ returns}{total\ \#\ of\ matches} \tag{3.2}$$

Similarly, the probability of a producer receiving a positive premium is calculated as:

$$\frac{\#\ recieving\ positive\ premium}{total\ \#\ of\ matches}. \tag{3.3}$$

Probabilities are calculated for three value-added management practices, including weaning, vaccinating, and dehorning, and three bundles of practices, including weaning plus vaccinating, weaning plus vaccinating plus dehorning, and a vac-45 preconditioning program consisting of a 45-day preconditioning period, vaccinating, dehorning, and certification.

Data

Data used to create matches include 2,973 lots consisting of 22,363 head of cattle (Williams et al. 2012c). Data were collected at 16 feeder cattle auctions from October through December 2010, eight of which include OQBN cattle and two are comprised entirely of OQBN cattle (Williams et al. 2012c). Information on price, lot size, management practices, and phenotype was collected for each lot of cattle. Producer participation in management practices such as vaccinating, weaning, certification from a preconditioning program, and age and source verification were also collected. To account for cattle price variation over time, a basis is calculated as the difference between the sale price of each lot and the weekly average Oklahoma City price for a 750-pound steer (USDA-AMS 2010). Observations with a mean lot weight of less than 300 pounds or greater than 800 pounds, observations with missing data, and observations with recording errors are removed from the dataset. The final dataset consists of 2,762 observations, including 816 OQBN certified lots and 1,946 uncertified lots (Williams et al. 2012b).

Revenue

Two revenues are calculated: A baseline revenue and a management revenue. The baseline revenue is the revenue received by the non-adopters and computed as price times the observed weight. The price used in calculating the baseline income is estimated as $113.95/cwt plus the basis for that observation plus an adjustment for the difference in weight between the adopter and non-adopter weight estimated by Williams et al. (2012c). The base price adjusted for weight differences between the treated and the control lot is calculated as:

$$Base\ Price = 113.95 + Control\ Basis + \ ((15.77 * (Sale\ Wt - Wt\ Adj) + \ 0.87 * (Sale\ Wt - Wt\ Adj)^2) - (15.77 * (Base\ Wt) + \ 0.87 * (Base\ Wt)^2) \tag{3.4}$$

where $Sale\ Wt$ is the weight of the treated lot when sold, $Base\ Wt$ is the weight of the control lot $Control\ Basis$ is the basis reported for the control group, and $Wt\ Adj$ is defined as:

$$Wt\ Adj = \frac{2lbs}{day} * (\#\ of\ days\ for\ management\ practice). \tag{3.5}$$

An average daily gain of 2 lbs is assumed for both a 45-day preconditioning period (Dhuyvetter 2010) and for a 21-day post-weaning period (Price et al. 2003). The base price of $113.95 is the weekly average price for a 750lb steer in Oklahoma City (USDA-AMS, 2010) averaged over all sale dates in the dataset. The management price is calculated as $113.95 plus the basis for treated observations reported for each lot in the data.

The difference between the baseline and management revenue is compared to the cost of implementing each value-added management practice and the probability that practices, singly and in bundles, generate positive returns is calculated.

Costs

In addition to the estimated revenues, the cost of implementing each value-added management practice or bundle of practices is needed to create a series of partial budgets calculating the expected net return from implementing each management practice. The cost of weaning consists of labor, death loss, interest costs, and feed costs. Because mortality rates peak in the first three weeks after weaning (Kelly and Janzen, 1986), we use a death loss of $1.80 reported by Dhuyvetter et al. (2010) for weaning. Also, following Dhuyvetter (2010), we assume feed costs of $0.85 per day, labor costs of $0.11 per day, and an interest rate of seven percent over a 21-day post-weaning period.

Assuming calves are already rounded up (as they would be for weaning), vaccinating requires running them through a chute and administering the vaccine. Published literature estimating the time required to administer a vaccination is unavailable, but based on the author's experience, vaccinating calves requires an additional 1.5 minutes per head over the time required to corral and sort the calves. Assuming a wage rate of $10/head for workers in the cattle sector in the Southern Plains (USDA NASS 2012), the labor cost for vaccinating is $0.25/head. Research has shown that vaccinating calves does not adversely affect death loss (Thurber et al. 1977), so no death loss is assumed for vaccinations. There is an $8.00/head (Lalman and Smith 2001) charge for the vaccination and supplies. The total cost of vaccinating is $8.25 per head, consistent with the cost reported by Donnell et al. (2008).

To minimize stress, infections, and weight loss, Hopkins et al. (2009) recommend dehorning calves early, preferably before one month of age. While no published estimates are available breaking down the cost components of dehorning, Rhinehart (2009) and Hopkins et al. (2009) both estimate the total cost of dehorning a calf at a young age to be

$5/head. For ease of calculating, the entire cost of dehorning is categorized under the cost for supplies and medical costs.

In addition to calculating the individual costs for weaning, vaccinating, and dehorning, we also calculate the cumulative cost of 1) weaning and vaccinating; 2) weaning, vaccinating, and dehorning; and 3) a certified vac-45 program consisting of weaning, vaccinating, dehorning, a 45-day preconditioning period, and certification. The cost for weaning and vaccinating together includes the cumulative costs for supplies and labor. The cost of rounding up and sorting calves is not included because calves must be corralled and sorted to be sold regardless of whether they are vaccinated. The combined cost for weaning, vaccinating, and dehorning has a cumulative supplies and medical cost of $13.00/head from the vaccination and dehorning costs described above and a death loss of $1.80/head reported by Dhuyvetter (2010). A labor cost of $2.56/head includes the marginal cost of $0.25/head vaccinating described above plus $0.11/head/day for post-weaning care.

We follow Dhuyvetter (2010) in calculating the cost for a certified vac-45 preconditioning program. Because producers already have the facilities required to precondition calves, facilities costs are subtracted from Dhuyvetter's total and an adjustment is made to the interest cost according to calf weight. Dhuyvetter's budget was constructed at approximately the same time data for this research was collected and represents an accurate approximation of costs for the time period and location, so no other changes are made.

Example budgets for premiums estimated using a matched-pairs method are presented in tables III-1, III-2, and III-3 and assume a mean sale weight of 529lbs from the dataset used by Williams et al. (2012b).

Results

Table III-4 displays ATE, ATT, and ATC for individual value-added management practices and bundles of practices estimated using a nearest-neighbor matching method. As reported by Williams et al. (2012b), the individual average treatment effects (ATE) for weaning, vaccinating, and dehorning are $5.23/cwt, $6.79/cwt, and $5.26/cwt, respectively. The average treatment effect for the treatment group (ATT) for weaning, vaccinating, and dehorning reported by Williams et al. (2012b) are $4.93/cwt, $5.40/cwt, and $5.36/cwt, respectively. Williams et al. (2012b) report the average treatments for control groups (ATC) for weaning as $5.80/cwt, for vaccinating as $8.02/cwt, and for dehorning as $3.77/cwt.

When estimated as a bundle of value-added characteristics, the ATE for weaning and vaccinating together is $4.86/cwt, the ATT for weaning and vaccinating together is $5.25/cwt and the ATC for weaning and vaccinating together is $4.42/cwt. Each of these values is less than the sum of the individual premiums for weaning and vaccinating, indicating sub-additivity in premiums. The ATE for weaning, vaccinating, and dehorning as a bundle is $8.78, the ATT is $8.65, and the ATC for weaning, vaccinating, and dehorning is $9.07. The ATE, ATT, and ATC for weaning, vaccinating, and dehorning together are sub-additive as well. The ATE for certification, weaning, vaccinating, and dehorning together is $12.46, the ATT is $12.59, and the ATC is $11.26.

Table III-5 presents the mean difference in basis between matched pairs and the probability that an individual producer will receive a positive premium. The mean calculated ATE for weaning is $5.13 and is positive 59% of the time. The mean calculated ATT is $4.93 the ATC is $5.40 with probabilities of a positive premium 58% and 59% of the time respectively. These results are similar to the results reported in table III-4, with the difference attributed to an adjustment for differences in weight. The mean calculated ATE for vaccinating is $6.01/cwt, $5.48/cwt for ATT, and $6.56/cwt for ATC with probabilities of 64%, 63%, and 65%, respectively. Similarly, the mean calculated ATE for calves without horns is $6.31/cwt, the calculated ATT is $6.49/cwt, and the calculated ATC is $4.84/cwt with probabilities of 0.59, 0.60, and 0.57. The calculated ATE for weaning and vaccinating together is $5.36/cwt, the calculated ATT is $5.62/cwt, and the calculated ATC is $5.07/cwt with probabilities of 58%, 59%, and 58%. Weaning, vaccinating, and dehorning together results in a calculated ATE of $10.98/cwt, a calculated ATT of $10.86/cwt, and a calculated ATC of $11.25/cwt and probabilities of receiving positive premiums of 67%, 67%, and 87%, respectively. The calculated ATE for a vac-45 program is $12.90/cwt with a probability of a positive premium of 79%, the ATT is $12.98/cwt with a probability of a positive premium of 80%, and the ATC is $12.58 with a probability of a positive premium of 77%.

The expected net returns and the associated probability of receiving positive net returns are reported in Table III-6. The mean net return for weaning calves is $31.14/head using an ATE, $24.62/head using an ATT, and $39.84/head using an ATC, with a probability of positive net returns in 62%, 61%, and 64% of lots, respectively.

The expected net return for vaccinating ranges from $17.17/head using an ATT to $30.18/head using an ATC with a probability of a positive net return between 0.60 and 0.61 for all three estimates. Dehorning calves garners an expected net return of $27.85/head for non-adopters, $15.49/head for adopters, and $16.86/head for all producers, yielding a positive net return 59%, 56%, and 60% of the time, respectively.

Weaning and vaccinating calves results in an expected net return of $28.44/head for the ATE, $20.90/head for the ATC, and $36.88/head for the ATT. Producers who do not currently wean and vaccinate (ATC) will have a positive net return 59% of the time by choosing to wean and vaccinate their calves while those who already wean and vaccinate their calves (ATT) receive a positive net return 60% of the time.

Calves that are weaned, vaccinated, and dehorned have an ATT expected net return of $37.43/head, $49.18/head for the ATE, and $61.85/head for the ATC. The probability a lot receiving a positive net return for weaning, vaccinating, and dehorning is 68% using an ATE, 67% using an ATT, and 88% using an ATC. These results suggest that while all producers benefit, those who do not wean, vaccinate and dehorn their calves are the ones who would receive the highest premium from implementing value-added management practices. Similarly, calves certified in a vac-45 program receive an expected net return of $58.78/head using the ATE. This result is higher than the net return of $47.29 for a 600lb steer found by Bulut and Lawrence (2006) the net return of $14.16 found by Dhuyvetter et al. (2006). Producers who already participate in a vac-45 program receive an expected net return of $58.84/head using the ATT, and producers who do not yet participate will receive an expected net return of $57.76/head if they choose to participate in a vac-45 certification program. Probabilities of positive net returns for a vac-45 program using ATE, ATT, and ATC are 79%, 79%, and 63%, respectively.

Conclusions

Published research extensively explores premiums for value-added management practices as a way for cow-calf producers to increase revenue. Others have created partial budgets incorporating the cost of implementing value-added management practices, but none have accounted for the variation in premiums. Given the uncertainty surrounding premiums and the cost incurred to realize each premium, cow-calf producers often question the profitability of implementing value-added management practices. We employ a matched-pairs estimation approach to estimate the premiums for bundles of value-added management practices and create partial budgets calculating the expected net return of each management practice and bundle of practices. The probabilities for the estimations are calculated using nonparametric techniques with the matched pairs.

Using a matched-pairs method, the average treatment effect (ATE) for weaning and vaccinating is \$4.86/cwt, the average treatment effect for the treated (ATT) for weaning and vaccinating is \$5.25/cwt and the average treatment effect for the controls (ATC) for weaning and vaccinating is \$4.42/cwt. Each estimate for weaning and vaccinating is sub-additive. When estimated as a bundle, the ATE for weaning, vaccinating, and dehorning is \$8.78, the ATT is \$8.65, and the ATC is \$9.07. Compared to the sum of the premiums estimated individually, the ATE, ATT, and ATC for weaning, vaccinating, and dehorning together are sub- additive. The ATE for a certified vac-45 program is \$12.46/cwt, the ATT is \$12.59/cwt, and the ATC is \$11.26/cwt.

Among individual practices, vaccinating has the highest probability of receiving a positive premium with probabilities ranging from 63% for adopters to 65% for non-adopters. The probability of a lot of cattle receiving a positive premium tends to increase with the number of practices adopted. Non-adopters would receive a positive premium for weaning, vaccinating, and dehorning 88% of the time. Adopters are found to receive a positive premium 80% of the time.

Partial budgets are created for each of the matched to calculate the expected net return of implementing each practice and bundle of practices and their associated probabilities. Weaning is found to have an expected net return of $31.14/head using an ATE, $24.62/head using an ATT, and $39.84/head using an ATC. The associated probabilities of a positive net return between 0.61 and 0.64.

We find the expected net return for vaccinating ranges from $17.17/head using the ATT to $30.18/head using the ATC with a probability of a positive net return between 60% and 61%. Dehorning calves yields an expected net return between $15.49/head and $27.85/head with a probability of positive net returns between 56% and 59% of the time, however this estimate is low because some producers have polled calves and will not incur the additional cost of dehorning.

Weaning and vaccinating results in an expected net return between $20.90/head and $36.88/head with probabilities of receiving a positive net return between 59% and 60%. Weaning, vaccinating, and dehorning calves prior to selling results in an expected net return of $49.18/head using an ATE, $37.43/head using an ATT, and $61.85/head using an ATC. Regardless of the estimation method for the premium, the probability of receiving positive net returns is close to 70% under our cost assumptions with the ATC estimate approaching 88%.. Similarly, calves certified in a vac-45 program receive an expected net return of $58.73/head using an ATE, $58.84/head using an ATT, and $57.76/head using an ATC and probabilities of positive net returns near 80% for the ATE and ATT estimates.

The results in this research have important implications for cow-calf producers and extension educators. Results suggest that producers who at least wean, vaccinate, and dehorn their cattle will see positive economic returns over 70% of the time. The expected net returns and the probability of positive net returns increases with the number of value-added practices adopted. By simply weaning and vaccinating their calves, producers realize an expected net return of $28.44/head. They could gain an additional $30.29/ head over weaning and vaccinating by participating in a certified preconditioning program. Producers who currently implement none of these practices will receive an expected net return of $57.76 to $61.85 per head by choosing to wean, vaccinate, and dehorn their calves or participate in a vac-45 preconditioning program. For a small producer selling 25 head, that translates into an extra $1,546.25 in net returns by wean, vaccinate, and dehorn their calves.

With probabilities of positive net returns for non-adopters of 88% for weaning, vaccinating, and dehorning calves, this research provides valuable information that is encouraging for risk-averse cow-calf producers. While researchers have reported increases in cattle prices and profits for producers who certify their calves in a vac-45 program, the majority of producers still choose not to adopt value-added management practices. By providing encouraging information tailored toward risk-averse producers, this research will encourage producers to adopt value-added management practices and provide buyers with a larger supply of cattle with preferred characteristics.

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Table III-1. Partial Budget for Value-Added Management Practices for Calves with a Sale Weight of 529lbs and Premiums Estimated using a Matching Pairs Average Treatment Effect (ATE)[a]

	Wean[b]	Vaccinate	Dehorn	Wean, Vaccinate[b]	Wean, Vac, Dehorn[b]	Wean, Vac, Dehorn, Certify[c]
Baseline Returns to Cow-Calf Expenses						
Weaning Weight (lbs)	487	529	529	487	487	439
Price ($/cwt)	$116.89	$113.98	$113.98	$116.89	$116.89	$120.60
Revenue ($/head)	$569.27	$602.97	$602.97	$569.27	$569.27	$529.42
Revenue with Value-Added Practice(s)						
Sale Weight (lbs)	529	529	529	529	529	529
Baseline Sale Price ($/cwt)	$113.98	$113.98	$113.98	$113.98	$113.98	$113.98
Added Premium ($/cwt)	$5.23	$6.79	$5.26	$4.86	$8.78	$12.46
Sale Price ($/cwt)	$119.21	$120.77	$119.24	$118.84	$122.76	$126.44
Revenue ($/head)	$630.64	$638.89	$630.79	$628.68	$649.42	$668.88
Value-added Expenses						
Labor ($/head)	$2.31	$0.25		$2.56	$2.56	$5.00
Death Loss ($/head)	$1.80			$1.80	$1.80	$1.80
Supplies and Medical ($/head)		$8.00	$5.00	$8.00	$13.00	$18.00
Interest ($/head)	$2.34			$2.35	$2.36	$4.85
Feed ($/head)	$17.89			$17.89	$17.89	$38.34
Certification Costs ($/head)						$3.00
Total Costs ($/head)	$24.34	$8.25	$5.00	$32.61	$37.62	$70.99
Returns to Cow-Calf Expenses with Value-Added Practice(s)	$606.30	$630.64	$625.79	$596.07	$611.80	$597.89
Net Returns from Value-Added Practice(s) ($/head)	$37.02	$27.67	$22.83	$26.80	$42.53	$68.47

[a] The ATE is the treatment effect for all observations and is equivalent to the marginal effect in a hedonic model.
[b] Assumes a 21-day weaning period and a weight gain of 2lbs/day.
[c] Assumes a 45-day weaning period with a weight gain of 2lbs/day.

Table III-2. Partial Budget for Value-Added Management Practices for Calves with a Sale Weight of 529lbs and Premiums Estimated using a Matching Pairs Average Treatment Effect for the Treatment Group (ATT)[a]

	Wean[b]	Vaccinate	Dehorn	Wean, Vaccinate[b]	Wean, Vac, Dehorn[b]	Wean, Vac, Dehorn, Certify[c]
Baseline Returns to Cow-Calf Expenses						
Weaning Weight (lbs)	487	529	529	487	487	439
Price ($/cwt)	$116.89	$113.98	$113.98	$116.89	$116.89	$120.60
Revenue ($/head)	$569.27	$602.97	$602.97	$569.27	$569.27	$529.42
Revenue with Value-Added Practice(s)						
Sale Weight (lbs)	529	529	529	529	529	529
Baseline Sale Price ($/cwt)	$113.98	$113.98	$113.98	$113.98	$113.98	$113.98
Added Premium ($/cwt)	$4.93	$5.40	$5.36	$5.25	$8.65	$12.59
Sale Price ($/cwt)	$118.91	$119.38	$119.34	$119.23	$122.63	$126.57
Revenue ($/head)	$629.05	$631.54	$631.32	$630.74	$648.73	$669.57
Value-added Expenses						
Labor ($/head)	$2.31	$0.25		$2.56	$2.56	$5.00
Death Loss ($/head)	$1.80			$1.80	$1.80	$1.80
Supplies and Medical ($/head)		$8.00	$5.00	$8.00	$13.00	$18.00
Interest ($/head)	$2.34			$2.35	$2.36	$4.85
Feed ($/head)	$17.89			$17.89	$17.89	$38.34
Certification Costs ($/head)						$3.00
Total Costs ($/head)	$24.34	$8.25	$5.00	$32.61	$37.62	$70.99
Returns to Cow-Calf Expenses with Value-Added Practice(s)	$604.71	$623.29	$626.32	$598.14	$611.11	$598.58
Net Returns from Value-Added Practice(s) ($/head)	$35.44	$20.32	$23.35	$28.86	$41.84	$69.16

[a]The average treatment effect for the treated (ATT) yields the premium received by producers who adopt a management practice.
[b]Assumes a 21-day weaning period and a weight gain of 2lbs/day.
[c]Assumes a 45-day weaning period with a weight gain of 2lbs/day.

Table III-3. Partial Budget for Value-Added Management Practices for Calves with a Sale Weight of 529lbs and Premiums Estimated using a Matching Pairs Average Treatment Effect for the Control Group (ATC)[a]

	Wean[b]	Vaccinate	Dehorn	Wean, Vaccinate[b]	Wean, Vac, Dehorn[b]	Wean, Vac, Dehorn, Certify[c]
Baseline Returns to Cow-Calf Expenses						
Weaning Weight (lbs)	487	529	529	487	487	439
Price ($/cwt)	$116.89	$113.98	$113.98	$116.89	$116.89	$120.60
Revenue ($/head)	$569.27	$602.97	$602.97	$569.27	$569.27	$529.42
Revenue with Value-Added Practice(s)						
Sale Weight (lbs)	529	529	529	529	529	529
Baseline Sale Price ($/cwt)	$113.98	$113.98	$113.98	$113.98	$113.98	$113.98
Added Premium ($/cwt)	$5.80	$8.02	$3.77	$4.42	$9.07	$11.26
Sale Price ($/cwt)	$119.78	$122.00	$117.75	$118.40	$123.05	$125.24
Revenue ($/head)	$633.65	$645.40	$622.91	$626.35	$650.95	$662.53
Value-added Expenses						
Labor ($/head)	$2.31	$0.25		$2.56	$2.56	$5.00
Death Loss ($/head)	$1.80			$1.80	$1.80	$1.80
Supplies and Medical ($/head)		$8.00	$5.00	$8.00	$13.00	$18.00
Interest ($/head)	$2.34			$2.35	$2.36	$4.85
Feed ($/head)	$17.89			$17.89	$17.89	$38.34
Certification Costs ($/head)						$3.00
Total Expenses ($/head)	$24.34	$8.25	$5.00	$32.61	$37.62	$70.99
Returns to Cow-Calf Expenses with Value-Added Practice(s)	$609.31	$637.15	$617.91	$593.75	$613.33	$591.54
Net Returns from Value-Added Practice(s) ($/head)	$40.04	$34.18	$14.94	$24.47	$44.06	$62.12

[a]The average treatment effect for the control (ATC) is the premium non-adopters would have received for adopting a practice.
[b]Assumes a 21-day weaning period and a weight gain of 2lbs/day.
[c]Assumes a 45-day weaning period with a weight gain of 2lbs/day.

Table III-4. Premiums for Value-Added Management Practices for ATE, ATT, and ATC Using a Matched Pairs Method

	Average Treatment Effect[b]		Average Treatment Effect for Treated[c]		Average Treatment Effect for Control[d]	
Practice Adopted	Estimate	p-value	Estimate	p-value	Estimate	p-value
Weaned[a]	$5.23	≤0.001	$4.93	≤0.001	$5.80	≤0.001
Vaccinated[a]	$6.79	≤0.001	$5.40	≤0.001	$8.02	≤0.001
Dehorned[a]	$5.26	0.001	$5.36	0.020	$3.77	0.037
Weaned and Vaccinated	$4.86	≤0.001	$5.25	≤0.001	$4.42	≤0.001
Weaned, Vaccinated, and Dehorned	$8.78	0.011	$8.65	≤0.001	$9.07	0.070
Weaned, Vaccinated, Dehorned, and Certified	$12.46	≤0.001	$12.59	≤0.001	$11.26	≤0.001

[a]Premiums taken from Williams et al. (2012b).
[b]The ATE is the treatment effect for all observations and is equivalent to the marginal effect in a hedonic model.
[c]The average treatment effect for the treated (ATT) yields the premium received by producers who adopt a management practice (or the discount if they had not implemented the practice).
[d]The average treatment effect for the control (ATC) is the premium non-adopters would have received had they adopted a management practice.

Table III-5. Mean Difference in Basis ($/head) Between Individual Treated and Untreated Pairs and the Probability of an Individual Receiving a Positive Premium for Value-Added Management Practices

	ATE		ATT		ATC	
Practice Adopted	Net Returns	Pr(Ret ≥ 0)	Net Returns	Pr(Ret ≥ 0)	Net Returns	Pr(Ret ≥ 0)
Weaned	$5.13	0.588	$4.93	0.583	$5.40	0.594
Vaccinated	$6.01	0.644	$5.48	0.634	$6.56	0.655
Dehorned	$6.31	0.594	$6.49	0.596	$4.84	0.573
Weaned and Vaccinated	$5.36	0.585	$5.62	0.594	$5.07	0.575
Weaned, Vaccinated, and Dehorned	$10.98	0.674	$10.86	0.672	$11.25	0.877
Weaned, Vaccinated, Dehorned, and Certified	$12.90	0.794	$12.98	0.800	$12.58	0.768

[a]The ATE is the treatment effect for all observations and is equivalent to the marginal effect in a hedonic model.
[b]The average treatment effect for the treated (ATT) yields the premium received by producers who adopt a management practice (or the discount if they had not implemented the practice.) .
[c]The average treatment effect for the control (ATC) is the premium non-adopters would have received had they adopted a management practice.

Table III-6. Mean Net Returns ($/head) and the Probability of Receiving a Positive Net Returns for Value-Added Management Practices for ATE, ATT, and ATC Using a Matched Pairs Method

	Average Treatment Effect[a]		Average Treatment Effect for Treated[b]		Average Treatment Effect for Control[c]	
Practice Adopted	Net Returns	Pr(Ret ≥ 0)	Net Returns	Pr(Ret ≥ 0)	Net Returns	Pr(Ret ≥ 0)
Weaned	$31.14	0.622	$24.62	0.612	$39.84	0.635
Vaccinated	$23.59	0.595	$17.17	0.614	$30.18	0.606
Dehorned	$16.86	0.566	$15.49	0.563	$27.85	0.591
Weaned and Vaccinated	$28.44	0.596	$20.90	0.604	$36.88	0.587
Weaned, Vaccinated, and Dehorned	$49.18	0.682	$37.43	0.672	$61.85	0.877
Weaned, Vaccinated, Dehorned, and Certified	$58.73	0.787	$58.84	0.793	$57.76	0.629

[a]The ATE is the treatment effect for all observations and is equivalent to the marginal effect in a hedonic model.
[b]The average treatment effect for the treated (ATT) yields the premium received by producers who adopt a management practice (or the discount if they had not implemented the practice.) .
[c]The average treatment effect for the control (ATC) is the premium non-adopters would have received had they adopted a management practice.

APPENDICES

APPENDIX A: Additional Tables of Results for Chapter 1

Table A-1 shows a sample budget for the spring calf fed production system similar to the budget found in Table I-4. The example budget in Table A-1 uses prices from 2007.

Table A-1. Example Budget by Stage of Production for the Spring Calf Fed Production System Using 2007 Prices

	Weaning	Preconditioning	Feedlot
Ending weight (lbs)	450.00	518.00	1,164.00
Weight net of shrink (lbs)	436.50	496.80	1,117.15
Sale price ($/cwt)	$127.04	$124.88	$95.81
Revenue	$554.53	$626.99	$1,067.65
Commission and transportation if sold	$9.00	$10.00	
Transportation from previous stage			$3.00
Beef checkoff (when sold)	$1.00	$1.00	
Death loss (1% and 0.25%)		$0.82	$1.10
Feed expense		$72.85	$346.79
Grazing rate ($/lb of gain)			
Grazing cost/head			
Veterinary costs		$4.50	$7.50
Labor		1.00	
Yardage (includes labor and other expenses)			$59.85
Other expenses		$1.00	
Interest and opportunity cost (6.5% annual)		$4.68	$25.13
Expenses from prior stages			$84.08
Total expenses	$10.00	$95.86	$527.45
Net returns	$544.53	$531.13	$540.20

Note: Values are in $/head unless otherwise specified.

Table A-2 shows a sample budget for the fall stocker production system similar to the budget found in Table I-4. Prices from 2007 are used in the example budget shown in Table A1.

Table A-2. Example Budget by Stage of Production for the Fall Stocker Production System Using 2007 Prices

	Weaning	Preconditioning	Wheat Pasture	Feedlot
Ending weight (lbs)	650.00	661.50	796.50	1,375.00
Weight net of shrink (lbs)	637.00	647.29	788.54	1,320.29
Sale price ($/cwt)	$120.83	$120.34	$111.80	$92.13
Revenue	$769.69	$771.15	$877.20	$1,213.34
Commission and transportation if sold	$9.00	$10.00	$15.00	
Transportation from previous stage		$1.80	$1.80	$3.00
Beef checkoff (when sold)	$1.00	$1.00	$1.00	
Death loss (1%, 0.5%, and 0.25%)		$0.19	$0.44	$0.91
Feed expense		$6.12	$13.49	$280.81
Grazing rate ($/lb of gain)			$0.38	
Grazing cost/head			$25.50	
Veterinary costs		$9.00	$2.00	$7.50
Labor		$1.00	$0.25	
Yardage (includes labor and other expenses)				$51.45
Other expenses		$1.00		
Interest and opportunity cost (6.5% annual)		$0.96	$11.83	$27.07
Expenses from prior stages			$19.16	$74.39
Total expenses	$10.00	$31.07	$90.30	$445.13
Net returns	$759.69	$740.08	$786.90	$768.21

Note: Values are in $/head unless otherwise specified.

Table A-3 shows a sample budget for the fall calf fed production system similar to the budget found in Table I-4. The example budget in table A-3 uses prices from 2007.

Table A-3. Example Budget by Stage of Production for the Fall Calf Fed Production System Using 2007 Prices

	Weaning	Preconditioning	Feedlot
Ending weight (lbs)	650.00	727.00	1,164.00
Weight net of shrink (lbs)	637.00	705.19	1,117.15
Sale price ($/cwt)	$120.83	$120.31	$91.85
Revenue	$769.69	$853.91	$1,150.31
Commission and transportation if sold	$9.00	$15.00	
Transportation from previous stage		$3.60	$3.00
Beef checkoff	$1.00	$1.00	
Death loss (1% and 0.25%)		$0.61	$0.88
Feed expense		$12.15	$270.63
Grazing rate ($/head/month)		$9.00	
Grazing cost/head		$11.40	
Veterinary costs		$9.00	$7.50
Labor		$1.25	
Yardage (includes labor and other expenses)			$51.45
Other expenses			
Interest and opportunity cost (6.5% annual)		$6.17	$26.32
Expenses from prior stages			$43.84
Total expenses	$10.00	$60.18	$403.62
Net returns	$759.69	$531.13	$540.20

Note: Values are in $/head unless otherwise specified.

Table A-4 shows the calculations for the feed costs in the feedlot stage of production. The calculations in table A-4 are for a ration using corn, soybean meal, sorghum silage, alfalfa, and a supplement. This ration is used for the years 1979 to 2000.

Table A-4. Feed Cost Calculations for the Feedlot Stage of Production using a Sorghum Silage Ration in the Fall Calf Fed Production System Using 2007 Prices

Feedstuff	Proportion of Ration	% Dry Matter (DM)	Feed Price	DM price/unit	Feed Units	DM Price/lb	($/lb DM) *Proportion
Corn	0.78	88	$3.51	$3.99	bushel	$0.07	$0.056
Soymeal	0.05	90	$388.00	$431.11	ton	$0.21	$0.011
Sorghum Silage	0.05	32	$53.70	$167.81	ton	$0.08	$0.004
Alfalfa	0.05	88	$122.00	$138.64	ton	$0.07	$0.003
Supplement	0.07	90	$307.00	$341.11	ton	$0.17	$0.012
					Total ($/lb)		$0.086
					lbs of feed/day		23
					Days on Feed		147
					Total Feed Cost		$269.86

VITA

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Scope and Method of Study: This research is composed of three essays about value-added management practices by cow-calf producers. The first essay estimates the real option value of retaining ownership of beef calves past weaning using a discrete stochastic dynamic programming model. The second essay estimates premiums received at auction by cow-calf producers for implementing value-added management practices using a matched-pairs method. The third essay determines the probability of an individual producer receiving a positive net return for implementing various value-added management practices. Each essay implements methods that have not been previously utilized in the beef economics literature.

Findings and Conclusions: Results in this research provides valuable insight for beef producers. The first essay finds that a value exists for retaining the option to sell calves at later stages of production. The second essay finds that producers who do not current participate in a program certifying that their calves have been weaned a minimum of 45 days, vaccinated, dehorned, and dewormed would have realized the highest premium for a certification program if they had chosen to participate. The third essay finds high probabilities of receiving positive net returns for bundles of value-added management practices with the highest net returns being for calves with lower sale weights.

ADVISER’S APPROVAL: Dr. Eric A. DeVuyst