Journal of Agricultural and Applied Economics, 28,1(July 1996):180–192

A Decision Support Aid for Beef Cattle Investment Using Expert Systems

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ABSTRACT

The beef cattle investment decision provides an excellent opportunity to increase the economic efficiency of beef cattle production. The investment questions that face beef cattle producers are of interest to beef cattle producers, educators, and financial institutions involved in lending to beef cattle producing firms. This study develops a decision support aid utilizing expert system technology to assist beef cattle producers in making well-founded investment decisions with respect to the firm's beef cattle herd.

Key Words: beef cattle investment, decision support, expert systems.

The development of sound tools that use economic theory to assist beef producers in making breeding cow investment decisions is an important effort. A major study focusing on competitive issues in the beef sector for the 1990s, conducted through the Hubert H. Humphrey Institute of Public Affairs, pointed to this need (Johnson et al.). One conclusion reached in that study was that beef producers must lower their costs of beef production to prevent further loss of market share to competing meats. The report concluded:

> Two factors are likely to be important in lowering cost of production in the future. The first is the need to use the most efficient production technology available. The second is the need to consolidate production into even larger units so that all economies of size are realized. The fact that consolidation into larger units has been taking place at such a rapid rate in recent years suggests that there are real economies of size at the production level (p. ii).

If the concentration of beef production into larger units in order to lower costs of production becomes more important to the ranching firm's survival in the future, then sound investment decision making by ranchers regarding beef breeding cattle will be key to their economic survival.

Initial results of an analysis of data gathered in the National Cattlemen's Association's national database of integrated resource management standardized performance analysis (SPA) for cow-calf producers (McGrann et al. 1992) clearly show that large operations over the 1990 to 1991 period have had lower costs of production vis-à-vis medium and small sized producers. Pre-tax cost of production was found to range from an average of $78.36 per cwt for firms with less than 200 head of cows, to $66.81 per cwt for firms with 200–500 head, to $60.34 per cwt for firms with over 500 head. (For discussion of SPA guidelines, refer to McGrann.)

Investment analysis related to breeding cows differs from the analysis of machinery or land investment in the uncertainty associated with the biological aspects of beef cow reproduction and mor-

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tality. The investment in cows relative to all other investments made by the beef cattle firm is significant, increasing the importance of the investment decision in beef cattle. SPA data reflect an average total investment of $2,097 per breeding cow on a cost basis. Thus, assuming a value of $700 to $1,000 per cow, investment in breeding cows would range from one-third to one-half of total beef cow herd investment.

The beef cattle investment decision provides an excellent opportunity to increase the economic efficiency of beef cattle production. Investment questions that face beef cattle producers—such as whether to raise or purchase replacement cows, whether to expand the herd size through raising or purchasing cows, how to cull cows with regard to expected reproductive performance, and what breed type of cattle to invest in—are of concern to beef cow-calf producers, educators, and financial institutions involved in lending to beef cow-calf producing firms.

The primary objective of this study is to develop a decision support aid (DSA) utilizing expert system technology to assist beef cattle producers in making well-founded investment decisions with respect to the firm's beef cattle herd. The DSA will be used to analyze how the proposed expansion/contraction in beef cow herd influences a representative firm's financial condition and performance.

Previous Research

The asset replacement problem has received attention in the agricultural economics literature for over 30 years. In his 1965 seminal study, Burt developed a model for economic analysis of asset life under conditions in which there was a chance of failure or loss, with replacement falling into planned and random categories. In a subsequent study, Perrin introduced a general replacement/investment principle applicable to both appreciating and depreciating assets, and considered theoretical implications of changing discount rates and market prices (salvage values).

The specific problem of beef cow replacement decisions was initially addressed in the literature when Rogers carried out an empirical investigation into the beef cow replacement decision under conditions of certainty. Bentley, Waters, and Shumway expanded the literature with an empirical study of the problem of determining the optimal replacement age for beef cows given stochastic elements relating to the probability of producing a marketable calf and the probability that a cow might die in a particular period. Kay and Rister developed two models to examine the effects of income tax policy on the decision to buy or raise replacement beef cows with a fixed herd size. Innes and Carman analyzed the effects of the Tax Reform Act of 1986 on the decision to either raise or purchase beef cow replacements.

The impact of market price uncertainty on the beef cow replacement decision and herd size began to be addressed in the 1980s. Yager, Greer, and Burt developed optimal policies for marketing cull cows through the use of discrete stochastic programming, resulting in changes in cow salvage prices. Bentley and Shumway examined the planning of cattle herd size over cycles in beef cattle inventories and prices. Trapp developed investment principles that resulted in separation of the investment and disinvestment decisions that allow for firm expansion or contraction through unequal rates of culling and additions.

More recent work has focused on the effects of herd management strategies on the beef cow replacement decision. The replacement decision was examined by Tronstad and Gum with a stochastic dynamic programming model that took into account herd productivity under multiple calving seasons and market price uncertainty. A model was developed by Frasier and Pfeiffer that incorporated the effects of different feeding regimes on expected herd productivity.

The review of previous research suggests that many factors enter into the beef cow investment decision process, most of which contribute to the level of economic efficiency of the beef cow operation. As noted by Long, Cartwright, and Fitzhugh, "The net efficiency of different systems of beef production is a function of the genetic and environmental inputs and their interaction" (p. 409).

The traditional measures of environmental inputs would include such factors as availability of grazing or raised feed resources. A broader definition of environmental inputs should include the financial position and performance of the firm, which measures the availability and application of financial resources. However, the previous works do not explicitly examine the relationship of proposed investment decisions to the financial performance and condition of the beef cow-calf producing firm. Further, previous research has not focused on the effect of proposed investment in beef cows on the herd age composition and the resulting impact on the overall financial structure of the firm. In the following section, we present the development of a model that will take these and other factors into account when analyzing the impacts of beef cow investment decisions on the firm's financial condition and performance.

Beef Cow Investment Analysis System

In this study, we develop a computerized simulation model of the beef cow firm, identified as the Beef Cow Investment Analysis System (BCIAS). This system is primarily a decision support aid (DSA). Decision support implies the use of computers: (*a*) to assist managers in their decision-making processes in semistructured tasks; (*b*) to support, rather than replace, managerial judgment; and (*c*) to improve the effectiveness of decision making rather than its efficiency (Keen and Morton). The DSA's impact is on decisions in which there is sufficient structure for computer and analytic aids to be of value, but where the manager's judgment is essential. Under the manager's control, the DSA should be a supportive tool, i.e., the DSA is not designed to automate the decision process, predefine objectives, or impose solutions (Keen and Morton).

The BCIAS simulation is a mathematical model of an actual ranching system. A system here can be defined as a collection of entities (such as cows, calves, grazing resources, or financial resources) that act and interact together to accomplish an end—which, in the case of the BCIAS, is improvement in the financial position and performance of the firm. The BCIAS employs discrete-event simulation, which models a system as it evolves over time with state variables that change only at countable intervals (Law and Kelton).

The BCIAS contains several features designed to address shortcomings of previous beef cow investment models. These features include: (*a*) introduction of stochastic elements, such as calving percentage, calf death loss, and weaning weights, into the model to account for uncertainty relating to reproduction and production parameters; (*b*) an expert system analysis of the financial position and performance of the firm under baseline and alternative beef cow investment scenarios; (*c*) decision support for the user regarding output pricing, production, and reproduction parameters; and (*d*) incorporation of standardized production, reproduction, grazing, and raised feed parameter definitions.

The BCIAS is comprised of five modules: the beef cow herd inventory (BCHI) module, the beef cow herd resource inventory (BCHRI) module, the beef cow herd cost/price expectations (BCHCPE) module, the beef cow herd investment analysis (BCHIA) module, and the Agricultural Financial Analysis Expert Systems (AFAES). Figure 1 illustrates how these modules relate to each other.

The data processed in the BCHI, BCHRI, and BCHCPE modules are used in the BCHIA module to simulate the projected performance of both the current cow herd and the proposed alternative cow herd over the user-specified planning horizon. This analysis includes examination of the firm's financial position and performance for both the current herd and the proposed investment, in addition to an economic analysis of the proposed investment.

The BCHI Module

The beef cow herd inventory (BCHI) module is designed to provide a vehicle for entering reproductive, productive, and financial data that are related to the firm's current beef cow herd. The measures for production and reproduction efficiency parameters used in the BCHI module are based on SPA recommendations (refer to McGrann). The SPA guidelines designate three primary measures for reproductive performance and two primary measures for productive performance within a herd. The primary reproductive performance measures are (*a*) calving percentage, (*b*) calf death loss, and (*c*) calf crop; the primary measures for productive performance are (*a*) actual weaning weights, and (*b*) pounds weaned per exposed female.

The production and reproduction measures were used to develop default production parameter estimates that are contained in the BCHI module. These default parameters are intended as examples for users who have the capability to generate such values from their own records, in which case these parameters may be overridden. However, in the

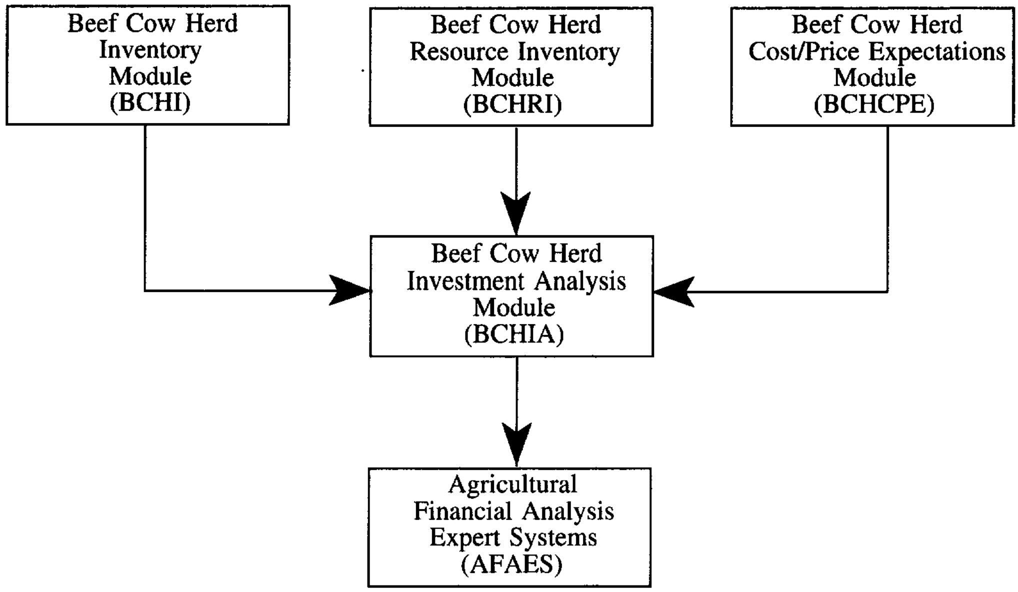

Figure 1. Beef Cow Investment Analysis System (BCIAS) modules

case where production records are missing, the default parameters can provide a basis for beginning the analysis.

The data for estimating default production and reproduction parameters were obtained from a study that included 5,903 calving records for 988 cows at the Texas A&M Research Center at McGregor, Texas. (See Long et al. for details of early management techniques applied to these cattle.) Cows were managed so as to conceive whenever they were physiologically able; cows failing to conceive within 18 months of their last parturition date and found to be open were culled. When necessary, cows were also culled for physical unsoundness (McElhenney et al.).

Following the work of Greer, Whitman, and Woodward, the Bernoulli distribution was estimated by breed type for the calving percentage reproduction parameter. The Bernoulli distribution for a random variable x is shown in equation (1):

$$(1)\quad f(x;\theta) = \theta^{x}(1-\theta)^{1-x}, \qquad \text{for } x = 0, 1.$$

For this study, the definition for success will be that the cow actually calved within any given period of time. With the additional assumption of independence between stages of the trials, the Bernoulli distribution can be extended to become the binomial distribution (Freund and Walpole). Here, we assume that at any specific age, the probability of any cow calving does not depend on any other cow calving that is the same age. The binomial distribution for a random variable x is shown in equation (2):

$$(2)\quad f(x;n,\theta) = \binom{n}{x}\theta^{x}(1-\theta)^{n-x},$$
$$\text{for } x = 0, 1, \ldots, n.$$

For simulation purposes, the number of cows that are available to be exposed would be specified as the number of trials, n, with x being the total number of cows calving.

The binomial distribution is used to estimate the calf crop reproduction parameter from the data by breed and age group. The probability of success is defined as a calf born. The simulated number of successes (here, live calves born) is adjusted for death loss and then divided by the simulated number of cows exposed in the corresponding breeding season to arrive at the simulated calf crop or weaning percentage.

Calf death loss and calf crop reproduction performance measures are based on the number of calves born option in the SPA guidelines. Breed type has been shown to be a significant source of

Table 1. Calf Death Loss Percentage and Weaning Weights by Breed Types

Breed	Percent Death Loss	Mean Weaning Weight (lbs.)
Angus	4.34	426
Brahman	10.58	435
Hereford	5.18	396
Holstein	4.76	503
Jersey	8.21	409
Angus × Brahman	5.96	456
Angus × Hereford	7.19	435
Angus × Holstein	5.81	481
Angus × Jersey	6.05	440
Brahman × Hereford	4.59	457
Brahman × Holstein	9.34	515
Brahman × Jersey	5.05	458
Hereford × Holstein	3.84	490
Hereford × Jersey	6.29	438
Holstein × Jersey	9.04	467

Source: Falconer

variation for calf survival from birth to weaning (McElhenney et al.). The estimated default calf death loss parameters by breed type are presented in table 1. To arrive at the SPA reproduction efficiency measure of calf crop for projection purposes, the number of calves born is calculated from starting exposed cow numbers and default calving percentages, to arrive at total calves born. The total number of calves born is then adjusted for calf death loss to arrive at total calves weaned. The SPA primary reproduction efficiency measure for calf crop is calculated by dividing total calves weaned by the total number of exposed cows.

The SPA productive performance measure for actual weaning weights is estimated for each cow breed type included in the study conducted by Long et al. The distributions used in the simulation process are based on normal curves, with estimated parameters shown in table 1. The average weaning weight is then simulated as a normal distribution that uses the mean and standard deviation of the samples by breed type, with a user-specified adjustment available to be used to correct for age of dam effects. The weights are then multiplied by the calves weaned in the respective breed type and age group, and then summed to arrive at the total pounds of calves weaned. The simulated SPA performance measure of pounds weaned per exposed cow is calculated by dividing the total pounds weaned by the number of exposed cows.

While cull cow sales is not a primary performance indicator designated by the SPA guidelines, it is addressed within the guidelines. To estimate weight of cull cows for sale, we drew from the work of Nelsen, Long, and Cartwright. The estimation procedure used here is shown by equation (3) (Brody):

$$(3) \quad Y_t = A - Be^{-kt},$$

where Y_t is the weight of the animal in kilograms at time t, A is the asymptotic weight, B is a constant of integration, k is the measure of the rate at which the curve is approaching the asymptote, and t is the time in months. This model for weight at any given time in months for breed type and condition score is used in the BCHIA module to calculate sale weight of cull cows by breed type and age group. (See Nelsen, Long, and Cartwright for a more detailed discussion of this method.)

The BCHRI Module

To evaluate the proposed beef cow investment, the resources available for input into the beef cow-calf enterprise must be accurately inventoried. This is accomplished through the beef cow herd resource inventory (BCHRI) module. To examine the performance of grazing and raised feed resources in the beef cow-calf enterprise, the BCIAS model incorporates the following two primary measures as defined by the SPA guidelines: (*a*) grazing acres per exposed female, and (*b*) pounds weaned per acre utilized by the cow-calf enterprise. The simulation model calculates the SPA grazing and raised feed performance grazing acres per exposed female measurement by dividing the number of grazing acres by the simulated number of exposed females.

To facilitate the establishment of baseline measures of the firm's financial condition and performance and to provide a general format for analysis of projected results from investment in beef cattle, the BCHRI module uses the FINYEAR software package (McGrann, Parker, and Neibergs). FINYEAR is a computer program that was created to assist in the development of a set of financial statements for a single operating year. The program's formulation has been closely coordinated with the published *Recommendations of the Farm Financial Standards Task Force* (Farm Financial Standards Task Force). The task force has developed financial analysis standards and terminology for agricultural businesses.

The BCHCPE Module

The beef cow herd cost/price expectations (BCHCPE) module is designed to aid the user in the development of cost expectations for grazing and forage production, discount rates used in economic investment analysis, and output prices for the beef cow enterprise. The output price expectations specifications for the beef cow enterprise used in this study are grouped into three major categories: (*a*) expectations based on past own information, (*b*) subjective expectations of the model user, and (*c*) expectations based on solutions from a structural agricultural sector model. A naive expectations model is used to represent the first category. For subjective price expectations, projected mean cattle prices are elicited from the producer, and then random deviates of historical prices are generated to create the price probability distribution (Richardson et al.). Expected cattle prices for the third category are taken from the AG-GEM model (Penson and Taylor), a structural econometric model that specifically links the agricultural sector with the general economy.

The BCHIA Module

To carry out an economic analysis of the proposed investment for the user-specified planning horizon, the beef cow herd investment analysis (BCHIA) module applies a net present value investment model (as suggested by Barry, Hopkin, and Baker), modified to include a time variant discount rate [equation (4)]:

$$(4) \quad NPV = -INV + \sum_{n=1}^{N} \left[\frac{P_n}{(1 + i_n)^n}\right] + \left[\frac{V_N}{(1 + i_N)^N}\right],$$

where NPV is the net present value, INV is the initial investment, P_n is the net cash flows attributed to the investment that can be withdrawn in period n, V_N is the terminal investment value, N is the length of the planning horizon, and i_n is the discount rate. For a single proposed investment, the decision rule for the economic analysis would be to accept the investment on an economic basis if the NPV is greater than zero. In the BCHIA module, the net cash flows and terminal values include both stochastic and deterministic elements.

The BCHIA module uses the net cash flow from operation of the cattle enterprise as the income flow per period stream in the net present value model. The simulation results also show the range that the simulation generates for net cash flow from operations, allowing the user to measure the range of outcomes as a factor of risk. Assuming independence of cash flows, the standard deviation of the net present value can also be calculated as shown in equation (5) and used as a measure of risk (Bussey):

$$(5) \quad V = \sum_{t=0}^{n} \left[\frac{\text{var}_t}{(1 + i_t)^{2t}}\right],$$

where V is the variance of the net present value, var_t is the variance of the cash flow in time period t, and i_t is the discount rate by period.

BCHIA Module Output as Input for AFAES Program

The output from the BCHIA module is used as input into the Agricultural Financial Analysis Expert Systems (AFAES) program. To analyze the firm's projected performance, the AFAES projected operating year performance expert system component uses four years of historic balance sheets, three years of income statements, and three years of statements of cash flow data, along with projected balance sheet, projected income statement, and projected cash flow data. Through this AFAES program component, a summary report is provided of actual historic and projected measures that are examined, as well as a graphic overall diagnostic analysis of the firm's financial position and performance. (For a comprehensive discussion of the AFAES program, see McGrann et al. 1990.)

Base Simulation Data

To validate the BCIAS, we selected an investment problem facing the Texas A&M University (TAMU) Farm, located in the Brazos River Valley of central Texas. The simulations that were carried out examine two possible courses of action: (*a*)

Table 2. Probability of Angus × Brahman and Brahman × Hereford Cows Calving Within 365 Days of Previous Parturition

	Age in Years									
Breed	3	4	5	6	7	8	9	10	11	12
Angus × Brahman	0.086	0.897	0.811	0.833	0.919	0.750	0.704	0.833	0.800	0.500
Brahman × Hereford	0.172	0.797	0.830	0.875	0.878	0.714	0.800	0.682	0.733	0.364

Source: Falconer

maintaining the cow herd at present levels, or (*b*) liquidating the cow-calf enterprise and leasing out the land on which the enterprise was operating. Using the three methods of developing expectations (previously discussed), the BCIAS was run to evaluate differences in economic analysis results under these options. Results from the simulation using the AG-GEM structural model expectations for the continuation and disinvestment strategies were then processed through the AFAES program.

The data used as a basis for the simulations were taken from actual SPA reports for the TAMU Farm. The farm's cattle are comprised of two main breed types—Beefmaster and Brangus. Thus, two sets of calving probabilities were generated. Because of the breed composition of Beefmaster cattle, which includes Brahman, Hereford, and Shorthorn, the Brahman × Hereford data set from the McGregor Experiment Station was selected to represent the Beefmaster cows. The Brangus were likewise represented by the Angus × Brahman data set from the McGregor Experiment Station because of the Brahman and Angus composition of the Brangus breed. The McGregor data were deemed appropriate to represent the calving performance of the TAMU Farm cows due to the proximity of the TAMU Farm to the McGregor, Texas, area and the overall management practices applied to the animals. These practices included adequate levels of nutrition and the use of artificial insemination, which can substantially improve reproductive performance.

To generate the required Bernoulli probabilities used in the binomial simulation for the model, a transition matrix moving from parturition probability data to a probability of parturition by age group under the desired culling strategy was developed for both breed types. The transition probabilities for Angus × Brahman and Brahman × Hereford cows are presented in table 2.

The TAMU Farm currently devotes 748 total acres to the beef cow enterprise. The grazing resources for the farm include 643 acres of improved perennial pasture, in addition to five acres of annual pastures or forage crops. The farm's raised feed resources include 100 acres of improved perennial grasses devoted to hay production. During fiscal year 1991, the TAMU Farm incurred $102,372 in total direct cash expenses relating to the beef cow-calf enterprise, $2,016 in direct noncash expenses relating to the beef cow-calf enterprise, $3,229 in total indirect cash expenses, and $1,245 in total indirect noncash expenses. This cost structure will serve as the base for cost structure estimates for all simulations in this study.

Table 3 shows the base cattle prices used in the simulation runs. The base for the naive expectations simulation for calf prices was the weighted average actual price received for all calves at the TAMU Farm for 1991, which was $83.85 per cwt. The AG-GEM price expectations simulation for calf prices was generated by using the annual percentage change in AG-GEM forecasted calf prices applied to the $83.85 per cwt base. Calf prices for the subjective expectations simulation were taken from unpublished survey data (Falconer and Neibergs). Highest and lowest expected prices, along with expected prices, were gathered from over 60 cow-calf producers in the spring of 1991 for the 1991–95 period. The mean of the survey data was used as the parameter input into the subjective price distribution.

As with calf prices, the base for the naive expectations simulation for cow prices was the weighted average actual price received for all cows at the TAMU Farm for 1991, which was $62.92 per cwt.

Table 3. Base Cattle Prices Used in Simulation Runs

	Year				
Simulations	1	2	3	4	5
	Calf Prices ($/cwt)				
Naive Expectations	83.85	83.85	83.85	83.85	83.85
AG-GEM Model	87.20	86.33	86.59	87.02	87.46
Subjective Expectations	93.21	90.21	88.21	87.21	87.21
	Cull Cow Prices ($/cwt)				
Naive Expectations	62.92	62.92	62.92	62.92	62.92
AG-GEM Model	67.29	65.62	64.82	64.06	63.31
Subjective Expectations	55.21	52.21	50.21	49.21	49.21

Table 4. Projected Cow Herd Composition and Production by Year

Year	Cows Exposed (head)	Birth (head)	Weaned Calf Production (lbs.)	Cull Cows (head)	Cull Sales (lbs.)
1	158	117	51,363	28	32,558
2	158	114	50,052	32	37,204
3	159	111	48,736	36	41,745
4	159	117	51,374	20	23,191
5	159	110	48,298	23	22,008

The AG-GEM price expectations simulation for cow prices was generated by using the annual percentage change in AG-GEM forecasted cow prices applied to the $62.92 per cwt base. The cow prices for the subjective expectations simulation were generated by adjusting the survey data taken from Falconer and Neibergs for a constant basis. The basis between cow and calf prices was assumed to be $38 per cwt (table 3).

The initial composition of the TAMU Farm herd by age and breed type was used as the basis for simulation runs. The culling strategy imposed on the herd was to cull any cow over three years of age that did not calve, and to cull all cows after reaching 11 years of age. The heifer must calve to enter the herd at all. All replacement animals were assumed to be retained from the Beefmaster herd. Table 4 presents the projected composition and production of the herd by year.

The projected herd becomes younger under the specified culling and replacement strategy (figure 2). In the initial cattle inventory, 39% of the total cows are less than five years of age, while in the fifth year of the simulation, 69% are less than five years of age. The number of cows under five years of age peaks at 72% in the fourth simulated year. The herd becomes less productive over time (table 5), dropping from 325 pounds weaned per cow exposed in the first year of the simulation to 304 pounds in the final year of the five-year planning horizon. This productivity decline is due to lower reproductive performance of the younger cows, primarily cows that are calved as two-year-olds, and attempts to rebreed and calve at three years of age.

The net farm/ranch income from operation of the beef cattle enterprise is literally the bottom line for the income statement in the BCHIA module. The net income is calculated in this model by subtracting accrued direct and indirect expenses from the accrued gross revenue, and then adjusting for total interest expense. The projected accrual-adjusted income statement for the beef cow enterprise utilizing AG-GEM cost and price expectations is shown in table 6.

Investment Analysis Results

Simulation results for net farm income from operation of the cattle enterprise were generated for each of the three alternative cattle price expectations methods used in the BCHIA module for the final investment analysis. The AG-GEM forecasted interest rate for non-real estate loans was used for the investment analysis in each scenario. The interest rate on non-real estate loans was selected for use as the discount rate because the TAMU Farm does have a small amount of debt which could be paid

Table 5. Standardized Performance Measures for Simulated Herd

	Meas. Unit	Year 1	2	3	4	5
Calving percent	%	74.1	72.2	69.8	73.6	69.2
Percent calf crop	%	70.9	69.6	67.3	70.4	66.7
Average weaning weight	lbs.	459	455	455	459	456
Pounds weaned per exposed female	lbs.	325	317	307	323	304
Total acres per exposed female	acres	4.7	4.7	4.7	4.7	4.7
Pounds weaned per acre utilized by cow-calf enterprise	lbs.	68.7	66.9	65.2	68.7	64.6
Financial cost (noncalf revenue adjusted) per cwt	$	1.94	2.08	2.22	2.47	2.81

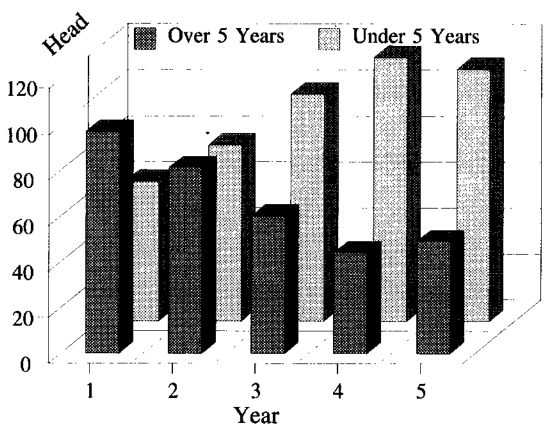

Figure 2. Age composition of projected herd

down (as an alternative to keeping capital tied up in the cattle operation).

The results for net farm income from operation of the cattle enterprise were not encouraging for any of the simulations, and in particular for the AG-GEM expectations simulations. The sharp increase in predicted feed costs early in the planning horizon causes a large increase in the total cost structure over the AG-GEM expectations planning scenario. This cost increase, coupled with steady to declining cattle prices over the AG-GEM expectations planning scenario, leads to a negative net cash flow from operation of the beef cattle enterprise at the TAMU Farm. The net present value of the net cash flow from operation of the cattle enterprise combined with the market value of the ending cattle inventory is −$238,253 for the AG-GEM expectations planning scenario.

The results for net farm income from operation of the cattle enterprise were also negative over the entire period for the naive expectations simulations. However, with costs held level, net farm income from cattle operations is higher in comparison to the AG-GEM expectations planning scenario. The net present value of the net cash flow from operation of the cattle enterprise combined with the market value of the ending cattle inventory is −$269,430 for the naive expectations planning scenario. The standard deviation of the net present value of the net cash flow from operations for the naive expectations option is $4,731, which represents the smallest of the standard deviations calculated for all expectations options.

The subjective expectations simulations likewise yielded negative results over the entire period for net farm income from operation of the cattle enterprise. Due to the expectation of declining calf and cow prices over much of the planning horizon, the subjective model produced the lowest returns of all three expectations scenarios. Under the subjective expectations planning scenario, the net present value of the net cash flow from operation of the cattle enterprise combined with the market value of the ending cattle inventory is −$275,275. The standard deviation of the net present value of the net cash flow from operations for the subjective price expectations option is $8,664—the largest of all the standard deviations for any expectations option.

A result of increased variability when employing the subjective expectations option relative to the naive and AG-GEM expectations options is not surprising. Since the subjective expectations option specifically introduces uncertainty in the

Table 6. Beef Cow Herd Investment Analysis (BCHIA) Module's Projected Income Statement for AFAES Evaluation of Continued Cattle Operation Strategy

	Year				
	1	2	3	4	5
	($)				
Gross Revenue	61,557	47,058	59,880	62,258	56,010
Total Direct Cash Expenses	115,120	121,957	128,248	135,149	142,453
Total Direct Noncash Expenses	2,151	2,229	2,311	2,401	2,495
Total Direct Operating Expenses	117,272	124,185	130,559	137,551	144,948
Gross Margin	(55,715)	(77,127)	(70,679)	(75,293)	(88,938)
Total Indirect Cash Expenses	3,229	3,229	3,229	3,229	3,229
Total Indirect Noncash Expenses	1,245	1,245	1,245	1,245	1,245
Total Indirect Operating Expenses	4,474	4,474	4,474	4,474	4,474
Income After Indirect Expenses	(60,189)	(81,601)	(75,153)	(79,767)	(93,412)
Total Interest Cash Expenses	0	0	0	0	0
Total Interest Noncash Expenses	0	0	0	0	0
Total Interest Expenses	0	0	0	0	0
Total Pre-Tax Farm/Ranch Expenses	121,746	128,659	135,033	142,025	149,422
Net Farm/Ranch Income from Operation	(60,189)	(81,601)	(75,153)	(79,767)	(93,412)

Note: The AG-GEM expectations option is used as a baseline for this strategy.

output price mechanism by specifying a price distribution, it follows that the subjective expectations option will lead to larger variances in returns relative to the single-valued estimates employed in the AG-GEM and naive expectations scenarios.

AFAES Comparison of Two Projected TAMU Farm Strategies

Given the negative results generated in the previous investment analysis, two projected strategies for the TAMU Farm were selected for AFAES evaluation and comparison. The first alternative is one of continued operation using the AG-GEM expectations option as a baseline (table 6). The second option is to sell all the cattle and lease the land currently occupied by use of the cattle (table 7).

The land utilized by the cattle operation at the TAMU Farm was deemed to have 300 acres suitable for growing cotton, and was assumed to have a cash lease rate of $40 per acre. The balance of the land utilized by the farm's cattle operation (448 acres) was deemed to be suitable only as grazing land and was assumed to have a cash lease rate of $16 per acre. The projected income statement for the sell at the end of 1992 strategy is shown in table 7.

For purposes of the expert system analysis, operations other than the cattle enterprise at the TAMU Farm were treated using a naive expectations approach. Under the continued-operation strategy, the expert system analysis on the projected financial performance of the farm fell from acceptable to unfavorable after the 1993 operating year. The AFAES diagnosis cited the extremely poor profitability of the operation (rating profitability at −29.6 based on a range of −30 to +30) and deterioration in firm growth as reasons for the change to an unfavorable performance rating.

In contrast, the AFAES diagnosis gave the TAMU Farm a favorable rating of 15 (from a range of −15 to +15) for its liquidity position, but noted that the liquidity position of the firm was not showing improvement over time. Because of a lack of debt, the AFAES diagnosis also gave the farm a favorable rating for debt repayment capacity of 12.5 (from a range of −25 to +25). In addition, the diagnosis produced a favorable rating of 6.7 (from a range of −20 to +20) for the farm's solvency position, but warned that the solvency position of the firm has been declining.

Conversely, the AFAES evaluation of the sell at the end of 1992 strategy gave the TAMU Farm acceptable ratings for the entire planning horizon. For example, the diagnosis assigned a favorable rating of 15 (from a range of −15 to +15) for the

Table 7. Beef Cow Herd Investment Analysis (BCHIA) Module's Projected Income Statement for AFAES Evaluation of Sell at End of 1992 Strategy

	Year				
	1	2	3	4	5
	($)				
Gross Revenue	39,687	19,168	19,168	19,168	19,168
Total Direct Cash Expenses	102,372	0	0	0	0
Total Direct Noncash Expenses	2,016	0	0	0	0
Total Direct Operating Expenses	104,388	0	0	0	0
Gross Margin	(64,701)	19,168	19,168	19,168	19,168
Total Indirect Cash Expenses	3,229	3,229	3,229	3,229	3,229
Total Indirect Noncash Expenses	1,245	1,245	1,245	1,245	1,245
Total Indirect Operating Expenses	4,474	4,474	4,474	4,474	4,474
Income After Indirect Expenses	(69,175)	14,694	14,694	14,694	14,694
Total Interest Cash Expenses	0	0	0	0	0
Total Interest Noncash Expenses	0	0	0	0	0
Total Interest Expenses	0	0	0	0	0
Total Pre-Tax Farm/Ranch Expenses	108,862	4,474	4,474	4,474	4,474
Net Farm/Ranch Income from Operation	(69,175)	14,694	14,694	14,694	14,694

farm's liquidity position, and cited strong improvement over time. Solvency, repayment capacity, and growth were also given favorable ratings, although AFAES noted slow increases in earned equity as a reason not to give the highest possible ratings for firm growth. The TAMU Farm's projected profitability received an extremely low rating of −14.47 (from a range of −30 to +30) under the sell at the end of 1992 strategy. While the farm is profitable under this strategy, the rate of return on farm assets was cited as being low, and not showing any improvement over time.

Model Validation

The SPA primary performance measures for the TAMU Farm simulation were compared with the latest SPA summary data (McGrann et al. 1992) for validation purposes (table 5). Although the simulated TAMU Farm calving and calf crop percentages are below the weighted average of the SPA summary, they are within the SPA summary's reported range, as are the simulated average weaning weights, pounds weaned per exposed female, and acres per exposed female. The simulated TAMU Farm pounds weaned per acre utilized by the cow-calf enterprise are above the weighted average of the SPA summary, and are also within the summary's reported range.

However, the TAMU Farm simulation shows the current operation's projected cost of production to be extremely high relative to the SPA summary financial data. The observed range in the SPA summary for weaned calf cost per cwt reflected a low of $31 per cwt and a high of $141 per cwt. In none of the projected years did the TAMU Farm simulation have a weaned calf cost less than the highest observed cost. Care should be taken in interpreting these particular projections, since they are dependent upon the changes in costs based on AG-GEM forecasts.

Summary and Concluding Remarks

In this study, we have developed a decision support aid that examines the impact of proposed investment decisions in beef cattle on the firm's financial performance and position. The model depends heavily on the use of electronic spreadsheets for generation of projections that are used as inputs in a computerized expert system. Data requirements are specific, i.e., the initial inventories of animals and related resources, as well as financial statement information, are required. However, these information requirements are not overly burdensome, as shown in the example where baseline data were taken from SPA reports and cattle inventories by age group.

The model is currently being used at the county agricultural extension level. While the main goals of this study have been achieved, further work is being conducted with the model to exploit the capabilities of the latest generation of computer software. These enhancements center on making the data transfer between modules more transparent to the user, which will reduce the training time and effort required to generate the analysis.

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