PRODUCTION AND MARKETING ALTERNATIVES IN THE BEEF CATTLE INDUSTRY WITH RISK CONSIDERATIONS

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Introduction

Large areas of the western United States, including the Pacific Northwest, are public lands. Society, represented through the U.S. Congress and various state legislatures, has directed that multiple-use management be applied to these public resources. Among those uses are agricultural, mineral, timber and wildlife production; watershed protection; and recreation. Agricultural production is realized through harvesting natural forage by range livestock. The Bureau of Land Management administers 270 million acres of federally owned rangeland, providing forage for 3.5 million head of livestock. The U.S. Forest Service and state agencies supervise public grazing lands as well.

Livestock production (primarily beef cattle) both competes with and complements other multiple uses of public lands. It also complements other agricultural sectors, such as crop production, cattle feeding and slaughtering, food processing, and agricultural supply and credit. The range livestock industry, intimately associated with public resource use management, is a basic component of the economic and social structure of rural communities throughout the Pacific Northwest.

In Idaho the beef cattle industry is a major component of the agricultural economy. Sales of cattle and calves have constituted more than one-fourth of the state's two billion dollar annual farm marketing receipts in recent years (*1989 Idaho Agricultural Statistics*, p. 14). In addition to this direct contribution, beef cattle production plays an important role in the state's total agricultural/natural resource complex.

More than sixty percent of the land area in Idaho is publicly owned. On nearly all of this land the forage cover can be harvested only by range animals. State owned lands provide additional livestock grazing. Thus the range livestock sector both depends on public lands as a feed source and complements its various other uses in the multiple-use management of public resources.

The environment in which the range cattle sector must operate raises the question: what management/marketing system is best suited for a ranching operation? Opportunities and limitations are subject to such factors as (1) resource base, (2) managerial talent, (3) financial and risk considerations and (4) operator preferences. Given these factors the challenge is to specify those combinations of management systems and marketing strategies which optimize net returns.

Objectives and Models

On the production side, animal scientists have used mathematical modeling to formulate least cost rations, develop optimal mating systems, and match genotypes to the level of environment and ranch resources (Miller, et al., 1978). Agricultural economists have used mathematical modelling for whole farm planning and to evaluate the economics of alternative management and marketing systems (Stokes, et al., 1981; Zimet and Spreen, 1986). Many linear programming analyses report outcomes based on mean costs, returns, and technical coefficients. A stochastic element is embodied in these

estimates due to probabilistic behavior (especially over time) and measurement difficulties. Linear programming as a whole ranch management tool has rarely paid adequate attention to risk (Angirasa, et al., 1981; Gebremeskel, et al., 1979). Quadratic programming has been used in income expectation-variance (E-V) analysis.

Objectives

This study uses linear programming (LP) MOTAD (minimization of total absolute deviations) models to address production, marketing and management decisions encountered by a cow-calf producer using public range in central Idaho. The specific objectives of the study are:

1. To develop whole ranch management policy for a long-run planning horizon.
2. To determine the expected gross margins-risk efficient sets of production and marketing alternatives, thereby illustrating the tradeoffs between gross margins (returns above variable costs) and the associated level of risk.

Long-run Deterministic Model

The long run ranch management system is described by a set of 42 equalities and inequalities in 46 activity variables. The system includes 19 cattle production and marketing activities, 10 crop production and marketing activities, 12 feed utilization and pasture forage activities, and 5 management activities. The annual hired laborer activity is an integer variable. The long-run LP model is a price deterministic model, i.e., all of the costs and prices are known with certainty and are assumed to be constant at the 5 year expected value. The long-run model is a conventional LP model which maximizes expected total ranch gross margin subject to structural constraints (land, labor and capital) and transfer constraints as follows:

$$\text{Maximize} \quad E(g) = C'X;$$

$$\text{Subject to:} \quad AX \leq B;$$

$$X \geq 0;$$

where:

E(g) is the expected total ranch gross margin. This value represents returns to investment, land, management, operator labor and risk. X is a vector of the activities while C is a vector of expected gross returns and costs of production for each activity. A is a matrix of technical coefficients representing the use of each resource by each activity as well as the amount of each activity which may be transferred to each of the other activities. B is the vector of right hand sides , i.e., available resources. Risk is not considered at this state since it is assumed that a cow-calf producer will attempt to manage risk by altering short-run marketing strategies rather than adopting ranch plans which will force him into a suboptimal situtation in the long run.

Risk Efficient MOTAD Model

Risk management is the major consideration in formulating the second stage of the model when optimal marketing strategies are determined. Once the optimum herd size, annual crop and cattle plans have been obtained from the deterministic long-run model, the expected-mean income (E-M) set of short-run ranch management plans can be calculated in the short-run models. The short-run models minimize the absolute deviations about total ranch gross margin.

The mathematical description of the MOTAD model is:

$$\text{Minimize } \Sigma Z_t^{-};$$

$$\text{Subject to: } AX \leq B;$$

$$E(g) \geq \lambda.$$

The short-run solutions are determined by incorperating the MOTAD deviation matrix in addition to the usual technical and transfer constraints of the long-run model. E(g) is also incorporated as an additional constraint, specifying the parameter (λ) on the right hand side of the equation. In order to simplify the calculations the equivalent but conceptionally more tidy approach of minimizing negative deviations about the mean (ΣZ_t^{-}) is used. This sum can be then converted to the mean absolute deviation (MAD) estimator of variance by using the equation:

$$\hat{V} = 4FS^2/T^2$$

where:

$\hat{V}$ is the MAD estimator of variance.
S is the sum of the negative deviations.
T is the number of sample observations used to determine the probability distribution of the coefficients in the equation for gross margin.
$F = 0.5\pi T/(T-1)$

Procedures

Unit of Analysis and Resource Assumptions

The ranching operation is located in Lemhi county at an elevation of approximately 4,000 feet. The median length of the growing season is 147 days with the first fall freeze occuring around mid-October (*1989 Idaho Agricultural Statistics*, p.8). The ranch holds title to 160 acres of irrigated cropland and 125 acres of meadowland. The model allows meadowland to be used for hay production and aftermath grazing or strictly as pasture. Private leases provide a total of 908 animal unit months (708 AUMs leased meadow pasture and 200 AUMs of hay aftermath) of grazing. Public range permits issued by the U.S. Forest Service and Bureau of Land Management provide an additional 820 AUMs of grazing. Forage crops (irrigated alfalfa hay, alfalfa-orchardgrass hay and meadow hay) are the principle crops grown in the area, although the model allows barley to be grown on the irrigated cropland and/or as a companion crop when establishing alfalfa. Ranches in this area tend to be self sufficient in feed for their cattle enterprises.

The models in this study were developed for a typical spring calving commercial beef cattle ranch. The resident livestock inventory includes 200 cows, 10 bulls, 36 replacement heifers and 3 horses. Breeeding animals are assumed to be of mature structural size and maternal ability characteristic of British breeds, i.e., Herford, Angus and their crosses. Average fall weights for cows, herd sires, and bred yearling heifers are 1,100, 1650, and 900 pounds, respectively. Replacement heifers are first bred as yearlings (15 months of age). The calf crop (expressed as the percentage of calves weaned per cow wintered) typically ranges from 89% to 97% and averages 94% (Loucks, personal communication, 1990). Weaning rates in this study embody the probabilities that 2% more heifer calves are weaned due to higher neonatal death losses of male calves. Calves are weaned in mid November at an average age of 7 months. Steer and

heifer calves weigh 565 and 510 pounds at weaning, respectively. Fourteen percent of the cows, 2% of the herd bulls, and 11% of the replacements are culled near weaning time.

The models are initialized at weaning time, the point at which pasture forage resources are depleted, and when the cow-calf operator makes production/marketing decisions for the current calf crop. Traditionally most cow-calf producers sell six to eight month old calves after weaning in the fall. The models allow weaned calves from the resident cow-calf enterprise to be sold or transferred to one or more of 4 postweaning enterprises.

Cow-calf operators are at the beginning of the beef production process and are the final recipients of slaughter cattle and feed price changes passed through the marketing system (Beale, et al., 1983). Vertical integration emerged as an alternative to traditional fall marketing.

There are two production alternatives for each sex of calf not sold at weaning: backgrounding to spring yearling ages or retained ownership to slaughter in a custom feedlot. Yearling backgrounded cattle may be sold as spring yearling feeder cattle or retained during the fattening period in a custom feedlot.

Backgrounding is a production alternative to selling calves at weaning time in November. In a backgrounding enterprise weaned calves are usually wintered on forages and high roughage feeds. Calves may be backgrounded on pasture, in drylot, or a combination of both; this study backgrounds calves on hay and barley. In the spring, yearling feeders may be fattened in a feedlot or summered on grass pastures. The pasture stocker option is not included in this study. Steers are fed 16.74 pounds of alfalfa hay equivalents and 3 pounds of barley per day. Heifers are fed 14.88 pounds of alfalfa hay equivalents and 3 pounds of barley per day. The primary emphasis is on low cost gains rather than maximum daily weight gains. The backgrounding period lasts 90 days.

Retained ownership is another method of vertical integration of perennial interest to the cow-calf segment of the beef industry. In a Kansas study (Lambert, et al., 1984), positive returns from retained ownership more than made up for negative returns at weaning in 3 of the 9 years of study. Producers selling calves at weaning would have experienced postive returns in 3 out of 9 years but producers retaining ownership of steer calves through the feedlot phase experienced positive returns in 6 of 9 years. Only in 2 years were losses large due to retained ownership. Retained ownership entails placing calves or yearling feeder cattle into a custom feedlot for "full feed" until slaughter. Placing calves directly in a custom feedlot for "full feeding" is also a production alternative to selling calves at weaning. Likewise placing backgrounded yearlings in a custom feedlot for fattening is a production alternative to selling short yearling feeders in the spring. In all alternatives examined ownership of the cattle is maintained by the cow-calf producer.

Data Sources

The 1989-90 University of Idaho Department of Agricultural Economics Livestock and Crop Enterprise Budgets (Smathers, et al., 1990) were the bases for all of the production activities in all of the models of this study. Estimated costs of production are exclusive of labor and interest expense. Feed costs for cattle enterprises are also excluded because the models include feed production and purchasing activities. The amounts of various feedstuffs fed were adapted to match the differing weights and

length of feeding period for each cattle activity. The models assume that crops produced on the ranch can be sold for $1 per ton less than they can be purchased off the ranch, thereby avoiding arbitrage transactions. Labor requirements for all activities were taken from the crop and livestock enterprise budgets and grouped into two month periods throughout the production year.

Weekly feeder and slaughter cattle prices (by sex and weight classification) were obtained from the detailed livestock quotations for the Idaho direct cattle market (USDA Agricultural Marketing Service). Prices reflect the month when the cattle activity terminates. Slaughter cattle prices are for weight classes in which 70% will grade USDA Choice with a $3.00 per cwt. quality grade discount for "no roll" cattle. All slaughter cattle were assumed to be yield grade 3. No yield grade credit (or discount) was assumed in pricing slaughter cattle. All prices are inflated to 1988 using the annual index of prices paid for factors of production (USDA, Annual Price Summary 1989). At each marketing decision point heifers were worth less than steer counterpart but prices were more variable.

Method of Solution

The Linear Interactive Discrete Optimizer (LINDO) computing package was used as the primary analysis tool. Short-run solutions were determined by parametrically altering the expected total ranch gross margin.

Results and Discussion

Long-Run Ranch Management Plan

Herd size in the long-run optimal ranch management plan is set by the number of AUMs of public grazing. The numbers of replacement heifers and culled breeding stock to maintain a constant herd size are, in turn, functions of herd size. Annual ranch gross margin resulting from the optimal long-run plan is $66,327 with a mean deviation of $24,720.

Annual Cattle Plan. The long-run optimal solution calls for a partially integrated cattle production plan in which all of the weaned calves (92 steers and 60 heifers) are backgrounded on the ranch and sold as spring yearling feeder cattle. Backgrounded yearling steers and heifers gain 1.83 and 1.56 pounds per day, respectively. The postweaning cost of gain was $53.79 and $56.20 for steers and heifers, respectively. Under the optimal ranch management plan prices received for weaned steer and heifer calves would have to rise $36.75 and $50.48 per head,respectively, before traditional fall marketing would enter as the optimal marketing alternative.

Annual Crop Plan. The optimal forage production plan allocates all (140 acres) of the irrigated cropland to alfalfa hay production. Sufficient alfalfa hay is produced on the ranch to meet the nutritional requirements of the cattle enterprises. Surplus alfalfa hay (41 tons) and all of the meadow hay (296 tons) are sold. Mixed hay (alfalfa-orchardgrass) does not enter the optimal long-run ranch plan. The pasturing option for the meadowland is not excerised. The model does not carry surplus feed into the next production year.

The optimal forage system utilizes 516 AUMs of leased meadow pasture, 72 AUMs of leased hay aftermath and 820 AUMs of public grazing. Spring barley is produced on 20 acres as a companion crop in the 7 year alfalfa establishment rotation.

The 33 tons of barley produced is not adequate to sustain the backgrounding cattle and replacement heifers, consequently an additional 21 tons must be purchased.

Annual Management Plan. Labor and capital are the two management activities in this model. The labor needs of the ranch are met by the operator, family and part-time hired laborers. As a result the long-run optimal ranch management plan does not use a hired man on an annual basis. A full-time hired man would enter into the optimal ranch plan if the wage rate was reduced to $6,332 per year. The long-run optimal ranch management plan utilizes family and part-time hired labor during the peak demands in January through June.

The available operating line-of-credit of $100,000 was not binding. Total variable costs of the operation are financed by an operating loan of $44,001.

Dual Solution. The dual solution points to some promising opportunities for improved beef cattle management. Management efforts which improve the calf crop by 0.5%, i.e., one additional steer or heifer at weaning, would add $464 or $382 to the ranch total gross margins, respectively. This is because most of the production costs for backgrounded feeders are "sunk" for unproductive cows.

An additional acre of deeded cropland in alfalfa would add $155 to total gross margins, $89 if the added acre was meadowland. The incremental gross value in improvements in public grazing is $28.79 per AUM. Added labor resources during the first two-thirds of the production year would only marginally increase total ranch gross margin. But because labor is not fully utilized during the last 4 months of the year additional labor resources during that period would not affect income.

Short-Run Ranch Management Plans

Crop disposition and cattle marketing activities were altered in the E-M efficient sets of the short-run optimal ranch management plans. Forage production activities of perennial crops cannot be altered in the long-run and thus are fixed in the short-run plans. Alfalfa hay is the preferred forage crop insofar as it is grown on all of the irrigated cropland in every optimal ranch management plan. Alfalfa hay serves to stabilize ranch total gross margin.

As the ranch total gross margin decreases, the mean absolute deviation in gross margin also decreases. The return to the maximum gross margin plan is 9.5% above that of the minimum plan, but is 30% more risky. The minimization of mean absolute deviation in gross margins occurs with shifts to three phases of beef cattle activities. At the higher risk levels all of the steers and all or most of the heifers are backgrounded.

The optimal long-run ranch management plan (plan 1) is the most risky. The mean absolute deviations in gross margins are minimized by diversifying the cattle enterprises and marketing an increasing tonage of alfalfa hay. As the cattle enterprises are diversified heifers calves are sold at weaning and at slaughter. Production of backgrounded steers shifts to marketing steer calves at weaning. Given the forage production capacity of the ranch, the decision to background calves is not solely determined by forage yield because the ranch produces a surplus of feed. Meadow hay is produced on all meadowland acres and is used to sustain the cow-calf enterprise.

Ranch management plan 2 feeds all meadow hay produced and sells about 50% of alfalfa hay. In the higher risk plans (1 and 2) all of the weaned calves are backgrounded. Risk is reduced less than 1% by substituting meadow hay for alfalfa

when all of the other ranch activities remained unchanged. Expected gross margin for plan 2 is $66,260 and mean absolute deviation is $24,504.

Ranch management plan 3 further integrates and diversifies the cattle marketing activities by retained ownership of 19 heifer calves in a custom feedlot and backgrounding all of the remaining steers and heifers. With fewer heifers being backrounded on the ranch this frees up more (13 tons) alfalfa hay for sale and reduces the amount of barley that needs to be purchased. (E[g] = $65,869; MAD = $23,337.)

Ranch management plan 4 continues to background all of the steer calves but evenly divides the marketing of the heifer calves as weaned feeders and slaughter heifers fed as calves. (E[g] = $64,145; MAD = $21,602.)

Ranch management plan 5 is the most diversified cattle marketing plan. Eighty-one calves (71 steers and 10 heifers) are sold at weaning. The remainder of the steers are backgrounded while the majority of the heifers are placed in a custom feedlot for full feeding until slaughter. This plan enables the operator to sell 65% of the alfalfa hay crop and requires less than 3 tons of purchased barley for the backgrounded steers and replacement heifers. (E[g] = $62,129; MAD = $19,683.)

Plans 6 and 7 are the most conservative. All steer calves are sold as weaners. Ninety percent of heifer calves are custom fed. Plan 7 differs through selling all alfalfa hay and buying needed meadow hay. (E[g] = $61,546 and $60,566, respectively; MAD = $19,130 and $18,991, respectively.)

Summary and Conclusions

This study uses an LP MOTAD model to determine income level/income variation tradeoffs in animal feed/livestock producing enterprises with public land grazing permits. The MOTAD model has advantages of modest data and computational requirements for risk analysis.

The results demonstrate that beef producers who rely on public land forage may have alternatives to marketing calves directly off the range. These potential value-adding activities include backgrounding calves for sale or for further growth, as well as retaining ownership of calves or yearlings through feeding to slaughter grade in custom feedlots.

Each alternative generates income and entails risk in a direct, but not proportional relationship. Using constant technical coefficients (yield) and 1984-88 production cost and price data indexed to 1988 values, the lower risk production/marketing alternatives showed considerable potential for increasing income. As risk level rose, income increased by relatively smaller increments. The most risky option showed a sharp rise in income deviation with essentially no improvement in expected mean income, relative to the second most risky alternative.

The usefulness of MOTAD programs as a risk analysis tool for agricultural producers might be enhanced both through theoretical refinement and by operational adaptation. Incorporating physical production (yield) variation along with economic (price) risk would improve realism at the expense of complication. Use in extension education requires the linkage of systems to provide (1) area-specific input data, (2) fast turnaround computational service and (3) timely reporting and interpretation of program results.

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