Retained Ownership of Beef Cattle When Considering Production and Price Risk

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Abstract

This study utilized a discrete stochastic programming model to examine optimal beef cattle retained ownership decisions given stochastic production, price and risk aversion levels. Optimal retained ownership decisions varied with sire growth potential, production year, level of risk aversion and profit realization at the selling point.

Introduction

Adding value to beef calves and increasing efficiency have been familiar cries by beef industry analysts throughout the 1990s (Beley, 1997). Retained ownership has been presented as an alternative to marketing weaned calves in order to reduce the inherent price risk of selling weaned calves and to capture more of the benefits of a sound breeding program. (Lambert and Sands 1984, Watt et al. 1987, Schroeder and Featherstone 1990, Lambert 1989, Held et al. 1992, Garoian et al. 1990). Past studies have typically modeled price risk because of the lack of data on production variability. This study examines optimal retained ownership strategies for beef cattle producers while considering price and production risk. Optimal retained ownership decisions are examined for calves sired by both high-growth and moderate-growth potential sires.

Methods

A discrete stochastic programming (DSP) model was developed to model the steer retention and production alternative decision process (Rae, 1971). The DSP model was designed with an information structure where the decision maker had complete knowledge of the past and present. Additional information was incorporated into the decision process at discrete points in time as information regarding production and prices became available. Information on the realization of past and current production and prices, along with the expected probabilities of future production and prices, was used in the DSP model to determine an optimal decision at each discrete decision point.

The DSP model consisted of six stages or decision periods. Stage 1 represented the calving and calf raising period from April to October (early wean alternative).

Decisions regarding calf retention and production alternatives were made in October, conditional on the production and price state of nature realized in Stage 1 and the expected states of nature in stages 2 and 6. Stage 1 had three production states of nature, each with four price states of nature, for a total of 12 possible states of nature.

At the end of Stage 1, a decision was made between placing the calves in a feedlot (Stage 6), or entering a stocker option (Stage 2). In Stage 6 (short lot), expected income was a function of the distribution of cattle and feed prices realized when steers were sold after feeding. All steers were slaughtered when they reached an average USDA quality grade of low choice. Stage 6 had three production states of nature, each with four cattle price states of nature, which each had three feed prices for total of 36 states of nature in the calf-fed finish lot. Given the 12 states of nature in Stage 1, 432 (12*36) terminal states of nature existed for the feedlot after weaning option.

Stage 2 consisted of a 75-day fall grazing period from October 15 to January 1. If calves were retained, they were suckled on their mothers (late weaning alternative). The decision to retain or sell steers in December was based on the realization of the cattle price, feed price and production states of nature in Stage 2 and the expected distribution of the cattle price, feed price and production states of nature in Stage 3. There were four cattle price states of nature in Stage 2 for a total of 4 states of nature.

Stage 3 was the 130-day winter lot period from January 1 to May 10. Two feed price states of nature and four cattle price states of nature were modeled in the winter lot period. Decisions to sell or retain yearlings were based on the realization of the feed and cattle price state of nature in Stage 3 and the expectations of the states of nature in Stage

4. Stage 3 had a total of eight states of nature (two feed prices and four cattle prices).

Stage 4 was the 130-day summer grazing period from May 10 to September 20. Three production states of nature and four cattle price states of nature were modeled in Stage 4. Decisions to sell or retain long yearlings were based on the realization of a production and price state of nature in Stage 4 and the expectations of the states of nature in Stage 5. Stage 4 had 12 states of nature (three production and four cattle prices).

Stage 5 was the yearling-finishing period (long lot). Steers were sold on the hoof following Stage 5 and were fed until they reached a constant endpoint of low-choice. Three production states of nature, three feed price states of nature and four cattle price states of nature were modeled, giving a total of 36 states of nature in Stage 5 (three production, three feed price and four cattle price). Combining all six stages gave a total of 165,888 (12*4*8*12*36) terminal states of nature and 664,156 selling points.

Risk aversion was incorporated in the objective function by specifying a terminal wealth, negative exponential function (Featherstone et al. 1990) as

$$E\left[U(W)\right] = \sum_{i=1}^{T} p_i (1 - e^{-\lambda W_i}),$$

where T is the number of terminal states, W_i is wealth at terminal node i, p_i is the probability of occurrence for terminal node i, and λ is the Pratt-Arrow coefficient of absolute risk aversion.

The DSP was solved for six levels of risk aversion ranging from 0.00005 to 0.001. The absolute risk aversion coefficients fell between 0 and 10 divided by the standard error of income as suggested by McCarl (1986). These ranges were rounded off to be similar to those used by Schroeder and Featherstone (1990). The DSP model was solved using the Generalized Algebraic Modeling System (GAMS).

Data

Production data was obtained from research conducted at the Fort Keogh Livestock and Range Research Center near Miles City, MT (Heitschmidt et al., 1996). The research was conducted from 1989 to 1992. Only cows with steer calves were included in the study. Treatments were designed such that one-half of the steers were sired by moderate-growth potential sires (MGP) and one-half of the steers were sired by high-growth potential sires (HGP). MGP sires were selected specifically for their genetic potential for moderate growth. The sires used were Line 1 Hereford bulls with yearling weight ratios of approximately 100 from the Fort Keogh Livestock and Research Center herd. To represent HGP sires, semen was obtained from Charolais bulls with high expected progeny differences for yearling weight.

Three production cycles were obtained from four years of experimental data. Weight gain and feed intake data for each year and each stage of production were estimated as linear relationships following Williams and Bennett (1995), Williams et al. (1995b), Hicks et al. (1987) and May et al. (1992). Independent variables included sire, days, initial weight, year, feed intake and several interactions.

A cumulative probability distribution of growing season precipitation for the last 96 years was obtained to determine the probabilities of occurrence of each production year. The range of production was represented by a very high precipitation year (1990) a very low preciptation year (1991) and an average year (1989) year. Probabilities were determined by dividing the range of annual precipitation into three equal ranges. Using the cumulative probability distribution, it was found that low precipitation years occurred 27 percent of the time, average precipitation years occurred about 53 percent of the time and high precipitation years occurred 20 percent of the time.

Cattle and feed prices were simulated using a procedure similar to Schroeder and Featherstone (1990). Cattle prices were conditional on the cattle and feed price realized in the previous stage. Feed prices were assumed to be independent of cattle prices and were conditional only on the historical distribution of feed prices.

Four cattle price states of nature were modeled at each stage of the DSP model. Two feed price states of nature were modeled in the winter lot period and three feed price states of nature were modeled in each of the feedlot stages. Feed price states of nature were reduced to two stages in the winter lot to help reduce the size of the DSP model.

Regression relationships were estimated for cattle prices at the end of each stage. Cattle price in stage t was estimated as a function of price in stage t-1 and feed price in stage t-1 where applicable. Six cattle price equations were estimated, one for each of the six stages. To account for across-equation residual correlation, equations were estimated using seemingly unrelated regression (SUR).

While the uncertainty of future cattle prices could be modeled by using the error structure of the estimated price model, McSweeny et al. (1987) suggested that using the mean-squared out-of-sample forecast error is more consistent and realistic. This process was accomplished by estimating the system of equations over the data 1975 to 1984 and then forecasting prices for 1985. The 1985 data was then added to the data set, equations were reestimated, and 1986 was forecast. This continued until the 1994 data was added and the 1995 prices were forecast. Variability was then measured as the mean-squared forecast error from the series of one-step-ahead forecasts.

Price data for feeder cattle were collected from the Wyoming Auction market located at Torrington, Wyoming (USDA-AMS). Prices for 1,100/1,300 lb. slaughter cattle were collected from the Nebraska direct market (USDA-AMS). Prices for 1,000/1,100 lb. slaughter cattle were collected from the Omaha, Nebraska auction market (USDA-AMS). Barley prices and private pasture lease rates were collected from various issues of Wyoming Agricultural Statistics. Silage prices were estimated based on the chemical composition of silage and the chemical composition of four reference feedstuffs and their prices using the FORVAL program (Fick and Wilkens, 1986). The four reference forages were alfalfa hay, other hay, corn and cottonseed meal. Prices were collected from Wyoming Agricultural Statistics.

To obtain the expected distribution of cattle and feed prices, it was necessary to attach a probability to the occurrence of each price state. The probability distribution was divided into four price regions. A normal distribution, centered on the mean forecast error, was assumed for each stage and the probability for each price region was calculated using numerical integration. Probabilities were multiplied together to obtain the probability of the later stages. Probabilities for feed prices were calculated in the same manner.

Enterprise budgets were developed for each production period. Budgets were combined with the simulated production variables and prices to simulate net returns for each selling point. All returns were inflated by an annual interest rate of 10 percent to account for opportunity costs.

Results and Discussion

Optimal retained ownership decisions for the MGP and HGP sired steers are shown in Table 1. Income was defined as the expected returns to management for 180 steers. The left side of the table describes the optimal decisions made at the end of Stage 1, where steers were either sold, retained in the short lot or retained in Stage 2. Decisions are presented in terms of the percentage of steers placed in each alternative. The percentages were summarized for three profit realization categories. Profit realization categories were chosen rather than cattle price levels because feed price and production level were stochastic in addition to cattle prices. Profit realization categories were established by sorting the per steer returns at each selling point from low to high for each stage. The low profit realization category included the lowest 30% of returns, the middle profit level included the middle 40% of returns and the high profit category included the highest 30% of returns. At the end of Stage 1 (October) the model forced the decision maker to place each of the 180 steers in one of the three alternatives, sell in October, retain through the short lot or retain through Stage 2. The right side of each table presents the average percentage of steers retained at the end of Stages 2, 3 and 4. All retained steers were sold after the long and short lots (Stages 5 and 6).

As the decision maker became more risk averse, expected income decreased, as did the standard deviation of expected income. Less risk averse decision makers tended to retain ownership longer into the production process. Less risk averse decision makers placed all steers in the fall pasture treatment and retained a majority of the steers through slaughter. As risk aversion increased, more steers were sold in October and progressively fewer steers were retained past December. Only the most risk averse decision makers placed any steers in the short lot, and then only when profit realizations were low.

Very few steers were sold as yearlings at the end of the winter lot. Most were retained though the summer pasture period, regardless of the decision maker's risk aversion level. Generally, long yearlings were retained in the long lot. Fewer long yearlings were retained as the decision maker became more risk averse.

As profit realizations increased, more steers were sold after weaning in October and fewer steers were retained in each subsequent stage. The December selling alternative was a popular option, especially under higher profit realizations.

Expected income and the optimal production and retention decisions varied across years when the DSP models were solved separately using each years production data (not shown in tables). For all treatments, more steers tended to be retained longer in the low precipitation year. This was particularly true for the December sell decision. Little difference existed in the optimal retention path between the mid and high precipitation years. There appeared to be sufficient moisture in the average precipitation year for calves to do well.

Table 1 also presents the optimal production and retention decisions for HGP steers across all production years. Variance of expected income was again highest when expected income was highest.

Profit levels were higher for HGP steers in general, but comparison of sire growth potential was not an objective of this study. Differences in sire cost, calving difficulties, breeding efficiencies, marketing premiums and other cost differences were not accounted for. Retention decisions between the breeds should be comparable, however.

Overall, HGP steers were retained longer than their MGP counterparts. HGP steers also tended to be sent to the short lot more frequently. However, no steers were sent to the short lot when the decision maker was risk neutral or slightly risk averse. More risk averse decision makers tended to sell a greater number of steers in October, send more steers to the short lot and retain fewer steers through the later production stages.

As profit levels increased, there was a slight tendency to sell more steers earlier in the production process, but the difference was much less than for MGP steers. The December sell alternative was not as popular with the HGP steers as with the MGP steers. HGP steers were always retained at the yearling stage, except in a few cases, where the decision maker was more risk averse.

Expected income varied more in terms of dollars across production years for HGP steers than for MGP steers. This could be because of the increased maintenance and growth requirements of the HGP steers. They fare relatively poorer in low moisture years, but perform relatively better in high precipitation years. The HGP steers still tended to be retained longer in the dryer year as did the MGP steers (not shown in table).

Summary and Conclusions

Retained ownership has been presented in the literature as a viable way for cow/calf producers to increase income and reduce the probability that income will be below a given level. This study utilized a discrete stochastic programming model to examine the optimal retained ownership and production decisions that could be made given various management alternatives, production levels and risk aversion levels.

Optimal retained ownership decisions varied with sire growth potential, production year, level of risk aversion and profit realization at the selling point. Given a risk neutral decision maker, steers were never sold in October, but were retained and transferred to later stages. Steers were also seldom sold in May as yearlings.

The producer's level of risk aversion affected the optimal retained ownership pattern. Risk neutral and slightly risk averse producers tended to retain ownership on a majority of the steers through the long lot. More risk averse decision makers sold more steers in October, placed more steers in the short lot and retained fewer steers in December and as long yearlings. This was a diversified selling strategy, which served to spread risk across several selling points and reduce the standard deviation of income. This general strategy held regardless of the sire growth potential.

The level of profit at each selling point had an effect on the decisions made. When profit levels were low, more steers were retained. As profits increased, more steers were sold; indicating an optimal "profit taking" behavior, where the decision maker sold when prices were high and retained ownership when prices were low.

MGP steers were not sent to the short lot except when the decision maker was more risk averse. HGP steers were sent to the short lot more often, but only as the decision maker became more risk averse. HGP steers were retained more often in December compared to MGP steers.

Past studies of retained ownership and risk (Watt et al., 1987; Schroeder and Featherstone, 1990; Held et al., 1992; Garoian et al., 1990) have concentrated on price risk and paid little attention to production risk. Results of this study indicate that production risk can affect optimal retained ownership decisions. Retention of steers occurred more frequently when growing season precipitation was low. Differences between the average and high precipitation years were small, probably because the precipitation in the average year was towards the upper end of average and therefore forage availability was likely adequate in both the high and average precipitation years.

Results of this study show that more risk averse decision makers tend to avoid retaining ownership of their calves. This would suggest that cow/calf producers are generally more risk averse individuals that prefer to accept a lower expected income as long as it is accompanied by a lower standard deviation of income. The results of this study also indicate that retaining ownership of steers may not be the best decision in every situation. Production level (precipitation), cattle price, and feed price are all significant sources of risk which affect the optimal retained ownership decision.

Table 1. Optimal Production and Retention Decisions for High and Moderate Growth Potential Sired Steers Under Three Profit Levels.

Pratt-Arrow		Std Dev	Avg. % Placed in Stage 1 Alteratives									Avg. % Retained Following Stages 2, 3 & 4								
Risk Aver.	Income	of Income	Sold in October			Short Lot			Stage 2			December			Yearling			Long Yearling		
Coefficient	($)	($)	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H
											High Growth Potential Sired Steers									
Risk Neutral	18,967	22,900	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	86	89	93
0.000005	18,829	23,034	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100
0.00001	18,784	22,569	0	0	3	0	0	0	100	100	97	100	100	100	100	100	100	100	100	100
0.00005	16,246	15,281	0	4	32	0	5	18	100	91	50	100	96	75	100	100	82	77	81	97
0.0001	14,479	11,608	0	12	36	1	6	26	99	82	38	78	65	53	100	100	82	69	81	97
0.0005	10,602	5,804	9	53	38	8	8	32	83	38	30	23	20	13	100	99	79	54	63	74
0.001	10,076	5,546	20	62	41	9	5	27	71	32	32	14	12	8	100	99	71	55	63	74
											Moderate Growth Potential Sired Steers									
Risk Neutral	9,403	14,976	0	0	0	0	0	0	100	100	100	100	53	17	100	100	100	100	100	68
0.000005	9,236	14,853	0	0	0	0	0	0	100	100	100	93	44	28	100	92	100	100	100	89
0.00001	9,299	14,687	0	0	0	0	0	0	100	100	100	94	38	22	100	97	100	100	100	84
0.00005	8,436	10,771	0	0	28	0	0	0	100	100	72	62	17	0	100	100	100	97	82	74
0.0001	7,440	8,588	7	2	44	0	0	0	93	98	56	38	9	0	100	100	100	96	73	73
0.0005	5,503	6,036	29	29	58	7	0	0	64	71	42	10	3	0	100	100	100	91	62	42
0.001	5,020	5,805	34	38	59	11	0	0	56	62	41	6	2	0	100	100	100	91	61	34

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