THE IMPACT OF SELECTED MANAGEMENT PRACTICES ON THE ECONOMIC SURVIVABILITY OF A RANCH UNIT: AN ANALYSIS FOR A SOUTHERN PLAINS RANCH

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LIST OF TABLES

Table Page

Table		Page

LIST OF FIGURES

Figure		Page

Figure | Page

CHAPTER I

INTRODUCTION

The beef livestock producer has been praised for perserverance and resourcefulness and characterized as having great faith in a cow and strong pride in a bull (Syntex, 1975). Strong determination to succeed has helped the ranching operator survive depression, drought, blizzard, and disease.

However, traditional methods of beef cattle production must yield to economic pressures for greater efficiency. The continued existence of a ranch is not dependent on producing more beef per head or per acre, but on the manager's ability to produce that beef while receiving an acceptable return to own resources. This study develops a method to examine the economic survivability of a Southern Plains ranch for various herd management alternatives under uncertainty.

The Problem Situation

Managing a beef ranch presents dynamic challenges, even to a long term cattleman-manager. Beef industry problems change and shift in emphasis, and new technology and marketing organizations evolve to create different managerial issues and opportunities. The problem situation confronting beef producers in the Southern Plains is discussed in this section.

Price Variability

The most persistent economic pressure facing Southern Plains ranchers, as well as agricultural producers through out the United States, is the "cost-price squeeze." This problem relates to the moderate level of prices producers receive for their products over time and the steadily rising cost of production and marketing. Table I lists the high and low annual steer calf prices, (No. 1 Med.; 400-500 lbs. steers) for 1974-1984. The annual range indicates price variations for a particular year. From the period 1974 through 1984, the ratio between the difference in the high and low and the annual average price varied from a high of 69 percent in 1974 to a low of 10 percent in 1984. In recent years, annual price variation has moderated.

The index of prices received and paid by ranchers (Table I) illustrates the high degree of variation in prices received by ranchers in the past decade is independent of the steadily increasing cost of production. Marketing and income problems occur because of large variations in prices received for livestock from year to year, and because ranches lack market power, they are price takers rather than price makers.

Supply and Demand

Supply and demand operate as major factors in determining the price of beef and therefore the returns to producers. In fact, this is the major factor at work in the relative demand and price for the three major meats--beef, poultry and pork. Trapp has provided

TABLE I

STEER CALF PRICES AND U.S. INDEX OF PRICE RECEIVED AND PAID BY FARMERS, 1974-1984

Year	Steer Calf Prices (No. 1 Med 400-500 lbs.)[a]				U.S. Index of[b]	
	High (H)	Low (L)	Annual Avg. (Ave.)	Difference (H-L)	Price Received by Ranchers (1910-14=100)	Price Paid by Ranchers (1910-14=100)
1974	56.92	29.06	40.11	27.86	545	558
1975	39.23	24.36	32.39	14.87	496	614
1976	48.59	37.70	42.17	10.89	550	653
1977	46.79	40.22	44.90	6.57	568	689
1978	83.71	47.95	67.50	35.76	782	745
1979	115.00	90.00	99.80	25.00	1,047	848
1980	103.38	78.20	85.73	25.14	951	948
1981	80.42	66.00	72.48	14.41	888	1,035
1982	73.81	63.90	68.89	9.91	844	1,071
1983	81.09	69.78	72.35	11.31	819	1,105
1984	74.83	67.77	69.72	7.06	818	1,132

[a]USDA (1985a).

[b]USDA (1985b).

empirical evidence of the forces behind the supply and demand for meat indicating that the meat industry is a "mature industry" in this country (Trapp, 1984). Growth of the beef industry will no longer be possible without at least maintenance of a constant market share. If the demand for beef has peaked and new technology continues in poultry production, then beef must be produced at a lower cost and/or less of it must be produced to maintain profitability.

There is concern about the ability of beef to compete with other meats and meat substitutes. Pork and chicken have enjoyed substantial gains which have impacted on the competition with beef. Since 1976, beef consumption has declined 19 pounds per person, while pork consumption has increased 16 pounds and broiler consumption has increased 10 pounds (U.S. Department of Agriculture, 1980). These gains are a direct result of efficient management practices and/or improved technology. In contrast, the beef industry, in particular the cow-calf and stocker producer, has not yet exploited the current technology available.

Financial Stress

In addition to the above problems, cow-calf and stocker operators are facing severe financial stress. During the late 1970's, beef cattle prices were unusually high and the income generated by these prices was capitalized into land and other long term capital items. Beginning ranchers and others used borrowed funds to purchase additional production inputs. Currently, farm and ranch incomes are lower than they were during a large part of the 1970's. As a result, ranchers and farmers have a much higher debt-to-income ratio than in prior years. Based on USDA data, aggregate debt of the U.S. agricultural sector was approximately 90 percent of net farm income in 1950, resulting in a debt to income ratio of less than one. This ratio rose to two in 1960, to approximately three in 1970, and now stands in excess of ten to one (U. S. Department of Agriculture, 1984). Thus, farmers and ranchers are carrying a much larger debt load per dollar of debt servicing capacity (i.e., income) which adds to their financial pressure.

Ranches have also suffered reduced liquidity. In 1950 approximately 27 percent of the asset base on the typical farm and ranch firm was liquid (i.e. financial assets and livestock inventories); in 1982 less than 11 percent was liquid (U. S. Department of Agriculture, 1984). In the past, liquidity provided a safety valve for the farmers and ranchers who did not generate sufficient income to meet the debt servicing requirement; he or she could sell part of the liquid asset base without sacrificing part of the productive plant--the land, machinery or breeding stock. Liquidity for the 1980's is scarce, forcing many farmers and ranchers to consider selling part of the fixed asset base to service their indebtedness.

In addition to the problem of income risk, ranchers are facing collateral risk as well. During the three decades from 1950 to 1980, even when ranch incomes turned down the lending community was willing to extend credit to the agricultural sector because collateral values (specifically land values) were stable and rising. During the last four years, land values have declined dramatically thus reducing collateral values and deteriorating security positions. A further consequence of declining collateral values is that the traditional safety valve of the 1970's for ranchers who could not meet the cash flow--that of refinancing--is either no longer available, or is quite costly because of higher interest rates. If credit is unavailable when livestock carry-over decisions are made, both short term and future meat and livestock supplies can be affected by reduction of breeding herds, as is currently being experienced.

An additional characteristic of today's financial stress in agriculture is higher and more volatile interest rates (Melichar, 1984). A shift from relatively low real and nominal interest rates to relatively high rates in the 1970's and early 1980's was stressful for an industry like agriculture that has a large proportion of its total debt used to finance fixed assets on a variable rate.

The farm and ranch sector is becoming increasingly prone to "boom or bust" cash flow situations. The variability of net incomes and lender restrictions on debt acquisition could inhibit the ability of the agriculture sector to obtain economically viable capital investment in improved technology or adopt specialized capital-intensive cost-reducing production methods.

Specific Ranch Problems

Current economic, environmental and institutional pressures generates much pessimism about the future survivability of ranchers in the Southern Plains and through out the United States. The cow-calf and stockers segment of the beef industry is largely land-based. As a result, many producers focus on using land, and they tend to adopt new management practices and technology slowly, if at all. This segment of the industry has a great opportunity to improve efficiency, but it also has the great problems to overcome in applying new technology in an uncertain environment.

It is difficult for a cow-calf and stocker producer to determine which production situation, technologies, and production and marketing practices will provide the best opportunity to compete, profit, and survive in the beef production business without information concerning possible economic potential or impact of such alternatives. Several mathematical optimization and budgeting procedures exist to estimate the profitability of alternative herd management strategies, if the cash benefits and costs associated with the alternative are assumed to be known with certainty. Inflation rates, weather, insects, animal diseases, technological advances, and institutional changes make the assumption of perfect knowledge of prices and input and output supplies highly artificial.

A method of realistically incorporating risks associated with beef production is needed in order to effectively determine what changes in economic and technical conditions would allow greater assurance of survival for ranchers. The broad intent of this study is to provide an analytical method and research information necessary to help beef producers manage their sources of risk. The model and information from this study will help ranchers, state and federal agencies, and future researchers to make decisions which will increase the efficiency of production and the probability of survival on beef ranches in the Southern Plains and through out the United States.

Objectives

The general objective of this study is to develop a conceptual and methodlogical framework to evaluate the impact of selected cattle and range herd management practices on the survivability of ranchers in the Southern Plains in an uncertain ranch business environment. The study is intended to provide knowledge concerning management alternatives and feasibility under stochastic conditions, going beyond studies which assume perfect knowledge.

Specific objectives are as follows:

1. To develop a conceptual and methodological framework, using Monte Carlo simulation techniques, to estimate the potential survivability of a ranch situation under uncertainty.

2. To specify and evaluate the survivability of a representative ranch situation for the Southern Plains.

3. To evaluate selected alternative management plans and economic scenarios for the representative ranch situation.

Study Area

The Oklahoma, Texas, New Mexico and Colorado counties indicated in Figure 1 and Table II were chosen to develop the representative Southern Plains ranch. The Southern Plains ranch study area described here is most representative for the Great Plains area which stretches from Oklahoma, where the prairie grasses end, to Colorado and New Mexico to include grama, buffalo and wheatgrass areas. About three-fifths of the land is in grass, about one-fourth is in dryland farms and the remainder is under irrigation. The study area

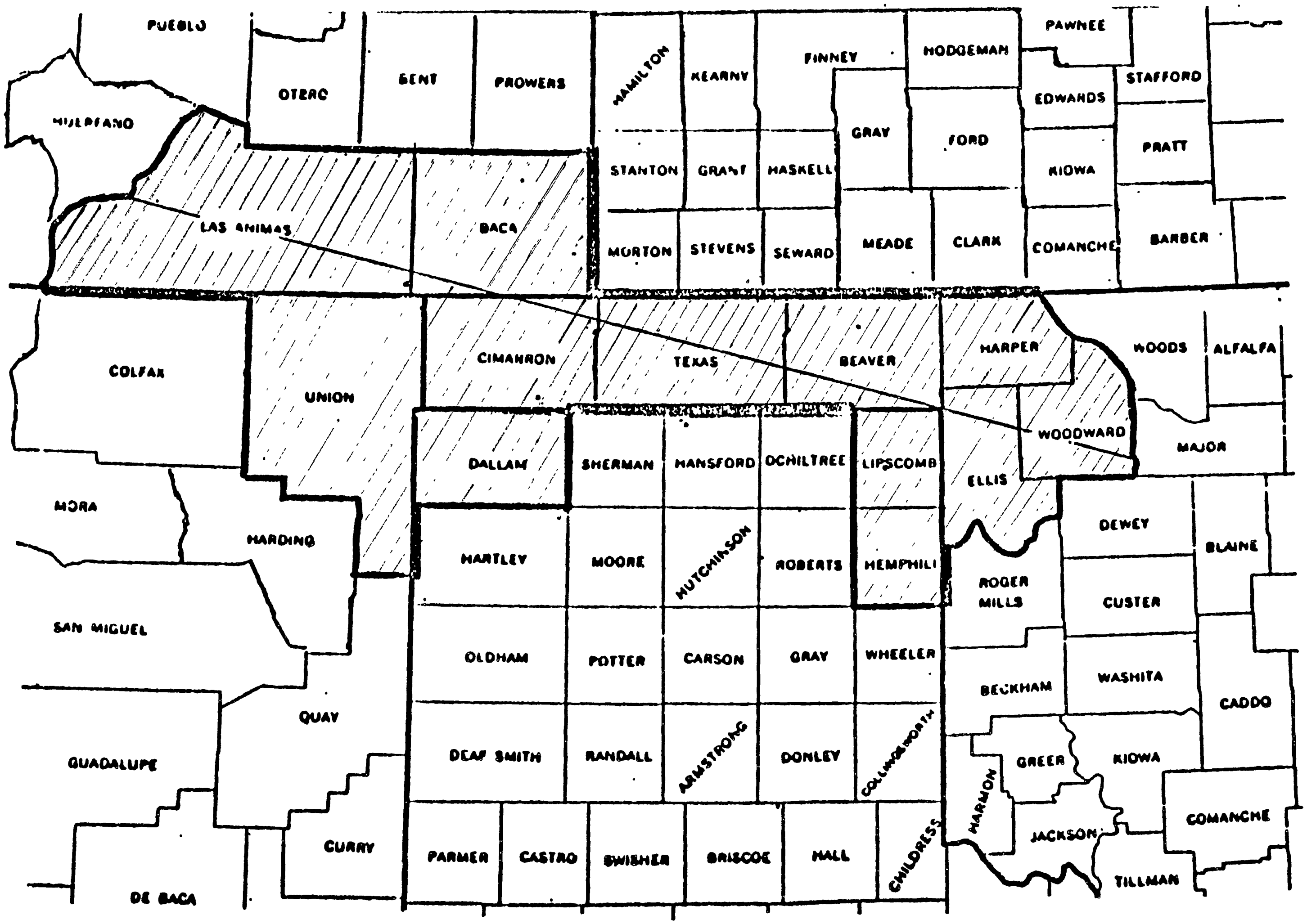


Figure 1. Study Area Transect

TABLE II

SELECTED FARM DATA FOR COUNTIES IN THE SOUTHERN PLAINS STUDY AREA

State and County	Number of Farms	Acres in Farms	Avg. Size	Percent of Land Area
Oklahoma				
Beaver	919	1,095,683	1,192	95.6
Cimarron	490	1,069,953	2,184	90.7
Ellis	685	710,002	1,036	89.3
Harper	530	610,947	1,153	91.7
Texas	875	1,176,529	1,345	89.2
Woodward	772	749,703	971	93.6
Subtotal	4,271			
Texas				
Dallam	385	850,348	2,209	88.9
Hemphill	214	575,340	2,689	99.4
Limpscomb	331	583,557	1,763	97.6
Subtotal	930			
New Mexico				
Union	441	2,279,603	5,169	93.3
Colorado				
Baca	718	1,332,920	1,856	81.3
Las Animos	471	2,156,118	4,578	70.3
Subtotal	1,189			
TOTAL	6,831			

U.S. Department of Commerce (1978).

represented has higher range forage productivity than found in the extreme southern part of the Great Plains area. Even from west to east in the transect area, ranch size diminishes rapidly because of increasing range forage productivity.

Review of Literature

> Explanation and prediction are the goals of economics as well as most other sciences. Both theoretical analyses and empirical investigations are necessary for the achievement of these goals. Theories employ abstract deductive reasoning whereby conclusions are drawn from sets of initial assumptions. Purely empirical studies are inductive in nature. The two approaches are complementary, since theories provide guides for empirical studies and empirical studies provide a list of the assumptions and conclusions of theories (Henderson and Quandt, 1980, p. 1).

The agricultural economics literature reveals numerous theoretical and empirical attempts to explain, predict, and prescribe farm and ranch firm behavior. The sections to follow review some of the theoretical and empirical studies relevant to this study.

The Representative Ranch

Proper specification of a typical or representative farm or ranch situation can save research resources and permit inductive research for a wider range of situations. Hatch, Gustafson, Baum, and Harrington (1982) used a three-step procedure in developing 20 typical farm data sets. First they identified relevant farm or ranch types and production regions. Selection of the type of farm or ranch unit depends largely on the study objectives, commodities under consideration and the study area. Census of Agriculture rankings of counties and states by commodities is useful in establishing ranch types and production regions (U. S. Department of Commerce, 1978). Hatch et al. (1982) established the location of a representative farm situation when five ranked counties fell within an area used for the U. S. Department of Agriculture cost of production estimates.

The second step invovled the specification of a typical farm or ranch. The Census Typical Farm Program (Hatch, 1982) uses farm and ranch level respondent data from the Census of Agriculture to determine the modal ranch size and most common enterprise mix. Additional information on ranch characteristics can be obtained from personal survey of the study area.

The third step involves developing budgets for each enterprise identified in the typical farm or ranch and aggregating them into a whole farm or ranch budget. Data from the Cost of Production surveys conducted by Economic Research Service (U.S. Department of Agriculture, 1978) is a source of technological and geographical homogenous budgeting information (Hatch et al., 1982). Ranch data from a state or area survey is an additional source of input and product prices and quantities, and specific machinery and labor complements for each ranch.

Operational Methods

The development of mathmatical programming techniques aided in the search for operational methods of dealing with the whole-farm/ ranch planning problem. Development of mathamatical programming techniques evoked interest in programming models which account for the randomness of output and input prices and supplies. Since the pioneering work of Freund (1956), several researchers have addressed the problem of stochastic commodity prices and input supplies (McFaguar, 1961; Rae, 1971; Hazell and Scandizzo, 1974; Simmons and Pomareda, 1975; Wiens, 1976; Musser and Samoulis, 1981; Boisvert and Jenson, 1973; Paris 1979; Kramer, McSureeny, and Stavros, 1983; Wicks and Guise, 1978; and Paris and Easter, 1985).

The first attempts to take explicit account of risk in mathematical programming formulations of the whole-farm/ranch planning problem were by quadratic risk programming (Camm, 1962; Freund, 1956; Heady and Candler, 1958; McFarguhar, 1961). Satisfactory applications of quadratic risk programming in agriculture have not been numerous because of data deficiencies, failure to use elicited joint distributions, and difficulties with quadratic programming algorithms.

A number of linear risk programming models have been developed that take into account the stochastic nature of activity net revenues in whole-farm planning. These approaches include the incorporation of game-theory decision criteria into programming models (McInerney, 1969; Hazell, 1970); the use of constraints on maximum admissible loss (Boussard and Petit, 1967); multistage linear programming with marginal risk constraints (Chen and Baker; 1974); and Minimization of total absolute risks, MOTAD, (Hazell, 1971).

An alternate approach to the problem of whole farm/ranch planning under uncertainty of interest to this study is simulation. Manetsch and Parks (1977) define simulation as a technique for obtaining particular time solutions of a mathematical model corresponding to specific assumptions regarding model inputs and values assigned to parameters. King (1979) noted one of the distinct advantages of simulation is that it is a remarkably flexible procedure which allows complex processes, such as whole-farm/ranch planning, to be represented realisticlly. Naylor, Balintty, Burdick and Chi (1966), Schmidt and Taylor (1970), and Manetsch and Park (1977) all provide authoritative discussion of simulation techniques.

Monte Carlo methods are commonly used in combination with simulation to model the performance of complex stochastic systems. Under this approach, numerical procedures are employed to generate sample observations from the decision maker's subjective probability distributions for input variables (King, 1979). A set of variates drawn from the probability distribution of random variables is used for the stocnastic parameters in the problem. The probability distribitions of the output variables are obtained by repeating the process. Monte Carlo sampling technique for estimating the distribution of Net Present Value, internal rate of return, ending net worth and net casn flow have been developed and examined for use in whole-farm/ranch planning (Hardin, 1978; Richardson and Condra, 1981; Richardson and Nixon, 1981; and Baum, McElroy and Ryan, 1985).

Use of Simulation in Whole-Farm/Ranch Planning

Halter and Dean (1965) demonstrated the use of simulation to evaluate ranch management policies under uncertainty. Distributions for price of feeder cattle and range condition were developed from historic data. The decision rules, information sources, and other interactions of tne organization components were formulated and the model's behavior generated on a digital computer. By generating the same set of range conditions in each simulation run, the effects of alternative price prediction models and management strategies could be tested. They concluded that it would be difficult to improve the level of income or reduce variability of income by adjusting stocking decisions. Price and weather variance had the greatest effect on income variability.

In a similar study Zusman and Amiad (1965) determined the optimal organization and managerial policies of a farm operation under low and unstable rainfall conditions. Random weather events were generated using actual rainfall data. Observation data were assumed to have a bi-variate normal distribution, and were generated using random normal deviates.

Patrick and Eisgruber (1968) developed a simulation model of farm firm behavior in a dynamic environment with elements of uncertainty. They used behavioral theory in modeling a decision maker's formulation of expectations regarding future prices and yields, and selection of alternative farm plans. The model used four goals in evaluating outcomes of the plans and implemented the plan offering the highest level of overall satisfaction. The expectations, goals and resource position of the firm were adjusted to reflect the outcome of the particular plan implemented, and the process was repeated for the next year. A case was simulated for a period of 20 years under three different levels of managerial ability and 27 different capital market structures. Patrick and Eisgruber (1968) concluded that managerial ability and long-term loan limits were the major factors considered influencing farm firm growth.

Hardin (1973) used Monte Carlo sampling techniques in a whole-farm simulation model to analyze capital investments in an intertempral and stochastic environment. The simulation model used stochastic yields and prices with either a normal or triangular distribuion. Direct comparisons of profitability, solvency, liquidity, and the chance of survival for alternative capital investments in land and machinery were made for small, medium, and large farms.

Using a substantial further development of Hardin's model, Richardson and Condra (1981) addressed the issue of farm size effects on farm survival and success in the El Paso Valley. The programming simulation model consisted of a linear programming model linked to a whole-farm simulation to permit determination of the farm's crop mix at the beginning of each year of the planning horizon. They concluded that the chance of survival and success increases as farm size increases from 160 to 960 acres and/or beginning equity level increases from 25 percent to 100 percent. The recursive system which optimizes the crop mix from year to year provides a great deal of resource and management flexibility for the farm firm.

Crawford and Milligan (1982) used a multi-year, stochastic, farm simulation model for northern Nigeria to illustrate the use of experimental design in simulation modelling. Income prospects for small farms in northern Nigeria were examined under deterministic and stochastic conditions. A partial factorial design was employed to assess the impact on growth of resource endowment, stochastic yields and returns, consumption behavior, and enterprise opportunities. Capital accumulation under stochastic returns was slower than under fixed average returns.

Baum and Harrington (1983) simulated several regional representative farms for the period 1980 to 1986 to determine the likely effects of alternative agricultural policies and economic environments on the micro economic well being of the farm sector. They reported that farms with a higher initial degree of asset ownership and percent equity had greater survivability, net cash income, and ability to maintain or increase net worth. Suspension of direct commodity programs would severly reduce net cash incomes and abilities to maintain net worths, but survivability would still remain high. Baum, Richardson and Schertz (1982) provide a detailed explanation of FLIPRIP, the farm level analysis income and policy simulation-programming model used in the Baum-Harrington analysis.

Other whole-farm/ranch simulation models which have been developed for various research purposes include: Patrick (1978); Roush, Mapp and Maynard (1979); Lins (1969); Boehlje and Griffin (1979); Holland and Young (1980); Baker and Dunn (1979); Hatch (1973); and Chien and Bradford (1976).

Stochastic simulation provides more information to the decision maker, offering complete distributions rather than single-valued estimates of returns. Because of the biological nature of production agriculture, most planning problems are sequential in nature. Simulation provides the flexibility of using numerical exploration procedures that describe the sequential behavior of a modeled system over time. Conceptually, there is no limit to the possible numerical explorations in stochastic simulation (Anderson, Dillion and Hardaker, 1980). However, many of these models require the decision maker to specify the key parameters of the distribution or to rely on historic data to estimate the parameters. Use of these distributions sometimes assumes statistical independence among the variables, and correlation among product yields and other variables in a given year is ignored. Exceptions to this modeling problem include those studies which have utilized the procedure by Clements, Mapp and Eidman (1971) that correlates the variation among normally distributed variables.

Organization of Remaining Chapters

Conceptual tones are discussed in Chapter II including some alternative methods of evaluating and ranking ranch management alternatives. Also, a stochastic process used for modeling random variables in whole-ranch simulation is discussed. Chapter III describes the Monte Carlo simulation model designed to provide comparative before and after measures of profitability, solvency, liquidity, and survival for a ranch unit. Sources and assumptions of required input data for the Base ranch simulation experiment are presented in Chapter IV. Chapter V verifies the accuracy of stochastic processes used and presents the results of the Base Ranch situation for the Southern Plains study area. Development and analysis of alternative mangement plans for the Base Ranch in a stochastic environment is described in Chapter VI. Simulation results are ranked according to stochastic dominance with respect to a function criteria. Chapter VII summarizes the study.

CHAPTER II

CONCEPTUAL FRAMEWORK

The whole-ranch planning problem is to resolve simultaneously which management alternatives to adopt on the ranch, the method of production to employ in each enterprise, and what amount of resources to allocate to each enterprises (Anderson, et al., 1980). Since farm and ranch firms exist in an environment characterized by continual change and imperfect knowledge, conclusions drawn from static neoclassical economic theory does not adequately describe the factors that influence firms' decisions and welfare in the real world.

Several issues assumed away in static theory of the firm are important in reality. Decisions to solve a particular problem affect subsequent decisions. Timeliness of management decisions, imperfect knowledge of prices, input/output supplies and technologies, and firm objectives which include more than profit maximization are of prominent importance. As a result, many ranch management decisions can only be evaluated properly in terms of the whole-ranch situation across time.

This chapter develops concepts for modeling the whole-ranch in an uncertain environment as follows:

1. Simulation is evaluated as an operational method for studying the ranch across time in a stochastic environment.

2. Firm performance measures for use in comparative analysis of stochastic simulation results are compared.

3. Alternative choice criteria for ranking management alternatives are considered.

4. Statistical techniques for generating and testing stochastic variables are presented.

The Role of Simulation in Whole-Firm Analysis

Direct analytics using production functions, several forms of activity analysis, and simulation are major ways of studying firm decision problems. The agricultural economics literature contains many agricultural production studies based on single-equation, production function models. The single-equation approach has been shown to be valid by Hock (1958), and Mundlak and Hatch (1965) under the assumption that input decisions are based on "anticipated" output, and by Zellner, Kmenta, and Dreze (1966) under the assumption that input decisions are based on maximizing expected profit. Single-equation estimates of production parameter, however, will be subject to simultaneous- equation bias (Antle, 1983). Production function models strongly imply that production inputs are chosen as part of a one-period decision problem. This view is inconsistent with most actual production decisions.

Stochastic programming is the generic name given to programming methods which model aspects of uncertainty. As noted in the review of the literature, a number of attempts have been made to develop linear programming models that take account of the stochastic nature of activity net revenues in whole-firm planning. In matrix notation, the MOTAD model (Hazell, 1971) may be formulated as follows:

$$\text{Minimize } Ld, \tag{1}$$

Subject to:

$$AX \leq B \tag{2}$$

$$DX + Id \geq 0 \tag{3}$$

$$CX = \lambda \tag{4}$$

and

$$X, d, \lambda \geq 0 \tag{5}$$

where:

X = a column vector of activity levels

A = a matrix of technical input-output coefficients

B = a column vector of available resources

C = a row vector of expected gross margins

D = a deviation matrix representing the difference between actual and expected gross margins in a particular year

d = a vector representing the total negative deviation summed over all risky enterprises

L = a row vector of ones

I = an identity matrix of the number of years in the period

λ = a scaler used to parametrize the expected total gross margin constraint level. The maximum value of λ is the maximum value of the basic L.P. solution.

There are two steps in the computational procedure of this model. First, a conventional linear programming maximization problem is formulated and solved to determine the maximum expected total gross margin or highest attainable income point on the risk efficiency frontier. Second, risk is introduced through minimization of total negative deviations represented by the objective function, Ld. Hazell (1971) demonstrated that the MOTAD model produces a set of efficient farm plans closely similar to the quadratic solution.

Despite MOTAD's wide acceptability as a suitable technique for evaluating whole-firm planning models under risk, i.e. Brink and McCarl (1978); Mapp, Hardin, Walker, and Persuad (1979); and Gebremesked and Shumway (1979), the model has limitations. Accurate and reliable time series data on gross margins for the enterprise activities are essential to evaluate risk associated with different plans. MOTAD measures risk as total negative deviation from expectation. This measure, however, is arbitrary and raises questions about how ranchers perceive risk and what measure of risk is appropriate (Brink and McCarl, 1978).

In general, stochastic programming problems are often simplified by assuming a linear utility function so that expected profit could be taken as the objective function. With a nonlinear utility function, stochastic programming problems become more complicated and may require either a quadratic or a separable nonlinear objective function, subject to the usual linear constraints and to a separable nonlinear constraint that is to be varied parametrically (Anderson, et al. 1980). Furthermore, in an attempt to obtain an adequate representation of the whole-firm problem, the size of the programming matrix may increase to an unmanageable and uneconomical size. In such instances, the decision analyst faced with these problems has no alternative but to simplify the planning problem.

In view of the difficulties and limitations of the mathematical programming approach to the stochastic whole-firm planning problem, it may be appropriate to consider a nonoptimizing programming procedure with more flexibility in the representation of the whole-firm problem over time.

Manetsch and Park (1977) define simulation as a technique for obtaining a particular time solutions of a mathematical model corresponding to specific assumptions regarding model inputs and values assigned to parameters. Monte Carlo methods are commonly used in combination with simuilation to model the performance of complex stochastic systems. Monte Carlo simulation techniques offer another method for incorporating risk into the whole-firm decision model. By specifying subjective probability distributions for key economic variables, the decision maker's personal experience with respect to risk of the decision can be explicitly considered. Numerical procedures are employed to generate sample observations from the decision maker's subjective probability distribution for exogenous system input variables (King, 1979). Random values drawn for these key parameters are used in the model simulating the firm's operation and performance measures of the whole-firm are calculated. By repeating the analysis many times, a probability distribution of the performance measures can be developed. The ability to generate probability distribution of outcomes rather than a single- valued estimate which has been adjusted for risk is an important advantage to the decision maker.

Monte Carlo simulation techniques permit a ranch analyst to represent the decision problem of the real system over time as suggested by the arguments in equation (6).

$$\text{Max } U = F(NW_T, C_{it}, D_t, DE_t, T, SP_t, r, NPV_o) \tag{6}$$

where:

U = utility

NW_T = ending net worth at T

C_{it} = cattle production (e.g. pounds of weaned calves)

D_t = debt in period t

DE_t = firm solvency measured in period t

T = years in the planning horizon

SP_t = stochastic price and production variables

r = discount factor for time preference

NPV_o = net present value of the ranch with returns to time T

Because ranch managers can be expected to use all available information in decision making, they will feed information from earlier production stages to later input choices. All variables may affect utility directly or indirectly through other variables, for example, SP_t affects C_{it}. If interdependence exists among input and outputs to the extent that some variables are determined within the system rather than exogenously, a simultaneous equation system is required (Trapp and Walker, 1985). Conceptually, there is no limit to the specification of a system of simultaneous equations in stochastic simulation. Simulation modeling of stochastic processes permits greater realism in the representation of underlying probabilities of diverse random variables.

Trapp and Walker (1985) propose biophysical simulation modeling as a means to provide the needed realism and flexibility required in application of production theory at the firm level. They also contend that important conceptual and pedological advantages are obtained by abstractions of whole-firm systems as presented in equation (6). Such equations provide a road map in theoretical development and exposition of system models of the whole-firm.

Adaptive programming in economic simulation models further describes a situation where decision making involves several enterprises and when decision makers have imperfect information. Adaptive programming suggests that economic decisions made by producers should be described with a dynamic optimization methodology, such as recursive interactive programming, or continuous optimization programming. Recursive programming-simulation models describe a situation where assets are fixed in the short run, limiting the choice of input mix and output.

Performance Measures

The economic criteria or performance measures by which stochastic whole-ranch situations are ranked, accepted or rejected is discussed in the next section.

Net Present Value. Future flows of annual net cash income associated with a ranch operating unit can be discounted to a net present value (NPV). The net present value can be compared with present values of alternative operating plans which have varying annual net income flows. The intuitive idea of the net present value method is that money in hand today is worth more than an equal amount of money to be received at some future date. This is true because the money in hand today can be invested and yield a return equal to the rate of interest. Exact present value of a future sum depends on the interest rate and how often the interest is compounded or credited to the investment. Compounding is a procedure for determining the net future value (NFV) of a net sum (NS) invested today at a specified interest rate (r) available at the end of N years.

$$NFV = \sum_{n=0}^{N} NS(1+r)^{n} \quad (7)$$

A dollar invested today at eight percent interest would have a future value of $1.08 at the end of one year.

The net present value or net discounted value (NPV) is the value today of a net sum (NS) invested at a specified interest rate (r) to be equal to the net income flow at the end of N years.

$$NPV = \sum_{n=0}^{N} \frac{NS}{(1+r)^{n}} \quad (8)$$

Comparably, a little over 92 cents must be invested today at eight percent interest to equal one dollar earned at the end of one year.

A traditional point of dispute about the present value approach is the choice and interpretation of the discount rate to be used (Anderson, et al. 1980). In whole-firm analysis, this rate typically represents the firm's minimum acceptable rate of return, the opportunity cost of funds. The opportunity cost is defined as the return that can be achieved for the use of a resource in its most profitable alternative use. If a decision maker can borrow all of the capital that can profitably be used in the business, then the nominal opportunity cost can be approximated by the market rate of interest (Boehlje and Eidman, 1984). The discount rate should be adjusted for the decision maker's marginal tax rate. The decision maker who requires a 8.0 percent after-tax rate of return and has a 35 percent marginal tax rate, must specify a 12.31 percent before-tax discount rate. If the net present value procedure determines discounted after-tax cash flow, the decision maker should specify an after-tax discount rate.

For whole-ranch analysis under uncertainty, the acceptability of alternative management strategies might depend on their probability distributions of net present value. The alternative strategy with the preferred distribution would be chosen.

Net present value analysis incorporates the time value of money and the decision maker's discount rate to yield a useful method for whole firm comparative analysis. However, the analysis does not consider the magnitude of funds committed to the firm. Swirles and Lusztig (1968) propose a ratio of discounted cash benefits and cash costs to determine a relative measure of the funds committed to a capital investment. Such a procedure could be applied to net present value analysis of the whole-firm under uncertainty.

<u>Internal Rate of Return</u>. The internal rate of return method is similar to the net present value method in that both utilize discounted flows. In the net present value method, the decision maker specifies the discount rate and equation (8) is solved for the net present value. The internal rate of return method equates net present value in equation (8) to zero and solves for the discount rate. This linkage is portrayed in Figure 2 which graphs the net present value of a projected series of cash flows at alternative discount rates. At a zero discount rate, the NPV is highly positive. Increasing the

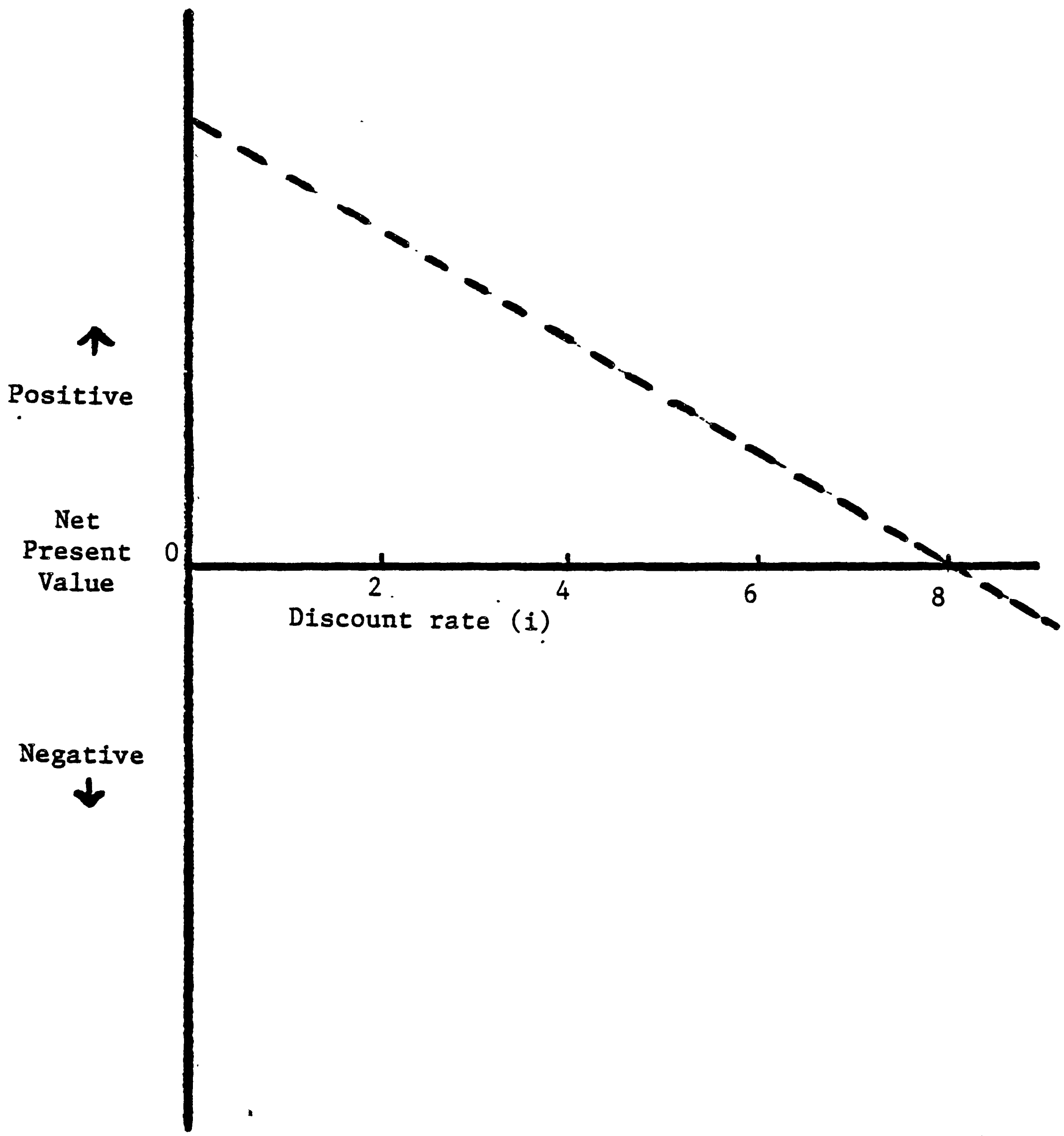


Figure 2. Linkage Between Net Present Value and Internal Rate of Return

discount rate lowers the NPV until it eventually becomes negative (i.e., below the horizontal axis). The internal rate of return (IRR) is found at that point where the NPV line crosses the horizontal axis. Thus, a negative NPV would yield a internal rate of return less than the decision makers specified opportunity cost. The acceptability of alternative management strategies depends upon the comparison of the firms internal rate of return with the decision maker's required rate of return.

One disadvantage of the internal rate of return method is that it assumes that positive cash flows can be capitalized to yield the internal rate of return. The net present value method assumes the positive cash flows are recapitalized at the discount rate. In this respect, net present value is superior because it may not be possible to actually reinvest excess funds that yield the internal rate of return.

In static models, the net present value and internal rate of return methods provide single-valued estimates of the rate of return or rate of growth a decision maker can expect from a proposed operating unit. Several methods of incorporating risk in net present value analysis have been proposed. Barry, Hopkin and Baker (1979) discuss adjustment of discount rate and certainty-equivalent methods for incorporating the degree of risk into net present value analysis. Both approaches consider the adjustment in returns needed to make a decision maker feel indifferent between a risky and a "safe" management strategy. The designation of a certainty-equivalent income is just as subjective as the choice of a risk premium to add to the discount rate. In both methods, the decision maker must express his risk aversion by a quantitative measure based on limited judgement. One important difference in the two methods occurs because the risk-adjusted interest rate implies that risks increase exponentially over time, even when the interest rate is constant (Barry et al., 1979). Using these methods, the net present values associated with certainty and varying degrees of risk can be compared, keeping in mind, without Monte Carlo simulation techniques that they represent single-valued estimates of the expected return from alternative enterprises adjusted for risk. Using Monte Carlo sampling techniques, risk can be measured by the range in net present value or the percent chance that the net present value will be greater than a specified level. The decision maker can evaluate the lowest to highest net present value that can be expected given a subjective evaluation of risk.

Whole Firm Comparative Analysis in a Stochastic Environment--Advantages and Disadvantages

Hardin (1978) suggests that, to obtain more complete information about the effect of a proposed change in a current operating unit, a detailed before and after analysis of the firm across time is necessary. This approach requires estimates of cash benefits and costs, net worth, and borrowing and repayment cash flows associated with the current operating unit and the proposed unit. Market values for all assets and liabilities for the current and proposed units are necessary to determine annual changes in net worth. Any capital investment and associated costs that are required to operate the current unit through the proposed planning horizon should be included in projected cost.

Given the required input data net present value, annual cash flow and net worth information should be calculated to determine the profitability, liquidity, and solvency of the current operating unit. The procedure is repeated to estimate cash benefits and costs, and calculate the net present value, cash flows, and net worth of the proposed new operating plan. Using Monte Carlo simulation techniques, the analysis is repreated many times to generate a probability distribution, rather than a single-valued estimate of the net present value, annual cash flow and net worth.

Advantages

The whole firm comparative analysis method allows direct comparison of performance of the current firm and the proposed firm. Comparison of the distribution of annual cash flow and net worth provides an indication of the degree of risk between the current operating unit and the proposed plan. Furthermore, the potential gain in real net worth could be weighed against the probability of negative net present value or other measures of financial disaster.

Disadvantages

This method requires large amounts of input data. Also, when the decision maker considers more than two management alternatives, it is difficult to quantify the marginal cost and benefits associated with each of the proposed management alternatives. While the comparative analysis method does not estimate the marginal net present value of the proposed management alternative alone, it can be determined by subtracting current firms net present value from the net present value of the proposed firm.

Ranking Management Alternatives

Decision making under risk is a problem of ordering management alternatives with uncertain outcomes. Where the precise risk preferences represented by derived utility functions are known, the expected utility of each management alternative can be calculated and ordered according to the expected utility index. In such situations the ordering is unique and complete. The theoretical base for such a procedure is the expected utility hypothesis by von Neumann and Morgenstern (1947). Alternative derivations of the expected utility index have been suggested by Mochina (1982), Kahneman and Tversky (1979), and Fishburn (1982).

In most applied problems, a unique preference measure represented by the decision maker's utility function is not readily available and utility functions are difficult to estimate. The difficulties associated with the use of single valued utility functions to order alternative choices in a practical context was the incentive for development of efficiency criteria which overcome some of the shortcomings identified above. An efficiency criterion is a preference relationship which provides a partial ordering of key measures of management alternatives for decision makers whose preferences conform to certain rather general specifications (King, 1979). As such, an efficiency criterion can be used to eliminate some feasible management alternatives from consideration without requiring detailed information about the decision maker's preferences.

First and second degree stochastic dominance are among the simplest and most common efficiency criteria. Both were formulated independently by Hadar and Russell (1969) and Hanoch and Levy (1969).

First degree stochastic dominance holds for all decision makers who prefer more of the output to less (i.e. for all decision makers having positive marginal utility with respect to the output variables). For example, the management alternative for which there is a cumulative distribution of net present value F(NPV) is preferred to a second management alternative with the cumulative distribution of net present value G(NPV) by the criterion of first degree stochastic dominance if:

$$F(NPV) < G(NPV) \quad (9)$$

for all possible levels of NPV and if the inequality in (9) is a strict inequality for at least some value of NPV. For example, in Figure 3 F(NPV) dominates G(NPV) by this criterion, since it is always below and to the right. At every level of probability the net present value associated with management alternative 1 is greater than the net present value associated with management alternative 2. Neither F(NPV) nor G(NPV) can be ordered with respect to H(NPV), management alternative 3, for any level of net present value.

Second degree stochastic dominance places an additional restriction on preferences. It requires that the marginal utility of the output variables be positive and decreasing. Explicitly, it requires that the decision maker's utility function be concave, reflecting risk adversion. Given two management alternatives having net present value distributions defined by the cumulative distribution functions F(NPV) and G(NPV), respectively, the first management alternative is preferred to the second under the criteria of second degree stochastic dominance if:

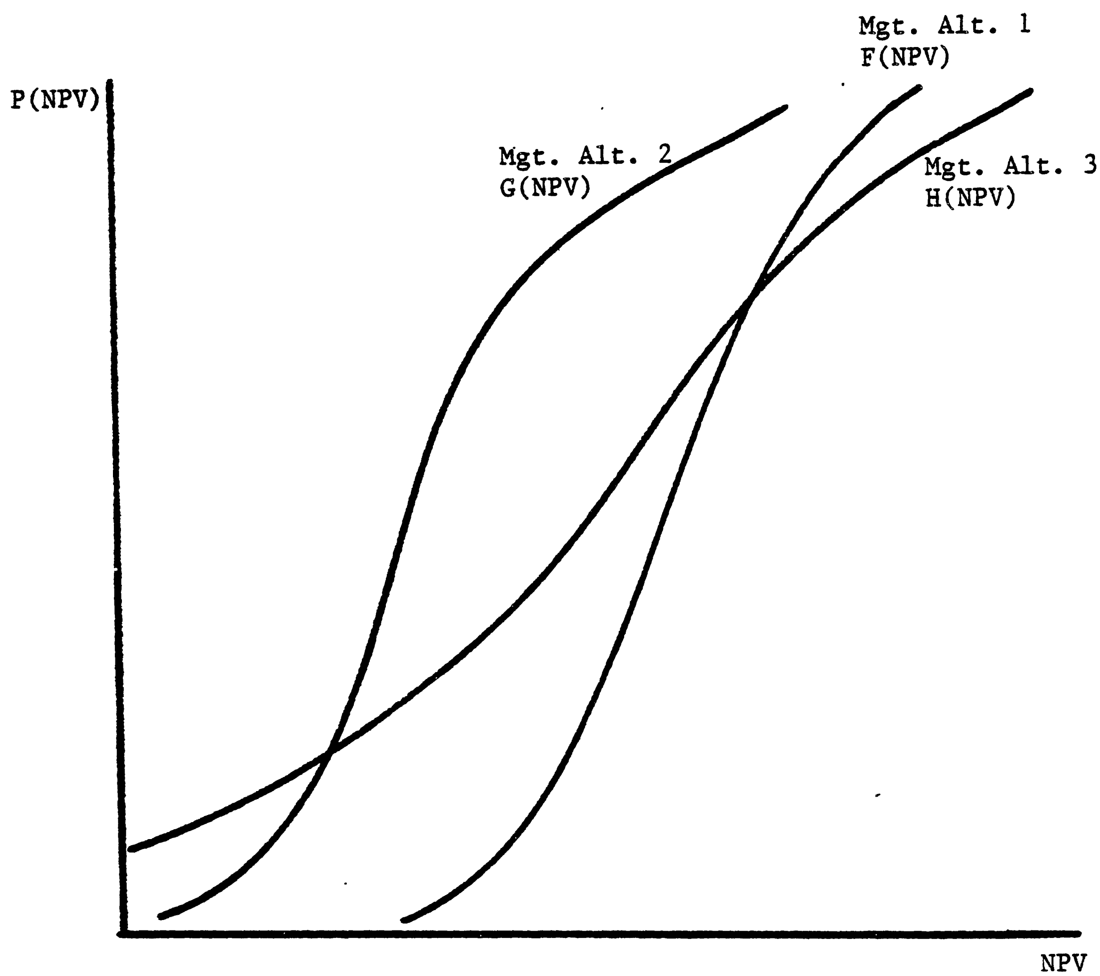


Figure 3. Illustration of First and Second Degree Stochastic Dominance

$$\int_{\infty}^{NPV} F(NPV)dx \leq \int_{\infty}^{NPV} G(NPV)dx \qquad (10)$$

for all possible values of NPV and if the inequality in (10) is a strict inequality for at least some value of NPV. This means that the first management alternative, F(NPV), dominates the second, G(NPV), if the area under cumulative F(NPV) is always less than or equal to that under G(NPV) (Figure 3). In Figure 3, management alternative 1 dominates both management alternative 2 and 3 by this criterion, since the area under F(NPV) is less than that under either of the others at all values of NPV. However, management alternative 2 and 3 cannot be ordered by this criterion, since the area under H(NPV) is at times less than that under G(NPV) and vice versa.

Other efficiency criteria depend on additional restrictions in the decision maker's preference or in the nature of the probability distribution of output variables. Third degree stochastic dominance (Whitmore, 1970) is similar to first and second degree stochastic dominance, but it requires the additional assumption that the decision maker's utility function has a positive third derivative with respect to the output variables. The decreasing stochastic dominance criterion (actually nonincreasing) (Vickson, 1977) is also consistent with the argument that the decision maker's utility function should be a nonincreasing function with respect to the output variables.

While the concept of an efficiency criterion is appealing, efficiency criteria have not proved useful tools in practice. None of the efficiency criteria mentioned above is a particularly discriminating evaluative tool. Each involves increasingly restrictive assumptions about the form of the utility function such that the set of efficient alternatives associated with each of these criteria is a subset of the efficient set for each less stringent rule. A more powerful efficiency criterion, stochastic dominance with respect to a function, is described for use in ranking management alternatives (Meyer, 1979) as follows.

Stochastic dominance with respect to a function is an evaluative criterion which orders uncertain management alternatives for classes of decision makers defined by specified lower and upper bounds, $r_1(y)$ and $r_2(y)$, on the absolute risk aversion function. The absolute risk aversion function (Arrow, 1971; Pratt, 1964), r(y), is defined by the expression:

$$r(y) = - u''(y)/u'(y) \tag{11}$$

where u'(y) and u"(y) are the first and second derivatives of a von Neumann-Morgenstern utility function u(y). The values of the absolute risk aversion function may be viewed as local measures of the degree of concavity or convexity exhibited by a decision maker's utility function. Since u'(y) is assumed to be positive if more of the performance measure is preferred to less, a positive value of r(y) implies a negative value of u"(y), which in turn implies a concave utility function (King and Robinson, 1981). Concavity of the decision maker's utility function and risk aversion are considered synonymous, and both are implied by a positive value of r(y). A negative value of r(y) implies both local convexity of the utility function and risk preferring behavior. More importantly, however, the absolute risk aversion function serves as a unique measure of the decision maker's preference. Thus, the upper and lower bounds on a decision maker's absolute risk aversion function define a interval measurement in his preferences. Stochastic dominance with respect to a function orders management alternatives on the basis of the decision maker's risk aversion interval.

The major advantage of this criterion is that it places no restriction on the width or shape of the relevant region of risk aversion. The interval measurement can be precise or imprecise as is determined necessary for a particular decision analysis. Furthermore, negative as well as positive levels of absolute risk aversion can lie within the risk aversion interval at some or all levels of output.

More formally stated by King (1979):

> ...stochastic dominance with respect to a function is a criterion which establishes necessary and sufficient conditions for the distribution of system outputs defined by the cumulative distribution function F(y) to be preferred to that defined by the cumulative distribution function G(y) by all agents whose absolute risk aversion functions lie everywhere between lower and upper bounds $r_1(y)$ and $r_2(y)$ (p. 98).

As developed by Meyer (1977a), the solution procedure requires the identification of a utility function $U_0(y)$ which minimizes:

$$\int_0^1 [G(Y) - F(y)]\ u'(y)\ d_y \qquad (12)$$

subject to the constraint:

$$r_1(y) \leq -\ u''(y)/u'(y) \leq r_2(y)\ ,\ Y^{[0,1]} \qquad (13)$$

where the range of outputs is normalized so that all values of y fall on the bounded interval [0,1]. The expression in equation (12) is equal to the difference between the expected utilities of output distributions F(y) and G(y). Where, if for a given class of decision makers the minimum of this difference is positive, F(y) is unanimously preferred to G(y). If the minimum is zero, it is possible for a individual in the relevant class of decision makers to be indifferent between the two management alternative and they cannot be ordered. Should the minimum be negative, F(y) cannot be said to be unanimously preferred to G(y). In this case, the expression:

$$\int_0^1 [F(y) - G(y)]\ u'(y)d_y \tag{14}$$

must be minimized subject to (13) to determine whether G(y) is unanimously preferred to F(y). It should be noted that a complete ordering is not ensured by the criterion. It is possible for the minimum of both (12) and (14) to be negative, which implies that neither distribution is unanimously preferred by the class of decision makers being considered.

Meyer uses optimal control techniques outlined by Arrow and Kurz (1970) to derive the necessary and sufficient conditions for the solution of this problem. These conditions define a rule for determining the absolute risk aversion function of the utility function which minimizes equation (12). Application of the rule is dependent on meeting the relatively unrestrictive assumption that [G(y) - F(y)] changes sign a finite number of times over the interval [0,1]. The following theorem (Meyer, 1977b) is the basis for the rule:

Theorem: An optimal control $-\mu''_0(y)/\mu'(y)$ which minimizes:

$$\int_0^1 [G(y) - F(y)]\ u'\ d_y$$ subject to

$r_1(y) \leq [u''(y)/u'(y)] \leq r_2(y)$ and $u'(0) = 1$ is given by:

$$\frac{-u''(y)}{u'(y)} = \begin{cases} r_1(y) \text{ if } S_y^1[G(x) - F(x)]\ u'(x)d_x < 0 \\ r_2(y) \text{ if } S_y^1[G(x) - F(x)]\ u'(x)d_x \geq 0 \end{cases}$$

This theorem implies that the value of the absolute risk aversion function which minimizes the difference in the expected utilities associated with F(y) and G(y) is determined at any point y^* by the sign of the objective function intergrated from y^* forward to 1 using the optimal control (King, 1979). Furthermore, it impilies that the value of the absolute risk aversion function is always $r_1(y)$ or $r_2(y)$.

Application of the above rule requires that the solution procedure work from back to front. For example, King and Robinson (1981) consider the two cumulative distribution functions shown in Figure 4. Neither dominates the other by first or second degree stochastic dominance. To facilitate calculation, let the lower and upper bounds on the absolute risk aversion function be constant, where $r_1 = .001$ and $r_2 = .002$. The utility function associated with each of these can be shown to be of the negative exponential form (Pratt, 1964), so that:

$$u_i(NPV) = -e^{-r_i NPV} \quad i = 1,2 \tag{15}$$

The function [G(NPV) - F(NPV)] is graphed in Figure 5. Between NPV=5,000 and NPV=7,000, its value is negative; and above NPV=7,000 its value is zero. According to the theorem above for values of NPV greater than 5,000, $r_i(NPV)=.001$ is the optimal control. Calculating the value of the objective function from NPV=5,000 and upward:

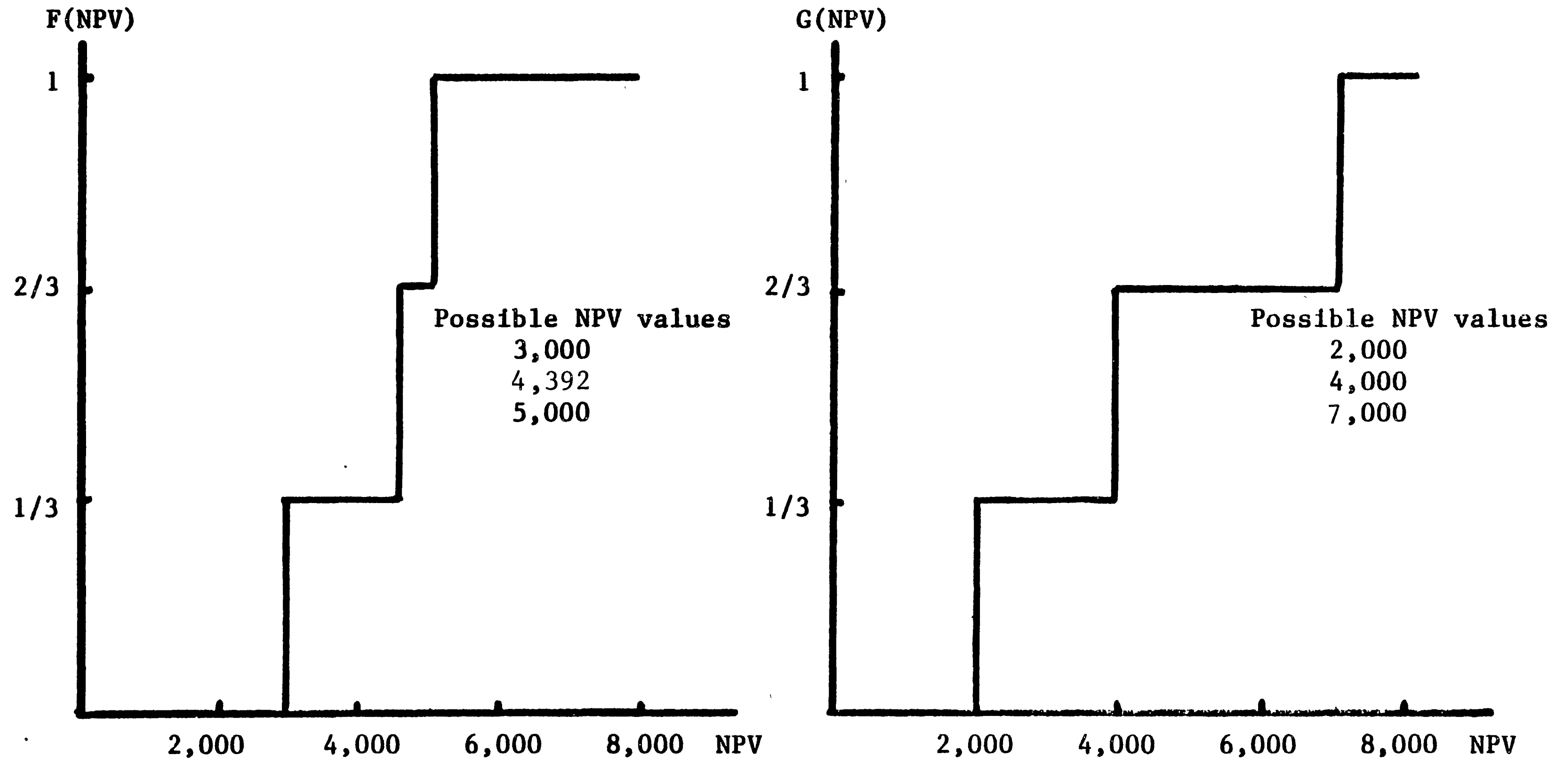


Figure 4. Cumulative Distribution Functions F(NPV) and G(NPV)

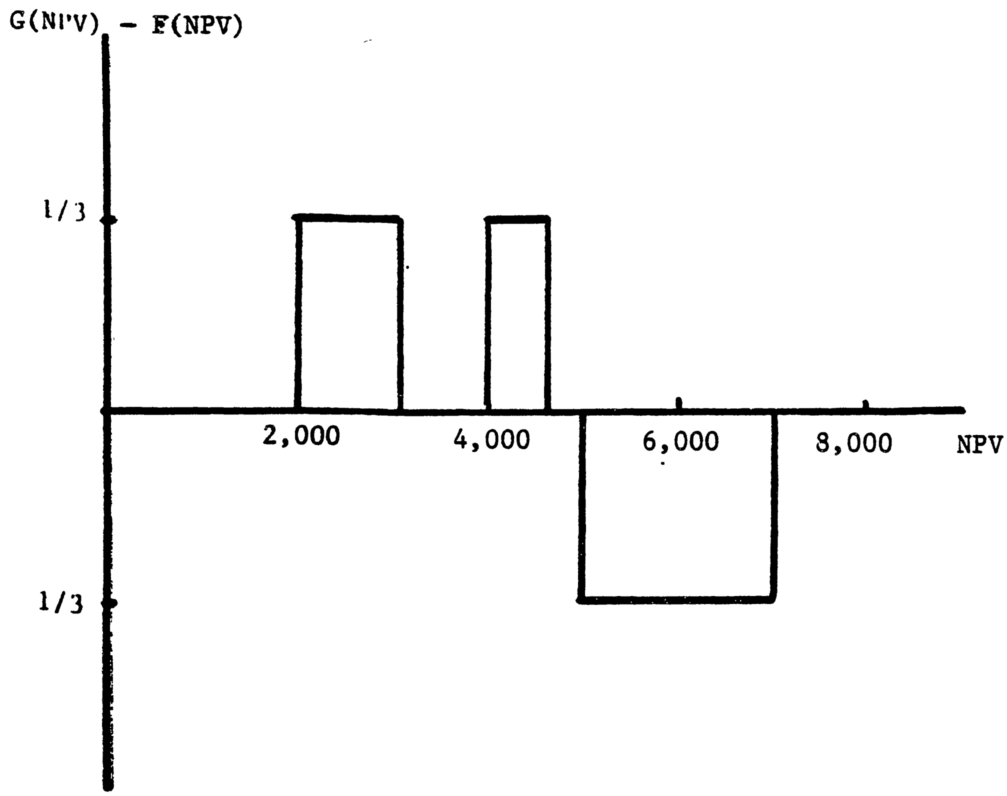


Figure 5. Graph of the Function [G(NPV) - F(NPV)]

$$\int_{5000}^{\infty} [G(NPV) - F(NPV)]u'(NPV)\, dNPV$$

$$= \int_{5000}^{7000} (-1/3)\,(.001)e^{-.001NPV}\, dNPV \qquad (16)$$

$$= -.00194$$

we see that it is negative.

The solution rule indicates that the optimal control remains at $r_i(NPV) = .001$. The procedure continues back until the point where NPV = 4,000. At this point:

$$\int_{4000}^{\infty} [G(NPV) - F(NPV)]u'(NPV)dNPV$$

$$= \int_{4000}^{4392} (1/3)(.001)e^{.001NPV}\, dNPV - .00194 \qquad (17)$$

$$= 0$$

Thus, the optimal control switches to $r_i(NPV) = .002$ for values of NPV less than 4,000. The procedure continues back with the same optimal control until:

$$\int_{\infty}^{\infty} [G(NPV) - F(NPV)]u'(NPV)dNPV$$

$$= \int_{2000}^{3000} (1/3)(.002)e^{-.002NPV} dNPV \qquad (18)$$

$$= .00528$$

Since the value of the objective function is positive, distribution F(NPV) is preferred to G(NPV) by all decision makers whose absolute risk aversion functions lie everywhere between

$r_1 = .001$ and $r_2 = .002$. The utility function which minimizes the objective function has an absolute risk aversion function such that:

$$r(NPV) = \begin{cases} .002 \text{ when } y \leq 4{,}000 \\ .001 \text{ when } y \geq 4{,}000 \end{cases} \quad (19)$$

Note that this utility function does not have constant absolute risk aversion, even though the bounds on absolute risk aversion are constant.

Stochastic dominance with respect to a function is relatively easy to apply. Unlilke other efficiency criteria, it does not require that fixed retrictions be imposed on the representation of the decision makers preferences, and unlike single valued utility functions, it does not require an exact representation of the decision makers' preferences. A computer program developed by Meyer (1977b) and modified by King and Robison (1981) can be used to implement the solution procedure defined above.

Stochastic Price and Production Variables

Variation in the input and output prices and supplies for production agriculture creates a large proportion of the income variability faced by farmers and ranchers. Weather, and other natural phenomena, institutional influences, and exports which are the major factors that cause variation in gross farm and ranch income can be reflected through their effect on commodity prices and output supplies.

As evidenced in the review of literature, much attention has been given to realistically accounting for the variation in cash flows associated with production agriculture, in particular farming. The most commonly used method of incorporating uncertainty in recent years is to specify probability density functions for the population of variables and use Monte Carlo simulation techniques to incorporate risk into a whole-farm model. The development and use of procedures like Clements' et al. (1971) computer routine, which utilizes the correlation coefficients in considering statistical dependence among agricultural data, has helped improve the accuracy of the stochastic process. But, after a decade of great progress in including variation in cash flows, computational complexities, probability issues and cumbersome and time consuming procedures for eliciting risk preferences and perceptions often preclude considering risk in routine agricultural extension and applied research problems.

Nelson, Casler and Walker (1978) identified four general approaches for field elicitation of subjective probabilities: (1) the cumulative distribution approach; (2) the conviction weights method; (3) direct elicitation of probabilities; and (4) the triangular distribution method.

The first method identified above consists of first establishing the full range of possible outcomes. The decision maker is then asked to identify the median outcome, the value for which there is a 50 percent probability of falling above or below. The decision maker is then asked to split the intervals below and above the median into equal probability segments which establish 25 to 75 percentile points. This process is continued until a adequate number of points are established which can then be plotted as a cumulative distribution function.

The conviction weights method asks the decision maker to assign an index, for example a number between 1 and 10, which reflects the strength of his conviction that the outcome will occur in each of a set of intervals covering the range of possible outcomes. These indices are converted to probabilities by dividing each index by the sum of the assigned indices.

The third method, direct elicitation, requires decision makers to specify a numerical percentage or probability for each outcome interval. The decision maker is asked to review and if necessary adjust his probabilities to ensure that they satisfactorily reflect his convictions and that they sum to one. Bessler (1980) elicited crop yield probability distributions from California farmers by asking respondents to distribute ten discrete probability weights over predetermined intervals. He employed a mathematical scoring rule to motivate accurate and honest responses.

A decision maker can totally describe a subjective triangular probability distribution by specifying the value for the (1) minimum, (2) maximum, and (3) the most likely or modal occurrence of the variable. These parameters are better understood by decision makers than mean, variance, or probablistic estimates of the parameters. In practice, respondents are generally asked to specify the "lowest possible" (A in Figure 6), "most likely" (M), and "highest possible", (B) outcome for the uncertain event. A triangular distribution can be skewed simply by specifying a most likely (M) value that is closer to either the minimum or maximum value.

Computationally, the probability density function, Figure 6 , of a triangular distribution is specified by equations (20) and (21):

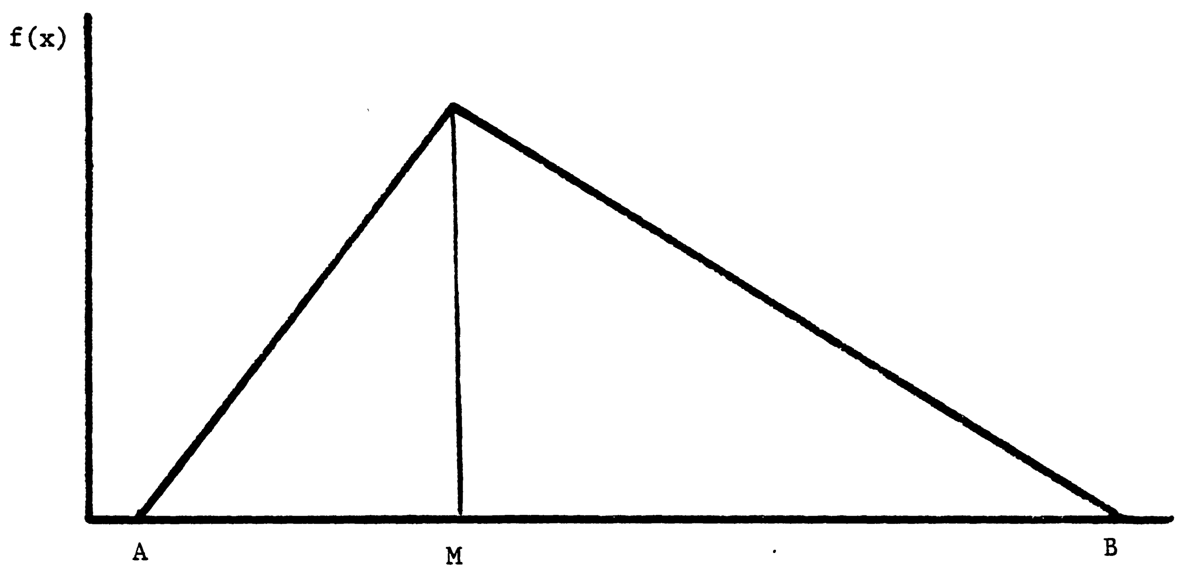


Figure 6. Graphical Illustration of a Triangular Probability Density Function

$$f(x) = \frac{2(X-A)}{(B-A)(M-A)} \quad , A < X < M \qquad (20)$$

$$f(x) = \frac{2(B-X)}{(B-A)(B-M)} \quad , M < X < B \qquad (21)$$

where:

A = minimum value

M = most likely value

B = maximum value

X = the value of the particular variable

The cumulative probability function is given by equation (22) and (23):

$$F(x) = \frac{(X-A)^2}{(B-A)(M-A)} \quad , A < X < M \qquad (22)$$

$$F(x) = 1 - \frac{(B-X)^2}{(B-A)(B-M)} \quad , M < X < B \qquad (23)$$

Figure 7 illustrates the cumulative probability function of a triangular distribution.

Equations (22) and (23) can be solved in terms of X to yield (24) and (25).

$$X = A + [F(X)(B-A)(M-A)]^{1/2} \quad , A < X < M \qquad (24)$$

$$X = B - [(1-F(X))(B-A)(B-M)]^{1/2} \quad , M < X < B \qquad (25)$$

For Monte Carlo analysis, a value of the stochastic variable is determined by randomly selecting a value for F(X) between zero and one and determining X by solving equation (24) or (25).

Among the four procedures discussed above, the triangular distribution is judged by Young (1983) to be the quickest and easiest to administer in elicitation and it is very convenient for simulation. Given the high degree of variability in output supplies from county to

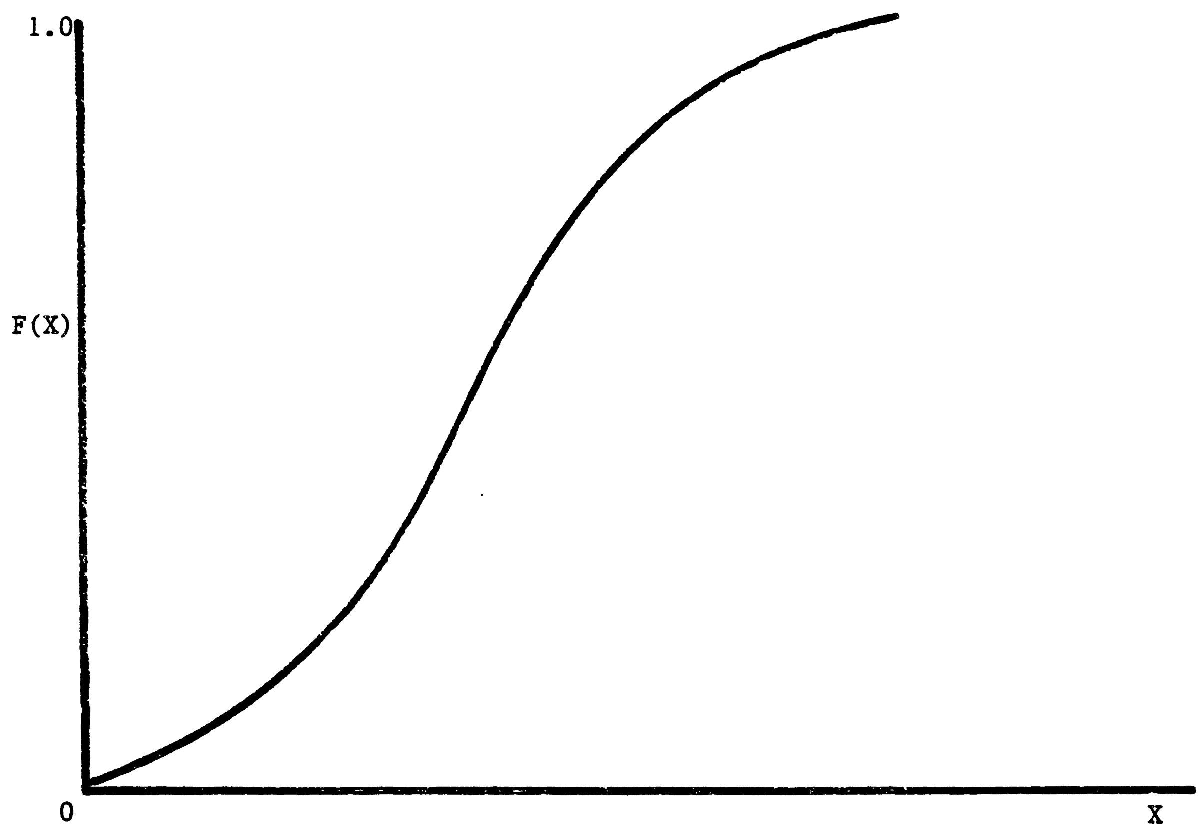


Figure 7. Graphical Illustration of a Triangular Cumulative Probability Distribution

county, ranch to ranch, and even among parcels of land within a ranch, specification of the minimum, maximum, and most likely output or input supplies expected could be superior to methods of incorporating output or input supplies based on historic data. Although simple to elicit and work with, the accuracy of the triangular distribution is frequently questioned. The triangular distribution imposes a rigid functional form on decision maker's probability assestments. The linear interpolation from the "lowest possible and highest possible" outcomes of the model might concentrate more probability in the "tails" of the distribution than the decision maker considers appropriate. Young (1983) has addressed this problem of endpoints for the triangular distribution and recommends a percentile-based method for eliciting triangular distributions.

The correlation among price and production variables has not yet been explicitly considered. The correlation coefficient matrix represents the correlation among variables, but is not scaled by the standard deviations of the variables. By using a modified version of the Clements et al. (1971) procedure and the historic correlation coefficient matrix, stochastic triangularly distributed price and production variables can be generated that exhibit a correlation coefficient matrix statistically equivalent to the correlation coefficient matrix of the historic data (Hardin, 1978). The triangular distributions used in the model described in Chapter IV are a combination of subjective parameter estimates and historic correlations among price and production variables. Estimation of correlations and triangular distribution parameters is described in Chapter IV.

R. A. Fisher developed a statistical test to pairwise compare the correlation coefficients of two matrices. The test is simplified by the Z transformation listed in equation (26).

$$Z = 1/2 LN \frac{1+r}{L-r} \quad (26)$$

The test statistic d equals:

$$d = \frac{Z_1 - Z_2}{\sqrt{1/N_1 - 3 + 1/N_2 - 3}} \quad (27)$$

Decision rules would be:

$$\text{Accept Ho if } |d| < Z_{1/2}, \alpha \quad (28)$$

$$\text{Accept } H_1, \text{ if } |d| > Z_{1/2}\ \alpha \quad (29)$$

Equality of the historic correlation coefficient matrix and the matrix resulting from repeated generation of triangularly distributed stochastic prices is the hypothesis to be tested.

$$Ho = \rho_1 = \rho_2 \quad (30)$$

where:

ρ_1 = the correlation coefficient from the historic matrix and

ρ_2 = the correlation coefficient generated by the stochastic triangular procedure.

To complete this test, each of the generated price coefficients and yield coefficients must be compared pairwise to the historic values. If results indicate failure to reject the null hypothesis, ρ_1 and ρ_2 at the 0.05 level of significance, the correlation matrix resulting from repeated generation of triangularly distributed prices is statistically equal to the historic matrix.

The following chapter provides a detailed description of the Monte Carlo type simulation model, the program logic and organization of the main program, and the accounting procedures used in the whole-ranch analysis.

CHAPTER III

SIMULATION MODEL

The simulation model used in this study is another generation of a farm level income and policy simulation model developed in the last ten years by several researchers (Hardin, 1978; Richardson and Condra, 1981; Richardson and Nixon, 1981; Baum, Richardson and Schertz, 1982; Salathe, Price and Gadson, 1982; and Baum and Harrington, 1983. REPFARM, a representative farm, recursive programming-simulation model, was the basis for the simulation model used in this study (Baum, McElroy and Ryan, 1985). REPFARM from ERS is primarily based on farm level income and policy simulation models built at Texas A&M University (Richardson and Condra, 1981).

The modifications in the REPFARM model reported here were made to allow cattle ranch analysis within a stochastic framework. The changes and the additional input cards required pertain only to stochastic runs of the REPFARM model using the triangular distribution.

Steps in the REPFARM modification included identifying key livestock variables, such as steer calf prices and weights, stochasticly estimating the variables and increasing the flexibility of the model by expanding the number of cattle enterprise systems that can be simulated. To accomplish these steps, the model was programmed to calculate stochastic steer calf prices, steer calf sale weights, and weaning percents for five cow-calf and five stocker enterprises, using a triangular distribution. Multiple cattle enterprises were needed to accomodate the usual range of cattle enterprises on ranches and will accomodate future research development of recursive programming-simulation of representative ranch enterprises. The new model was named OKIE to distinguish the modified version.

The major purpose of the model is to analyze selected cow herd management practices in an intertemporal and stochastic environment. It determines the profitability, solvency, liquidity, and probability of firm survival for alternative cow herd management plans-economic scenario combinations. Direct comparison of a base ranch unit and the selected scenarios will provide an estimate of the net effect of the alternative cow-herd management plans-economic scenarios on a representative ranch. The model calculates probability distributions for over 35 output variables including net present value, present value of ending net worth, internal rate of return and cash flow, and calculates the probability of firm survival. Thus, potential gains from management plans and economic scenarios can be weighed against the risk of financial disaster.

General Model Description

A general description of the basic components of the program outlined in Figure 8 will provide an introductory orientation. Most of the components in Figure 8 are from the original simulation models, FLIPSIM (Richardson and Nixon, 1981) and REPFARM (Baum, et al., 1985).

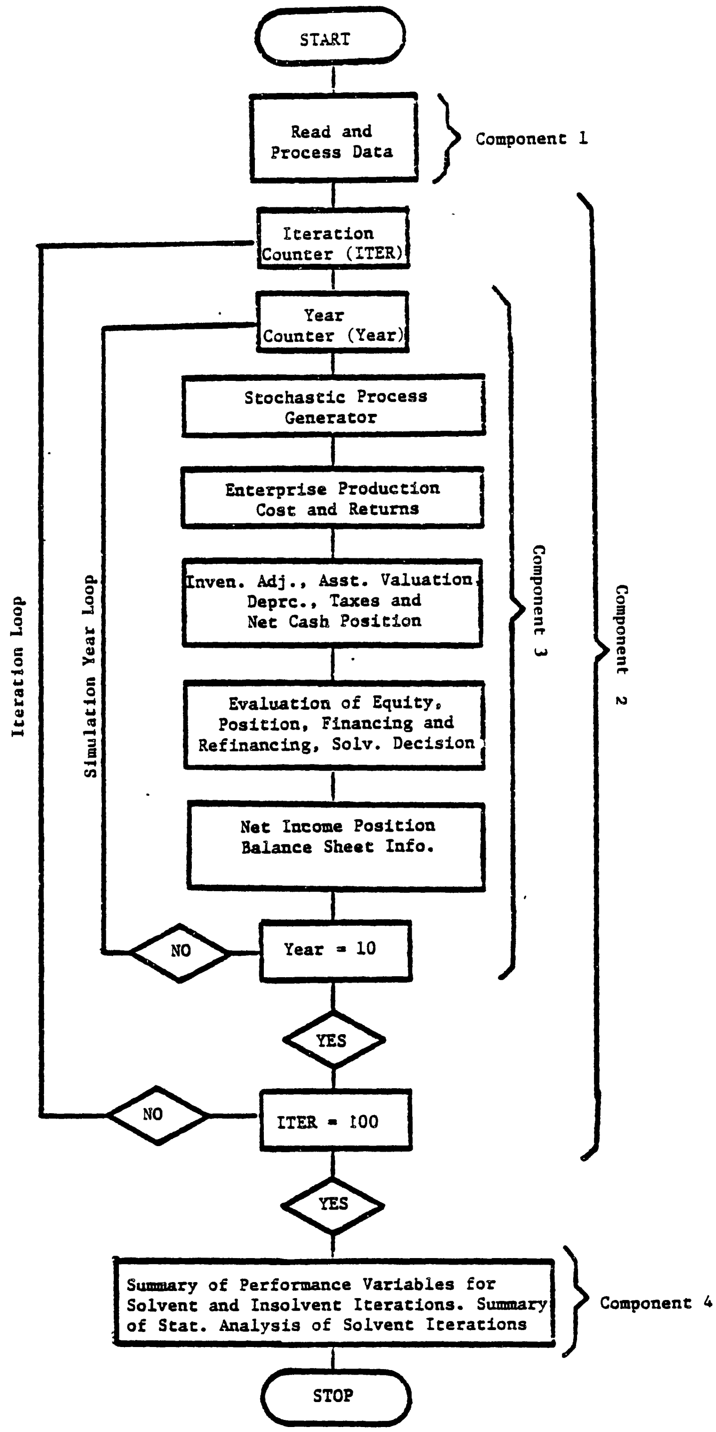


Figure 8. Flow Digram of the Simulation Model OKIE

The MAIN program executes the program logic which consists of a series of subroutine, call statements and two do-loops. Execution of the program logic is divided into four components.

Component 1

The model begins each simulation by reading and processing the data cards. The model writes a summary of options and input data provided by the user and calculates values which do not change in each replication of the planning horizons. The amortized costs of existing liabilities, market values of present assets, off-farm income, and other costs associated with asset replacement affect all replications of the analysis equally and do not change with stochastic variables. They are deterministic but may have trends and cycles. User supplied input data are stored on a sequential data set and retrieved at the beginning of each iteration to insure that the model is using the same environment for each iteration.

Component 2

The second component initiates the first program do-loop, the iteration loop. The number of iterations for the stochastic simulation is set equal to a value specified by the user. A stochastic simulation from 11 to 100 iterations can be executed.

For a stochastic simulation, each iteration begins with the same biological and economic environment, except for annual range pasture yields, livestock prices, supplemental feed prices, livestock weights and weaning percent which are selected at random from triangular distributions from one iteration to the next.

Component 3

The third component of the program logic is the planning horizon do-loop, the simulation loop for years. The planning horizon do-loop is within the iteration loop (component 2) and may be set to a value between 1 and 10 years. This loop begins with the calculation of stochastic variables. Then annual total enterprise costs and receipts are calculated for each individual class of livestock. The main program reads and processes input data concerning the kinds and number of head of livestock, the number of acres of owned range land, assets, liabilities, family living requirements, non-farm income, and other relevant data for the current operating unit. Existing assets are valued for net worth purposes and annual liabilities are recorded. Machinery, equipment and breeding livestock purchased during the planning horizon are depreciated for tax purposes and are valued for net worth. The liabilities associated with these investments are amortized and annual payments are specified.

The ranch net cash position at the end of each year simulated is determined. Family living is paid and taxes are deducted. Net cash income, total net farm income, operator's total net income, net worth and net present value are calculated for each year of the planning horizon. If net cash is positive, it is accumulated for future use and/or invested. If it is negative, equity levels are calculated to determine whether funds can be borrowed to meet the cash flow deficit. If not, the iteration fails the survival test. If the ranch is declared insolvent during the planning horizon loop, the iteration is terminated and a new iteration is begun. At the end of an iteration in which the ranch remained solvent for all years in the planning horizon, output variables for the iteration are stored for statistical analysis in component four.

The planning horizon loop of the current situation is repeated for a specified number of iteration loops to provide data necessary for cumulative probability distributions of prices, yields, weights and weaning percent and the resulting annual net ranch incomes, net worths, cash flows, and net present values.

Component 4

The fourth component of the main program logic calculates values for various performance variables and stores selected results for each iteration on a direct-access disk. The net present value, present value of ending net worth, the ranch's internal rate of return and other performance variables (Table III) are calculated and reported for each iteration in which the ranch remains solvent. The total number of performance variables is a function of the number of years in the planning horizon and the number of range land units, supplemental feed and livestock enterprises.

A second function of component four is to print a brief summary of each iteration in which the ranch is declared insolvent. This summary includes annual values for feed prices and range land yields, acres owned, acres leased, net cash farm income, total net farm income, net cash flow deficits, total assets, total liabilities, net worth, equity-asset ratio, debt-asset ratio and leverage ratio.

TABLE III

LIST OF THE PERFORMANCE VARIABLES FOR A STOCHASTIC SIMULATION WITH OKIE

1. Net Present Value
2. Present Value of Ending Net Worth
3. Internal Rate of Return
4. Van Horn Profit Index
5. Rangeland Owned in the Last Year of the Planning Horizon
6. Rangeland Leased in the Last Year of the Planning Horizon
7. Total Rangeland Used in the Last Year of the Planning Horizon
8. Maximum Bid Price for Land in the Last Year of the Planning Horizon
9. Ending Cash Reverse in the Last Year of the Planning Horizon
10. Market Value of Owned Real Estate in the Last Year of the Planning Horizon
11. Market Value of Machinery in the Last Year of the Planning Horizon
12. Total Long-Term Debts in the Last Year of the Planning Horizon
13. Total Intermediate-Term Debts in the Last Year of the Planning Horizon
14. Contingent Capital Gains Taxes Due in the Last Year of the Planning Horizon
15. Contingent Depreciation in the Last Year of the Planning Horizon
16. Ending Net Worth in the Last Year of the Planning Horizon
17. Leverage Ratio in the Last Year of the Planning Horizon
18. Equity to Assets Ratio in the Last Year of the Planning Horizon
19. Annual Values for the Long-Term Debt to Asset Ratio
20. Annual Values for Family Consumption Expenditures
21. Annual Values for Net Ranch Income
22. Annual Values for Investable Funds at Year End
23. Annual Values for Accrued Personal Income Taxes
24. Annual Values for Accrued Self-Employment Taxes
25. Annual Values for Money Borrowed to Meet Cash Flow Deficits
26. Annual Prices for Steer Calf for Each Livestock Enterprise
27. Annual Steer Calf Weights for Each Livestock Enterprise
28. Annual Weaning Percent for Each Livestock Enterprise
29. Annual Prices for Each Supplemental Feed and Pasture
30. Annual Yields for Range Forage

The third function of component four is to calculate the probability of the ranch remaining solvent in each year of the planning horizon.

The last function of component four is to calculate and print summary statistics for selected performance variables. Summary statistics (mean, variance, standard deviation, minimum, maximum, and coefficient of variation) are calculated for the performance variables listed in Table III. Cumulative probability distributions are calculated for each of the performance variables to allow probablistic comparisons of current and alternative operating units in a stochastic environment.

Detailed Description of Main Program Function

Required input data, definitional equations, and model capabilities will be discussed according to Figure 8, the model flow diagram. Input data read and processed by the first component of the MAIN program may be classified into four categories: (1) program option data; (2) non-variable input data; (3) annual input data, and (4) monthly input data. Baum, et al. (1985) provides a complete discussion for coding input data.

Price and Production Variables

As previously indicated, each iteration begins with the same biological and economic environment, except for annual range pasture yield, livestock prices, supplemental feed prices and livestock weights. The following section develops the process by which these stochastic price and production variables are determined in the model.

Stochastic Process

A subjective triangular probability distribution can be totally described by specifying the minimum (A) and maximum (B) values of the distribution and the mode (M), as illustrated in Figure 9. From both an applied and research point of view, the triangular distribution method is quick and easy to administer.

The model utilizes stochasticly estimated livestock prices, supplemental feed prices, range pasture yield, steer calf weights and weaning percent that exhibit a multivariate triangular distribution based on subjective estimates of variation and using correlations among variables as deemed appropriate. The first step in developing the multivariate triangular distributions was to identify and collect data series for each variable possible. Each series of data was read into the SAS package to compute the historical correlation matrix. Clements et al. (1971) computerized procedure was used to factor these correlation matrices into a unique upper right triangular matrix. In that procedure, the "square-root method" is used to calculate R, so that it satisfies $\Sigma = RR'$, where Σ is the correlation (or covariance) matrix and R is a unique upper-triangular matrix used to generate correlated random variables (Richardson and Nixon, 1981). The unique upper-right factored correlation matrices are read into the model as non-variable input data.

The model utilizes modal values for price and production variables that are determined exogenously from a cylically trended price model or user trended modal values read into the model as annual

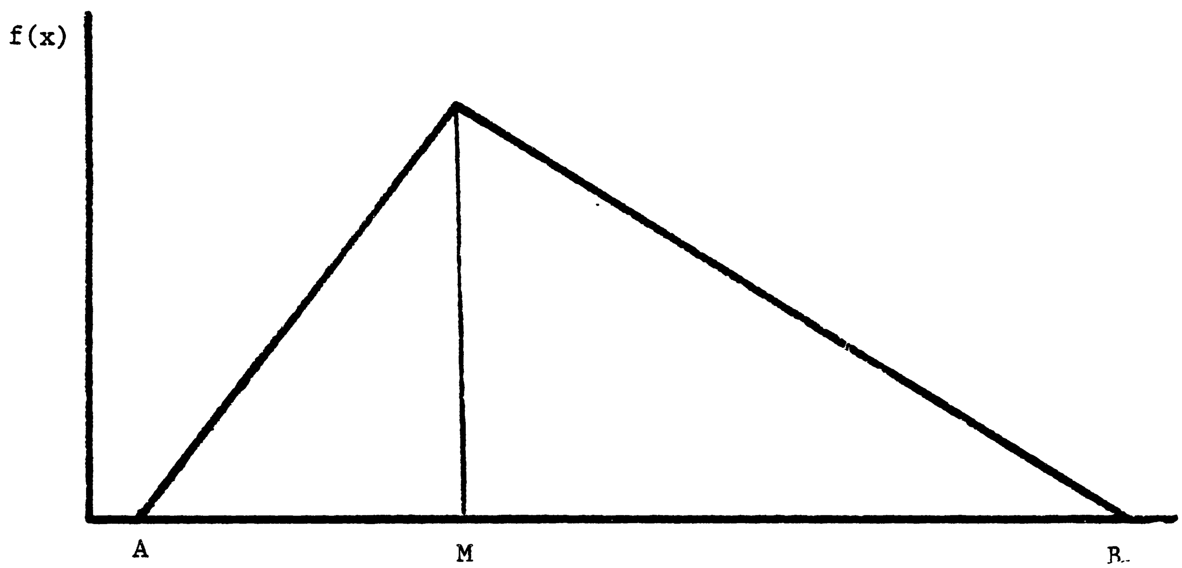


Figure 9. Illustration of a Triangular Probability Density Function

input data. For example, exogenously determined modal steer calf prices were based on the following cylical trend model (Franzmann and Walker, 1972):

$$P_t = [B_0 + B_1 2\pi t - B_2 SIN(^{2\pi t}/T_1) + B_3 COS(^{2\pi t}/T_1) + B_4 SIN(^{2\pi t}/T_2) + B_5(COS(^{2\pi t}/T_2) \quad (31)$$

where

P_t = the predicted average beef price per hundred pound in period t

B_0 = intercept

B_1 = long-term linear trend coefficient

B_2 and B_3 = cylical component coefficients

B_4 and B_5 = seasonal component coefficients

t = time trend variable with values 0,1,2,...

T_1 = total months per cycle

T_2 = total months per season

Minimum and maximum values for the triangular distribution in terms of the percent less than the mode and the percent greater than the mode are also determined exogenously for each stochastic variable and read into the model as non-variable input data. That approach facilitates changing the distribution when the intercept, trend, and/or the cylical and seasonal component (if applicable) of any of the equations used to predict price and production variables are changed. The modal values, M, can be an average value, a trended value or a functional form using any independent variables.

The stochastic values for each variable are calculated based on the following sequence of equations:

Minimum and maximum values and percent left of the mode.

$$A_t = M_t - (LM_t) \quad (32)$$

$$B_t = M_t + (VM_t) \quad (33)$$

$$PCT_t = (M_t - A_t)/ (B_t - A_t) \quad (34)$$

where:

A_t = minimum value in period t

B_t = maximum value in period t

PCT_t = percent of value left of the mode in period t

M_t = model value in period t

L = percent less than the mode inputed by the user

V = percent greater than the mode inputed by the user

The next step in developing a multivariate triangular distribution involves drawing random deviates from a random number generator and correlating them as in Equation (35). The unique upper-triangular correlation matrices are matrix multipled by a vector of psedo-random normal deviates to determine a set of multivariate deviates:

$$DRD = DRD + (FCM * SND) \quad (35)$$

where:

DRD = the array of empirically integrated variates, the product of the matrix-multiplication of the appropriate element of the factored correlation matrix and its psedo-random normal deviate

FCM = unique upper-right factored correlation matrix

SND = deviates generated from a psedo-random number generator

If the triangular distribution is specified for only one random variable or the variables are independent, then an identity matrix is substituted for FCM in equation (35).

The model transforms correlated deviates to uniform variates, variates which are rectangularly distributed over the interval 0 to 1, in the following equations:

$$E_t = DRD * \sqrt{2}/2 \quad (36)$$

$$UCRD_t = .50 + (0.50 * ERF\ (E_t)) \quad (37)$$

where:

E_t = factor adjusted correlated random deviates in period t

$UCRD_t$ = uniform factor correlated deviates in period t

ERF = Fortran error function subprogram, the result of this function will be $\sqrt{2}/2$ times the definite integral from 0 to the argument of e^{t^2} dt.

Variates of any distribution can in principle be sampled in the inverse cumulative probability distribution function (CDF) method by projecting a uniform factor correlated deviate UCRD on the cumulative probability scale through the CDF to the scale of the specified random variable (Anderson et al, 1980). The projection process is illustrated graphically in the lower part of Figure 10, where if D is a particular value of UCRD, the corresponding triangular variate is E.

The stochastic values left of the mode and right of the mode are represented by equation (38) and (39), respectively:

$$SP_t = A_t + [(M_t - A_t) * (B_t - A_t) * UCRD]^{1/2} \quad (2) \quad (38)$$

$$SP_t = B_t - [((B_t - A_t) * (B - M_t)) * (1.0 - UCRD)]^{1/2} \quad (39)$$

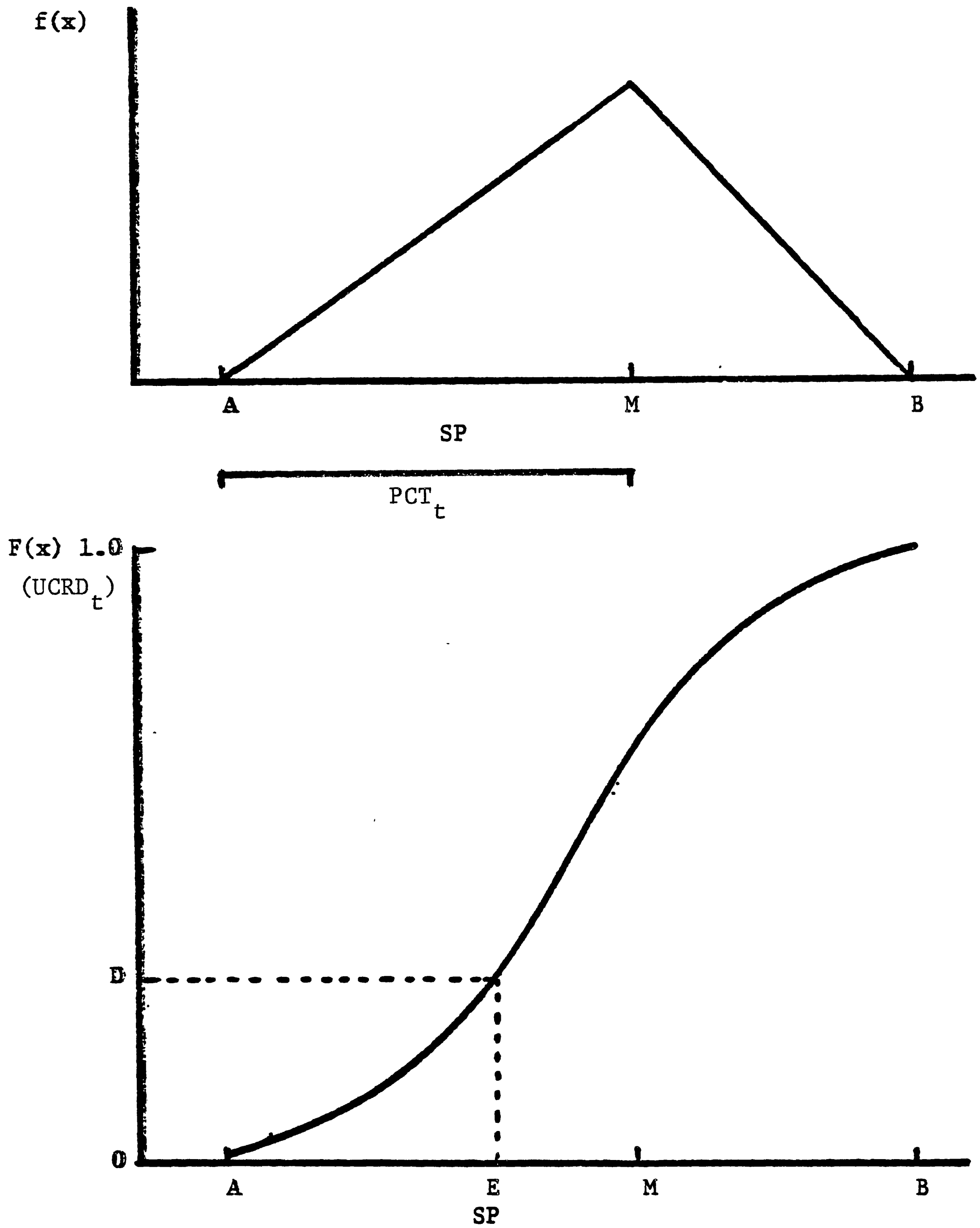


Figure 10. Probability Density Function and Cumulative Probability Function for a Random Variable SP Which Follows a Triangular Distribution

where:

SP_t = a matrix of stochastic triangularly distributed trended and factored correlated observations in period t

For each year within the iteration loop, if the uniform factored correlated deviate $UCRD_t$, a random deviate between 0 and 1, is greater than the percent of the value to the left of the mode PCT_t (Figure 10), then the model calculates the stochastic value to the right of the mode for time period t (equation 39) otherwise the model calculates the stochastic value to the left of the mode for time period t (equation 38). The distribution can be skewed to the left or right of the mode over the planning horizon by changing the modal values. A modal value of a random variable that is equal to the mean defines a triangular distribution that is symmetrical.

The above general discussion applies to the calculation of stochastic variables in this study: range forage yield, supplemental feed prices, steer calf prices, steer calf weight and weaning percents. Data for specifying the stochastic variables and the results of the use of simulation to determine the impact of these variables on the outcomes associated with particular management strategies are discussed in the following chapters.

Annually Adjusted Variables

Beef livestock prices generally move in the same direction through time, although some major differences between prices may be accounted for in seasonal and cylical spreads between prices. Similarly, most of the weight difference between different classes of beef cattle can be accounted for in the type of cattle and herd management practices under consideration. Thus, prices and weights of different classes of livestock are highly correlated. Stochastically estimating prices and weights for each individual class of livestock would increase the cost of running the program considerably, and the marginal value of the additional information is believed to be far less than the marginal cost. Therefore, prices and weights for all other classes of cattle, are based on stochasticly estimated steer calf prices and weights.

Stochastic steer calf price and steer calf weight are multiplied by user specified price and weight adjustment factors read into the model as annual input data for use in calculating annual price and weights for cull cows, replacement heifers, heifer calves, bulls, and stocker enterprises.

Annual livestock weights for all classes of livestock are further adjusted to reflect the stochastic level of range forage production. Equation 40 was formulated to adjust livestock weight for stochastic range condition less than and greater than the mode:

$$ASWT_t = [((((SRY_t/MRY_t)-1)\ .167)+1)SWT_t] \qquad (40)$$

where:

$ASWT_t$ = a matrix of annually adjusted livestock weights based on the stochastic level of range forage production in period t

SRY_t = matrix of stochasticly estimated range yields for period t

MRY_t = matrix of modal range yield in period t

SWT_t = matrix of triangularly distributed livestock weights in period t

Total feed consumption of cattle is highly dependent upon the quality of the roughage being consumed. Both adults and growing young animals are capable of maintaining relatively stable body weight or uniform growth rates overtime in spite of marked variation in physical activity and energy expenditure, indicating the animal is able to adjust energy intake to energy expenditure by some means of appetite control (Church, 1977). Thus, if no other problems interfere such as nutrient deficiencies, animals eat to meet their caloric needs. Therefore, assuming that livestock are supplemented the hay dry matter equivalent of decreases in range forage, the total adjustment in livestock weights due to variation in range forage is assumed to be relatively small. The basic assumption of equation (40) is that livestock weights are adjusted by a factor of 16.7 percent of the residual of the ratio of stochastic range forage yield to modal range forage yield. Range is assumed to be stocked for the modal range yield level. A more complex biophysical relationship between livestock weights and stochastic range forage yield could be developed.

Total Ranch Costs

Inputs required to determine total ranch enterprise costs are cash production costs per unit (head or acre), and the number of units (head or acres) to be produced. Cost items are adjusted annually to reflect the user's assumptions regarding the annual rate of inflation for different types of inputs. Trended enterprise costs are multiplied by the specified number of units (head or acres) for each class of livestock and acres of range land and summed to determine total ranch enterprise costs. Variable range pasture costs include pasture and fence maintenance costs. Livestock production costs include herd health care expenses (veterinarian, medicine and vet-med supplies), hauling and marketing expenses, salt and minerals and livestock supplies plus the cost of livestock purchased for resale. Some stochastic variation in cost is introduced through prices of cattle purchased. These stochastic buying prices are determined in the same manner as the livestock sale prices. Stocker steers and heifers may be either purchased or raised. The price for purchasing stocker steers is assumed to be the price received for steer calves. The price for purchasing stocker heifers is assumed to be a fraction of the price received for steer calves. Interest costs for operating expenses are calculated as the product of total variable cost, the annual interest rate for short-term capital, and the fraction of a year the operating capital is used.

The model calculates labor costs in two steps. The ranches' part-time labor requirement is the total labor by months required less available family and full-time hired labor by months. Total monthly labor required is the monthly sum of per head monthly labor requirements for each class of livestock and the sum of per acre monthly labor requirements for range pasture. The model computes total labor cost as the sum of annual salaries for full-time employees and hourly wage rates paid to part-time labor. Salaries for full-time employees and hourly wage rates for part-time labor are inflated over time based on rates of inflation provided by the user as annual input data.

A cash lease is assumed for rangeland rented. The cost for cash leasing rangeland is calculated using a constant lease rate per acre adjusted annually by a user specified rate of escalation or decline.

Annual interest and principal payments are calculated assuming simple interest loans based on user specified loan life, interest rate, and existing principal due on long-term, intermediate-term, and livestock debts. Debts may be acquired over the planning horizon through refinancing cash flow deficits and purchasing machinery. Credit terms for new loans, refinancing existing loans, and financing cash flow deficits are read into the model as non-variable annual input data.

Annual property taxes are determined by multiplying the previous year's market value of land by the property tax rate. The annual property tax rate is inflated by a user specified inflation rate. Other fixed costs; such as other taxes, accountant and legal fees, insurance, unallocated maintenance, and miscellaneous costs; are calculated annually by inflating the initial values by their respective user specified annual inflation rates.

Total Ranch Receipts

Gross enterprise receipts are determined by combining stochastic and annually adjusted prices, weights, weaning percent and number of head of each class of livestock. Simulation experiments conducted in this study use cow-calf and stocker cattle grazed on owned and leased land. Livestock income includes receipts for steer calves, heifer calves, cull cows, stocker steers and stocker heifers. The number of livestock in a livestock class may be trended up or down over the planning horizon. The number of replacement heifers and replacement herd sires may be changed each year by trending the respective culling rates. Similarly, the number of stocker cattle purchased each year may be changed from year to year.

Gross income for cow-calf enterprises is influenced by the stochastic sale weights and calving percentages. The degree of variation is determined by the minimum (percent of mode), maximum (percent of mode), and modal values of the sale weights and calving percentage inputed. Half the calf crop is assumed to be bull calves, half heifer calves. Cull cow receipts are reported as capital gains. Equation (41) through (44) describe calculation of gross receipts for cow-calf enterprises.

$$HRECPTS_t = (NOCOW_t * 0.5 \times CLFPR_t - FBREP_t) * HCLSPR * HCLSWT \quad (41)$$

$$SRECPTS_t = (NOCOW_t * 0.5 \times CLEPR_t) * SCLSPR_t * SCLSWT \quad (42)$$

$$CRECPTS_t = NOCUL_t * COWSPR_t * COWSWT_t \quad (43)$$

$$GROSS\ RECPTS_t = HRECPTS_t + SRECPTS_t \quad (44)$$

where:

$HRECPTS_t$ = cash receipts from sale of heifer calves in year t

$SRECPTS_t$ = cash receipts from sale of steer calves in year t

$CRECPTS_t$ = capital gain from sale of cull cows in year t

$GROSS\ RECPTS_t$ = total gross receipts for the enterprise in year t

$NOCOW_t$ = number of broad cows in year t

$FBRER_t$ = number of raised replacements in year t

$NOCUL_t$ = number of cull cows in year t

$CLFPR_t$ = stochastic weaning percentage in year t

$HCLFPR_t$ = stochastic heifer calf sell price in year t

$HCLSWT_t$ = stochastic heifer calf sell weight in year t

$SCLSPR_t$ = stochastic steer calf sell price in year t

$SCLSWT_t$ = stochastic steer calf sell weight in year t

$COWSPR_t$ = stochastic cull cows sell price in year t

$COWSWT_t$ = stochastic cull cows sell weight in year t

Gross receipts for stocker steer and stocker heifers are determined according to equations (45) and (46).

$$SSRECPTS_t = NOSTKRS_t * (1-DLSTKR) * STKRSPR_t * STKRSWT_t \quad (45)$$

$$SHRECPTS_t = NOSRKRH_t * (1-DLSTKR) * STKRHPR_t * STKRHWT_t \quad (46)$$

where:

$SSRECPTS_t$ = cash receipts from sale of stocker steers in year t

$SHRECPTS_t$ = cash receipts from sale of stocker heifers in year t

$NOSRKES_t$ = number of stocker steers in year t

$NOSTKRH_t$ = number of stocker heifers in year t

$DLSTKR_t$ = average annual stocker death loss

$STKRSPR_t$ = stochastic stocker steer sell price in year t

$STKRHPR_t$ = stochastic stocker heifer sell price in year t

$STKRSWT_t$ = stochastic stocker steer sell weight in year t

$STKRHWT_t$ = stochastic stocker heifer sell weight in year t

The value of supplemental feed stuffs used by each class of livestock is influenced by the stochastic determination of feed stuff prices and the producer specified feeding rate. Furthermore, such supplemental feeding rates are influenced both by earlier decisions and by stochastic parameters whose values become known after earlier decisions. To partially model this phenomena as it relates to feeding rates, it is assumed that supplemental roughage feeding rates in a given year was a function of the level of stochastic range forage yield in that year. The earlier decision, number of cattle, has not changed.

The value of feed stuff, for each class of livestock, is determined according to equation (47) and (48):

$$FEDRATE_{tk} = [((LBSDM_t - SRY_t)\ .5) * TAUM_{t,k}/PCTDM_f] * FRATIO_t * ROUGHPR_t * NOLVSTK_t \quad (47)$$

$$VALFED_t = (NOLSTK_t * FEDPR_{t,k} * FRATE_{j,k}) + (FEDRATE_{t,k} * ROUPR_t) \quad (48)$$

where:

$FEDRATE_{tk}$ = the supplemental roughage feed rate, adjusted for stochastic range forage condition for each class of livestock in period t

$VALFED_t$ = value of all supplemental feed stuff fed to each class of livestock in year t

$LBSDM_t$ = modal lbs. of dry matter per acre per AUM for year

SRY_t = stochastic range forage yield in year t

$TAUM_{t,k}$ = total acres required per animal unit of the kth class of livestock in year t

$PCTDM_t$ = percent dry matter of supplemental roughage in year t

$FRATIO_t$ = the ratio of range forage dry matter to supplemental roughage dry matter, the rate at which roughage dry matter is supplemented for mature range forage dry matter in year t

$ROUGHPR_t$ = the stochastic feed stuff price in year t

$NOLVSTK_k$ = the number of livestock in each kth class in year t

$ROUPR_t$ = the stochastic price for supplemental roughage in year t

$FEDPR_{t,j}$ = the jth stochastic feed stuff price in year t

$FRATE_{j,k}$ = the user specified feeding rate per head for the kth class of livestock for the jth feed stuff

Modal lbs. of dry matter per acre per month (LBSDM) was based on the assumption that 50 percent of the modal range forage DM yield is harvested by range livestock. The residual yield is accounted for by losses to insects, wildlife, weather and residue. Total acres required per animal unit ($TAUM_t$) is based on the number of animal unit months required for each class of livestock divided by the number of animal unit months available per acre. The percent dry matter for supplemental roughage ($PCTDM_t$) was used to convert the adjusted feed rate to an as-fed weight. The ratio of range forage dry matter to supplemental roughage dry matter ($FRATIO_t$) was used to adjust the rate at which roughage is substituted for range forage. Equation (47) equals zero if $LBSDM_t$ is less than SRY_t, implying a non-drought year.

Total nonranch cash receipts include interest on cash reserves, dividends from off-ranch investments, off-ranch wages, and other income. Proceeds from the sale of ranch assets such as land and machinery is included in total cash sources of funds.

The annual net cash returns of the ranch are calculated by accounting for all cash sources and uses of funds, from both ranch and non-ranch resources. Equation (49) specifies net cash ranch income.

$$NETCSH_t = GROSS\ RECPTS_t - VALFED_t - BUY\ COST_t - COST_t \qquad (49)$$

where:

$NETCSH_t$ = net cash ranch income in year t

$GROSS\ RECPTS_t$ = cash receipts from sale of livestock in year t

$BUY\ COST_t$ = the cost of livestock purchased for resale in year t

$COST_t$ = enterprise production cost, both variable and fixed in year t, and other variables previously defined.

NonCash Adjustments

Year-to-year changes in the value of livestock held for sale or breeding are calculated based on age, sex, average weight, and current prices. These changes in livestock values are part of the non-cash adjustments to ranch income. Equation (50) specifies the change in the value of inventories for breeding stock, and equation (51) specifies the change in the value of inventories for livestock owned for sale.

$$BINVEN_t = VALB_t - VALB_{t-1} \quad (50)$$

$$LINVEN_t = VALL_t - VALL_{t-1} \quad (51)$$

where:

$BINVEN_t$ = change in value of all livestock owned for breeding in year t

$LINVEN_t$ = change in value of all livestock owned for sale in year t

$VALB_{t/t-1}$ = market value of herd sires, brood cows, and replacement heifers in year t and t-1

$VALL_{t/t-1}$ = market value of stocker steers and heifers held for sale in year t and t-1

The initial market values of off-farm investments and owned machinery are inflated or deflated across time based on the annual inflation rates provided by the user. The annual market value of farmland is calculated by multiplying acres owned by the updated per acre value of land. Annual per acre land values are obtained by adjusting the previous year's value by a user specified land inflation rate.

The initial market value of beginning machinery inventory in year t equals:

$$MHVALUE_t = MHMKVAL_{t-1} * (1.0 + INFRMH_t)^{YR} * [1-((1.0-SALV_t) * ((AGE_t +1)/USELIF))] \quad (52)$$

where:

$MHVALUE_t$ = market value of beginning machinery inventory in year t

$MHMKVAL_{t-1}$ = market value of machinery, year t-1

$INFRMH_t$ = annual rate of inflation for machinery

$SALV_t$ = ratio of salvage value to purchase price in year t

AGE_t = age of the asset in year t

YR = year in the planning horizon

USELIF = years of useful life

Similarly, market value for buildings equals:

$$BLDVALVE_t = BLDMKVAL_{t-1} * (1.0 + INFRBLD_t)^{YR} *[1-((1.0-SALV_t) * ((AGE_t + 1)/ USELIF))] \quad (53)$$

where:

$BLDMKVAL_{t-1}$ = market value of buildings, year t-1

$INFRBLD_t$ = annual rate of inflation for buildings in year t

The first year market value of machinery and buildings is added to intermediate and long-term assets, respectively. Each year, the change in market value of machinery is added to intermediate assets while the change in market value of buildings is added to long-term assets. At the end of their useful life, the asset values have been reduced to "zero" or salvage value, they are sold and deleted from intermediate or long-term assets. Equation (52) is also used to determine market value of new assets purchased during the planning horizon. Purchase cost is substituted for market value.

Depreciation

After calculating updated market values for the ranch operators' assets for use in the balance sheet, the model calculates depreciation for buildings, machinery, and purchased breeding livestock for use in calculating income tax. Depreciation is calculated using the straight-line method according to the guidelines in the Farmers Tax

Guide. The model provides the option of keeping, selling, or trading in fully depreciated ranch machinery at the end of its tax life or for a number of years afterwards. For example, a second pickup truck may be kept for utility purposes even though it has been fully depreciated. A machine that is not kept on the ranch after it is fully depreciated can be traded-in on a replacement machine or sold with the proceeds applied to the purchase of a new machine. The model automatically replaces fully-depreciated breeding stock in each herd age complement (sires at 120 percent of the price received for selling cull sires).

The replacement cost for each piece of machinery is determined by multiplying the original cost of the machine by the annual rate of inflation for new machinery as indicated by the user. Machinery and breeding livestock replacements are paid for with a cash down payment rate inputed by the user and the remaining balance added to the current intermediate-term debt.

Capital gains and/or depreciation recapture is calculated for a fully-depreciated asset when applicable. Annual contingent depreciation recapture is computed for each piece of machinery based on its current market value. Contingent depreciation recapture is reflected as a contingent liability in the balance sheet. Additional first-year depreciation is taken on machinery as well as the normal depreciation where applicable.

The accumulated straight-line depreciation for calculating the beginning balance sheet liabilities is calculated by the model based on equation (54):

$$ADEPRE_1 = (ASSETCOST - SALV - ADFIRST) * (1.0 - ((DEPLIFE - AGE_1)/DEPLIFE) + ADFIRST \quad (54)$$

where:

$ADEPRE_1$ = accumulated depreciation of the asset in year 1

SALV = salvage value of the asset

DEPLIFE = depreciation life of the asset

AGE_1 = the current age of the asset in year 1

ADFIRST = additional first year depreciation for the asset

ASSETCOST = purchase price for the asset

Annual depreciation for existing machinery and buildings is calculated by the model based on equation (55).

$$DEPRE_t = (ASSETCOST - SALV)/DEPLIFE \quad (55)$$

where:

$DEPRE_t$ = the annual depreciation of the asset in year t

Annual depreciation for new machinery purchased during the planning horizon is calculated by the model based on equation (56).

$$DEPRE_{t+1} = (ASSETCOST - SALV - ADFIRST)/DEPLIFE \quad (56)$$

Equations (54) and (56) specify calculation of that portion of the asset eligible for additional first year depreciation.

$$ADFIRST = (.2 * ASSETCOST) \quad (57)$$

where:

ASSETCOST = purchase price for the asset

Straight-line depreciation for purchased breeding livestock is calculated by the model based on equation (58).

$$DEPRE_t = (TC - ADFIRST - SALV) * [1- (DEPLIFE - AVGLIFE)/DEPLIFE] + ADFIRST \quad (58)$$

where:

TC = total cost when purchased all n head

AVGLIFE = average number of years the replacement is in the breeding herd plus one

DEPLIFE = depreciation life for breeding stock.

Accumulated depreciation for the balance sheet throughout the planning horizon is based on equation (59).

$$ADPREC_t = ADPREC_t + DPREC_t \quad (59)$$

Investment tax credit allows a reduction of the tax liability up to ten percent of the new amount invested in qualified capital assets. If new machinery was traded for, the investment tax credit base reflects the difference between the trade-in value and the purchase price. The applicable limitations on the asset amount eligible for tax credit as specified within the model. The tax saving due to investment tax credit is limited to the amount of the tax liability and is carried forward as allowable.

Income and Capital Gains Tax

The modified ERTA-TEFRA legislation was used to determine the ranch's tax liability and the user inputed tax rates (Baum, et al., 1985) State income tax rates, expressed as a fraction of the ranch operator's adjusted gross income are read into the model as input data.

Equation (60) describes the components of total taxable ranch income.

$$TTAXI = NETTRANCH + TAXGAIN + OFFTAXI + TAXDIVI \quad (60)$$

where:

TTAXI = total taxable ranch income

NETTRANCH = net ranch income less changes in inventories and/or raised livestock, plus depreciation recapture, plus the value of home consumption at its cost

TAXGAIN = taxable income from realized capital gains

OFFTAXI = total taxable off-ranch income

TAXDIVI = taxable interest and dividends from off ranch income less the $200 exclusion

Equation (61) describes taxable income for ranch operator.

TAXI = TTAXI - TEXEMP - EXIDEDUC - NETLOSS (61)

where:

TAXI = taxable income for farm operator

TEXEMP = total personal exemptions

EXIDEDUC = itemized personal deduction

NETLOSS = net operation loss carry forward

A farm operator is assumed to be married and to file a joint income tax return. Each user specified income tax exemption claimed is multiplied by $1,000 to obtain the value of personal exemptions.

The income tax liability is computed annually by three alternative methods and the minimum liability strategy is chosen automatically. First, the model computes the income tax liability using income averaging. Second, the model computes the income tax liability in the standard manner from the current year's income. Thirdly, the income tax liability is computed using the maximum tax on earned income a provision of the Internal Revenue Code.

Annual self-employment taxes are added to the income tax liability to determine the total annual tax liability. The self-employment tax is based on net farm taxable income. Rates and maximum income levels are read in as annual input data. The resulting income tax and self-employment tax liabilities become an accrued liability paid in the following year.

Cash Flow Deficits

After calculating income and self-employment taxes, the year end cash reserve for the ranch is calculated. When an annual cash flow deficit is encountered the model will draw on accumulated cash from previous years. If accumulated cash is exhausted, the model finances as much of the deficit as possible by obtaining a second mortgage on the long-term assets and then finances any remaining deficit by obtaining a second mortgage on intermediate-term assets. If the deficit causes both the long-term and intermediate-term equity ratio to fall below user specified minimum levels, the farm is declared insolvent and the iteration is terminated. The long-term equity ratio is calculated as follows:

$$LTEQUART = (MKTVAL - LTDEBT - ACONTCAP) / MKTVAL \quad (62)$$

where:

LTEQUART = current long-term equity ratio

MKTVAL = market value of all land and buildings

LTDEBT = total long-term debt on all real property

ACONTCAP = accumulated contingent capital gains taxes

If the ratio exceeds the specified minimum when the new loan is included as a liability, then funds are borrowed and the new total liability equals:

$$LTDEBT = LTDEBT + (NEWLOAN * LNINTR * (1+LNINTR)^{ILNLF} / (1+LNINTR)^{ILNLF-1}) \quad (63)$$

where:

LNINTR = the loan interest rate

ILNLF = the life or length of the loan in years

The loan life and interest rate are user specified and read in as non-variable input data and annual input data, respectively. The intermediate equity ratio is calculated exactly as equation (62), substituting intermediate assets and liabilities.

For both the new intermediate and new long-term loans, the principle is added to the total expense, and the interest is added to deductible expenses. The total amount of the liability is added to the intermediate or long-term liability category in the year of the loan, and the principal payment subtracted in the year paid.

Annual contingent capital gains taxes and annual contingent depreciation recapture tax are calculated in equation (64) and (65), respectively, assuming a marginal income tax rate of 30 percent:

$$CONTCAP_t = 0.30 * (CAPEXCRA_t * (UNCAPGAIN_t - RECAPGAIN_t) \quad (64)$$

$$CONTDEPRE_t = 0.30 * DEPRE_t \quad (65)$$

where:

$CAPEXCRA_t$ = capital gain exclusion rate in year t

$RECAPGAIN_t$ = realized capital gain in year t

$CONTCAP_t$ = contingent capital gains tax in year t

$CONTDEPRE_t$ = contingent depreciation recapture tax in year t

$UNCAPGAIN_t$ = unrealized capital gain in year t

$DEPRE_t$ = total depreciation in year t

Net Ranch Income is the amount of income generated by the business during the year which is available for family living, principal debt repayment, savings and reinvestment in the business. A positive Net Ranch Farm Income is a prerequisite for continued success and growth of the ranch business (Egbert, 1984). Total Net Ranch Income (profit or loss) is calculated by the model as described in equation (66):

$$NETRIN_t = NETCSH_t - DEPRE_t + BINVEN_t + LINVEN_t + VALREPL_t \quad (66)$$

where:

$NETRIN_t$ = net ranch income in year t

$VALREPL_t$ = value of raised breeding herd replacements in year t

Total net income without and with unrealized capital gains are calculated as follows: equation (67) specifies net income without unrealized capital gains, and equation (68) specifies net income with unrealized capital gains.

$$NETWITHOUT_t = NETRIN_t - NEWDEPRE_t - ADFIRST + NETOFF_t \quad (67)$$

$$NETWITH_t = NETWITOUT_t + UNCAPGAIN_t + DEPRE - CONTCAP_t - CONTDEPRE_t \quad (68)$$

where:

$NETWIHOUT_t$ = total net income without unrealized capital gains and after operator withdrawls in year t

$NETWITH_t$ = total net income adjusted for realized capital gains and contingent tax liabilities in year t

$NETRIN_t$ = net ranch income in year t

$NETOFF_t$ = total off-farm income in year t

$UNCAPGAIN_t$ = total unrealized capital gains in year t

$NEWDEPRE_t$ = total depreciation new machinery in year t

ADFIRST = additional first year depreciation

$CONTCAP_t$ = contingent capital gains tax in year t

$CONTDEPRE_t$ = contingent depreciation recapture tax in year t

Net Worth

After simulating the last year of the planning horizon, the model calculates the ranch's year-end net worth. The beginning inventory of liabilities, the beginning inventory of machinery and buildings, and the non-depreciable and depreciable assets purchased during the planning horizon have a deterministic effect on cash flow and net worth in each iteration. However, the net worth and cash flow effects of cash usage and borrowing during an iteration to meet cash flow deficits will be different for each iteration depending on the stochastic income and expense flows. The value of total assets and total debts for a specific year in a specific iteration are as follows:

$$TASSETS_t = MKTVALLB_t + MKTVALMA_t + BCASH_t + VALBSTK_t + VALSSTK_t + OFFINVST_t \quad (69)$$

$$TDEBTS_t = LTDEBT_t + ITDEBT_t + TTAXLIAB_{t-1} + EMPLYTAX_{t-1} + ACONTDEPRE_t + ACONTCAP_t \quad (70)$$

where:

$MKTVALLB_t$ = market value of all land and buildings in year t

$MKTVALMA_t$ = market value of all ranch machinery in year t

$BCASH_t$ = beginning cash reserve in year t

$VALBSTK_t$ = value of livestock for breeding at year end in year t

$VALSSTK_t$ = value of livestock held for sale at year end in year t

$OFFINVST_t$ = total market value of other assets, as off-farm investments in year t

$TTAXLIAB_{t-1}$ = total income tax liability, federal and state, from year t-1

$EMPLYTAX_{t-1}$ = self-employment tax from year t-1

$ACONTDEPRE_t$ = accumulated contingent depreciation recapture taxes in year t

$ACONTCAP_t$ = accumulate contingent capital gains taxes in year t

These variables determine net worth as follows:

$$NET\ WORTH = TASSETS - TDEBTS \quad (71)$$

Net Present Value

The net present value criterion uses discounting formulas to value the projected cash flows for alternative ranch situations at one point in time (Barry, et al., 1979). The model uses the net present value criterion to summarize estimated net cash flows over the planning horizon for each iteration.

Net present value of net cash flow reported for each iteration is the ten year discounted net cash flow of the ranch.

$$NPV = NETCSH/(1.0 + DISRATE)^{YR} \quad (72)$$

where:

NPV = net present value of the ranchs' net cash flow over the planning horizon

NETCSH = net cash ranch income

DISRATE = discount rate (after-tax)

YR = last year of the planning horizon for the iteration

The discount rate assumed here is the after tax rate of return that the decision maker could receive on his or her next best alternative investment. A positive net present value indicates that the ranch operation and its assets will yield a rate of return greater than the discount or opportunity cost rate.

This chapter described how data and variables are specified and described accounting procedures used in the model. Chapter IV describes input data sources and assumptions and presents data for the simulation of a representative ranch in the Southern Plain study area.

CHAPTER IV

INPUT DATA FOR THE SOUTHERN PLAINS BASE RANCH

Evaluation of ranch survivability in the Southern Plains is the basic purpose of the simulation model. Producers need to know what management strategies will insure or enhance their probability of survival in a uncertain economic, business, and biological environment. This study does not try to identify all possible combinations and permutations of management strategies and economic scenarios. The simulation model outlined in Chapter III and the input data described in this chapter are designed to provide evaluative information about the success of a representative ranch unit under selected management strategies in the Southern Plains study area.

Manetsch and Park (1977) identify five broad classes of variables which should be considered in any modeling situation: system outputs, controllable system inputs, exogenous system inputs, system state variables, and system design parameters (Figure 11). These major elements are used in this chapter to identify and explain the input data for the representative ranch base economic scenario experiment for the Southern Plains study area. To facilitate discussion, this ranch situation will be referred to as the Base Ranch.

Chapter V evaluates simulation results for the Base Ranch system. Additional management plans and economic scenarios are developed in

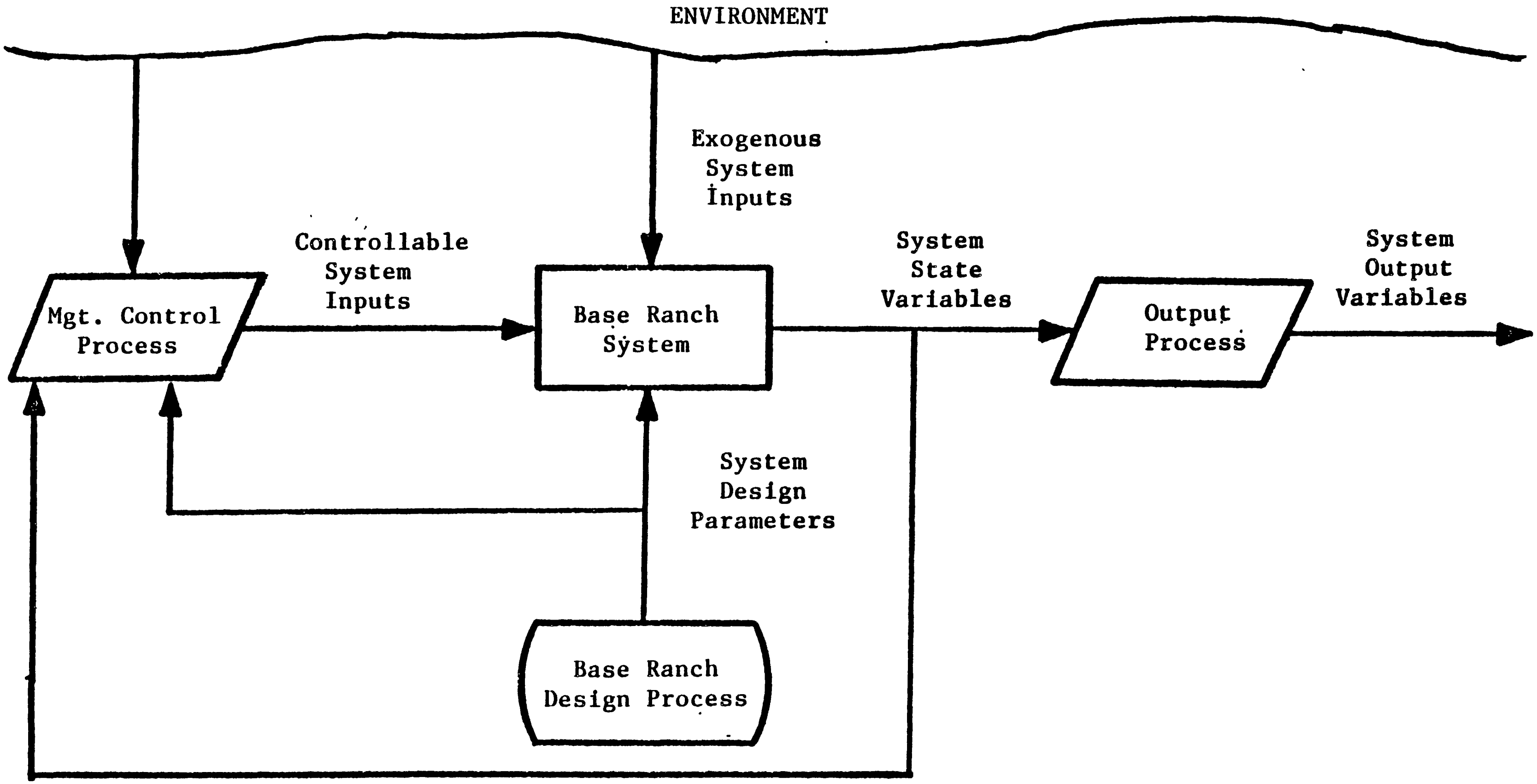


Figure 11. General Base Ranch System

Chapter VI for the same Base Ranch to illustrate the capabilities of the simulation model and test effects of varying key control, exogenous and/or state variables.

Exogenous Variables

The levels of exogenous system inputs are determined by the system environment, a set of processes which affect system performance but are not significantly affected by the system's behavior. The distinction between the controllable system inputs and the environment is not always evident, nor is it necessarily fixed. It depends on the situation under consideration and on the decision maker's degree of causality within the system. It is important to make the distinction between exogenous and controllable system inputs, especially in the analysis of decisions made under uncertainty, since stochastic factors in the environment can be viewed as the primary source of uncertainty in most decision situations.

Livestock Prices

The market price of beef cattle plays an important role in equilibrating the demand and supply of beef and the channeling of resources into and out of beef production. Precise short-run price predictions require a detailed understanding of the interrelationships among the variables affecting the demand and supply for beef, as well as knowledge of the characteristics of any combination of nonsystematic elements present in the system.

Analysis of livestock prices over the longer-run planning horizon indicates the direction and magnitude of change in beef prices to guide longer-run management decisions. Although precise estimates of the absolute levels of price may not be obtained, the turning points and relative level of price provide useful decision information. Franzmann and Walker (1971) fitted Harmonic regressions to monthly data to provide a means of predicting beef livestock prices. The model was updated and used in this study to predict a cylically trended price series for steer calf prices.

The Franzmann-Walker model incorporates terms that allow for seasonal variation, cyclical variation, and long-term linear trend (equation 31, Chapter III). The cyclical component has a period of 120 months (10 year cattle cycle) and the seasonal component has a period of 12 months. The following (estimated) equation is used:[1]

$$P = 8.84179 + \underset{(40.87)}{(0.00812t)} - \underset{(-14.01)}{(0.62209 * SIN(3t))}$$

$$+ \underset{(26.05)}{(1.5536 * COS(3t))} + \underset{(10.06)}{(0.44348 * SIN(30t))}$$

$$+ \underset{(0.93)}{(0.04107 * COS(30t))} \qquad (73)$$

$$R^2 = .83$$

where:

P = the predicted average cost per hundred pounds of steer calf

t = time trend variable with values 0,1,2...

---

[1]For a 10-year cycle, the period, T, must be 120 months = 360°; therefore, $2\pi t/T1 = 2\pi t/120 = 3t$. Similarly, for the seasonal component, the period, T2, must be 12 months = 360° and $2\pi t/T = 2\pi t/12 = 30t$.

Annual modal steer calf prices are obtained from equation (73) for the month the livestock were marketed. Actual (stochastic) prices vary around these predicted modal values as described in the stochastic process section of Chapter III.

Figure 12 presents the modal prices estimated by equation (73), for the 10 year planning horizon. As indicated in Chapter III, the stochastic prices for all other classes of livestock were based on stochastic steer calf prices. Figure 13 shows the relationship between prices of the cattle classes from 1964 to 1984. To model this relationship, average monthly price spreads for the period 1964 to 1984 were determined between steer calves and all other classes of livestock. The period 1964 to 1984 included one full cattle cycle (1967-1977) and the end (1964-1967) and beginning (1977-1984) of two other cycles. Monthly adjustment factors were cyclicly based over time on three characteristic stages of cattle cycles: (1) "rapid growth" stage; (2) "deceleration" stage, and (3) "turnaround" stage (USDA, 1983). Cyclically based price adjustment factors for the months in which the livestock are marketed are reported in Table IV. The planning horizon used in all simulation experiments starts in the "rapid growth" stage because that is the approximate stage for 1985.

Price, and Production Distribution Parameters

The decision maker can incorporate his subjective evaluation of the variation in steer calf prices, supplemental feed prices, steer calf weights, weaning percent, and range forage yield. As discussed in Chapter III, triangular distributions of these price and production

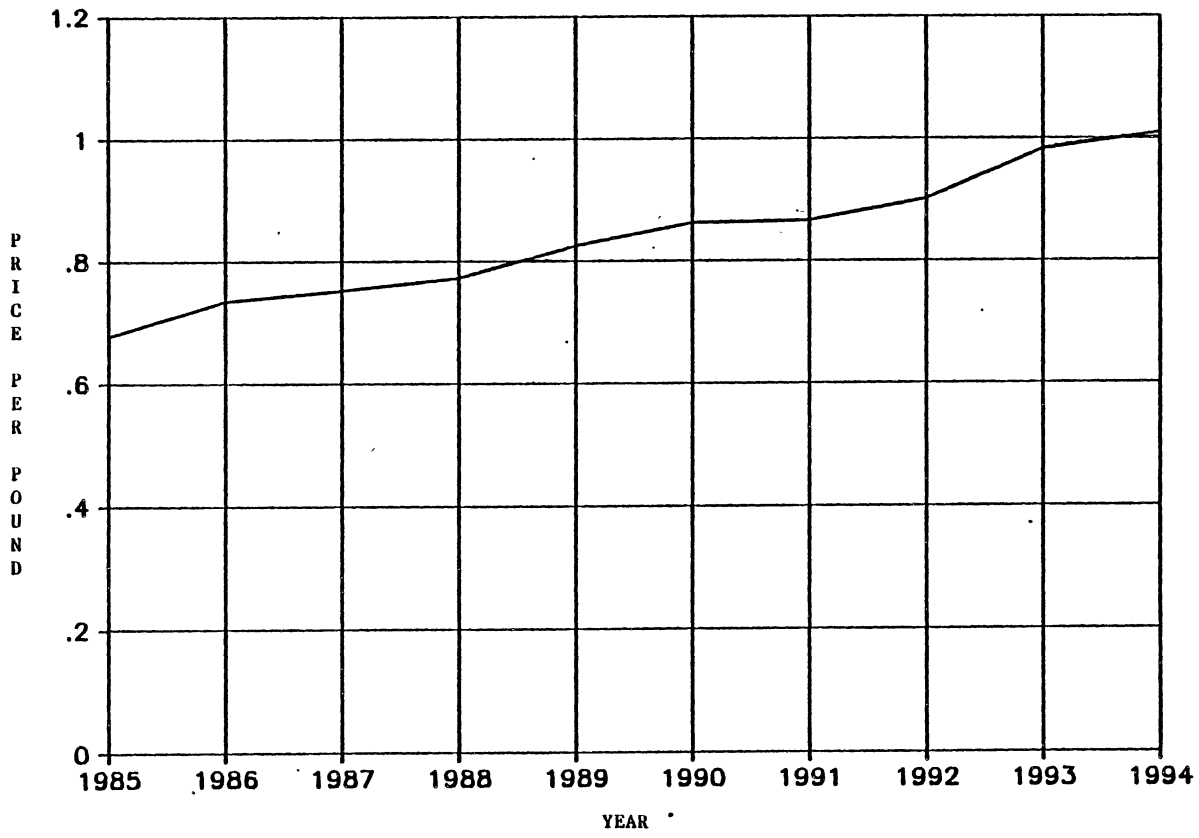


Figure 12. Estimated Modal Steer Calf Prices, Base Ranch Situation

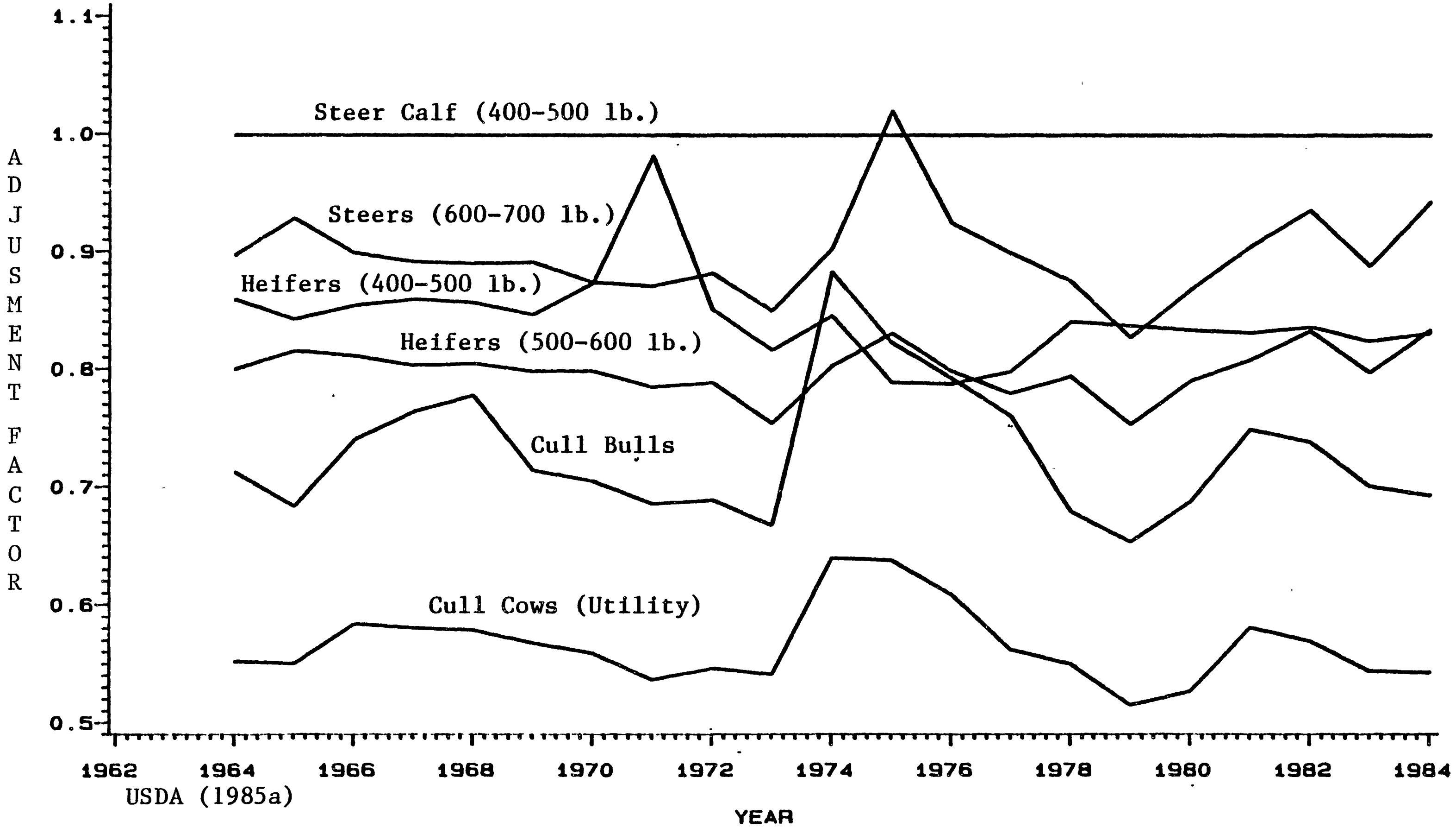


Figure 13. Historic Price Spread Relationships Between Steer Calves (400-500 lb.) and other Classes of Cattle, 1964-1984

TABLE IV

ESTIMATED CYCLICLY PATTERNED PRICE ADJUSTMENT FACTORS
FOR EACH CLASS OF CATTLE

Class of Livestock	Annual Adjustment Factor[a]									
	1985	1986	1987	1988	1889	1990	1991	1992	1993	1994
	---Fraction of Steer Calf Price---									
Steer Calf (400-500 lbs)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Heifer Calf (400-500 lbs)	.8599	.8563	.8462	.8735	.8827	.8505	.8159	.8462	.7885	.7873
Rpl Heifer (600-700 lbs)	.8028	.8052	.7979	.7987	.7847	.7894	.7439	.8033	.8311	.7979
Cull Cow (Utility)	.5799	.5776	.5668	.5584	.5282	.5447	.5399	.6397	.6375	.6084
Cull Bull (Canner)	.7644	.7784	.7137	.7045	.6853	.6892	.6673	.8833	.8222	.7920
Purchased Stocker Steer (600-700 lbs.)	.8911	.8897	.8991	.8733	.8705	.8818	.8490	.9033	.9243	.8984
Raised Steer (500-600 lbs.)	.8911	.8897	.8991	.8733	.8705	.8818	.8490	.9033	.9243	.8984

[a]Price adjustment factors based on Prices Received by Oklahoma Farmers, USDA (1985a).

variables can be completely specified by the minimum, maximum and most likely values, for each of the variables. Table V lists the parameters and modal values for the price and production variables used in the base ranch simulation experiments. The absolute level of variation in the price and production variable for each year is defined by the minimum percent and maximum percent for each variable. Figures 14 through 16 illustrate the specified triangular distributions for the first year of the simulation for each price and production variable. Pasture yield and steer calf prices are the only two distributions skewed to the right of the mode. The other distributions are skewed to the left. The percent variation in the level of within year prices was based on reported prices for the past seven years.

Modal steer prices for the planning horizon were obtained from the price model (equation 73). Modal supplemental feed prices were based on supplemental feed costs reported in Oklahoma State University Livestock Budgets (1985) and were assumed to increase 2 percent each year in the planning horizon. Annual modal production variables were not trended over the planning horizon to reflect an constant level of management on the base ranch over the planning horizon. Weaning percent reflects the number of live calves weaned per number of exposed cows. Range forage yield represents the weighted average of total pounds of dry matter per acre of forage for reporting Oklahoma range sites in the study area (USDA, 1959-1971).

It would be possible to specify different sets of price and production expectations for simulation experiments. For example, simulations could be initialized at different points in the patterned

TABLE V

PRICE AND PRODUCTION PARAMETERS AND MODAL VALUES FOR BASE RANCH SYSTEM

Name	Parameters: Minimum % of Mode	Parameters: Maximum % of Mode	Unit	Year: 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
	----Percent------			------Modal Prices and Production Variables------									
Steer Calf Price[a]	-07.35	10.30	$/lb	.6773	.7348	.7586	.7730	.8255	.8625	.8662	.9017	.9831	1.010
Steer Calf Weights[b]	-01.78	01.56	lb/hd	450	450	450	450	450	450	450	450	450	450
Weaning Percent[c]	-03.75	02.5	pct	.80	.80	.80	.80	.80	.80	.80	.80	.80	.80
Range Forage Yield[d]	-30.2	36.25	lbs/acre	700	700	700	700	700	700	700	700	700	700
Supplemental Feed:[e]													
Prairie Hay	-12.5	12.	$/lb	.0300	.0306	.0312	.0320	.0325	.0325	.0331	.0337	.0343	.0351
Cttn Seed Meal	-08.55	08.	$/lb	.1050	.1071	.1092	.1114	.1136	.1159	.1182	.1205	.1229	.1250
Cubes, 20% Protein	-14.34	14.	$/lb	.0630	.2642	.0655	.0668	.0682	.0695	.0709	.0723	.0738	.0752
Soybean Meal	- 7.40	7.0	$/lb	.130	.1326	.1352	.1379	.1380	.140	.1435	.146	.149	.1523

[a]Cylicly patterned estimates based on Prices Received by Oklahoma Farmers, USDA (1985a).

[b]Based on steer calf weights reported in Oklahoma State University Livestock Calf Budgets, (1985).

[c]Based on cow reproductive performances and percent calves weaned, Donald Monroe Marshal, (1984).

[d]Based on range site forage yields, USDA (1959-1971).

[e]Based on supplemental feed prices reported in Oklahoma State University Livestock Budgets (1985).

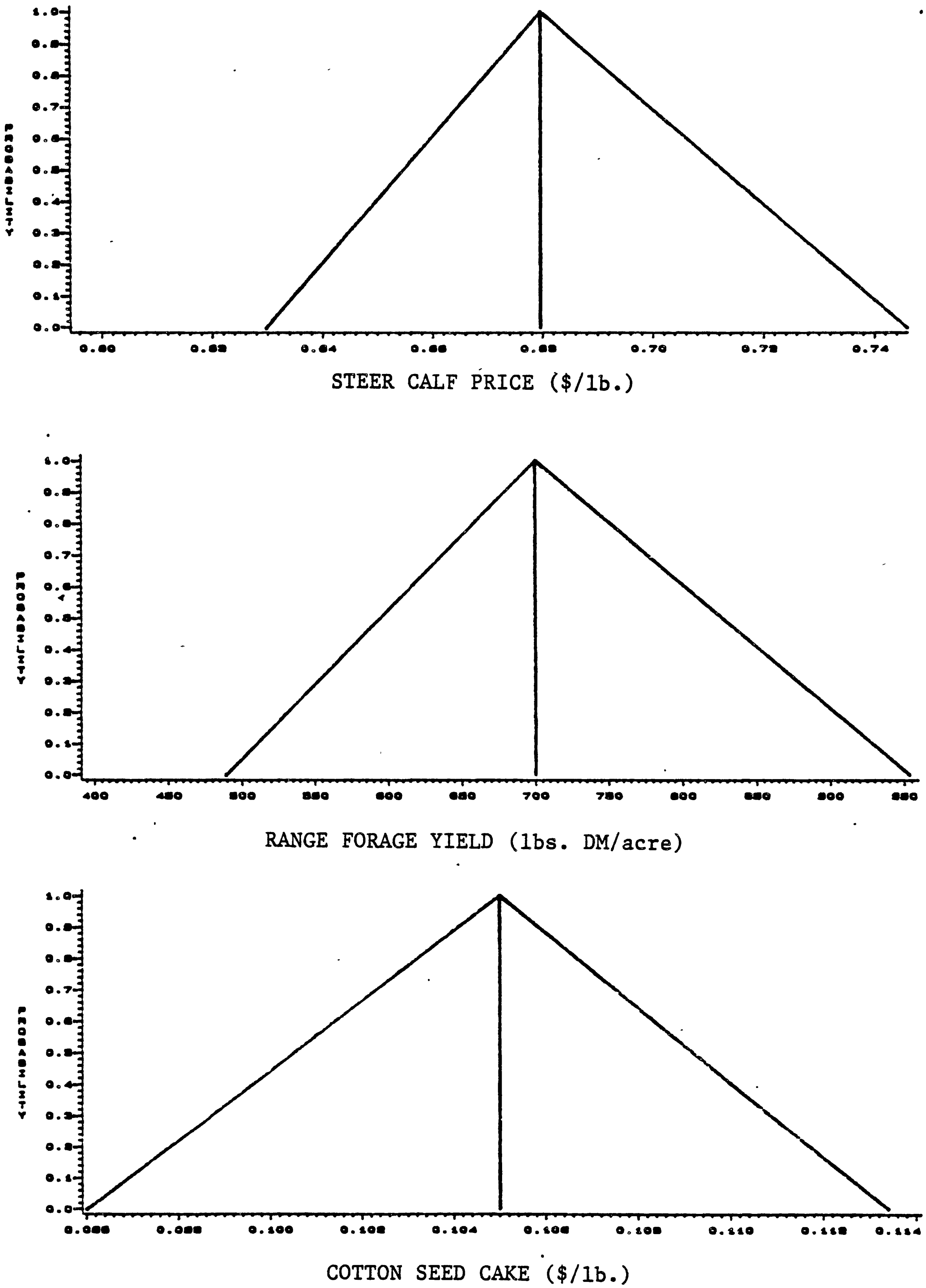


Figure 14. Triangular Distribution for Steer Calf Price, Range Forage Yield and Cotton Seed Meal Price, in Year 1 for Base Ranch

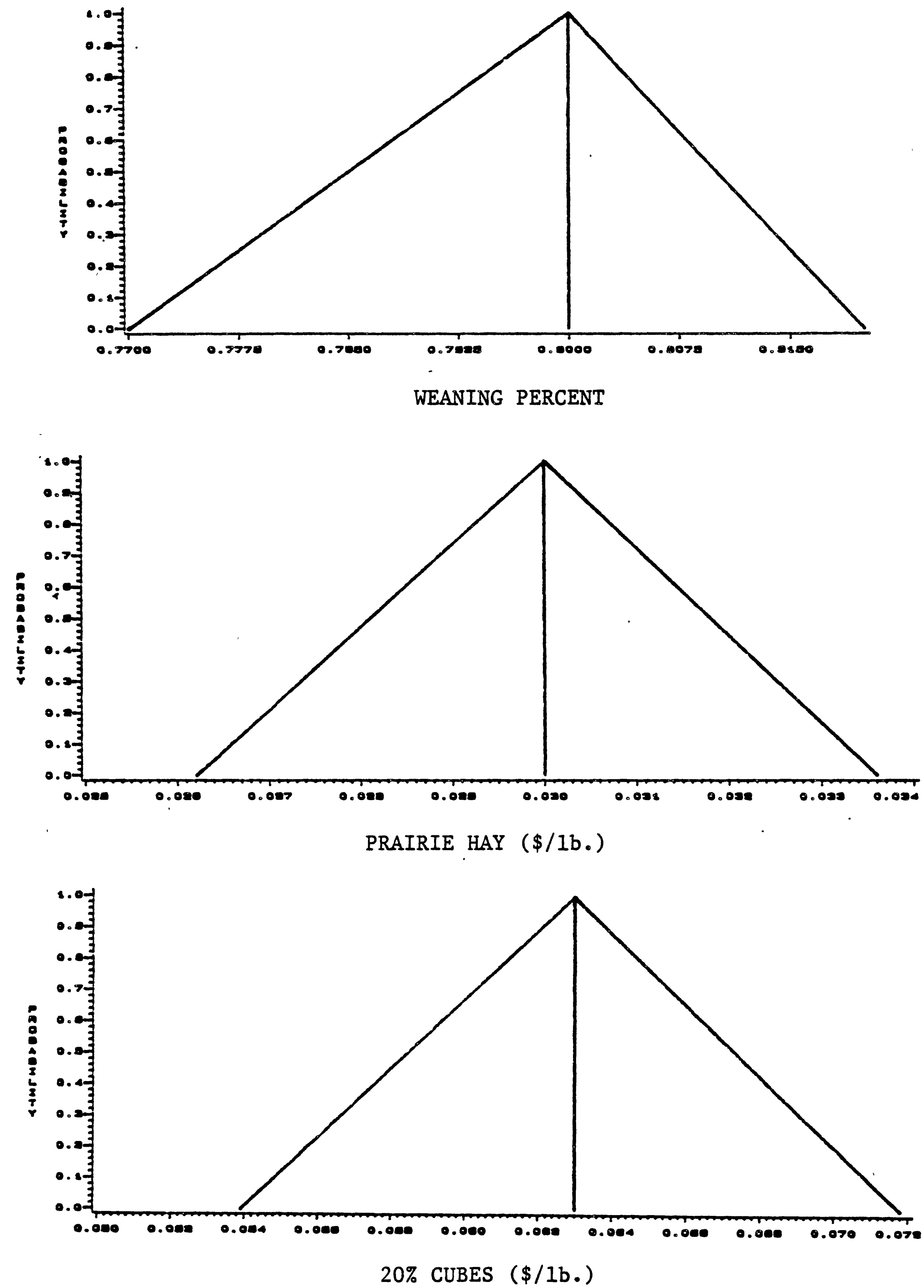


Figure 15. Triangular Distribution for Weaning Percent, Prairie Hay, and 20% Cubes Price, in Year 1 for Base Ranch

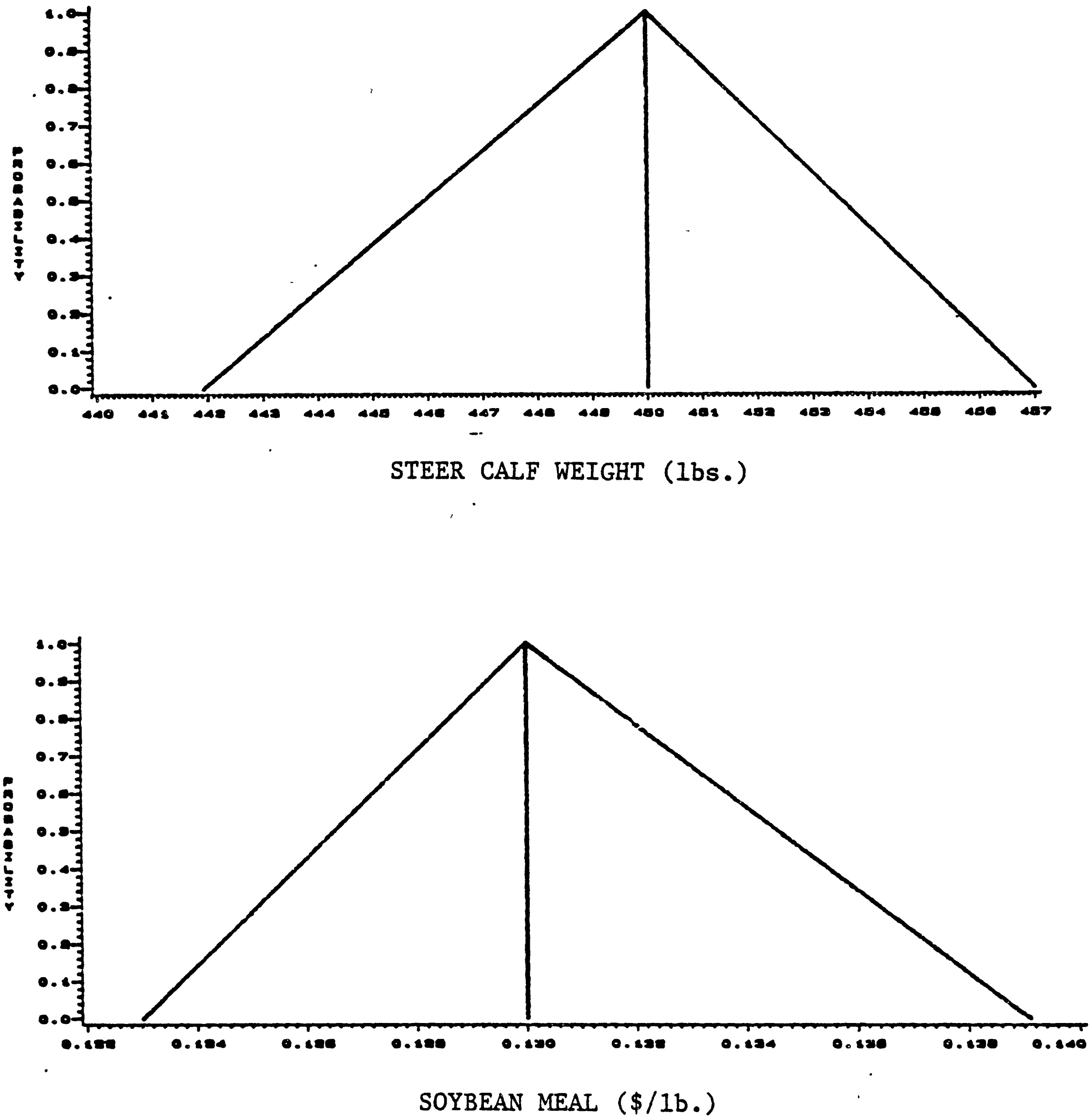


Figure 16. Triangular Distribution for Steer Calf Weight and Soybean Meal Price in Year 1 for Base Ranch

price cycle. Modal steer calf weights and modal weanning percent may be trended up or down to reflect cow-herd management practices. Similarly, range forage variation could be increased, decreased and/or skewed to the left or right of the mode to reflect the adoption of an alternative range management practice.

Like stochastic livestock prices, livestock weights for all other class of livestock are based on stochastic steer calf weights. Weight adjustment factors read into the model for each class of livestock are reported in Table VI. These factors were based on livestock weights reported in Oklahoma State Livestock Budgets (1985). The factors may be trended over time to reflect a change in the type and/or size of cattle being produced and marketed.

Stochastic steer calf prices, steer calf weights, and weaning percent are based on the specification of modal values, and the draw of a random deviate. Because we are estimating the stochastic value for single independent variables, there was no statistical dependence to account for here. Stochastic range forage yield was also estimated as a single observation.

Correlation Matricies

One serious criticism to the modelling of stochastic processes is that statistical dependence between random environmental factors is too often ignored (Anderson, 1974). As described in Chapter III, a multivariate process generator is used in the model to generate sample observations from an multivariate triangular distribution. Factored correlation coefficients must be read in as input data to generate price and production observations which are multivariate triangularly distributed.

TABLE VI

WEIGHT ADJUSTMENT FACTORS FOR EACH CLASS OF LIVESTOCK

Class of Livestock	Annual Adjustment Factor[a]									
	1985	1986	1987	1988	1889	1990	1991	1992	1993	1994
	Factor of Steer Calf Weight									
Steer Calf (400-500 lbs)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Heifer Calf (400-500 lbs)	.95	.95	.95	.95	.95	.95	.95	.95	.95	.95
Rpl Heifer (600-700 lbs)	1.30	1.30	1.03	1.30	1.30	1.30	1.30	1.30	1.30	1.30
Cull Cow (Utility)	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80
Cull Bull (Canner)	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Purchased Stocker Steer (600-700 lbs.)	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
Raised Steer (500-600 lbs.)	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49

[a]USDA (1985a).

Stochastic supplemental feed prices are based on budgeted estimates of price per pound of feed, the historic correlation between prices, and the random draw of an uniform psedo- normal deviate. Because of the statistical dependence between feed prices and to ensure an accurate estimate of feed prices, the upper right triangle of factored correlation coefficients in Table VII were determined and used to generate feed prices as described in Chapter III.

State Variables

The structure of a system is described by system state variables and by system design parameters. State variables are descriptors of the state or condition of a system at any point in time. In general the system outputs can be viewed as a function of the system's state through time. The state of the system may also affect the range of allowable levels for controllable system inputs.

The state of the system for the Base Ranch situation is assumed to represent a stable economic environment exhibting a moderate level of growth over time. The financial state of the Base Ranch is assumed to be very favorable at the beginning of the planning horizon.

Resource Situation

The resource situation for the Base Ranch was developed from Agricultural Census Data (1978) using the Census Typical Farm Program developed by NED-ERS (Hatch, 1982). Of the 6,831 farms in the 13 county area indicated on Table VIII, 3,796 have predominately livestock income. Of the 3796 cattle farms or ranches, income from

TABLE VII

CORRELATION COEFFICIENT MATRICES FOR SUPPLEMENTAL FEED PRICES

	Prairie Hay	Soybean Meal	Cttn Seed Meal	20% Cubes
	---Factored Correlation Coefficients---			
Prairie Hay	.07855	.01038	-0.0897	.02298
Soybean Meal		.04698	-0.2480	.21291
Cttn Seed Meal			0.9344	.21081
20% Cubes				.41223
	---Correlation Coefficients[a]---			
Prairie Hay	1.0	.86196	.96225	.91376
Soybean Meal		1.0	.87582	.86796
Cttn Seed Meal			1.0	.97343
20% Cubes				1.0

[a]Price Correlation Coefficients were based on Prices Paid by Oklahoma Farmers, USDA (1985).

TABLE VIII

CENSUS DATA SUMMARY OF FARMS AND RANCHES, SOUTHERN PLAINS STUDY AREA

Item	For all Farms & Ranches in Transect	For All Ranches in Transect
Farm and Ranch Numbers	6,831	3,647
Total Acres	13,190,703	9,405,677
Rangeland and Pasture Acres	9,758,088	8,231,551
Total Sales ($)	903,760,394	246,204,612
Cattle Sales ($)	773,135,375	218,092,824
Total Cattle Sales-- Fat Cattle and Calf Sales	519,128	477,808
Cattle Sold (head)	1,474,627	489,107
Cattle Sold < 500 lb. (head)	195,087	166,711
Total Cattle on Farms and Ranches	1,224,652	669,605
Total Cows on Farms and Ranches	257,560	202,602

Source: USDA (1978)

fat cattle was predominate on 149 operations. This left 3,647 ranch units from which the representative Base Ranch resource situation was developed.

The Census Typical Farm Program was used on the 3,647 ranches to define a "modal" ranch containing 10 percent of total value of sales. The modal ranch had 2,034 acres, 59 beef cows and 135 total head of cattle (Table IX). However, preliminary analysis indicated that the modal ranch could not survive as an economic unit. A larger ranch operation is needed to provide a better economic basis by which to evaluate the performance of the model. Evaluation of larger ranches will provide more insight into the survivability of ranching as a way of life in the Southern Plains. The modal ranch identified in the census data was more represntative of a part-time ranch operation or one in which the operator is phasing out. Larger operations are more likely to adopt alternative management practices and technology at economically efficient levels.

The representative Base Ranch choosen for this study may be characterized as a large commercial cow-calf stocker ranch. The Base ranch has 6,926 acres, 130 brood cows, and 682 total head of cattle. It is essentially the large ranch in Table IX. The beginning inventory of assets and liabilities is outlined in Table X. Initial land values are based on a pasture cash lease cost of $95.00 per cow, an annual stocking rate of 25 acres per cow and a 3.5 percent return to assets. These values are generally representative of land valuation procedures in the Southern Plains study area, with location and mineral values excluded. Machinery and equipment includes the market value of one three-quarter-ton pickup truck, one 1-ton feed

TABLE IX

SOUTHERN PLAINS RANCHES: PROFILES, DISTRIBUTIONS AND CONTRASTS

Item	All Ranches & Livestock Farms (Not Primarily Feedlots)	Small	Modal	Large
Number	3,647	1,985	734	927
Percent of Farms	100	54.4	20.2	25.4
Percent of Cattle Receipts	100	6.3	9.4	84.3
Percent of Total Acres	100	15.9	15.9	68.2
Percent of Total Sales	100	6.4	10.0	83.6
Percent of All Cows	100	23	22	55
Percent of Cattle Sold (excluding fats and calves)	100	5	9	86
Percent Land Rented	43	35	46	42
Acres Per Unit	2,579	752	2,034	6,926
Average Total Sales	$67,509	$7,945	$33,458	$222,051
Average Beef Sales	$59,801	$6,912	$28,043	$198,231
Average Crop Sales	$ 7,180	$ 894	$ 4,710	$ 22,621
Cropland per Total Acres (A)	.07	.09	.09	.06
Pasture per Total Acres (A)	.88	.82	.83	.80
Pasture per Cow (A)	40.63	26.05	28.59	47.22
Pasture per Head (A)	12.29	12.77	12.47	12.16
Pasture per Stocker (A)	17.23	51.84	29.73	13.97
Beef Cows per Unit	56	24	59	131
Total Head per Unit	183	48	135	511

Source: USDA (1978).

TABLE X

SUMMARY OF BEGINNING ASSETS AND LIABILITIES FOR BASE RANCH

Item	Unit	Market Value
Acres of Owned Land	Acres	4,156
Percent Equity in Owned Land	Pct.	.70
Acres of Cash Leased Land	Acres	2,770
Cost Per Acre of Leased Land	Dol/Ac.	3.80
Beginning Inventory:		
Assets		
Beginning Cash Reserve	Dol.	1,000
Breeding Livestock	Dol.	52,985
Machinery and Equipment	Dol.	20,300
Building and Improvements	Dol.	80,000
Market Value of Owned Land	Dol.	451,215
Total Assets	Dol.	605,500
Liabilities		
Livestock Debt	Dol.	10,597
Intermediate Term Debt	Dol.	4,060
Real Estate Debt	Dol.	212,486
Total Liabilities	Dol.	227,143
Net Worth		$378,357

truck, one 21-foot gooseneck stock trailer, livestock handling equipment and facilities, and feeding equipment. Building and improvements include the current market value of all buildings and improvements, fencing, watering facilities and all other permanent improvements and are valued at $80,000.

Financial Information

Detailed input for the planning horizon and related financial information is presented in Table XI. All annual interest rates and annual rates of return were assumed to increase at a moderate rate of 2 percent annually throughout the planning horizon. The annual interest rates for new land and intermediate-term loans were assumed to equal the current Federal Land Bank loan rates and PCA loan rates, respectively. The annual rate of return on cash revenues was assumed equal to three month T-Bills. The before tax rate of return on off-ranch investment is assumed equal to three month T-Bills plus 2 percent. The annual rate for new short-term (operating) debt was assumed equal to the prime rate plus 2 percent. The annual interest rate for refinancing long and intermediate-term debts were assumed equal to the Federal Land Bank loan rate plus 2 percent and the PCA loan rate plus 1 percent, respectively. Cash lease terms were also trended up at a 2 percent annual rate. The annual inflation rate for range land was assumed to be 3 percent.

The loan terms on initial long-term debts are 25 years, 11 percent interest and an amortized repayment to be made on the 30 percent of the original loan remaining. The loan life for new long-term debts and for refinancing long-term debt is assumed to be 30

TABLE XI

PLANNING HORIZON FINANCIAL DATA FOR BASE RANCH SITUATION

Item	Year									
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Interest rate on new long-term loan[a]	.1250	.1275	.1300	.1326	.1352	.1379	.1406	.1434	.1462	.1491
Interest rate on new intermediate-term loan[b]	.1360	.1387	.1414	.1443	.1471	.1501	.1531	.1561	.1593	.1625
Min. down on new long-term purchases, percent of purchase price	.250	.250	.250	.250	.250	.250	.250	.250	.250	.250
Min. down on new intermediate-term purchases, percent of purchase price	.200	.200	.200	.200	.200	.200	.200	.200	.200	.200
Rate of return on cash reserves[c]	.0777	.0792	.0808	.0820	.0841	.0857	.0875	.0892	.0910	.0928
Before tax rate of return on off-ranch investments[d]	.0877	.0894	.0912	.0930	.0949	.0968	.0987	.1007	.1027	.1048
Interest rate on new short-term (operating) debt[e]	.1250	.1275	.1300	.1326	.1353	.1380	.1407	.1435	.1464	.1493
Interest rate for refinancing long-term debt[f]	.1450	.1475	.1500	.1526	.1552	.1579	.1606	.1634	.1662	.1691
Interest rate for refinancing intermediate-term debt[g]	.1460	.1487	.1514	.1543	.1571	.1601	.1631	.1661	.1693	.1725
Escalation rate for cash lease[h]	.0430	.0438	.0447	.0456	.0465	.0474	.0484	.0493	.0503	.0514

TABLE XI (Continued)

[a]Based on 1985 Farm and Ranch Loan Rate, to date, as reported by the Federal Land Bank, Wichita, Kansas office, July 1985.

[b]Based on 1985 Farm and Ranch Loan Rate, to date, as reported by the Production Credit Association located in Woodward, Oklahoma, July 1985.

[c]Based on 1985 three month T-bills as reported in the Federal Reserve Bulletin, Vol. 71, pages 383-476, June, 1985.

[d]Based on 1985 three month T-bills, plus 2 percent, as reported in the Federal Reserve Bulletin, Vol. 71, pages 383-476, June, 1985.

[e]Based on 1985 prime rate charged by banks on short-term business loans, plus 2 percent, as reported in the Federal Reserve Bulletin, Vol. 71, pages 383-476, June, 1985.

[f]Based on 1985 Farm and Ranch Loan Rate, plus 2 percent, as reported by the Federal Land Bank, Wichita, Kansas office, July, 1985.

[g]Based on 1985 Farm and Ranch Loan Rate, plus 1 percent, as reported by the Production Credit Association located in Woodward, Oklahoma, July 1985.

[h]Based on rates of return to farm assets as described by Emanuel Melichar, Federal Reserve Bulletin, Vol. 70, January, 1984.

and 18 years, respectively. Long-term financing can be obtained at the interest rates identified in Table XI, if the long-term equity ratio is above .35.

Outstanding debt on intermediate-term assets is assumed to be 20 percent of the original loan. Intermediate-term debt is amortized at 13 percent for eight years. Repayment periods for new and refinanced intermediate-term loan are 7 and 6 years, respectively. Intermediate-term financing can be obtained at the interest rates previously specified (Table XI) if the intermediate-term equity ratio is above .40.

Annual Inflation Rates

Costs can be trended over time by means of annual inflation rates to reflect the decision maker's continuously changing economic environment. The annual inflation rate for new and used machinery and equipment was 3.7 percent and -1.6 percent, respectively. Annual fixed cost were inflated at a rate of 3.9 percent.

The inflation rates for fuel and lube, variable pasture cost and hired labor cost were 3.6 percent, 3.4 percent and 2.6 percent, respectively. Variable pasture cost includes fence, roads and watering facilities maintenance. Variable livestock costs were assumed to inflate 4.1 percent annually. The high annual inflation rate associated with variable livestock costs is reflective of the rapidly increasing cost of pharmaceutical, veterinarian and medical supplies. Variable livestock cost also includes tack and livestock supplies, salt and mineral and hauling and marketing charges. Family living expenses and off-farm income were inflated annually in the model by the consumer price index (CPI). The initial value of the CPI was 319.8 and the CPI was assumed to escalate at an annual rate of 4.5 percent.

Tax Information

The annual tax rate for real property, expressed as dollar of property tax per thousand dollar of market value, is .00137. The value of personal property taxes is assumed to be $1200. An annual cost of $500 is assumed to account for additional tax liabilities, excluding State and Federal income taxes. Personal property and additional tax liabilities are indexed each year using the annual inflation rate for fixed costs.

Table XII summarizes the annual self-employment tax rates and the maximum income level subject to self-employment tax for the planning horizon. The lower level tax brackets, tax bracket minimum liability and marginal bracket rates corresponding to income tax Schedule Y for each tax schedule period are reported in Table XIII. Four personal income tax exemptions are assumed. The marginal income tax rate for computing state income taxes is .10 and the ratio of personal itemized deductions to taxable ranch income is .20.

Controllable System Inputs

Controllable system inputs are those which can be specified by the decision maker. The level of a controllable system input may represent the amount of a physical factor of production flowing into a process within the system or it may specify the level of a production

TABLE XII

ANNUAL SELF-EMPLOYMENT TAX RATE AND MAXIMUM INCOME LEVEL THAT IS SUBJECT TO SELF-EMPLOYMENT

Calendar Year of Planning Horizon	Self-Employment[a] Tax Rate	Self-Employment[a] Max Income Level
	Percent	Dollars
1985	.118	39,600
1986	.123	41,700
1987	.123	43,800
1988	.1302	45,900
1989	.1302	48,200
1990	.153	50,500
1991	.153	52,700
1992	.163	54,800
1993	.163	57,000
1994	.173	59,300

[a]Check List Planning Special Tables, Standard Federal Tax Reporter, Index I-404, 1985.

TABLE XIII

FEDERAL TAX BRACKETS, TAX BRACKET MINIMUM LIABILITY AND BRACKET MARGINAL RATES

Tax Brackets	Lower Level Tax Brackets	Tax Bracket Min. Liability	Marginal Bracket Rates
	Dollars	Dollars	Percent
First	3,540		.11
Second	5,720	239.80	.12
Third	7,910	502.60	.14
Fourth	12,390	1,129.80	.16
Fifth	16,650	1,811.40	.18
Sixth	21,020	2,598.0	.22
Seventh	25,600	3,605.60	.25
Eighth	31,120	4,985.60	.28
Ninth	36,630	6,528.40	.33
Tenth	47,670	10,171.60	.38
Eleventh	62,450	15,788.00	.42
Twelfth	89,090	26,976.80	.45
Thirteenth	113,860	38,123.30	.49
Fourteenth	169,020	65,151.70	.50
Fifteenth	215,400	89,100.00	.50

Source: Check Lists Planning Special Tables, Standard Federal Tax Reporter, Index I-404, 1985.

activity. Controllable input variables can be varied during the planning horizon to achieve desired system performance. Controllable input variables are part of a producer's integrated financial, production, and marketing decisions. Financial decisions cannot and should not be made without considering production, marketing and policy decisions. Controllable system input variables are the fuel for improved management decisions in an uncertain environment.

Financial Decision Variables

Financial decision variables derive from a producer's decision to buy or sell land, livestock, machinery and equipment or borrow to cover a cash shortfall. Such decisions are influenced by exogenous variables and the current system state. For the Base Ranch situation in this study, the ranch could not sell land to avoid insolvency, or buy or lease land when the financial position permitted. A minimum cash reserve of $1,000 is required and operating capital is borrowed for 7 months out of the year.

Production and Marketing Decision Variables

Production and marketing decision variables include the number, type, mix and management practices for livestock to be produced as well as the timing of production and marketing. The base cow herd consists of 130 medium framed English type crossbred cattle with 950 lb mature cows and two year old first calf heifers. Replacement heifers from the base herd are kept at a rate of 12 percent of the base herd. A 2 percent cow death loss is assumed. Five registered herd bulls are kept in service for four years, on the average. One bull is sold and one bull purchased each year on the average. The number of cows and bulls and culling rates is assumed constant across the 10 years simulated for the Base Ranch.

Cows calve in the spring and calves were weaned at approximately 210 days. Steer calves are held over and marketed as feeder steers in September of the following year. Heifer calves not held back for replacements are marketed in the fall. Five hundred head of summer stocker steers are purchased May 1 and marketed September 30 in each year of the Base Ranch planning horizon.

One of the most costly production decisions is feeding. This decision is governed greatly by the environment, but regulated by the producer. Supplemental hay for periodic bad winter weather is based on Oklahoma State University cow-calf and stocker budgets for Northwestern Oklahoma (Table XIV). In addition, provisions for substituting hay for pasture during drought years are specified as a function of the level of stochastic range forage yield as described in Chapter III. It is assumed that a moderate stocking rate on the Base Ranch of about one cow for 25 acres would enable the ranch to maintain a constant number and mix of livestock throughout the planning horizon. Total requirements for a cow-calf unit, raised stocker steers, and purchased stocker steers are 25.7 acres, 7.77 acres and 5.5 acres, respectively.

The age of the operator at the beginning of the planning horizon is 42.0. The initial minimum annual family living expense for a family with two teenaged children is assumed to be $18,000. Annual

TABLE XIV

BAD WEATHER AND NORMAL FEEDING RATES FOR BASE RANCH SITUATION

Feed[a]	Cows	Replacement Heifers	Bulls
	------------	lbs./hd./year	------------
Prairie Hay	135	150	140
Cotton Seed Cake	286	0	300
20 Percent Cubes	0	502	0

[a]Based on values reported in Oklahoma State University Livestock Budgets (1985).

taxable off-farm income is $14,000. These values are for the year preceding the first year in the planning horizon and are inflated by the Consumer Price Index. The calendar year for the first year in the planning horizon is 1985.

System Design Parameters

System design parameters define the relationship between inputs to the system and its resultant state. They help describe the processes which comprise the system. System design parameters have a important impact on system performance, and in some instances can be altered by the decision maker.

Labor Requirements

Labor requirements are based on primary data obtained from personal interviews with cow-calf and stocker cattle producers in the Great Plains Study area. Production periods within a year include weaning, precalving, calving and breeding. Other livestock labor activities considered include feeding, marketing and livestock handling. Monthly labor requirements per head for each class of livestock are listed in Table XV.

Two hundred and forty hours of family labor are available each month with no full-time employees. The hourly wage rate for part-time labor, if needed, is $5 per hour. Hourly wage rates for part-time labor is inflated over the planning horizon based on annual rates of change in the Consumer Price Index.

TABLE XV

MONTHLY LABOR REQUIREMENTS PER HEAD FOR EACH CLASS OF LIVESTOCK, BASE RANCH

Month	Class of Livestock				
	Cows	Replacement Heifers	Bulls	Raised Stockers	Purchased Stockers
	Hrs/Head				
January	.52	.71	.2	.20	0
February	.72	.71	.2	.20	0
March	.72	.71	.2	.20	0
April	.20	.24	.1	.24	.46
May	.60	.20	.4	.24	.25
June	.20	.24	.1	.25	.25
July	.20	.20	.1	.25	.25
August	.20	.20	.1	.25	.25
September	.20	.20	.1	.31	.31
October	.75	.28	.4	0	0
November	.50	.71	.2	.20	0
December	.52	.71	.2	.20	0

Variable Costs

Overhead costs, accrued taxes, return to production assets and the after-tax discount rate are listed in Table XVI. Overhead costs are calculated annually by inflating the initial values by their respective annual inflation rates. The after-tax discount rate of 8 percent is used for calculating net present value and the present value of ending net worth. The discount rate used here represents opportunity cost, the rate of interest that could be earned in the most attractive alternative investment of equivalent risk.

The preceeding chapters developed the basic components of the conceputal and methodological framework for evaluating the survivability of a ranch unit over time, under uncertainty. This chapter, Chapter IV, developed a representative ranch for the Southern Plains study area. Chapter V evaluates the survivability of the specified ranch situation overtime in a stochastic environment.

TABLE XVI

ADDITIONAL SYSTEM DESIGN PARAMETERS

Item	Unit	Value
Accountant and legal fees	Dol.	500
Unallocated maintenance and repair costs	Dol.	100
Insurance premiums for ranch business	Dol.	1,000
Past four-year average appreciation rate for land	Pct.	2.0
Return to production assets for ranch in year t-2	Pct.	3.5
Return to production assets for ranch in year t-1	Pct.	3.5
After tax discount rate	Pct.	8.0

CHAPTER V

SIMULATION OF THE BASE RANCH SITUATION

The focus of the preceding chapters was on formulation of a whole ranch simulation model and a representative ranch for the analysis of ranch decisions and survivability under uncertainty. This chapter presents the Base Ranch solution obtained from the simulation model. The solution is examined to determine whether or not the methodological tools developed above realistically depict the performance of an ranch organization in an uncertain environment. The chapter is divided into two sections. First, the accuracy of the stochastic processes are verified for the Base Ranch. Second, the simulation results for the Base Ranch are presented and evaluated.

Verification of Stochastic Variables

A model is a mathematical representation of the set of processes by which controllable inputs, exogenous system inputs and system design parameters determine system output levels (King, 1979). Given information about the levels of controllable system inputs which define a particular strategy and accurate information about the probability distributions of exogenous system inputs, a model can be used to determine the associated probability distribution of system output variables. In most decision situations, direct prior probability statements can be made only for the distributions of exogenous system input variables (Anderson et al, 1980). Direct probability assessments usually cannot be made for the distribution of system output variables which are a primary concern in the evaluation of farm and ranch survivability. System output distributions which depend on complex interactions among a number of factors and variables must be determined indirectly by modeling system performance.

Exogenous system inputs discussed in Chapter IV were assumed to have triangular probability distributions and were correlated as deemed appropriate. The accuracy of the stochastic processes modeled are evaluated in this section. In modeling terminology, this step might be labeled model verification. Graphical comparison and statistical tests of significance are made between the specified population and observed culmultive triangular distributions for stochasticly estimated steer calf prices, supplemental feed prices, weaning percent, steer calf weights, and range forage yields.

Stochastic Prices

Recall from Chapter IV that annual modal steer calf prices are derived from a cylical and time trended model and an error term is added from a multivariate triangular probability distribution. One problem with modelling stochastic processes is making enough repetitions to effectively represent the population distribution. Figure 17 graphically compares the specified cumulative population probability distribution with the observed cumulative probability distribution for 11, 50 and 100 iterations of steer calf prices in

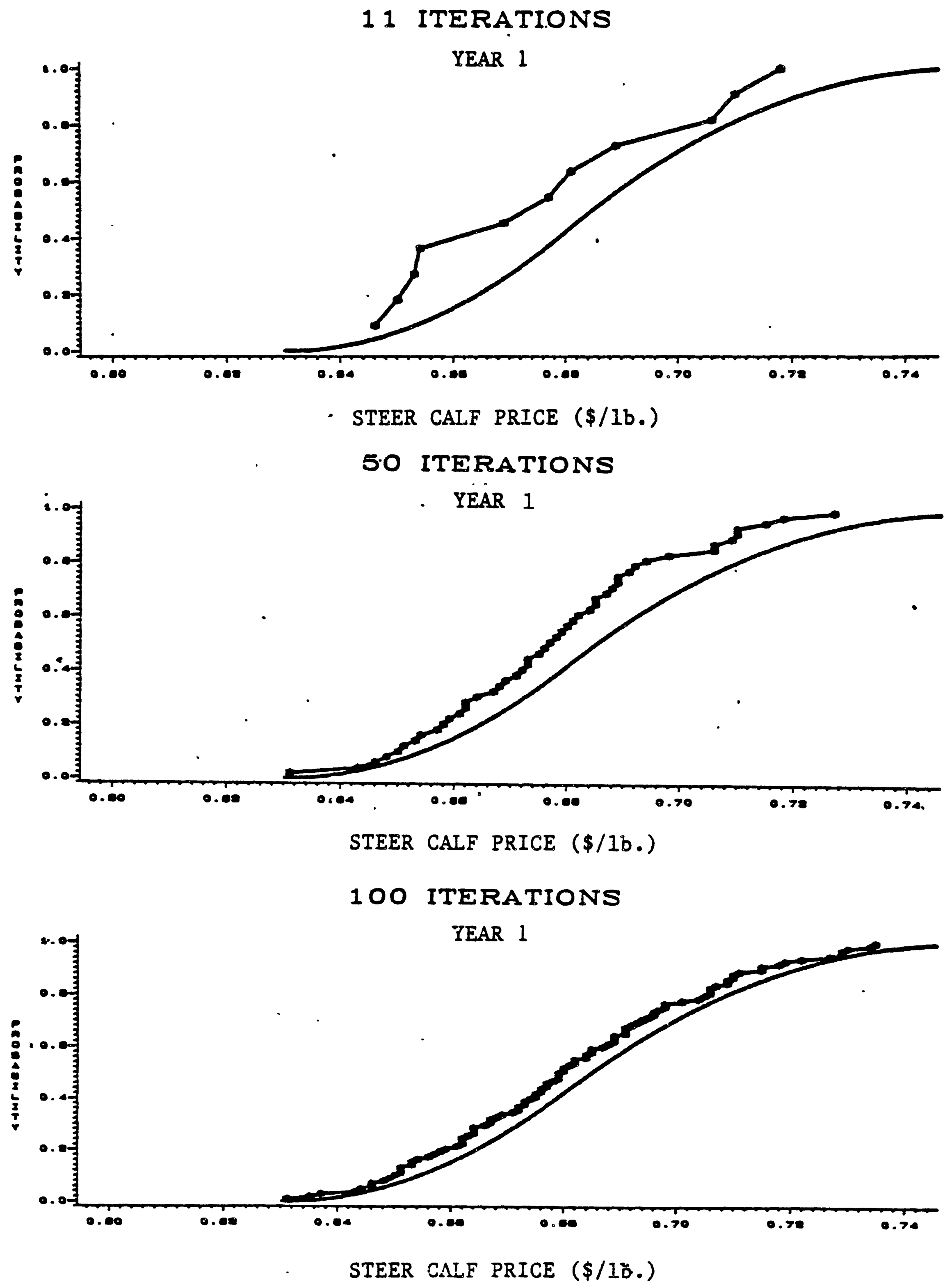


Figure 17. Cumulative Probability Distribution of Steer Calf Price in Year 1 for 11, 50 and 100 Iterations of the Analysis

the first year of the planning horizon. Visual appraisal indicates that 100 iterations more accurately describes the specified population distribution. Figures 18 through 20 compare the fit between the cumulative population distributions and the observed cumulative distributions for steer calf prices over the 10 year planning horizon for 100 iterations of the analysis.

The correlation coefficient matrix in Table XVII represents the correlation among variables, but is not scaled by the standard deviations of the variables. Thus, each subjective specification of the triangular distribution parameters for feed prices would yield a different standard deviation and thus a different variance-covariance. Work by Richardson (1977) indicates that triangular distribution can be correlated by factoring the historic correlation coefficient matrix. By using a modified version of the Clements, et al., (1971) procedure and the historic correlation coefficient matrix, stochastic triangularly distributed feed prices should be generated that exhibit a correlation coefficient matrix statistically equivalent to the correlation coefficient matrix of the historic data. Fisher's statistical test to pairwise compare the correlation coefficients of two matrices (Equation 27, Chapter II) was used to verify the correlations used of accuracy in estimating supplemental feed prices for 100 iterations (Table XVII). Results indicated failure to reject the null hypothesis, ρ_1 and ρ_2 at the 0.05 level of significance for all pairs. The correlation matrix resulting from repeated generation of triangularly distributed prices (the "observed" matrix in Table XVII) is statistically equal to the historic matrix in the same table.

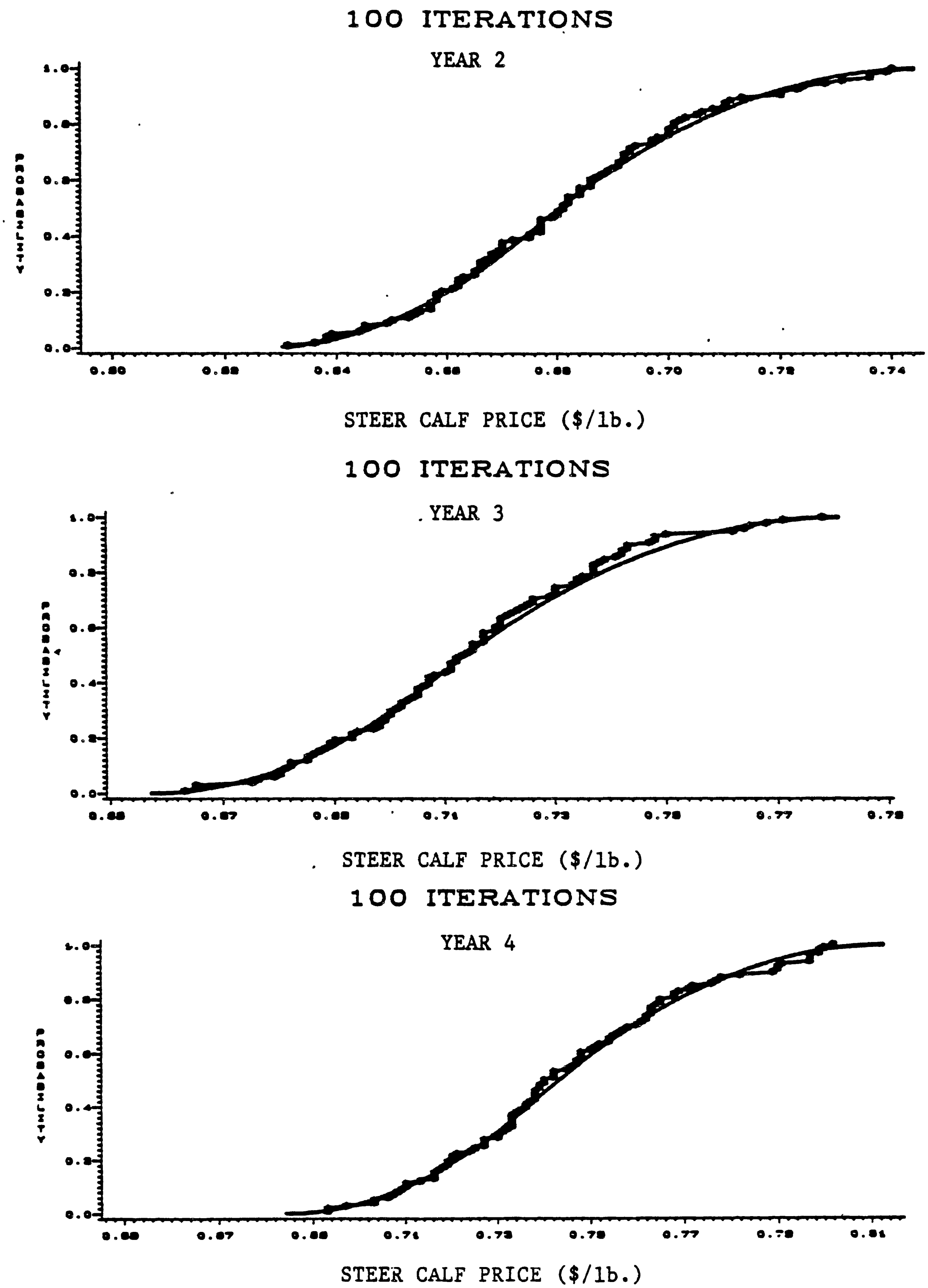


Figure 18. Cumulative Probability Distribution of Steer Calf Prices, Years 2-4

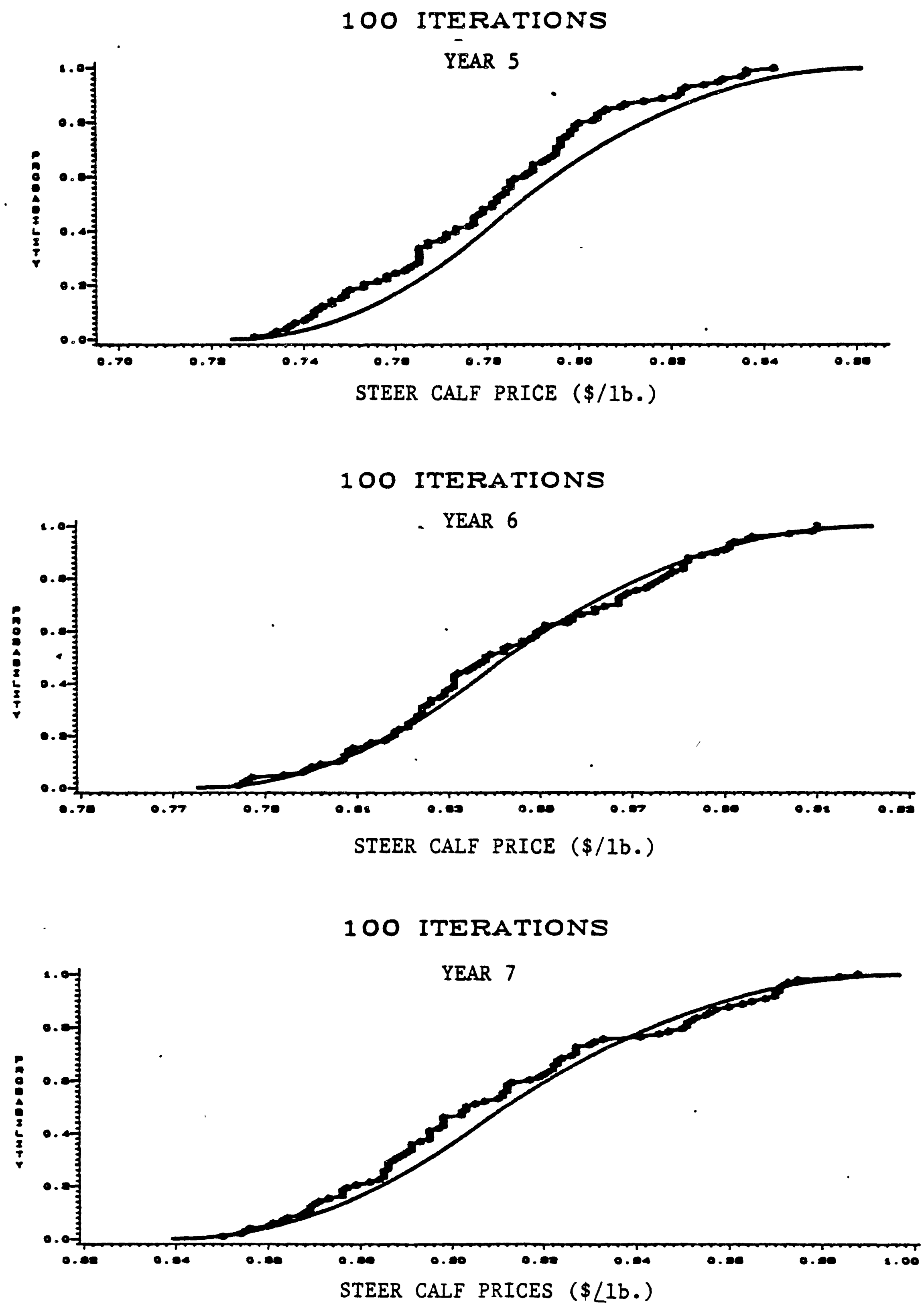


Figure 19. Cumulative Probability Distribution of Steer Calf Prices, Years 5-7

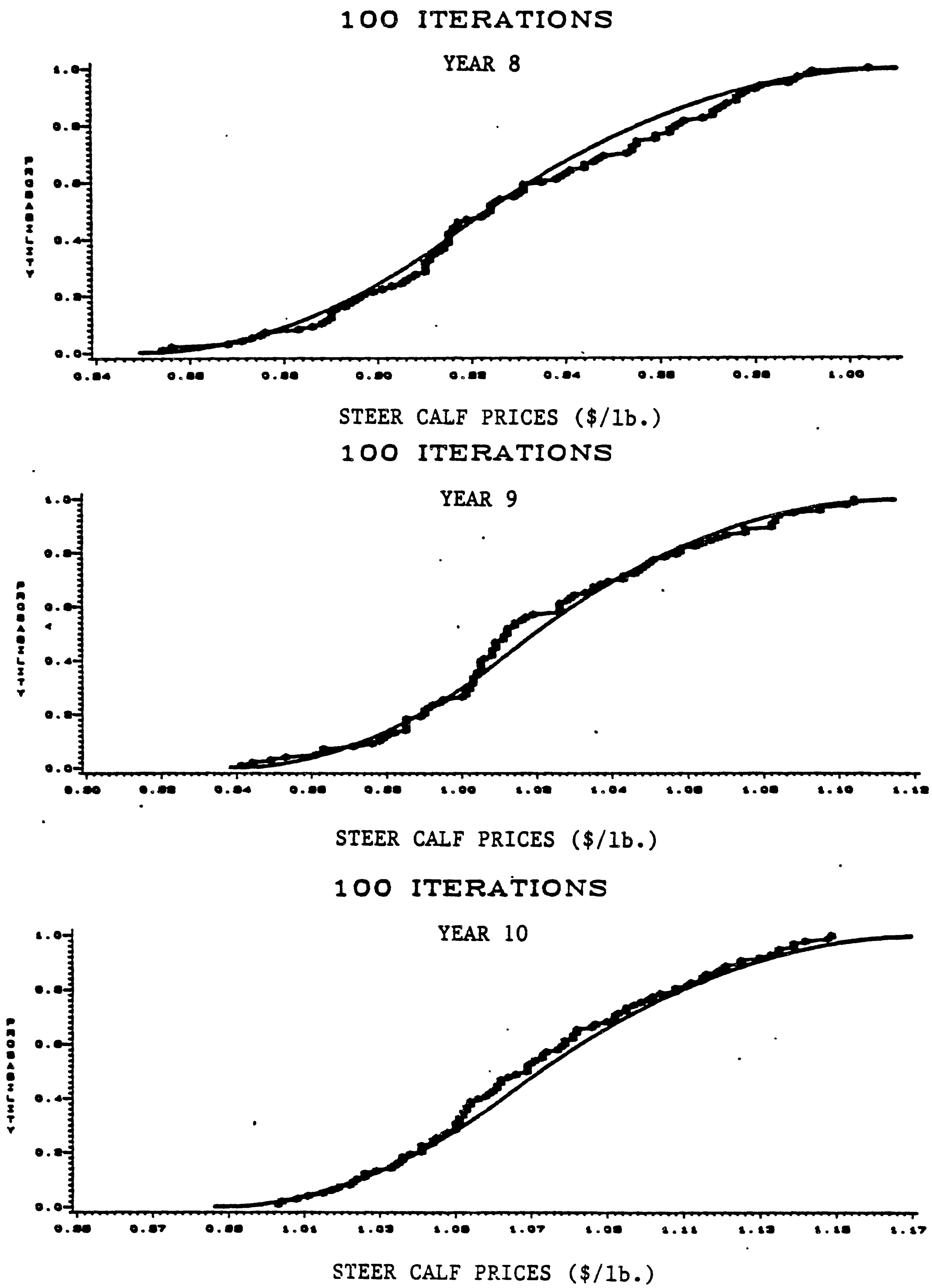


Figure 20. Cumulative Probability Distribution of Steer Calf Prices, Years 8-10

TABLE XVII

CORRELATION COEFFICIENT MATRICES FOR SUPPLEMENTAL FEED PRICES

	Historical Correlation Coefficients			
	Prairie Hay	Soybean Meal	Cttn Seed Meal	20% Cubes
	"Population"			
Prairie Hay	1.0	.86196	.96225	.91376
Soybean Meal		1.0	.87582	.86796
Cttn Seed Meal			1.0	.97343
20% Cubes				1.0
	"Observed"			
Prairie Hay	1.0	.94530	.95829	.96967
Soybean Meal		1.0	.95165	.92981
Cttn Seed Meal			1.0	.94090
20% Cubes				1.0

Stochastic Production Variables

The annual modal values for steer calf weight, weaning percent, and range pasture yield were assumed constant over the planning horizon for the Base Ranch (Table V, Chapter III). Therefore, a single year test is adequate to verify the stochastic efficiency of the production variables. Figures 21 through 23 compare the hypothesized cumulative population probability distribution with the observed cumulative distribution for each of the production variables. Visual appraisal indicates a good fit between the population and observed probability distributions for range forage yield and weanning percent (Figures 22 and 23). The observed cumulative distribution for steer calf weights does not present a good fit (Figure 21) because the observed distribution is biased to the left and up by the stochasticly estimated range forage yield distribution. The upward biasiness is partially reflective of the skewness to the left of the mode exhibited by the specified triangular distribution for steer calf weights (see Figure 16, Chapter IV). If the observed cumulative distribution for steer calf weight would have closely fit the population distribution in the absence of the stochastic effect of range forage yield on steer calf weights. The chance of obtaining a steer calf weight above 450 lbs. is reduced when the relationship between stochastic range forage yield and steer calf weights is considered.

A great advantage of having a simulation model of a whole-farm situation is the relative ease afforded to exploring the consequences of stochastic dependence among variables (Anderson, et al, 1980). The price and production variables observed (generated in the model)

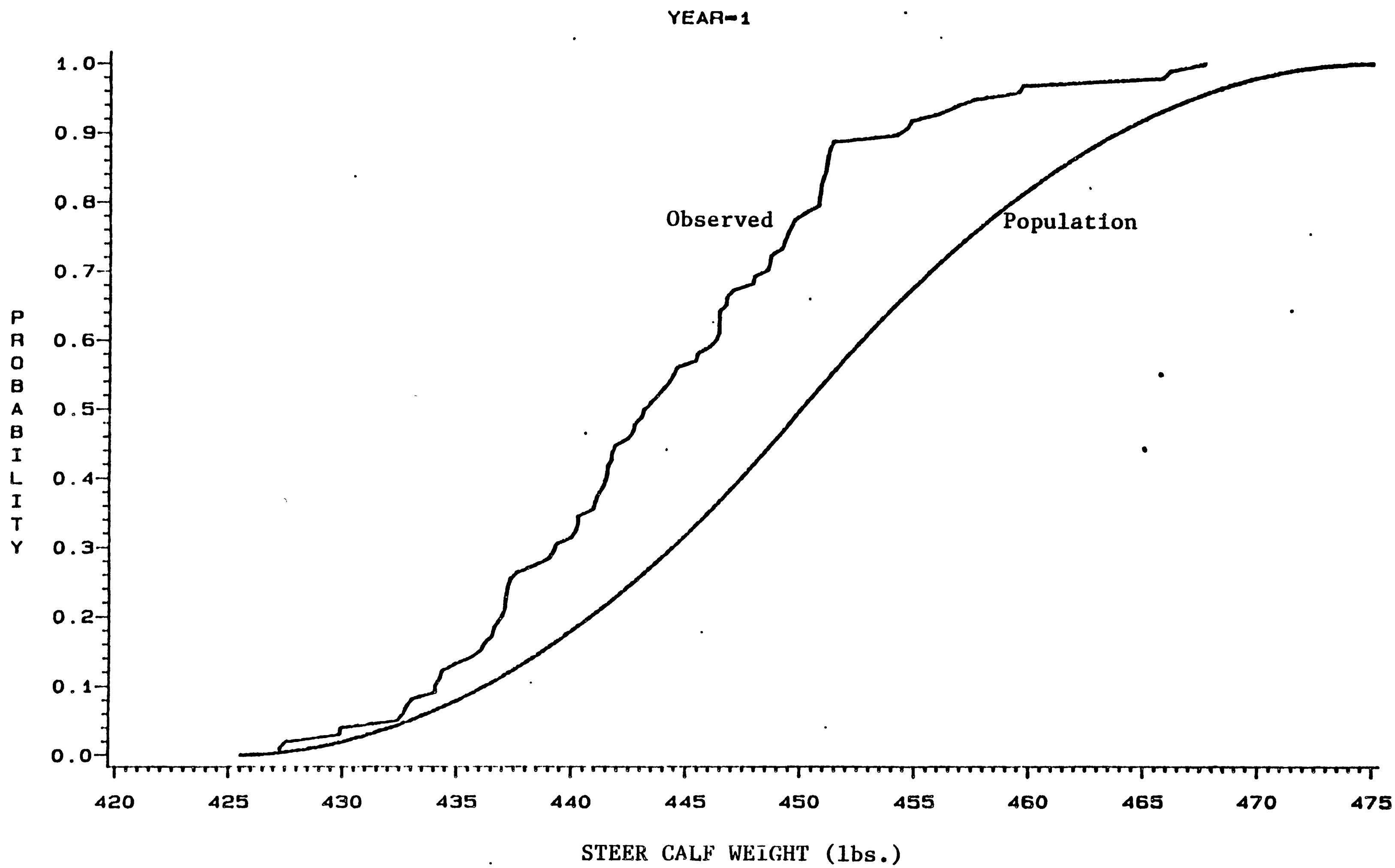


Figure 21. Specified Cumulative Population Probability Distribution and Observed Cumulative Probability Distribution for Steer Calf Weights, Base Ranch

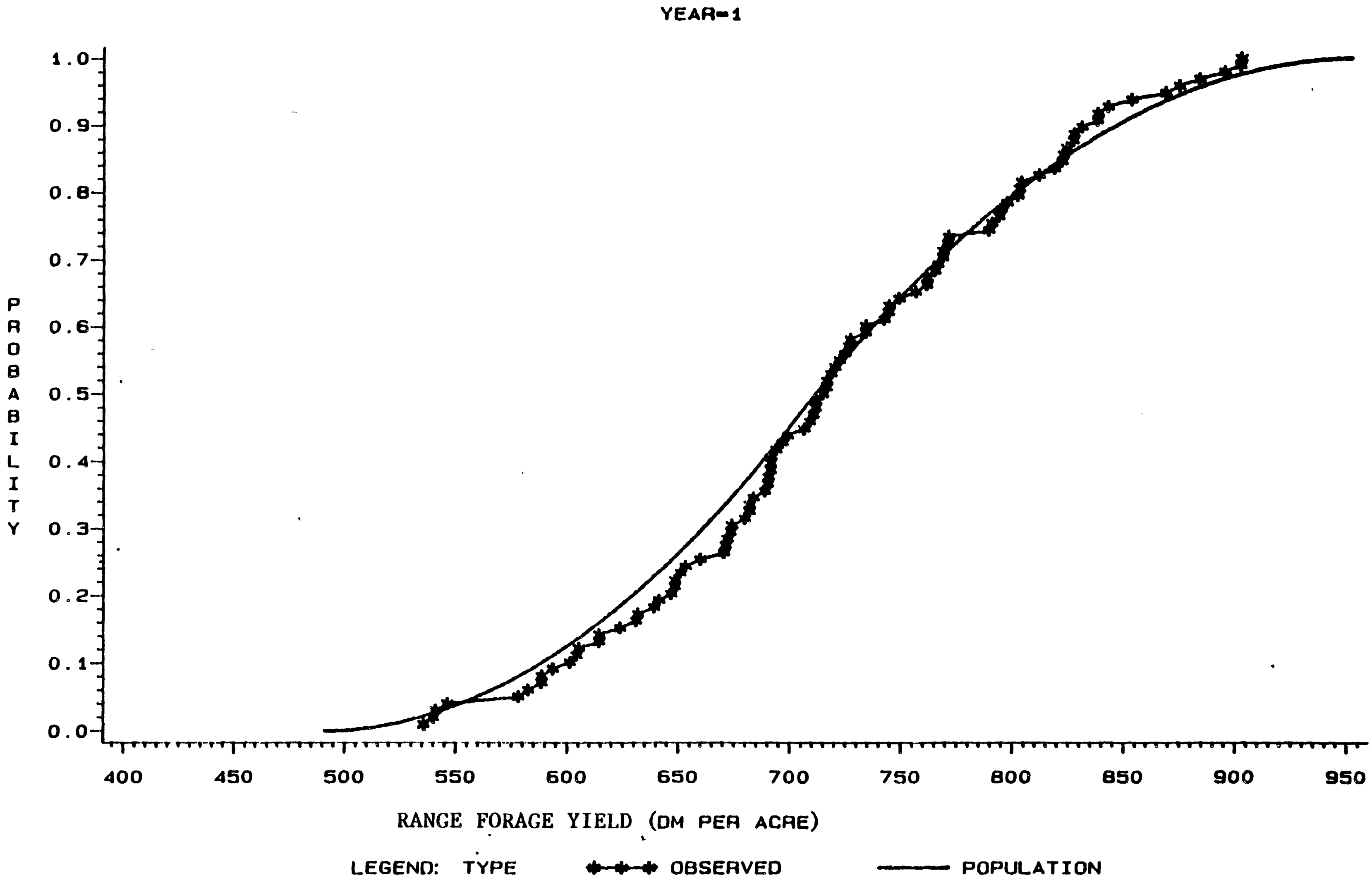


Figure 22. Specified Cumulative Population Distribution and Observed Cumulative Probability Distribution for Range Forage Yield, Base Ranch

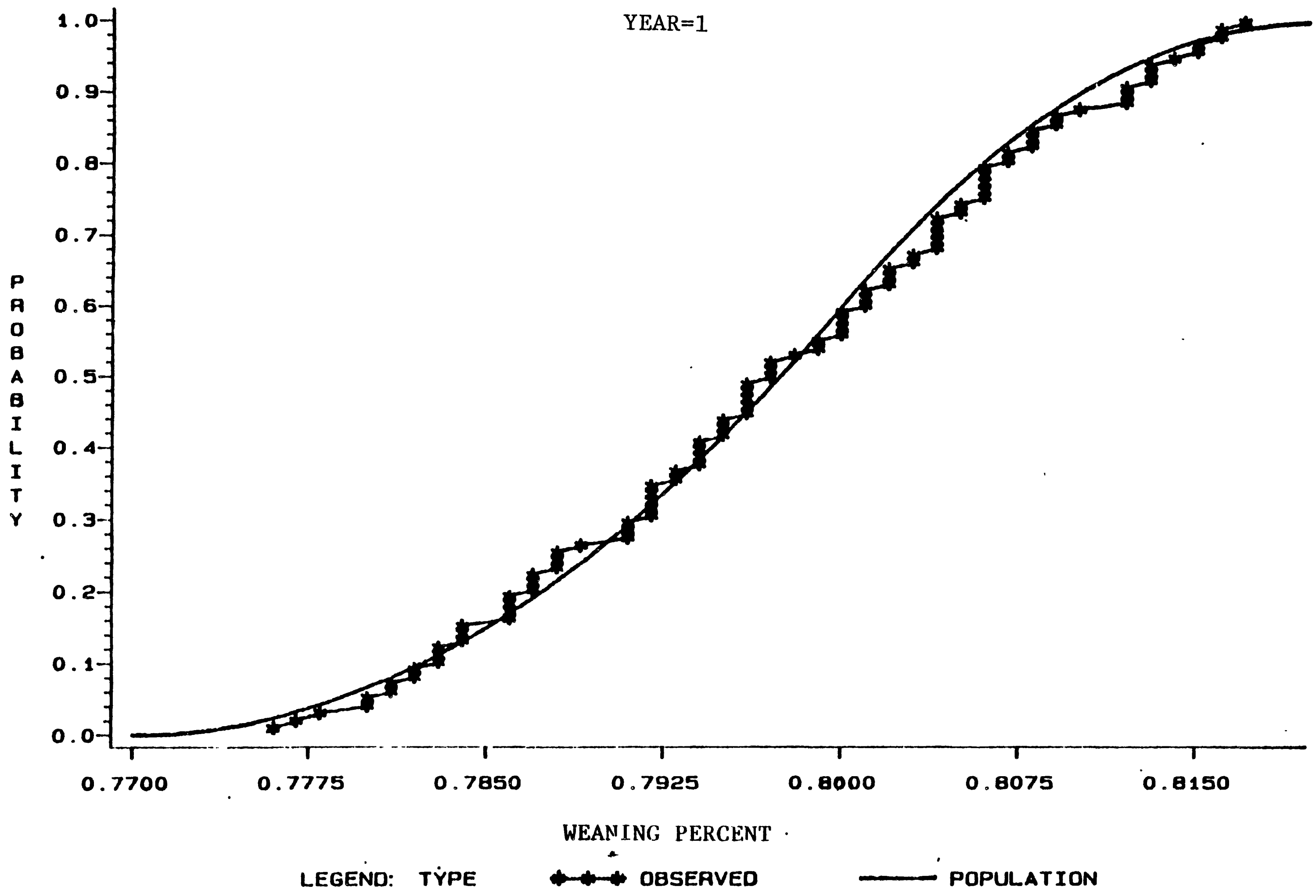


Figure 23. Specified Cumulative Population Probability Distribution and Observed Cumulative Probability Distribution for Weaning Percent for Base Ranch Analysis

appear to be from the specified population of random variables. The following sections present and evaluate the results for the Base Ranch situation in an uncertain price and production environment. Chapter VI develops alternate management plans and economic scenarios for the Base ranch to further evaluate the survivability of the representative ranch under uncertainty.

Results for Base Ranch Situation

Survivability of the ranch is measured in several ways. The profitability of the ranch over the planning horizon is represented by net present value of the ranch. Net present value is the discounted value of the income stream associated with the ranch situation. A zero net present value indicates a rate of return equal to the discount rate. Negative net present values indicate a return of less than the discount rate while a positive net present value implies rates of return greater than the discount rate. Beginning and ending net worth provide a measure of the solvency of the ranch. Real (deflated) ending net worth compared to beginning net worth measures real firm growth and, thus, overall profitability. Annual cash flow surpluses and deficits indicate the ranch's liquidity and required credit. A probability measure based on the number of solvent and insolvent interations for each year of the planning horizon is provided to further evaluate the overall survivability of the Base Ranch. A ranch has failed the survival test when the long-term equity ratio is below .35. The ranch can no longer borrow funds to meet negative annual cash flow.

Since each experiment is repeated 100 times utilizing the stochastic prices and production variables discussed in the previous section, cumulative distributions of the key system output variables can be presented. Cumulative probability distributions can be used to indicate the probability of obtaining a larger or smaller value of a particular variable and for comparing alternative management plans. Variables such as net present value and net worth are also described by their minimum, mean, maximum, standard deviation and coefficient of variation.

The Base Ranch Resource Situation

The Southern Plains ranch is designed to represent a realistic ranch situation, as indicated by 1978 census data for the Southern Plains study area. No attempt was made to optimize (e.g. by means of linear programming) the Base Ranch organization. Individual ranch operations are unique to the resources available for the unit. By modeling resource situations based on census data information, general information about the Southern Plains study area are provided and not necessarily about individual units.

As indicated in the previous chapter, the Base Ranch situation simulated has 4,156 acres of owned land and 2,770 acres of leased land. The ranch is rated a large commercial cow-calf stocker operation with 130 head of brood cows and approximately 500 head of stocker cattle. The beginning equity ratio is 70 percent. Other input information and related financial information are described in detail in Chapter IV.

Simulation Results

The following sections of this chapter evaluate the profitability, solvency, liquidity and chance of survival for the Base Ranch situation. First, to illustrate the information provided by the simulation model, financial statements for the last iteration are evaluated. The financial statements also aid in interpreting the model discussion in Chapter III. Then, cumulative distributions and summary statistics are presented to evaluate performance of the ranch under uncertainty for the ten year planning horizon. Finally, the Base Ranch simulation results and the chance of survival are discussed and interpreted.

Profitability of the Base Ranch

The income statement, or profit and loss statement, measures the profitability of a business over a specified period of time. The primary purposes of the income statement are to: (1) determine the profitability of the ranch business; (2) identify sources of profits or losses, and (3) show disposition of net income (Williams, Love, and Hardin, 1985).

Table XVIII presents an income statement of the ranch situation for the last iteration of the base run. Note that the ranch was declared insolvent in 1993 for this iteration of the Base Ranch analysis. Stochastic prices for crop enterprises in the simulation model were used to simulate stochastic prices for supplemental feed. That is, the crop activities were used as feed purchase activities and crop cash receipts are really feed costs. Thus, the first item on the

TABLE XVIII

INCOME STATEMENT FOR LAST ITERATION OF THE BASE RANCH ANALYSIS, YEAR 1985-1994

YEARS 1985 - 1994	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
CASH INCOME (NET OF SHARE LEASE)										
CROP CASH RECEIPTS	-22683.3	-9792.9	-19538.9	-12303.3	-10333 8	-9096.9	-10162 8	-17949 2	-9903.0	0 0
LIVESTOCK CASH RECEIPTS										
AREP HEIFERS	8271.5	9830.6	8557.5	10088 3	13003 8	10954 3	10630 2	11521 4	10676.7	0 0
ASTKR STEERS	179404 7	214303.0	191251.7	207084 4	240372.0	239651 2	223316 0	253732 8	260366.4	0 0
ASTKR STEERS	19305 9	22656.2	20185.0	21817.9	25754 6	25389 1	23476 4	27509 2	27803 6	0 0
DEFICIENCY & DIVERSION PAYMEN	0.0	0.0	0.0	0 0	0 0	0 0	0.0	0.0	0 0	0.0
DISASTER PAYMENTS	0.0	0.0	0.0	0.0	0.0	0 0	0 0	0.0	0 0	0 0
FCIC CROP INSURANCE INDEMNITY	0.0	0.0	0.0	0.0	0 0	0.0	0 0	0 0	0 0	0.0
VALUE OF CCC LOANS	0.0	0.0	0.0	0 0	0 0	0.0	0.0	0 0	0 0	0 0
LOAN FOR IMMEDIATE ENTRY FOR	0.0	0.0	0.0	0.0	0 0	0.0	0 0	0.0	0 0	0 0
PAYMENT FOR FOR STORAGE	0.0	0.0	0 0	0.0	0 0	0 0	0 0	0 0	0 0	0 0
OTHER RANCH INCOME	0.0	0.0	0.0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
TOTAL CASH RECEIPTS	184298.8	236996.9	200455.3	226687 3	268796.7	266897 6	247259 8	274814 2	288943 7	0 0
CASH RANCH EXPENSE (NET OF SHARE LEASE)										
PRODUCTION & HARVESTING COSTS	31838.3	34193.9	34546.6	36621 4	40093 3	41180.1	42139 3	44615 9	46351 0	0 0
HIRED LABOR	475 6	485.8	485 6	485.4	487 4	486 1	485 1	488 9	487 0	0 0
CASH RENT FOR RANCHLAND	10525.8	10894.2	11275.5	11670 2	12078 6	12501 4	12938 9	13391 8	13860 5	0 0
LIVESTOCK PURCHASED FOR RESAL	141251 5	169910.8	148259.9	160018 5	188291 2	185452 4	180613 1	193078 5	196158 8	0 0
PROPERTY TAXES	756.1	809.0	870 0	935.5	1006 0	1081 9	1163 4	1251 1	1345 4	0 0
OTHER FIXED COSTS	3427 8	3560.6	3698 5	3841.7	3990.5	4145 1	4305 7	4472 5	4645 8	0 0
INTEREST ON LONG-TERM DEBT	23373 5	28191.6	30730 2	36927 1	42863 7	47260 8	52814 6	61271 9	64298 1	0 0
INTEREST ON INTERMEDI DEBT	1905 4	1518.0	1585 9	2836.3	3747 0	3569 3	3294 9	3731 6	9544 6	0 0
INTEREST & STORAGE COSTS	0 0	0.0	0.0	0.0	0 0	0 0	0.0	0 0	0 0	0 0
FCIC CROP INSURANCE PREMIUMS	0.0	0.0	0.0	0 0	0 0	0.0	0 0	0 0	0 0	0 0
TOTAL CASH EXPENSES	213554 1	249563.9	231452 2	253336 0	292557 9	295677 0	297755 1	322302 2	336691 3	0 0
NET CASH FARM INCOME	-29255 3	-12567.0	-30996.9	-26648 7	-23761 2	-28779.4	-50495 2	-47488 0	-47747.5	0 0
NON-CASH ADJUSTMENTS (-)										
DEPREC OF MACHINERY, BLDGS. & PURCHASED BREEDING STOCK	-11706.3	-11269.4	-13630.9	-12173 8	-9056 0	-8643 8	-8390 2	-8724 5	-10925 4	0 0
VALUE RAISED LVSK ADD TO HERD	1818.1	2166.1	1890 3	2175 2	2849 7	2427 4	2253 8	2496,2	2332 6	0 0
NET CHANGE IN VALUE OF INVENTORIES										
CROPS OWNED FOR SALE	0.0	0.0	0 0	0.0	0 0	0 0	0 0	0 0	0 0	0 0
LIVESTOCK OWNED FOR BREEDING	632.4	10769.1	-9428.2	3602 0	7045.0	717.6	-2785 4	16658 3	974 7	0.0
LIVESTOCK OWNED FOR SALE	-1639.6	2493.6	-1957.5	669.6	2904.9	-242.5	-1232 8	2853.8	463.0	0.0
TOTAL NON-CASH ADJUSTMENT	-12713.5	1993.2	-25016.6	-7902 3	893 8	-8168 7	-12408 3	10787 5	-9487 7	0 0
TOTAL NET RANCH INCOME	-41968.8	-10573.8	-56013.5	-34551 0	-22867 4	-36948 2	-62903 6	-36700 5	-57235 2	0 0
CASH AND OTHER ADJUSTMENTS (+)										
REALIZED CAPITAL GAIN OR LOSS	7743.7	9227.8	7595 8	8108 2	8876 3	8386 0	6697 9	10255 8	8782 4	0.0
DEPRECIATION RECAPTURE	921.0	902.6	338 1	360 2	412 3	408.4	385 1	544 9	515 3	0 0
VALUE OF HOME CONSUMPTION	0.0	0.0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
TOTAL OTHER ADJUSTMENTS	8664.7	10130.4	7933.9	8468.4	9288 6	8794 4	7083 0	10800 7	9297 8	0 0
OFF-RANCH & OTHER INCOME (+)										
OFF-RANCH INCOME	14000 0	14630.4	14632.6	14625 3	14629 2	14627 9	14629 0	14628 9	14627 6	0 0
DIVIDENDS & INTEREST ON RES	77.7	79.2	84.4	90 0	96 0	102 2	109 0	116 1	123 8	0 0
NEW CAPITAL INVESTED IN FARM	0.0	0.0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
TOTAL OFF-RANCH INCOME	14077.7	14709.6	14717 0	14715 3	14725 2	14730 0	14738 0	14745 0	14751.4	0 0

TABLE XVIII (Continued)

OPERATOR WITHDRAWALS(-)										
FAMILY LIVING EXPENSES	18000.0	18810.5	19660 4	20538.5	21461.5	22424.0	23431.5	24484.1	25581.6	0.0
PERSONAL INCOME TAX PAYMENTS	0.0	0.0	0.0	0 0	0.0	0 0	0 0	0 0	0.0	0.0
SELF EMPLOYMENT TAX PAYMENTS	150 0	0.0	0 0	0.0	0.0	0 0	0 0	0 0	0.0	0.0
TOTAL OPERATOR WITHDRAWAL	18150.0	18810.5	19660 4	20538.5	21461.5	22424.0	23431.5	24484.1	25581.6	0.0
UNREALIZED CAPITAL GAINS										
OWNED RANCHLAND	15792 6	19145.3	19815 4	20508.9	21226.7	21969.7	22738.6	23534.5	24358 2	0.0
OWNED RANCH MACHINERY	-324 8	-319 6	-314.5	-477.8	-604 5	-594 8	-585.3	-575.9	-566.7	0 0
OFF-RANCH INVESTMENTS	0 0	0 0	0.0	0.0	0.0	0.0	0.0	0.0	0 0	0.0
TOTAL UNREALIZED CAP GAIN	15467.8	18825.7	19500 9	20031 1	20622 3	21374.9	22153.3	22958.5	23791.5	0.0
CONTINGENT LIABILITIES										
ACCRUED PERSONAL INCOME TAX	0 0	0.0	0.0	0.0	0.0	0 0	0 0	0 0	0.0	0.0
ACCRUED SELF EMPLOYMENT TAX	0 0	0.0	0.0	0 0	0 0	0.0	0.0	0.0	0.0	0 0
CONTINGENT CAPITAL GAINS TAX	1390.3	1151.7	2142.9	1430.7	2114.3	1558.7	2782.0	1524.3	2701.6	0 0
CONTINGENT DEPREC RECAP TAX	7033.2	7176.6	6601.6	9156.3	12031.3	11678.5	11347.2	11399 7	11014.2	0 0
OPERATOR"S TOTAL NET INCOME										
NET INCOME AFTER WITHDRAWALS	-27891 1	4135.8	-41296.5	-19835.7	-8142.2	-22218.1	-48165.5	-21955.5	-42483 8	0 0
NET INCOME ADJUSTED FOR UNREALIZED CAPITAL GAINS, DEPREC, AND CONTINGENT LIABILITIES	-9140.5	25902.6	-16909.3	1782.1	7390.5	-5436.6	-31751.2	-3196.5	-21482 8	0.0

income statement, crop cash receipts, represents the value of all supplemental feed fed to all livestock in year t (Equation 48, Chapter III). The high cost of feed (mostly hay) in years 1985, 1987,and 1992 reflects drought years in which supplemental levels of roughage were increased (see equation 47, Chapter III) to offset a 22 percent, 17 percent and 14 percent decrease in stochastic range forage yield below the mode for each year, respectively. Livestock cash receipts reflect sales of heifer calves, purchased stockers and raised stockers as determined by equations (41) and (45), Chapter III.

Production and harvesting costs are the total variable operating costs for enterprises in the base organization. Hired labor represents part-time labor requirements. The difference between total cash receipts and total cash expenses yields net cash ranch income for the ranch situation (equation 49, Chapter III). Recalling that the number of livestock, the operating cost and inflation trends are constant over the planning horizon, the variability in net cash farm income from year to year is a result of stochasticly estimated steer calf prices, steer calf weight, weaning percent, supplemental feed prices and range forage yield. The trend in net cash farm income reflects low ranch profitability.

Noncash adjustments are necessary to determine net ranch income during any accounting period. Inventory and other balance sheet charges reflect income earned or expenses accrued during an accounting period. Adjustments are made to reflect income received from livestock produced in previous years but not sold until this year or livestock produced this year but held for sale at a later date. Depreciable assets provide a flow of service that is consumed by the ranch unit over a period of years (Boehlje, et al, 1983). Increases in depreciation of machinery, building and purchased breeding stock in years 1987, 1992 and 1993 are due to the replacement of depreciated out machinery and equipment (Table XVIII). Value of raised livestock added to the herd represents the value of replacement heifers.

The algebraic sum of net cash ranch income and total noncash adjustments equals total net ranch income, the measure of profitability of the Base ranch situation. Net ranch income measures the return to unpaid operator and family labor, the return to operator's management, and return to net worth or equity capital. Net ranch income is the monetary value available to the Base Ranch for family living, principal debt repayment, increased equity in the business, and off-ranch investment or other savings.

Cash and other adjustments include capital gains from sales of breeding stock (cull cows) and depreciation recapture from sale of purchased breeding stock (herd sires). Depreciation recapture is not taken on machinery, because it is credited in the new basis of the replacement. Off-farm and other income includes income from work off the ranch and interest from savings and cash balances. Operator withdrawals include family living expenses inflated annually by the consumer price index and personal and self-employment tax payments due. The above items are used to calculate operator's net income after withdrawals (see equation 67, Chapter III).

Unrealized capital gains, contingent liabilities, and other balance sheet items are used to calculate adjusted net income (see equation 68, Chapter III). Net income after withdrawals and net income adjusted for unrealized capital gains, depreciation, and contingent liabilities are to measures the potential net change in net worth of the ranch through the planning horizon. Net income after withdrawals represents the potential net change in net worth due to the retention of profits. Net income adjusted for unrealized capital gains, depreciation, and contingent liabilities provide an indication of potential net change in net worth if capital gains (losses) in land and machinery were realized.

Table XIX lists the minimum, mean and maximum ending net present value for the 100 replications of the Base Ranch situation. All iterations in Table XIX allowed the ranch to meet negative annual cash flow and remain solvent. Net present value is based on an 8 percent discount rate. The base run exhibited negative expected net present value for all iterations, with a minimum of $-138,028 during iteration 64 and a maximum of $-29,591 during iteration 77. The internal rate of return (IRR) in Table XIX is that rate of interest which equates the net present value of the projected values of cash-flow to zero. For each negative expected net present value, the IRR is less than the 8 percent discount rate. The standard deviation and coefficient of variation measure the relative variations in the output variables. Ending net worth over the 10 year planning horizon is greatest for iteration 22 and smallest for iteration 48.

Figure 24 presents the cumulative probability distribution of net present value for the base run. The chance of a net present value less than $-125,000 is 10 percent. The chance of a net present value smaller than $-80,000 is about 95 percent for the Base Ranch. Conversely, the probability of obtaining more than $-80,000 in net present value is about 5 percent. The analysis of net present value

TABLE XIX

NET PRESENT VALUE, INTERNAL RATE OF RETURN, ENDING NET WORTH AND REAL ENDING NET WORTH FOR 100 REPLICATIONS OF THE BASE RANCH

NO. OF ITERATIONS.	NET PRESENT VALUE	INTERNAL RATE OF RETURN	ENDING NET WORTH IN YEAR 10	REAL ENDING NET WORTH (AT 8%)
1	-115667.0	0.034	306148.14	141805.8
2	-88325.5	0.046	355950.65	164874.0
3	-111565.1	0.034	291028.73	134802.6
4	-103476.9	0.039	323988.43	150069.3
5	-31214.5	0.043	322542.61	149399.6
6	-101127.5	0.040	322428.86	149347.0
7	-100342.6	0.041	330285.48	152986.1
8	-101567.6	0.039	316873.21	146773.6
9	-97855.2	0.041	316183.22	146454.0
10	-88011.6	0.046	341086.71	157989.1
11	-87359.1	0.046	351469.61	162798.4
12	-104240.6	0.039	316719.12	146702.2
13	-113254.5	0.034	294772.05	136536.5
14	-112824.6	0.034	291632.60	135082.3
15	-84153.2	0.048	364369.96	168773.8
16	-116459.5	0.033	293364 72	135884.6
17	-90365.0	0.046	362678.24	167990.2
18	-101320.3	0.040	326211.40	151099.0
19	-114131.3	0.032	280432.49	129894.5
20	-89730.6	0.046	361267.36	167336.7
21	-135913.9	0.024	266768.21	123565.3
22	-48327.6	0.064	485282.55	224779.7
23	-125826.3	0.029	281716.77	130489.4
24	-86918.7	0.045	330095.15	152897.9
25	-109898.4	0.034	286926.17	132902.3
26	-120673.9	0.033	316659.21	146674.5
27	-87322.0	0.048	375038.90	173715.6
28	-85220.0	0.046	326572.23	151266.1
29	-114100.9	0.032	275950.79	127818.6
30	-123127.1	0.030	286486.20	132698.5
31	-119158.6	0.031	281369.36	130328.5
32	-96503.7	0.041	318791.66	147662.2
33	-121217.9	0.030	278113.53	128820.4
34	-86349.2	0.046	345667.71	160111.0
35	-98134.8	0.042	330875.61	153259.4
36	-106609.1	0.036	300319.54	139106.1
37	-34876.5	0.068	451545.07	209152.7
38	-116874.2	0.031	278720.05	129101.3
39	-116228.4	0.029	256099.14	118623.5
40	-112778.2	0.034	297976.00	138020.5
41	-104174.3	0.039	322257.84	149267.7
42	-128699.4	0.027	270523.61	125304.8
43	-119851.3	0.033	310088.79	143631.1
44	-108255.5	0.037	316130.55	146429.6
45	-99211.0	0.041	324312.97	150219.7
46	-79297.3	0.050	380075.40	176048.4
47	-108917.7	0.035	295291.44	136777.1
48	-130258.2	0.023	239215.38	110803.0
49	-112006.6	0.036	318795.20	147663.9
50	-76062.8	0.051	371868.72	172247.2
51	-133724.1	0.025	266563.52	123470.5
52	-104049.3	0.038	304568.17	141074.0

TABLE XIX (Continued)

NO. OF ITERATIONS	NET PRESENT VALUE	INTERNAL RATE OF RETURN	ENDING NET WORTH IN YEAR 10	REAL ENDING NET WORTH (AT 8%)
53	-112892.8	0.034	292256.84	135371.5
54	-118163.5	0.031	276905.69	128260.9
55	-116296.5	0.031	270589.52	125335.3
56	-108151.6	0.034	278545.58	129020.5
57	-99410.1	0.039	297555.38	137825.7
58	-101041.9	0.039	307085.04	142239.8
59	-118104.3	0.033	302235.54	139993.5
60	-93461.2	0.042	321258.80	148805.0
61	-112561.3	0.035	310401.50	143776.0
62	-112613.9	0.033	286253.46	132590.7
63	-119179.8	0.031	279734.59	129571.2
64	-138028.3	0.022	258266.69	119627.4
65	-123120.8	0.029	274870.46	127318.2
66	-122015.5	0.029	273925.70	126880.6
67	-124375.7	0.029	278731.31	129106.5
68	-124092.4	0.029	281270.73	130282.8
69	-113800.0	0.030	256991.51	119036.8
70	-53608.0	0.061	443587.94	205467.0
71	-98189.6	0.043	349980.67	162108.8
72	-89114.4	0.046	358701.39	166148.1
73	-89339.0	0.047	371338.03	172001.4
74	-123403.7	0.030	291082.34	134827.4
75	-96458.4	0.043	339088.10	157063.4
76	-81037.6	0.048	343198.85	158967.5
77	-29591.1	0.069	451398.66	209084.9
78	-124059.1	0.027	263926.40	122249.0
79	-124927.9	0.025	241736.19	111970.6
80	-108101.6	0.035	287976.76	133389.0
81	-129156.7	0.026	264505.87	122517.4
82	-112353.9	0.034	290325.89	134477.1
83	-136299.0	0.023	255824.98	118496.5
84	-115332.4	0.032	283568.94	131347.3
85	-93773.6	0.046	375222.88	173800.8
86	-103593.1	0.038	305695.31	141596.1
87	-112782.1	0.030	247282.07	114539.4
88	-101508.1	0.041	333946.48	154681.8
89	-118526.5	0.033	299936.25	138928.5
90	-105157.4	0.039	326855.96	151397.6
91	-132980.0	0.026	281100.48	130203.9
92	-82542.6	0.049	369785.47	171282.2
93	-77858.9	0.049	341878.97	158356.1
Min	-138028.25	0.022	239215.37	110803.00
Mean	-104951.81	0.068	313167.25	145058.37
Max	- 29591.09	0.68	485282.50	224779.68
Std. Dev.	20118.44	0.008	45842.46	21233.98
Coeff. Variation	- 19.16	19.4622	14.64	14.64

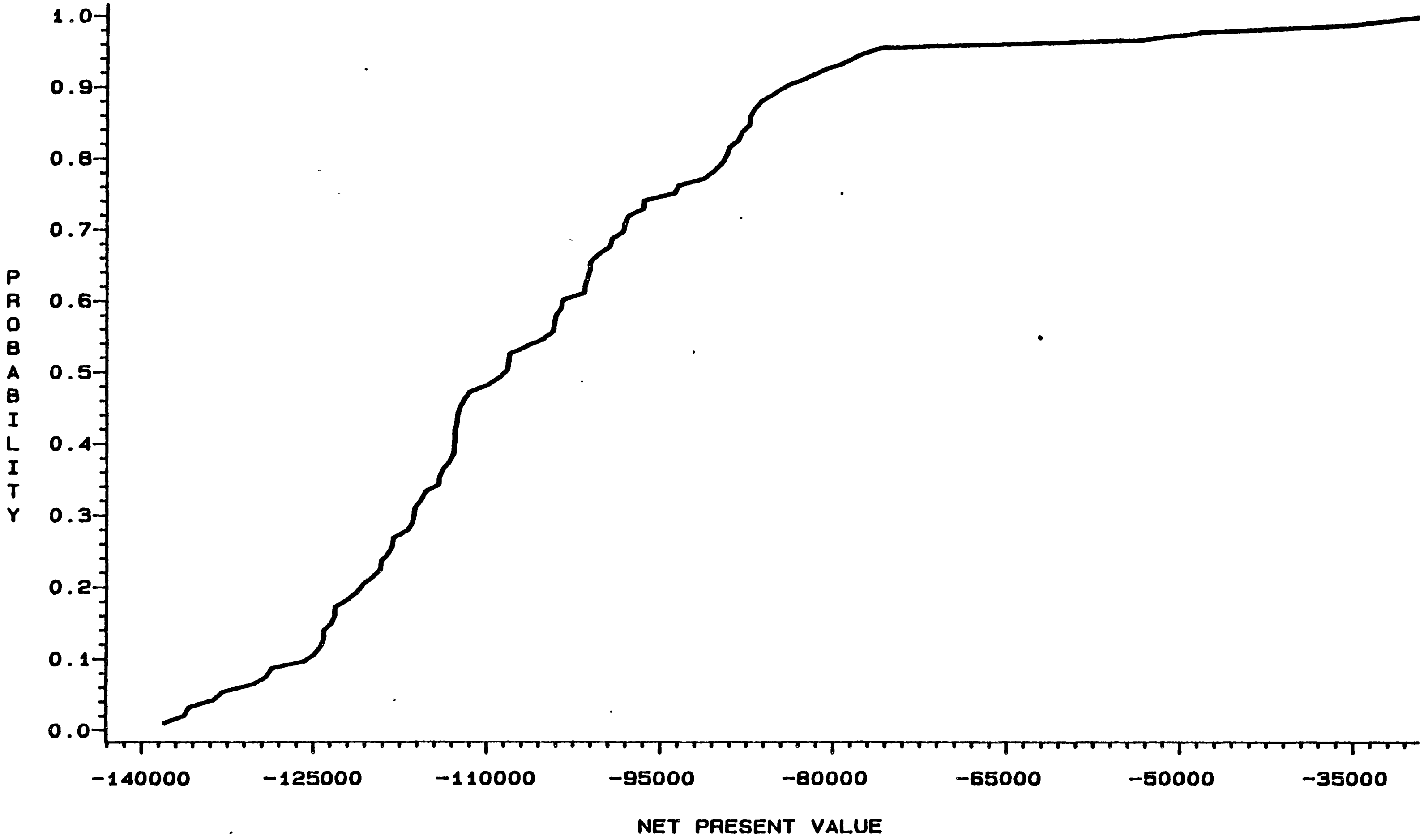


Figure 24. Cumulative Probability Distribution of Net Present Value for Base Ranch Analysis

alone indicates a rate of return less than the discount rate of 8 percent. Internal rate of return method provides the exact rate of return. The average rate of return was 4.3 percent.

Net Worth of Base Ranch

Net worth is a generally accepted measure of firm solvency and changes through time provide a measure of profitability. Positive net worth indicates that the firm could be liquidated, creditors paid, and the residual claimed by the owners. The terms net worth statement and balance sheet are used interchangeably. The current market value balance sheet for the last iteration of the Base Ranch is provided in Table XX. Note that the Base Ranch was declared insolvent in 1993 during this iteration (bottom of Table XX). The market value approach values all assets at their estimated value in the market place, based on a current appraisal net of selling expenses. Table XX presents the balance sheet for only one iteration of the ten year planning horizon and is reflective of the stochastic prices and production variables for that iteration. Total assets for the Base Ranch increased only 26 percent from 1985 to 1993, while total liabilities increased over 127 percent for the same period. Net Worth adjusted for unrealized capital gains, depreciation recapture and contingent liabilities decreased over 45 percent for the period 1985 to 1993. The Base Ranch was declared insolvent in 1993 as it was unable to refinance net cash flow deficit and maintain a long-term equity ratio above .35.

Net worth is also used to measure firm growth through time. Ending net worth can be discounted to equal beginning net worth. Table XIX lists the minimum, mean, and maximum values of ending net

TABLE XX

CURRENT MARKET VALUE BALANCE SHEET FOR LAST ITERATION OF THE BASE RANCH ANALYSIS, YEARS 1985-1994

YEARS 1985 - 1994	1985	1986	1987	1988	1989	1990	1991	1992	1993	1991
ASSETS:										
CASH ON HAND AT END OF YEAR	1000.0	1045.0	1092 2	1141.0	1192.3	1245.8	1301.8	1360.2	-61636.8	0 0
CROPS OWNED FOR SALE	0.0	0.0	0.0	0 0	0 0	0.0	0 0	0 0	0.0	0 0
CROPS UNDER CCC LOAN	0.0	0.0	0.0	0.0	0 0	0.0	0.0	0.0	0.0	0 0
CROPS IN FARMER OWNED RESERV	0.0	0.0	0.0	0 0	0 0	0.0	0.0	0.0	0.0	0 0
LIVESTOCK OWNED FOR BREEDING	53617.4	64386.5	54958.2	58560.2	65605.2	66322.8	63537.4	80195.7	81170.4	0 0
LIVESTOCK OWNED FOR SALE	13860.4	16354.0	14396.5	15066.0	17970.9	17728.4	16495.6	19349.4	19812.4	0 0
REAL ESTATE	547008.6	566153.9	585969.2	606478 2	627704.9	649674.6	672413 2	695947 6	720305.8	0 0
FARM MACHINERY	19975.2	19655 6	29864.7	37779.2	37174.7	36579 9	35994 6	35418 7	42479.3	0 0
OFF-FARM INVESTMENTS	0 0	0.0	0.0	0 0	0 0	0 0	0 0	0 0	0.0	0 0
TOTAL =	635461.6	667595.0	6862[illegible] 9	719024 7	749648.0	771551.5	789742 6	832271 7	802131 2	0 0
LIABILITIES:										
LONG TERM	243589 1	253262.8	286952.0	317039 3	342718 2	375637.1	427279 8	439795.3	437520 4	0 0
INTERMEDIATE TERM	11584.9	11941.5	20452.3	26281.9	24548 0	22178.8	25913 1	62285 9	58991 8	0 0
CROPS UNDER CCC LOAN	0.0	0.0	0.0	0 0	0.0	0 0	0 0	0 0	0 0	0 0
CROPS IN FARMER OWNED RESERV	0.0	0.0	0.0	0 0	0 0	0 0	0 0	0.0	0.0	0 0
ACCRUED PERSONAL INCOME TAX	0.0	0.0	0.0	0 0	0 0	0.0	0 0	0.0	0.0	0.0
ACCRUED SELF EMPLOYMENT TAX	0.0	0.0	0.0	0 0	0.0	0 0	0 0	0.0	0 0	0.0
CONTINGENT CAPITAL GAINS TAX	1390.3	2542.1	4685.0	6115 7	8230 0	9788.7	12570.7	14095.0	16796.6	16796.6
CONTINGENT DEPREC RECAP TAX	7033 2	14209.8	20811.3	29967.7	41999.0	53677.5	65024 6	76424 3	87438.6	87438 6
TOTAL =	263597 5	281956.1	332900.6	379404 6	417495 2	461282 1	530788 2	592600 5	600747.4	0.0
NET WORTH ADJUSTED FOR UNREALIZED CAPITA INS, DEPREC & CONTINGENT LIAB	371864.1	385638.8	353380 3	339620.0	332152 8	310269 3	258954 4	239671.2	201383 8	0 0
UNADJUSTED NET WORTH	363358 8	362070.7	314111.9	285163 1	268029 3	234818.1	172289 0	139781 4	86983.7	0 0
PERCENTAGE CHANGE IN										
ADJUSTED NET WORTH	-1.716	3.704	-8.365	-3.894	-2 199	-6 588	-16 539	-7.447	-15.975	0.000
UNADJUSTED NET WORTH	10 619	-0.355	-13.246	-9 216	-6 008	-12.391	-26 629	-18 868	-37.772	0.000
DEBT TO ASSETS RATIO	0 415	0.422	0.485	0.528	0 557	0.598	0.672	0 712	0.749	0 000
LONG-TERM EQUITY RATIO	0.552	0.548	0 502	0.467	0 441	0 407	0.346	0 348	0 369	0 000
INTERMED-TERM EQUITY RATIO	0.790	0.742	0.589	0.500	0 454	0.378	0 225	-0.018	-0.790	0.000
OVERALL EQUITY TO ASSETS RATIO	0 585	0.578	0.515	0.472	0.443	0.402	0.328	0.288	0.251	0 000
LEVERAGE RATIO	0.709	0.731	0.942	1 117	1 257	1.487	2 050	2 473	2.983	0 000

FARM WAS DECLARED INSOLVENT IN	1993
NET CASH FLOW DEFICIT WAS	61636.7981
MINIMUM CASH RESERVE WAS	1421.2008
REFINANCE CHARGES WERE	1261.1600
TOTAL DEFICIT WAS	64319.1562
LONG-TERM EQUITY RATIO IF REFINANCED	0.3033
INTERM-TERM EQUITY RATIO IF REFINANCE	0.0027

worth for the Base Ranch. Beginning net worth is $378,357 for the Base Ranch. Ending net worth is less than beginning net worth for all but 14 replications of the Base Ranch. If the decision maker's goal is to increase ending net worth in an uncertain environment, this comparison indicates that the Base Ranch will not meet aspirations.

Cumulative probability distributions of ending net worth and discounted ending net worth (assuming an 8 percent discount rate) for the base run is presented in Figure 25. The chance of a less than expected ending net worth of $313,167 (see Table XIX), is approximately 55 percent. The chance of getting an ending net worth greater than beginning net worth for the Base Ranch, is approximately 5 percent.

Ranch Growth

Firm growth comes from a combination of saving, reinvestment and appreciation of asset values. The net growth can be evaluated by discounting ending net worth to a net real present value using the assumed overall inflation rate of 4 percent. Discounted ending net worth can be compared to the beginning net worth to determine real firm growth. Given a beginning net worth of $378,357 for the Base Ranch situation, Table XIX, column 3 lists expected ending net worth of $313,167, for the 100 iterations of the analysis. When ending net worth is discounted for the effects of inflation, net worth decreases in real terms. Given a four percent inflation rate, the Base Ranch showed a decrease in real net worth, on the average, of $101,603.

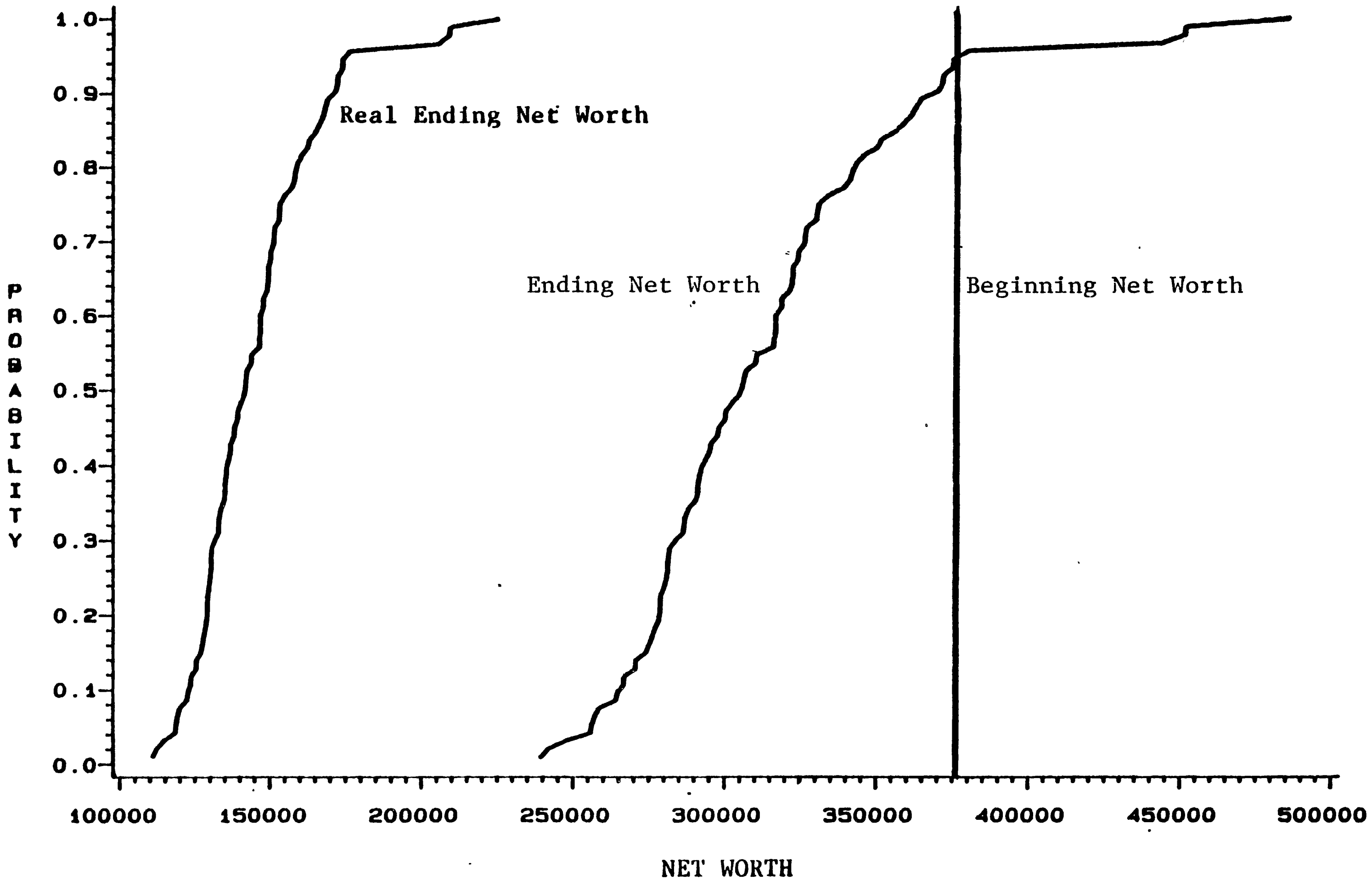


Figure 25. Cumulative Probability Distribution for Real Net Worth and Real Ending Net Worth for the Base Ranch Analysis

Cash Flow and Base Ranch Solvency

Ability to meet cash flow is a critical factor when evaluating the survivability of a ranch. A ranch that has good net worth and growth potentil may fail if financial flexibility is not available to meet a series of deficit cash flow years.

Table XXI contains a cash flow statement for the last replication for the Base Ranch. The cash flow statement records all cash inflows and outflows of the ranch during the planning horizon. The cash flow statement provides insight into all aspects of the financial performance of the business including liquidity, solvency and profitability.

Estimates of expected cash flow deficits and surpluses help the decision maker plan future credit needs and determine if ranch equity is sufficient to allow borrowing to meet these deficits. Table XXII lists the minimum, mean, and maximum values of annual net cash flow and funds borrowed to meet cash flow deficits for the Base Ranch. These net cash flows are the algebraic sum of all variable costs, principle and interest cost, purchases of cattle for resale, taxes, and gross income. Mean cash flow is negative for all years. The negative pressures on net worth throughout the planning horizon fail to provide needed equity and financial flexibility to support deficits and the ranch becomes prone to insolvency in the latter years of the planning horizon.

Annual net cash flow, equity ratios, and credit availability are determinants of the financial survival of a ranch. If the ranch has an acceptable level of equity and a supportive lender, negative cash

TABLE XXI

CASHFLOW STATEMENT FOR THE LAST ITERATION OF THE BASE RANCH ANALYSIS, YEARS 1985-1994

YEARS 1985 - 1994	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
BEGINNING CASH ON HAND	1000.0	1000.0	1045.0	1092.2	1141.0	1192.3	1245.8	1301.8	1360.2	-61636.8
PLUS:										
NET CASH RANCH INCOME	-29255.3	-12567.0	-30996.9	-26648.7	-23761.2	-28779.4	-50495.2	-47488.0	-47747.5	0.0
TOTAL OTHER ADJUSTMENTS	8664.7	10130.4	7933.9	8468.4	9288.6	8794.4	7083.0	10800.7	9297.8	0.0
TOTAL OFF-RANCH INCOME	14077.7	14709.6	14717.0	14715.3	14725.2	14730.0	14738.0	14745.0	14751.4	0.0
SALVAGE VALUE RECAPTURE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIS IN RANCHLAND SOLD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MINUS:										
BREEDING STOCK PURCHASED	345.0	422.6	338.1	360.2	412.3	408.4	385.1	544.9	515.3	0.0
DOWNPAYMENT FOR MACHINE REPLA	0.0	0.0	2104.7	1678.5	0.0	0.0	0.0	0.0	1525.5	0.0
DOWNPAYMENT FOR NEW MACHINERY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DOWNPAYMENT FOR RANCHLAND BOUG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PRINCIPAL PAID LONG-TERM DEBT	48714.2	54358.6	60548.5	50558.4	1210.7	1410.1	1659.0	1992.1	2274.9	0.0
PRINCIPAL PAID INTR TERM DEBT	4452.1	1333.8	1260.5	2325.1	3383.2	4002.8	4722.5	6009.9	9277.5	0.0
FAMILY LIVING EXPENSES	18000.0	18810.5	19660.4	20538.5	21461.5	22424.0	23431.5	24484.1	25581.6	0.0
PERSONAL INCOME TAX PAYMENTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SELF EMPLOYMENT TAX PAYMENTS	150.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENDING CASH (BEFORE BORROWING)	-77251.9	-61731.7	-81297.7	-77923.4	-25170.1	-32410.1	-57735.5	-53787.7	-61636.8	0.0
NET CASH DEFICIT REFINANCED OR COVERED BY SELLING RANCHLAND	79816.9	64032.3	84237.7	80645.7	26889.6	34329.0	60218.0	56250.9	64319.2	0.0
ENDING CASH (AFTER BORROWING OR SELLING CROPLAND)	1000.0	1045.0	1092.2	1141.0	1192.3	1245.8	1301.8	1360.2	-61636.8	0.0

TABLE XXII

SUMMARY STATISTICS OF ANNUAL NET CASH FLOW AND MONEY BORROWED TO MEET CASH FLOW DEFICITS ACROSS ALL ITERATIONS OF THE BASE RANCH ANALYSIS

	Net Cash Flow					Money Borrowed to Meet Cash Flow Deficits				
Year	Minimum	Mean	Maximum	Std. Dev.	Coeff. Variation	Minimum	Mean	Maximum	Std. Dev.	Coeff. Variation
1	-28.283	- 9.697	10,144	6,940	- 71.56	38,160	59,370	78,943	7,280	12.26
2	-27.745	- 7,094	16,308	8,382	-118.15	33,858	58,851	80,788	8,812	14.97
3	-27,425	-10,372	8,731	7,747	- 74.69	52,710	72,607	91,584	8,218	11.31
4	-39,033	-18,677	1,349	8,086	- 43.29	51,188	71,982	92,804	8,473	11.77
5	-39,954	-20,948	8,076	8,619	- 41.14	0	24,608	44,096	8,862	36.01
6	-41,936	-20,882	-3;431	8,210	- 39.31	7,751	25,897	43,386	8,703	33.60
7	-57,524	-38,520	-12,733	9,669	- 25.10	19,781	47,183	67,674	10,300	21.83
8	-50,989	-28,503	-997	10,423	- 36.57	8,086	35,954	59,371	11,013	30.63
9	-51,599	-21,132	5,844	11,274	- 53,34	1,801	30,834	62,031	11,953	38.76
10	-62,578	-29,737	4,097	12,524	- 42.11	4,180	39,724	73,622	13,274	33.41

flows can be financially endured. Financial failure occurred in the simulation model when equity ratios were below a specifed minimum level and additional funds were needed to meet an annual cash flow deficit. If the long-term equity ratio is below .35 and the intermediate term equity ratio is below .40, then the Base Ranch has failed the survival test for this iteration of the analysis. At this point the analysis is terminated and results of selected variables are reported for each year until the year in which the iteration was declared insolvent.

Table XXIII lists the frequency of annual financial failure and the probability of survival for the Base Ranch. The total represents the number of financial failures in 100 interations of each year of the planning horizon. Financial failures occurred in years 7, 8, 9, and 10. The chance of failure for the Base Ranch for the ten year planning horizon is 7 percent.

Interpretation of Simulation Results

As defined previously, a model is a deterministic representation of the relationship between a set of system inputs and a set of system outputs. Given specific levels of all system inputs, controllable and exogenous, the set of system outputs can be calculated. However, in situations involving uncertainity, levels of stochastic exogenous system inputs cannot be known exactly prior to their occurence. Therefore, system output levels associated with a particular strategy cannot be determined exactly, but can be specified only in probalistic terms. Stochastic price and production variables modeled here represent the uncertain environment faced by the decision maker.

TABLE XXIII

CHANCE OF SURVIVAL UNDER BASE ASSUMPTIONS FOR THE SOUTHERN PLAINS REPRESENTATIVE RANCH

Year	No. of Insolvent Iterations	Probability of Survival
1	0.000	1.000
2	0.000	1.000
3	0.000	1.000
4	0.000	1.000
5	0.000	1.000
6	0.000	1.000
7	1.000	.990
8	1.000	.980
9	1.000	.970
10	4.000	.930

Efficient modeling of these stochastic variables, despite the otherwise deterministic character of the model, provides valuable information about the ranch system's performance.

The ranch had sufficient equity at the start of the planning horizon to meet cash flow deficits. However, as successive negative cash flows incurred during the planning horizon, the ranch had decreasing net worth throughout the 10 year planning horizon. The variability of returns due to the stochastic price and production variables was not as detrimental to ranch survival as was the overall lack of profitability of the Base Ranch situation. For example, bankruptcy occurred only in later years after the financial base was badly eroded. Evaluation of the income statement for the last iteration (Table XVIII) for the Base Ranch indicates that stochastic range forage production and stochastic steer calf price had the greatest impact on the variability of returns over the planning horizon. For example, high feed cost and low cash receipts in the third year of the planning horizon (Table XVIII) had a substantial negative effect on net cash income.

The base conditions in which the ranch was simulated represents current expectations for price and inflation levels and the level of management reflected in practices, organization and results is moderate. The assumed 70 percent beginning equity level for the Base Ranch situation yielded seven insolvencies for 100 iterations of the analysis (Table XXIII). Preliminary runs indicated that lower beginning equity levels decreased the chance of ranch survival substantially for the 10 year planning horizon. For example, a 60 percent beginning equity level for the Base Ranch resulted in more than 30 insolvencies for 100 iterations of the analysis. Beginning equity levels above 75 percent yield no insolvencies.

The model assumes that the decision maker cannot predict and interact with the variable steer calf prices, steer calf weight, weaning percent, supplemental feed prices and range forage production. Hay feeding changes with pasture conditions but other herd and range management practices were held constant over the planning horizon. These seemingly restrictive assumptions allow evaluation of the effect of stochastic price and production variables on ranch performance in the absence of higher managerial input or technological improvements.

The results for the Base Ranch does indicate the importance of cash flow. Without some positive change in the economic environment and the system performance, the probability of ranch survival is pessimistic. The analysis of the Base Ranch will now focus on the formulation and representation of other possible levels of controlled and exogenous system input variables and economic conditions for the representative ranch. Chapter VI develops and analyzes three alternative management plans and economic scenario combinations.

CHAPTER VI

ANALYSIS OF SELECTED MANAGEMENT PLANS AND ECONOMIC SCENARIOS FOR THE REPRESENTATIVE RANCH

A basic objective of this study is to develop and use a conceptual and methodological framework for evaluating the survivability of a ranch in the Southern Plains. Chapter V presented and evaluated simulation results for the Base Ranch situation specified for the study area. Survivability prospects under base conditions are not good. This chapter addresses additional questions prevalant on many ranch operations: What management alternatives could improve profitability and survivability in the current economic environment?; How would greater or smaller levels of variability of the key exogenous variables effect the survivability of the ranch unit?; What impact would changes in the level or long-term trend of product prices have on the survivability of the ranch unit?.

The chapter is divided into four sections. The first section develops and describes three alternative management plans. The second presents and evaluates the results of the proposed management plans. The third presents and evaluates two alternative product price scenarios for use with the best proposed management plan. The final section ranks results from the above simulation experiments using the stochastic dominance with respect to a function criterion.

Proposed Management Plans

The biophysical aspects of beef production require careful attention in designing ranch management alternatives. The simulation model used in this study does not simulate the day to day, week to week or month to month details inherent in most management alternatives. However, the model will measure the general effect over time resulting from a proposed management plan. The following sections develop three management plans based on herd management practices and results reported in agricultural economics and animal and range science literature.

Management Plan 1

Some economists have argued that the greatest problem plaguing ranchers is not necessarily low prices but volatile prices (Brown and Purcell, 1978). When stable prices exist the rancher can, through a systematic adjustment process, seek the most profitable set of management alternatives available. Hiebert (1984) examined producer preference, at the mean, for product price variability versus price stability, using a simple two-input model where one input is chosen after price is known while the other input must be chosen before price is observed. The results indicated that risk-neutral producers may strictly prefer price stability. Price variability makes effective production and marketing decisions very difficult.

Hedging and other forward pricing schemes receives much attention as an approach that can be used to alleviate the risk associated with fluctuating prices of both inputs and outputs. The major objective of hedging is to reduce the risk inherent in the price patterns of most ranch commodities by offsetting a cash transaction by a futures transaction. If hedging activity can increase returns in addition to reducing risk it is even more desirable.

Research has indicated that for markets as volatile as the cattle markets, price risk can be reduced and average returns increased through the use of multiple hedging techniques (Brown and Purcell, 1978; Franzmann and Lehenbauer, 1979; and Franzmann and Shields, 1980). Multiple hedging as a management plan, involves hedging the same commodity more than once. For cattlemen, this means placing sell hedges when there is a high probability that the market will move significantly higher. Timing the placement and removal of the hedges is crucial to the success of the multiple hedging strategy (Franzmann and Shields, 1981).

The use of moving averages and point-and-figure analysis has been demonstrated to be profitable for multiple hedging of feeder cattle (Brown and Purcell, 1978; Franzmann and Lehenbauer, 1979; and Franzmann and Shields, 1980). Brown and Purcell (1978) simulated eight hedging strategies using moving averages, price predictions, and feeder cattle future contracts applied to four production alternatives over a four-year period beginning in November of 1972. The four production alternatives were:

1. Steers weighing 500 lbs. placed on wheat pasture in November and sold off wheat pasture in March weighing 650 pounds.

2. Steers weighing 400 lbs. are placed on wheat pasture in November. Steers grazeout wheat and are sold in May weighing 650 lbs.

3. Steers weighing 450 lbs. are grazed on native pasture from March until August and sold in August weighing 650 pounds.

4. Steers weighing 450 lbs. are grazed on native pasture from May until October and are sold in October weighing 650 pounds.

The strategies were as follows:

1. No hedging. This strategy corresponds to the production activity and was used as a control for comparison.

2. Hedge-and-hold, the hedge is placed at the beginning of the production period and held throughout.

3. The hedge is placed the first time the moving averages signal a downturn in futures prices in the production period and held throughout the period.

4. Hedges are placed when moving averages indicate a downturn in futures prices and are lifted when a upturn is signaled.

5. The hedge is placed in Strategy 2 when the first futures price of the production period is greater than the adjusted price forecast for the end of the period.

6. The hedge is placed in Strategy 3 if the first futures price is greater than the adjusted price forecast.

7. Hedges are placed and lifted with Strategy 4 if the initial futures price is greater than the adjusted price forecast.

8. The hedge is placed and lifted with adjusted price forecasts only.

Table XXIV presents the summary statistics of the eight alternative strategies considered in the above study. The mean and standard deviation of net returns in dollars per head were calculated for each observation of the production alternatives and for the seven strategies tested for each production alternative. The standard deviation was used as a measure of variability. The coefficient of variation, the standard deviation expressed as a percentage of the mean, was also used. The variation in return per head was reduced considerably for the hedge-and-hold strategy compared to the no hedge strategy as indicated by the standard deviation, coefficient of variation, and low and high values of return (Table XXIV). All other strategies raised the mean and reduced variability compared to no hedging.

Franzmann (1979) and Franzmann and Lehenbauer (1979) simulated three production situations representative of north central and northwestern Oklahoma to test alternative hedging strategies using both moving average strategies and point-and-figure chart strategies. Moving average strategies were:

1. No hedge corresponds to the production activity only and serves as a benchmark to compare the effectiveness of the other strategies.

2. The hedge-and-hold hedge was placed at the beginning of the production process and lifted when sold.

3. A selective hedging strategy based on the 3-day and 10-day moving average.

4. A selective hedging strategy based on a 4-day linearly weighted, 5-day and 10-day moving average combination.

TABLE XXIV

SUMMARY RESULTS OF HEDGING STRATEGIES IN DOLLARS PER HEAD[a]

Strategy	Low	Mean	High	Standard Deviation	Coeff. of Variation
1	-58.09	31.65	121.10	53.21	168.1
2	-24.70	30.57	64.63	20.66	67.6
3	-24.70	31.82	76.20	22.73	71.4
4	0.40	60.83	117.11	35.17	57.8
5	-56.37	48.16	121.20	38.32	79.5
6	-56.37	47.42	121.10	38.56	81.3
7	-56.37	49.77	121.20	39.97	80.3
8	-56.36	48.46	121.20	49.95	103.1

[a]Brown and Purcell (1978).

5. This strategy used a 4-day and 8-day linearly weighted moving average with a \$.05 per cwt. minimum penetration rule to place and lift hedges.

Point-and-figure chart strategies were:

1. No hedge strategy.

2. Hedge-and-hold hedge is placed at the beginning of the production process and lifted when sold.

3. Used the point-and-figure charting method of technical price analysis to hedge selectively, based on a \$.20 box size and three-box reversal.

4. Selectively hedged using a \$.60 box size and one-box reversal chart in conjunction with a \$1.45 trailing stop.

5. Selective hedging based on a \$.05 x five-point-and-figure chart with a \$1.50 trailing stop.

Table XXV present the summary statistics for the short hedging strategies for the summer stocker production alternatives.

The results of the hedging strategies presented in Tables XXIV and XXV strongly suggest that all of the hedging programs presented are as good or better than not hedging at all. Each of the technical hedging strategies were superior to the no-hedge and the hedge-and-hold strategies in terms of the average return per head. Variability of returns for multiple hedging strategies measured by the standard deviation of returns was less than for the no-hedge strategy but greater than for a hedge-and-hold strategy;. The coefficients of variation were all much smaller than for the no-hedge strategy, illustrating effectiveness of the hedging strategies in reducing the risk of price variability.

TABLE XXV

RESULTS OF SHORT HEDGE STRATEGIES USING MOVING AVERAGES AND POINT AND FIGURE ANALYSIS FOR SUMMER STOCKER PRODUCTION IN DOLLARS PER HEAD

Strategy	Low	Mean	High	Standard Deviation	Coeff. of Variation (percent)
	-----Moving Average Analysis[a]-----				
1. No Hedge	-72.73	1.90	60.72	53.50	2791.2
2. Hedge & Hold	- 2.85	17.78	35.69	17.47	93.3
3. 3-10	-14.63	22.89	76.86	36.08	157.7
4. 4w-5-10	-17.94	21.43	84.01	36.25	169.2
5. 4-8w (8.05)	- 8.22	31.29	79.69	29.76	95.1
	-----Point and Figure Analysis[b]-----				
1. No Hedge	-72.73	1.90	60.72	53.05	2792.2
2. Hedge & Hold	- 2.85	17.78	35.69	17.47	98.3
3. 20x3	3.20	23.97	68.76	24.82	103.6
4. 40x1 ($1.45T)	-14.90	27.08	70.10	27.72	102.3
5. .05x5 ($1.50T)	-12.69	26.72	58.35	30.69	114.9

[a]Franzmann (1979).

[b]Franzmann and Lehenbauer (1979).

Based on the hedging studies presented above, a hedge of summer stockers in the representative ranch situation should reduce the variability of average net returns. Management Plan 1, a marketing management plan, tests this hypothesis as follows:

1. The manager's preferences concerning price variability risk are such that he wishes to cut price variability to a minimum by adopting the traditional hedge-and-hold strategy.

2. The production and economic situation is the same as the Base ranch situation described in Chapter V. The summer stockers hedged are grazed on native pasture from May 1 until October 1.

3. The hedge-and-hold strategy reduces price variability by 65 percent leaving the risk of the basis movement in the futures market.

4. Commission and interest on the margin requirement for a feeder cattle futures contract were charged against the annual modal steer calf price, at a rate of 2 percent. That decrease in the annual modal price represents a risk premium for the assurance of less price variability.

Figure 26 illustrates the effect of the hedging assumption on the parameters of the triangular probability density function for steer calf prices in year 1. Simulation results of Management Plan 1 are presented later in this chapter.

Management Plan 2

The level and variability of range forage production is an important component of profitable ranching. A ranchers crop is dependent on desirable forage--forage which is to be harvested by grazing animals and marketed as meat and fiber (Gutierrez, 1980).

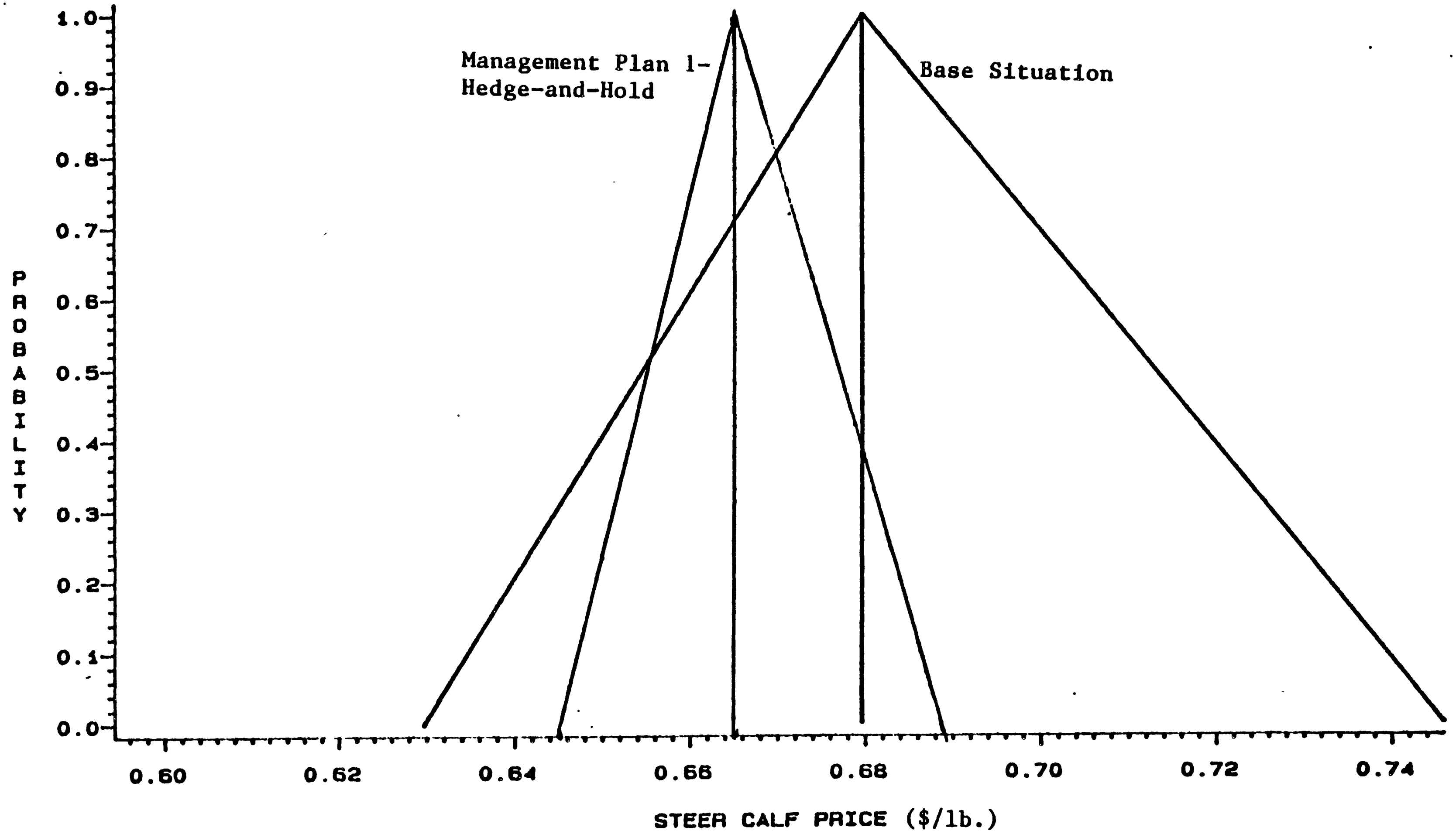


Figure 26. Triangular Probability Density Function for the Base Economic Situation and the Proposed Management Plan 1, for Steer calf Price

Returns from a favorable year of livestock prices can be offset by high feed cost and/or lower sell weights due to an insufficient amount of quality pasture.

Several studies have been done on grazing systems with respect to physical production impacts on range forage and/or livestock production. The subject of grazing management dates back to antiquity and appears to have been a problem in Biblical times. A reference in English literature on grazing management dates back to the early 1600's. Rotation grazing systems were described in 1791 (Johnstones and Kennedy, 1944). Pieters (1936) dated his review of pasture research literature in North America to 1855. Jared Smith (1897) suggested that rotational grazing on Southern Great Plains rangelands would improve range conditions. Smith recognized the economic importance of rangeland very early.

Merrill's (1954) four-pasture/three-herd, deferred-rotation grazing system study indicated opportunities for improved range conditions as well as increased livestock production (Merrill, 1954). Merrill's study concluded that during a four-year period, the advantage in livestock gain per acre was held by pasture heavily grazed yearlong. But in succeeding years, the advantage in gains held by pastures grazed yearlong steadily diminished, while the deferred-rotation pasture made consistent gains.

Hickey and Garcia (1964) conducted a six-year study in West Central New Mexico to evaluate the changes in perennial grass cover following conversion from yearlong to summer-deferred grazing. The study indicated that under summer deferment, the ground cover index showed a marked change. Alkali Sacaton increased 400 percent, Galleta increased an average of 359 percent, and Blue Grama increased an average of 206 percent.

In more recent studies, a case ranch comparison of continuous and deferred-rotation on a large cow-calf ranch in Northeastern New Mexico showed a 13 percent increase in stocking rates in both drought and nondrought years and a 6 percent increase in average sale weights (Gutierrez, 1982). The average investment for initiating the specialized grazing system was $30,000.

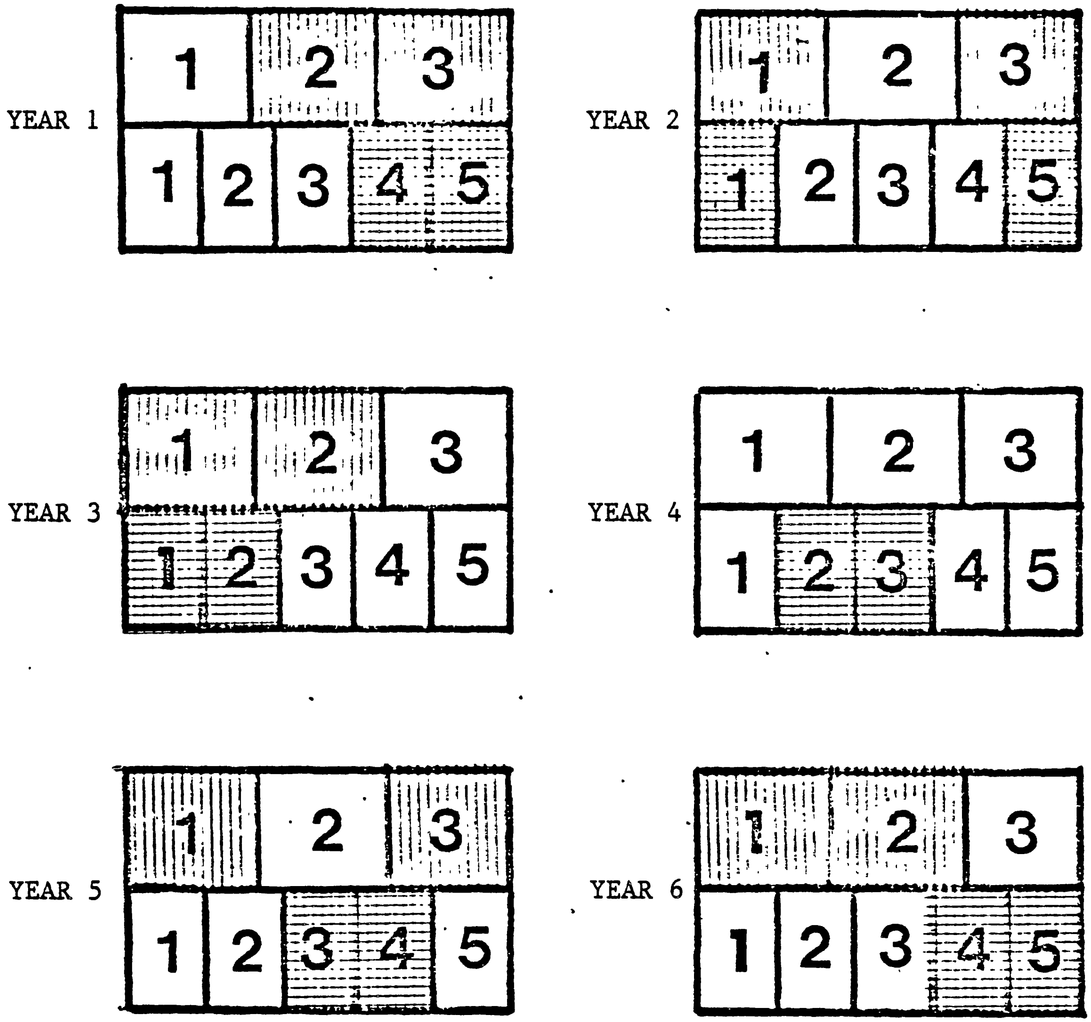
Owensby, Clenton and Launchbaugh (1983) showed that stocking rates twice that of normal for the first half of the growing season would increase gain/acre and not reduce individual animal gains per day. They also reported that range productivity and conditions were enhanced using the system they termed "intensive-early stocking". A normal stocking rate of 3.5 acres per head from May 1 to October 1 was used for the season-long conventional method of grazing summer range with yearling cattle. Compared with that were treatments of grazing only from May 1 to July 16 at two times normal; three times normal and three times normal plus daily feeding of 200 mg. Rumensin mixed with 4 lb. ground sorghum grain per head. The test animals were good quality Hereford and Hereford x Angus yearling steers averaging 550 to 600 lbs. at the start of grazing.

Intensive-early stocking resulted in an average increase in beef per acre of 37 lbs., 64 lbs., and 94 lbs. for the two times normal, three times normal, and three times normal plus supplementation, respectively, over normal stocking during the same 70-day period.

Grazing systems depend on the principles of proper forage use, proper season of use, proper grazing distribution, and proper class and kind of livestock. A grazing management plan which incorporates these basic principles should help reduce the variability of available quality forage and provide for the needs and growth requirements of both plants and animals. Management Plan 2, outlined in the following paragraphs, will evaluate the economic impact of an improved grazing management system on the Southern Plains ranch.

Improvements assumed necessary for adoption of the system included additional fencing, water lines, tanks and corrals for a total investment of $30,000. The investments in grazing system improvements are amortized into long-term debt. The grazing management plan consists of two system improvements. The cow-calf enterprise is assumed to be managed within a deferred-rotation grazing system, while the summer stocker enterprise is assumed to be managed within an intensive-early stocking grazing system. Figure 27 illustrates the proposed grazing management plan.

Summer stockers under the intensive-early stocking grazing system are grazed from May 1 to July 16 at two times the normal stocking rate. No change in gain per head from the Base Ranch situation for summer stockers was assumed. The modal sale price per pound for summer stockers is assumed higher to reflect the value of a lighter stocker sold earlier in the season. The total acres required for summer stockers is assumed to be half of that required in the Base Ranch situation due to the doubling of the stocking rate. As a result of doubling the summer stocker stocking rate, more acres per animal unit month were available. The additional acres per animal



DESCRIPTION

Intensive Early Grazing	
Number of Pastures	3
Avg. Pasture Size (acres)	1083
Number of Herds	2
Deferred Rest Rotation Grazing	
Number of Pastures	3
Avg. Pasture Size (acres)	650
Number of Herds	2

KEY

Pasture Number

Grazed Year-Round

Intensive Early Grazed 5/1-7/16

Deferred 7/16-10/15

Figure 27. Management Plan 2's Intensive Early Grazing and Deferred Rotation Grazing System Plan for Base Ranches

unit were assumed to be used to purchase additional summer stockers, for an average annual total of 1,000 head. Raised stockers are grazed in separate pastures until the time summer stockers are purchased. It is assumed that the summer stockers gain 65 percent of the total weight gains that were obtained in the Base Ranch situation in the period May 1 to July 16. Twice the number of summer stockers coupled with the assumption of 65 percent of total weight gains is a major source of the increased productivity per head for this plan.

Under the deferred-rotation grazing system for cows, modal calf weaning weights were assumed to increase 5 percent. The modal range yield was assumed to increase by 20 percent, to 840 lbs.of dry matter per acre, while the variability around the mode was assumed to decrease by 40 percent, to a minimum and maximum percent of the mode of 18.2 and 21.75, respectively. Full benefits from the grazing management plan were assumed to be realized by the fourth year of the planning horizon. Production gains were assumed to increase linearly over the first four years. These assumptions are within productivity gain levels found in previous studies cited. Both Management Plan 1 and Management Plan 2 generalize the possible effects of alternative management strategies and do not account for the day-to-day decisions necessary to carry out these alternative plans. Clearly, full managerial capability is assumed for the strategies.

Management Plan 3

Management Plan 3 is simply a combination of Management Plans 1 and 2. The effects of the marketing decision to hedge and hold and the effects of the production decision to improve herd management within specialized grazing systems are combined here. It is important to evaluate the combined effects of alternative management plans to determine if there is a complimentary, supplementary or competitive relationship between the plans for the ranch situation under consideration.

Simulation Results for the Three Proposed Management Plans

The desirability of each management plan is measured by comparing the results from Chapter V with the results from the proposed management plans. The proposed management plan is simulated to provide comparative measures of profitability, solvency, liquidity and firm survival using the same beginning resource and economic situation as described for the Base Ranch situation.

Table XXVI lists the ending net worth and net present value for the Base, Management Plan 1 (marketing plan), Management Plan 2 (production plan), and Management Plan 3 (marketing and production plan). Expected net worth ranges from $284,798 for the worst situation, Management Plan 1, to $635,672 for the best situation, Management Plan 2. Expected present value ranges from -$115,953 for the worst situation, Management Plan 1, to $42,470 for the best situation, Management Plan 2. Standard deviation for both ending net worth and net present value is the smallest for Management Plan 3, the management plan in which the combined variability of exogenous variables was specified to be the lowest. The ending net worth and net present value for Management Plans 2 and 3 are far superior to that of the Base or Management Plan 1.

TABLE XXVI

NET WORTH AND NET PRESENT VALUE FOR THE BASE RANCH SITUATION AND THE THREE PROPOSED MANAGEMENT PLANS

Simulation Experiment	Low	Mean	High	Standard Deviation	Coeff. of Variation
	Net Worth				
Base Ranch	239,215	313,167	485,282	45,842	14.64
Mgt. Plan 1 (Hedge & Hold Mkt Plan)	235,213	284,798	454,714	39,928	14.02
Mgt. Plan 2 (Prod Plan)	554,532	635,672	760,766	32,754	5.15
Mgt. Plan 3 (Mgt. Plans 1 + 2)	526,513	603,082	707,210	30,386	5.03
	Net Present Value				
Base Ranch	-138,028	-104,951	-29,591	20,118	-19.16
Mgt. Plan 1	-143,739	-115,953	-42,278	17,540	-15.12
Mgt. Plan 2	3,287	42,470	85,702	13,175	31.02
Mgt. Plan 3	1,914	30,455	71,648	12,458	40.91

Figure 28 presents the cumulative distribution of net present value for the Base Ranch situation and the three proposed management plan situations. The chance of obtaining a net present value greater than -$60,000 is 4 percent for both the Base situation and Management Plan 1. The chance of obtaining a net present value greater than $30,000 is approximately 43 percent for Management Plan 3 and 82 percent for Management Plan 2. The combination of Management Plan 1 with Management Plan 2, Management Plan 3, has a substantial negative effect on the chance of obtaining a greater net present value.

The inclusion of Management Plan 1 in the Base Ranch situation reduced expected ending net worth $28,369 or 9 percent, compared to $32,590 or 5 percent, when it was included with Management Plan 2 in Management Plan 3. The standard deviation for Management Plan 2, is less than that of Management Plan 1, implying that the reduced variability in the exogenous variables of the production plan has a greater effect than the reduced variability due to the marketing plan, and/or that the more profitable the plan, the greater the effect of reduced variability of the exogenous variables.

Tables XXVII and XXVIII list the annual net cash flow (equation 49, Chapter III) for the Base and Management Plans 1, 2, and 3 ranch situations. Expected net cash flows are all negative for the Base Ranch situation and Management Plan 1 (Table XXVII). Expected cash flows were mostly positive for Management Plan 2 and 3, except in years 1 and 5. The probability of survival is 93 percent and 79 percent chance for the Base and Management Plan 1, respectively. Management Plans 2 and 3 exhibited a 100 percent chance of survival over the 10 year planning horizon.

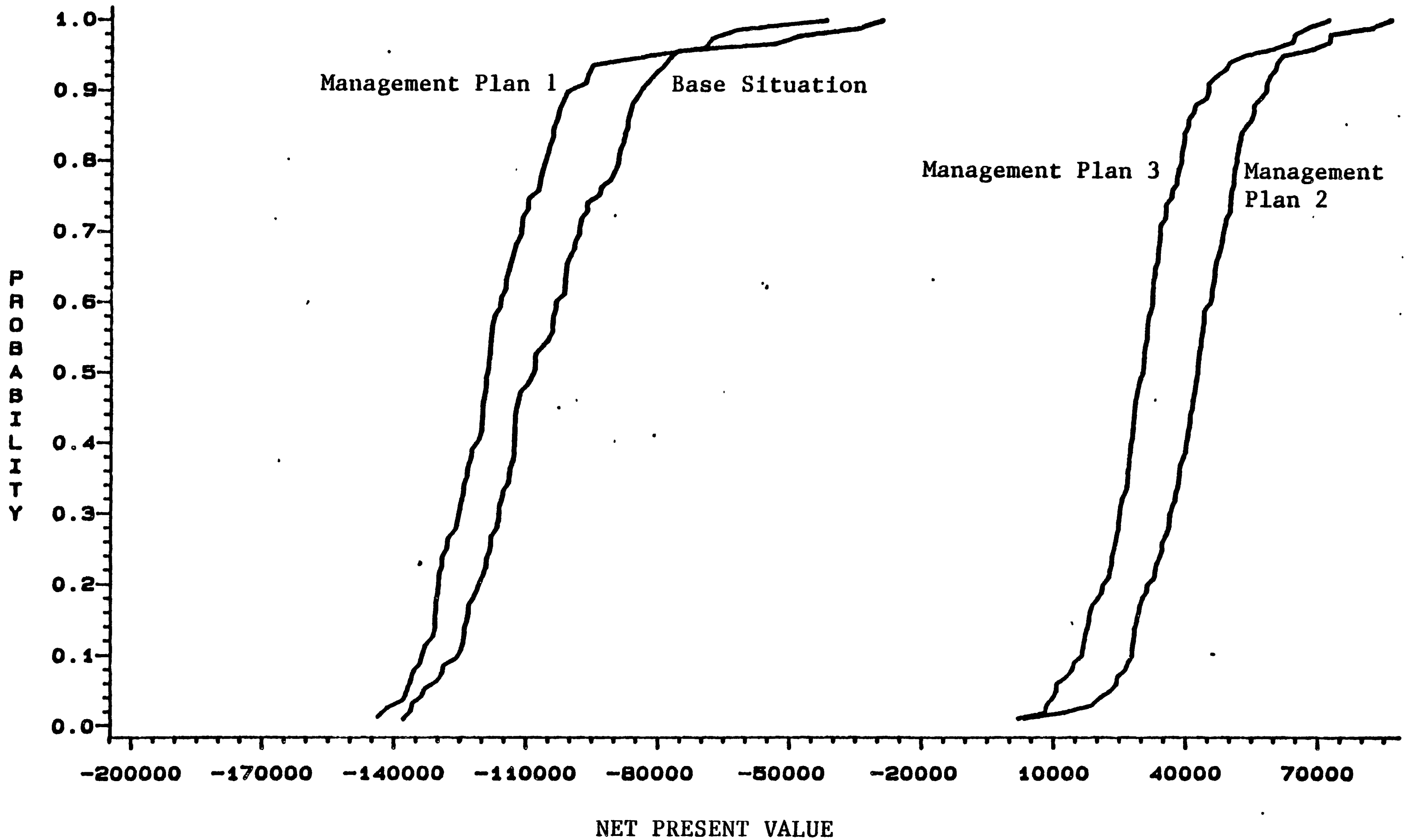


Figure 28. Cumulative Probability Distribution of Net Present Value for the Base Ranch and Management Plan 1, 2 and 3 Ranch Situations

TABLE XXVII

ANNUAL NET CASH FLOW FOR THE BASE RANCH SITUATION AND MANAGEMENT PLAN 1

Year	Base Ranch					Management Plan 1				
	Min	Mean	Max	Std. Dev.	Coeff. Variation	Min	Mean	Max	Std. Dev.	Coeff. Variation
1	-28,283	-9,697	10,144	6,940	-71.56	-25,509	-9,422	16,076	7,015	-74.46
2	-27,745	-7,094	16,308	8,382	-118.15	-32,836	-7,964	8,798	7,235	-90.84
3	-27,425	-10,372	8,731	7,747	-74.69	-29,533	-11,007	4,938	6,609	-60.04
4	-39,033	-18,677	1,349	8,086	-43.29	-40,932	-20,129	-3,018	7,663	-38.07
5	-39,954	-20,948	8,076	8,619	-41.14	-41,412	-23,045	-2,468	7,948	-34.49
6	-41,936	-20,882	-3,431	8,210	-39.31	-46,987	-24,959	948	9,811	-39.31
7	-57,524	-38,520	-12,733	9,669	-25.10	-57,880	-40,044	-23,183	8,445	-21.09
8	-50,989	-28,503	997	10,423	-36.57	-52,185	-31,084	-378	10,374	-33.37
9	-51,599	-21,132	5,844	11,274	-53.34	-42,241	-26,878	514	9,249	-34.41
10	-62,578	-29,737	4,097	12,524	-42.11	-64,028	-35,983	-4,571	11,559	-32.12
Probability of Survival			93 percent					79 percent		

TABLE XXVIII

ANNUAL NET CASH FLOW FOR MANAGEMENT PLANS 2 AND 3

	Management Plan 2					Management Plan 3				
Year	Min	Mean	Max	Std. Dev.	Coeff. Variation	Min	Mean	Max	Std. Dev.	Coeff. Variation
1	-24,552	-8,730	2,665	5,309	-60.80	-23,489	-10,183	233	4,596	-45.13
2	-12,677	3,741	19,438	6,581	175.90	-12,834	1,236	14,656	5,798	469.06
3	-15,980	3,295	25,688	7,951	241.30	-15,485	416	20,321	6,781	1630.62
4	-5,509	17,464	47,724	9,900	56.69	-6,013	13,423	44,624	8,988	66.95
5	-21,038	-1,869	28,421	9,062	-484.75	-22,560	-5,308	26,169	8,280	-156.01
6	-9,232	15,835	56,784	11,912	75.22	-10,268	10,801	51,500	11,421	105.73
7	-4,917	18,905	63,155	12,027	63.62	-8,451	13,753	51,947	11,039	80.26
8	8,225	34,840	75,750	12,223	35.08	6,273	28,566	69,536	11,416	39.96
9	18,792	46,472	97,768	13,517	29.08	17,765	39,999	86,958	12,375	30.93
10	2,324	28,364	95,170	15,154	53.42	-2,587	22,574	78,086	13,655	60.49
Probability of Survival			100 percent					100 percent		

The negative expected cash flow situation (Table XXVII) for the Base and Management Plan 1 tends to get worse over the ten year planning horizon as evidenced by the minimum, mean, and maximum values of annual net cash flow. Conversely, the positive expected cash flow situations (Table XXVIII) for Management Plans 2 and 3 exhibit improving net cash flow positions over the planning horizon.

Tables XXIX presents beginning, current ending and real ending net worth, and the nominal interest rate that equates current ending net worth to beginning net worth. Assuming a 4 percent annual inflation rate, the Base situation and Management Plan 1 generated real losses of -5.18 percent, or -$65,190, and -6.80 percent, or -$185,958, respectively. Management Plans 2 and 3 exhibited a real growth in net worth of 1.32 percent, or $51,080, and .77 percent, or $29,063, respectively.

In summary, all three proposed management plans had a significant influence on ending net worth, net present value, annual net cash flow and ranch survival. Management Plan 1 was successful in reducing the variability of ending net worth, net present value and annual net cash flow, compared to the Base Ranch situation. However, Management Plan 1 was less profitable than the Base Ranch situation. The hedge-and-hold strategy reduced the variation of steer calf price on the downward and upward sides. The loss of a chance of higher prices reduced long-term profitability. Risk avoidance tools such as hedging and forward contracting are not necessarily bad management decisions, but results indicate that in the absence of formulating realistic cattle price expectations for use in multiple hedging such tools may not be effective as fixed long run strategies.

TABLE XXIX

CURRENT AND REAL ENDING NET WORTH AND THE NOMINAL RATE THAT EQUATES BEGINNING AND ENDING NET WORTH FOR THE BASE AND MANAGEMENT PLANS 1, 2, AND 3 RANCH SITUATIONS

Simulation Experiment	Beginning Net Worth	Ending Current Net Worth	Real Ending Net Worth 4 Percent Annual Inflation	Nominal Inflation Rate That Equates Beginning & Ending Net Worth
	$	$	$	%
Base	378,357	313,167	211,564	-1.18
Mgt. Plan 1	378,357	284,798	192,399	-2.80
Mgt. Plan 2	378,357	635,672	429,437	5.32
Mgt. Plan 3	378,357	603,082	407,420	4.77

Management Plan 2 is most promising. As indicated before, Management Plan 2 considers expected increases in range and livestock productivity and a decrease in range forage variability. Many factors contribute to the substantial increase in profitability exhibited in the Management Plan 2 results. Increased range forage yields coupled with decreased variability of range forage yield reduced the cost of supplemental feed (hay) in drought years. Some cost savings per head were realized from paying less interest on operating capital to purchase summer stockers compared to the Base Ranch situation. Gains in receipts were realized from increased weaning weights due to the management of the cow herd in a defered-rest rotation grazing system and increased production per acre of summer stockers due to the "intensive-early grazing" system. Weaning weights were assumed to increase 5 percent by year four under deferred-rest rotation grazing system, resulting in an average production increase of 18 lbs. per cow. In addition, lower range variability indirectly reduced calf weight variability (equation 40, Chapter III). The most substantial effect was the production increase for stocker cattle. Twice the number of stockers and 65 percent of the weight gain in the period May 1 through July 16 increased stocker production per acre 30 percent. In addition a higher price was received compared to the Base situation because of higher seasonal prices in July. Results for Management Plan 2 indicates that the level of management assumed for the Base Ranch situation is very conservative and has considerable room for improvement through range and herd management practices. The variability of ending net worth and net present value was less for Management Plan 2, compared to the Base ranch and Management Plan 1 situation.

Management Plan 3, the combination of the hedge-and-hold marketing plan and the production plan, yielded the lowest variability in ending net worth and net present value but decreased mean values of those variables compared to Plan 2. It is important to develop a production and marketing plan that work together in achieving long-term goals. However, in this case the marketing plan did not complement the production plan.

Economic Scenarios and Simulation Results

Ranch operators most often site low product price as their "biggest problem". Considering the level of beef livestock prices the past four years, they can present a pretty good case. In the analysis of the Base Ranch situation (Chapter V), the lack of overall profitability was identified as the major deterrent to its survival in an uncertain environment. The lack of profitability could be attributed to inadequate management, unfavorable economic conditions or a combination. The previous sections of this chapter developed and evaluated three management plans to address the issue of management on the Base Ranch situation. The sections to follow address the issue of economic conditions by considering two alternative product price scenarios for the Base Ranch situation and the most profitable management plan, Management Plan 2.

Economic Scenario I

The term firm growth, as used in financial management, refers to increases in the size or net worth of an ranch business. Rates of growth refer to how fast the business is changing over time. Net worth or equity grows by: (1) the retention of profits and (2) capital gains in the firm. Until recent years, the risk of equity or net worth loss has been less important than the risk of variable returns because of the substantial increase in land values in the 1960's and 1970's. Producers' expectations of capital gains favored high financial leverage to stabilize the effect of variable returns. However, as asset values decline, the leverage ratio increases and the impact of capital losses on equity increases (Barry et al. 1979). Considering the decline in land values experienced the past four years, producers' expectations for growth over time may depend more on the retention of profits.

Economic Scenario I attempts to answer the question: What change in the current long-term trend of beef livestock prices would be necessary to obtain a real growth in ending net worth of 3.5 percent for both the Base and the Management Plan 2 situations, assuming a 4 percent inflation rate in real estate assets. The long-term trend component was increased in the cyclical and time trended model for steer calf prices identified in equation (31), Chapter III, and specified in equation (73), Chapter IV. The simulation model is not capable of finding the exact value of ending net worth that would yield a 3.5 percent real rate of return, thus annual price series yielding a real growth rate in ending net worth between 3.5 and 4.0 percent were identified.

The long-term trend in steer calf prices for the Base scenario is \$.00812/year, less than 1 percent. Figure 29 illustrates the shifts in the long-term trend for steer calf prices necessary for the Base Ranch and Management Plan 2 situation to yield a 3.5 to 4.0 percent rate of growth in real ending net worth for the ten year planning horizon. The Base Ranch situation required a ten fold increase in long-term trend, \$.0812/year, compared to a four fold increase, \$.03248/year for Management Plan 2.

Table XXX presents minimum, mean, and maximum values of net worth and net present value for the Base Ranch and Management Plan 2 for Economic Scenario I simulation experiments. Note that direct comparisons between the Base-Economic Scenario I and Management Plan 2-Economic Scenario I cannot be made in terms of what ranch situation is more desirable. Comparisons are made in terms of the change needed in the current long-term trend of product prices to yield an acceptable real rate of growth. Management Plan 2 and its respective trend shifted price series generated the largest expected net worth, \$796,242. The Base Ranch situation and its respective trend shifted price series generated the largest expected net present value. This is reflective of the high prices experienced during the latter years of the planning horizon. The standard deviation for net worth and net present value is the lowest for Management Plan 2-Economic Scenario 1, \$30,874 and \$12,636, respectively, while the Base Ranch situation, the least profitable situation, yielded standard deviations of \$45,842 and \$20,118, respectively. The coefficient of variation exhibited similar results. The more favorable the price trend or the more profitable the situation, the less the variation in net worth and net present

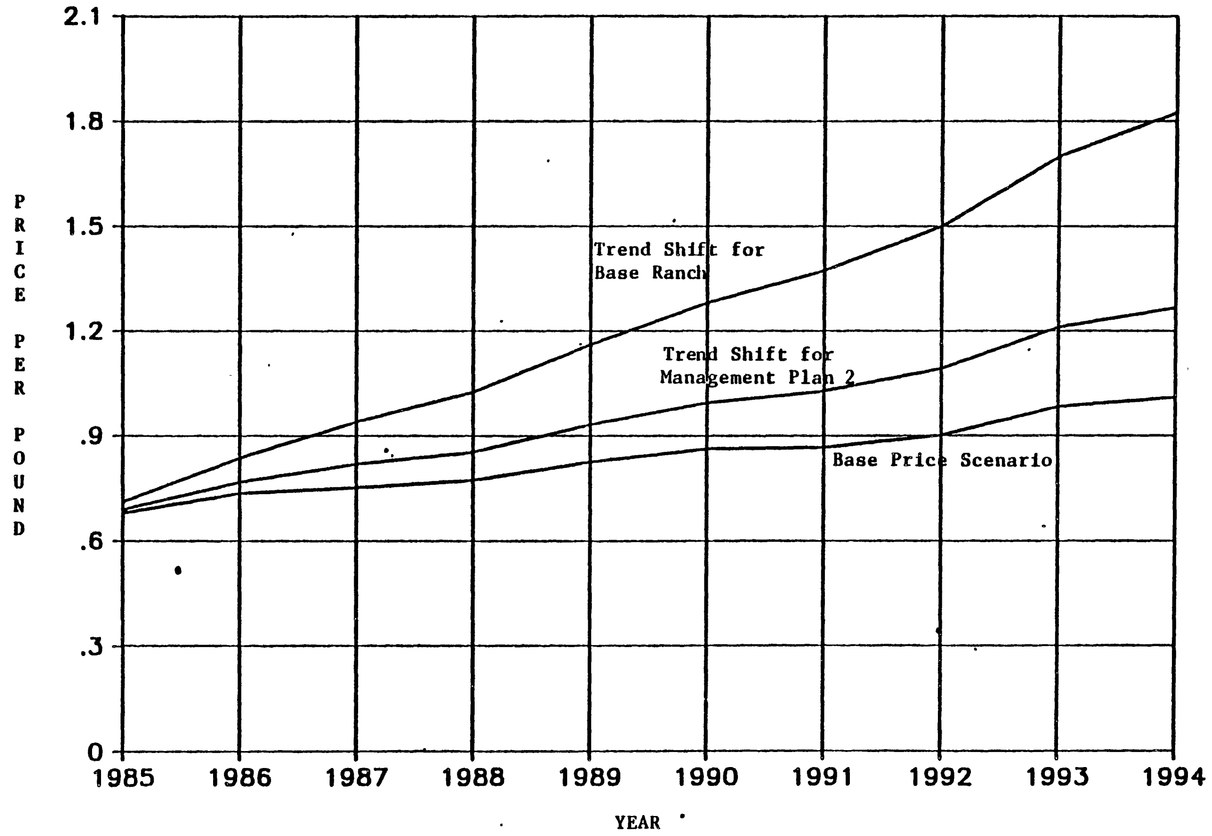


Figure 29. Trend Shift in Modal Steer Calf Prices Necessary to Yield a 3.5 Percent Real Rate of Growth in Ending Net Worth for Base and Management Plan 2

TABLE XXX

ENDING NET WORTH AND NET PRESENT VALUE FOR THE BASE RANCH AND MANAGEMENT PLAN 2: ECONOMIC SCENARIO I

Description	Economic Scenario	Min	Mean	Max	Std. Dev.	Coeff. Variation
		-----------------------Net Worth-----------------------				
Base Ranch Situation	Base	239,215	313,167	485,282	45,842	14.64
Management Plan 2	Base	554,532	635,672	760,766	32,754	5.15
Base Ranch Situation	I	682,829	778,966	902,655	36,378	5.67
Management Plan 2	I	717,753	796,242	919,150	30,874	3.87
		----------------------Net Present Plan-------------------				
Base Ranch Situation	Base	-138,028	-104,951	-29,591	20,118	-19.16
Management Plan 2	Base	3,287	42,470	85,702	13,175	31.02
Base Ranch Situation	I	76,848	123,732	163,313	14,656	11.85
Management Plan 2	I	77,322	114,568	159,216	12,636	11.03

value. Figure 30 illustrates the cumulative probability distribution of net present value for the Base Ranch and Management Plan 2 situations, with and without the estimated trend shifts. For a $120,000 present value, the probability of a worse net present value is 35 percent for Management Plan 2 and 75 percent for the Base Ranch situation, considering economic scenario I.

Tables XXXI and XXXII list annual net cash flow and probability of survival for the Base Ranch and Management Plan 2 Economic Scenarios. Net cash flows are largest for Management Plan 2-Economic Scenario I (Table XXXII). Standard deviation of net cash flow for both the Base Ranch and Management Plan 2 situation is increased with the improved long-term price trends. This is reflective of the greater absolute variation in the distribution of prices around the mode at a higher price level.

Gains in real net worth over the 10 year planning horizon are indicated by Table XXXIII. Assuming a 4 percent annual inflation rate and a $.0812/year long-term price trend, the Base Ranch exhibited a 3.49 percent, or $147,884 real growth in ending net worth, while Management Plan 2 yielded a 3.72 percent, or $159,555 real growth in ending net worth with only a $.0325/year long-term price trend.

The more management intense plan, Management Plan 2, required considerably less improvement in the long-term trend of steer calf prices to obtain a comparable real rate of growth in ending net worth as compared to the Base Ranch situation. The high product price level experienced by the Base Ranch situation in the latter years of the plannings horizon were not enough to offset the lack of profitability in the earlier years of the planning horizon and the time value affect on ending net worth.

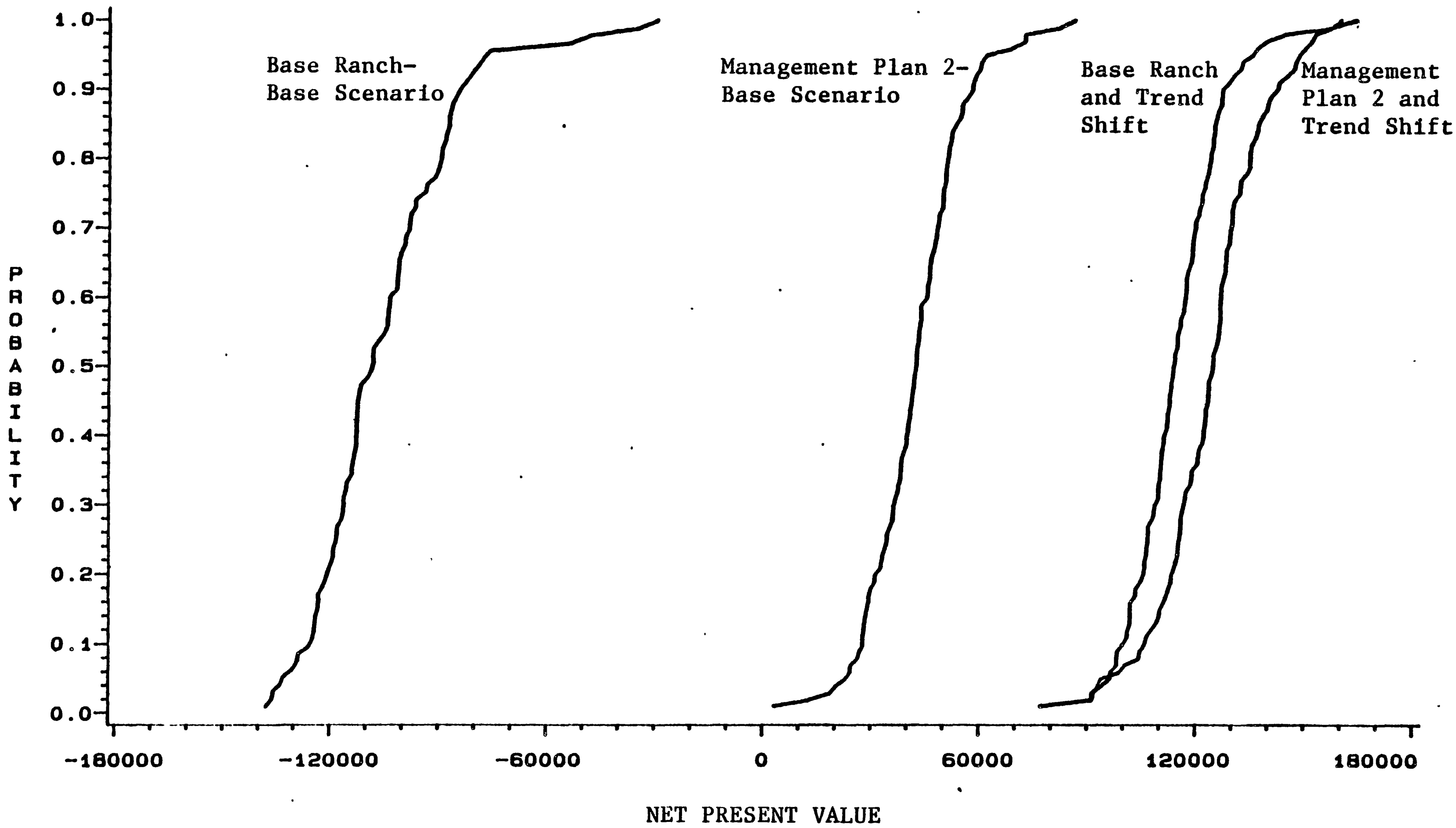


Figure 30. Cumulative Probability Distribution of Net Present Value for the Base Ranch and Management Plan 2-Economic Scenario I

TABLE XXXI

ANNUAL NET CASH FLOW FOR THE BASE RANCH: ECONOMIC SCENARIO I

Year	Base Ranch Situation					Base Ranch - Economic Scenario I				
	Min	Mean	Max	Std. Dev.	Coeff. Variation	Min	Mean	Max	Std. Dev.	Coeff. Variation
1	-28.283	-9,697	10,144	6,940	-71.56	-32,760	-8,362	8,600	7,641	-91.38
2	-27.745	-7,094	16,308	8,382	-118.15	-20,177	1,257	21,719	8,254	656.46
3	-27,425	-10,372	8,731	7,747	74.69	-20,618	9,494	40,238	10,809	113.84
4	-39,033	-18,677	1,349	8,086	-43.29	-24,643	5,371	26,837	10,537	196.15
5	-39,954	-20,948	8,076	8,619	-41.14	-8,938	13,449	47,328	10,669	79.32
6	-41,936	-20,882	-3,430	8,210	39.31	-3,473	23,433	50,974	12,676	54.09
7	-57,524	-38,520	-12,733	9,669	-25.10	-18,201	13,352	47,844	12,864	96.34
8	-50,989	-28,503	997	10,423	-36.57	15,183	51,126	102,125	15,599	30.51
9	-51,599	-21,132	5,844	11,274	-53.34	40,062	75,530	120,141	15,555	20.59
10	-62,578	-29,737	4,097	12,524	-42.11	29,318	67,962	125,411	17,939	26.39
Probability of Survival			100 percent					100 percent		

TABLE XXXII

ANNUAL NET CASH FLOW FOR MANAGEMENT PLAN 2: ECONOMIC SCENARIO I

Year	Management Plan 2 - Base Scenario					Management Plan 2 - Economic Scenario I				
	Min	Mean	Max	Std. Dev.	Coeff. Variation	Min	Mean	Max	Std. Dev.	Coeff. Variation
1	-24,552	-8,730	2,665	5,309	-60.80	-23,602	-7,661	3,886	5,374	-70.14
2	-12,677	3,741	19,438	6,581	175.90	-8,886	8,416	24,851	6,886	81.826
3	-15.980	3,295	25,688	7,951	241.30	-3,721	16,842	41,693	8,838	52.47
4	-5,509	17,464	47,724	9,900	56.69	9,253	34,284	68,150	11,010	32.11
5	-21,038	-1,869	28,421	9,062	484.75	-5,481	15,867	49,802	10,144	63.93
6	-9,232	15,835	56,784	11,912	75.22	12,533	41,589	85,463	13,393	32.20
7	-4,917	18,905	63,155	12,027	63.62	21,952	49,515	101,682	13,974	28.22
8	8,225	34,840	75,750	12,223	35.08	39,542	72,687	118,724	14,361	19.75
9	18,792	46,472	97,768	13,517	29.08	57,902	90,655	158,017	16,556	18.26
10	2,324	28,364	95,170	15,154	53.42	31,314	63,265	139,038	17,740	28.04
Probability of Survival			100 percent					100 percent		

TABLE XXXIII

CURRENT AND REAL ENDING NET WORTH AND THE NOMINAL RATE THAT EQUATES BEGINNING AND ENDING NET WORTH FOR THE BASE AND MANAGEMENT 2: ECONOMIC SCENARIO I

Simulation Experiment	Economic Scenario	Beginning Net Worth	Ending Current Net Worth	Real Ending Net Worth 4 Percent Annual Inflation	Nominal Rate That Equates Beginning & Ending Net Worth (Percent)
Base Ranch	Base	378,357	313,167	211,564	-1.18
Management Plan 2	Base	378,357	635,672	429,437	5.32
Base Ranch	I	378,357	778,966	526,241	7.49
Management Plan 2	I	378,357	796,242	537,912	7.72

Economic Scenario II

Agricultural programs which directly or indirectly subsidize product prices are not new to production agriculture, in particular the crop and dairy industries. However, the beef livestock industry has managed to survive over the years in the absence of agricultural programs designed to support product prices. But in more recent years, policy makers have considered the possibility of subsidizing product prices in the beef livestock industry. Without developing the details of a specific program, Scenario II asks the question: What would be the effect on the Base Ranch situation and Management Plan 2 if policy makers (or some other event) shifted the intercept up 2 points from 8.84179 to 10.84179 (see equation 73, Chapter IV). Figure 31 illustrates the resulting shift in modal steer calf prices for the planning horizon.

Table XXXIV presents the ending net worth and net present value for the Base Ranch and Management Plan 2 situation for both the Base economic scenario and the proposed price level, Economic Scenario II. Expected ending net worth was greatest for Management Plan 2. The approximate $.15 per pound increase in the Base price scenario yielded a lower standard deviation of net present value and higher ending net worth for both the Base Ranch and Management Plan 2 situation. The more profitable the ranch situation, the less variation in ending net worth and net present value. The variability of price and production variables decreases in importance as the profitability of the ranch increases.

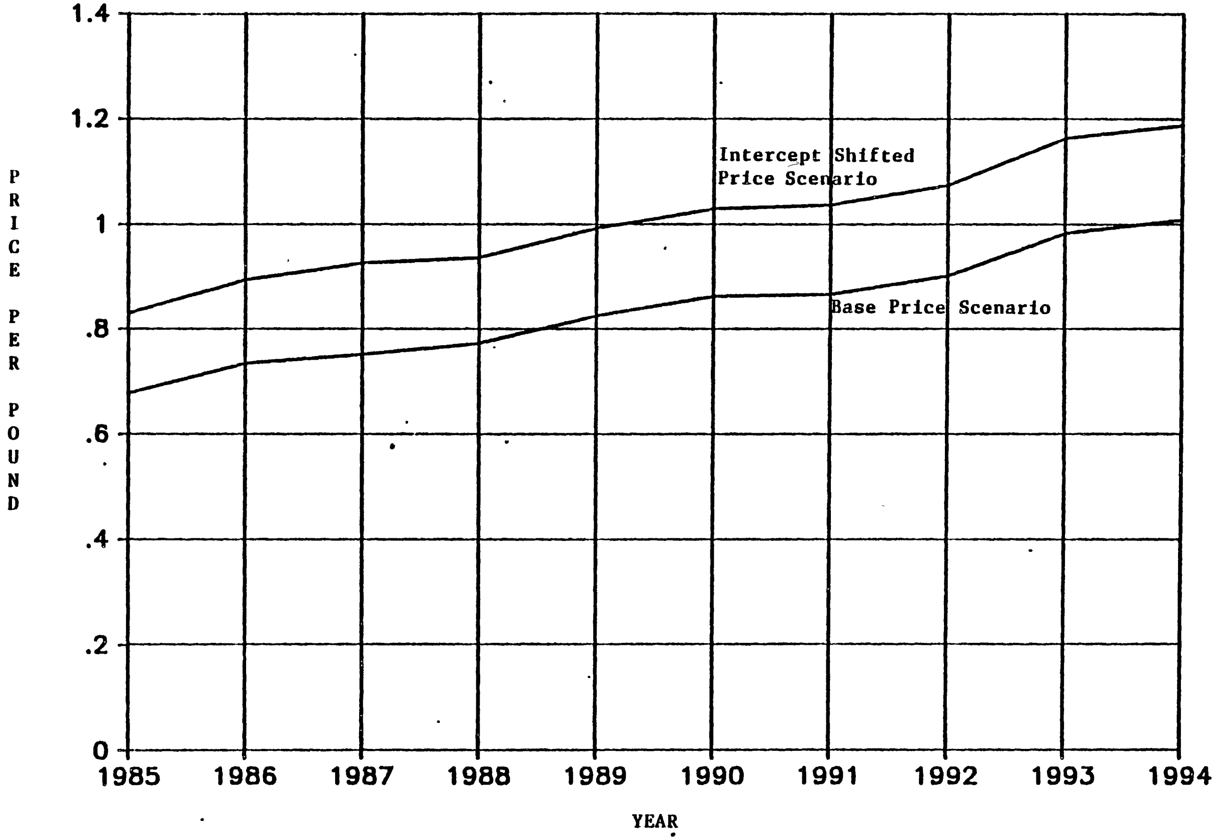


Figure 31. Shift in the Current Price Level of Modal Steer Calf Prices-
Economic Scenario II

TABLE XXXIV

ENDING NET WORTH AND NET PRESENT VALUE FOR THE BASE RANCH AND MANAGEMENT PLAN 2: ECONOMIC SCENARIO II

Description	Economic Scenario	Min	Mean	Max	Std. Dev.	Coeff. Variation
		------------------------Net Worth------------------------				
Base Ranch Situation	Base	239,215	313,167	485,282	45,842	14.64
Management Plan 2	Base	554,532	635,672	760,766	32,754	5.15
Base Ranch Situation	II	463,711	601,570	722,130	44,258	7.35
Management Plan 2	II	780,370	851,674	968,031	29,456	3.45
		-----------------------Net Present Plan--------------------				
Base Ranch Situation	Base	-138,028	-104,951	-29,591	20,118	-19.16
Management Plan 2	Base	3,287	42,470	85,702	13,175	31.02
Base Ranch Situation	II	-50,552	-1,245	36,905	17,443	-1400.74
Management Plan 2	II	75,452	110,879	153,620	11,981	10.80

Figure 32 illustrates the cumulative probability of net present value. The chance of getting a net present value greater than $12,000 is 10 percent for the Base Ranch with the intercept shift compared to 95 percent for Management Plan 2--base scenario. It is interesting to note the shape of the distributions in Figure 32. The distribution for the more profitable ranch situations tend to be smoother due to the reduced variability of net present value exhibited in the more profitable ranch situations.

Annual net cash flow for the Base Ranch and Management Plan 2 are presented in Tables XXXV and XXXVI. Net cash flows are improved considerably for both the Base and Management Plan 2 situation due to the intercept shift in modal steer calf price level. In contrast to ending net worth and net present value, the standard deviation for net cash flow is increased for the ranch situations with the improved product price level. Similar results have been observed in all simulation experiments. The more favorable the production and/or economic condition are for the ranch situation the greater the variation in net cash flow and the larger the cash flows. Price and production variation decrease in importance as the profitability of a ranch situation decreases.

Table XXXVII lists current and real ending net worth and the nominal rate the equates beginning and ending net worth. Assuming a 4 percent annual inflation rate, a 70 percent beginning equity level, and an approximate $.15 per pound increase in the product price level, the Base and Management Plan 2 situations yielded a growth in real ending net worth of .75 percent, or $28,042, and 4.45 percent, or $196,985, respectively, for the ten year planning horizon.

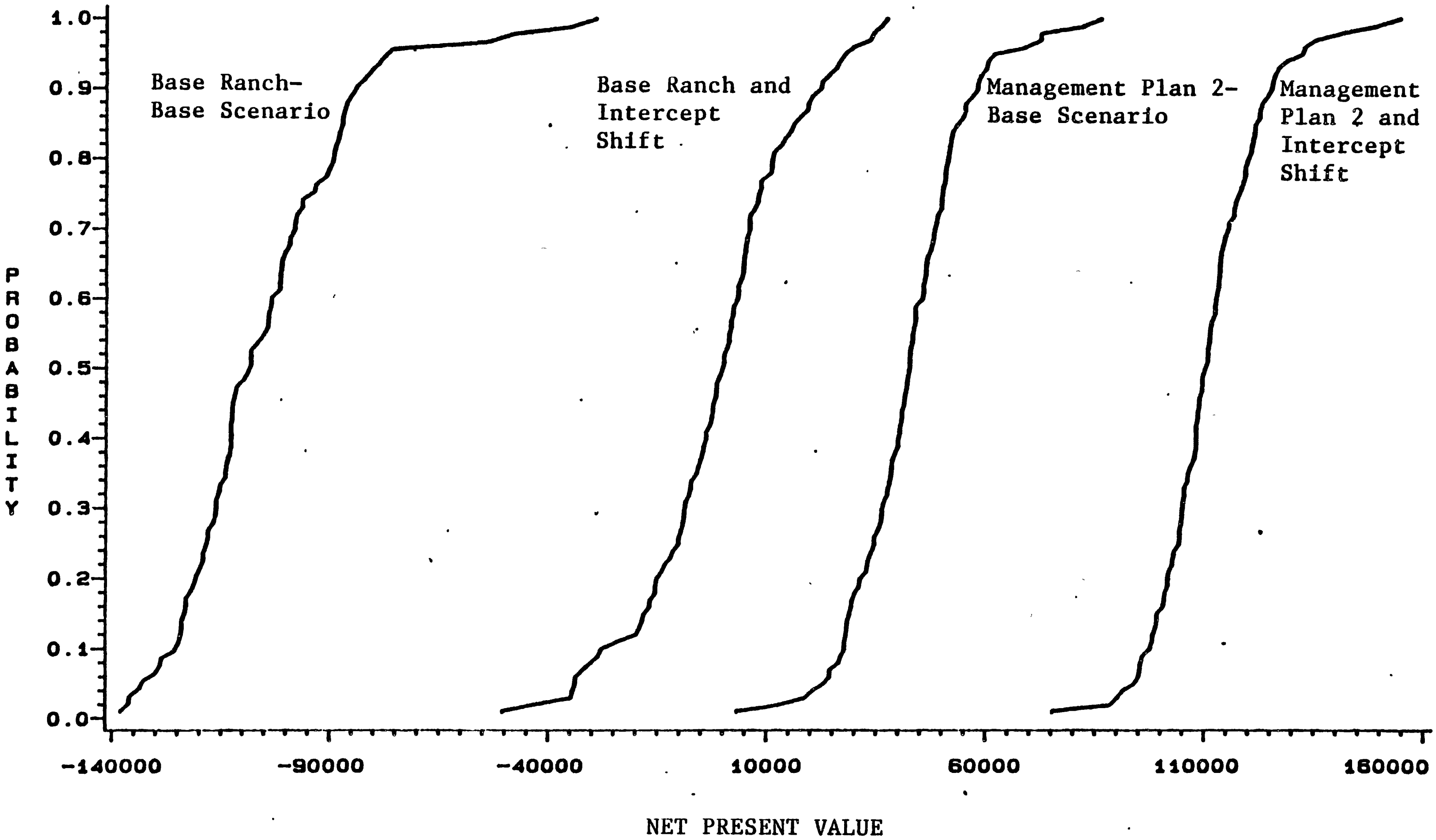


Figure 32. Cumulative Probability Distribution of Net Present Value for the Base Ranch and Management Plan 2-Economic Scenario II

TABLE XXXV

ANNUAL NET CASH FLOW FOR THE BASE RANCH: ECONOMIC SCENARIO II

	Base Ranch Situation					Base Ranch - Economic Scenario II				
Year	Min	Mean	Max	Std. Dev.	Coeff. Variation	Min	Mean	Max	Std. Dev.	Coeff. Variation
1	-28,283	-9,697	10,144	6,940	-71.56	-21,512	4,850	24,268	8,410	173.40
2	-27,745	-7,094	16,308	8,382	-118.15	-11,519	10,614	32,353	8,676	81.736
3	-27,425	-10,372	8,731	7,747	74.69	-16,620	13,321	43,796	10,725	80.51
4	-39,033	-18,677	1,349	8,086	-43.29	-25,281	3,233	22,913	9,960	308.08
5	-39,954	-20,948	8,076	8,619	-41.14	-16,577	4,018	34,066	9,493	236.24
6	-41,936	-20,882	-3,430	8,210	-39.31	-17,361	5,900	29,819	11,104	188.18
7	-57,524	-38,520	-12,733	9,669	-25.10	-37,714	-8,042	18,523	10,775	-133.98
8	-50,989	-28,503	997	10,423	-36.55	-15,769	12,883	48,137	12,283	95.33
9	-51,599	-21,132	5,844	11,274	-53.34	-4,350	24,207	50,658	11,949	49.36
10	-62,578	-29,739	4,097	12,524	-42.11	-18,244	12,311	55,507	13,765	111.80
Probability of Survival			100 percent					100 percent		

TABLE XXXVI

ANNUAL NET CASH FLOW FOR MANAGEMENT PLAN 2: ECONOMIC SCENARIO II

	Management Plan 2 - Base Scenario					Management Plan 2 - Economic Scenario II				
Year	Min	Mean	Max	Std. Dev.	Coeff. Variation	Min	Mean	Max	Std. Dev.	Coeff. Variation
1	-24,552	-8,730	2,665	5,309	-60.80	-10,896	6,640	20,219	6,256	94.21
2	-12,677	3,741	19,438	6,581	175.90	4,540	24,858	43,641	7,895	31.76
3	-15,980	3,295	25,688	7,951	241.30	11,679	33,520	60,872	9,757	29.10
4	-5,509	17,464	47,724	9,900	56.69	24.287	50,810	87,406	11,834	23.29
5	-21,038	-1,869	28,421	9,062	-484.75	8,439	31,054	67,489	10,715	34.50
6	-9,232	15,835	56,784	11,912	75.22	25,566	55,311	99,816	13,732	24.82
7	-4,917	18,905	63,155	12,027	63.62	32,424	59,715	112,145	14,048	17.90
8	8,225	34,840	75,750	12,233	35.08	45,910	78,809	123,494	14,108	17.90
9	18,792	46,472	97,768	13,517	29.08	60,697	92,055	157,242	15,964	17.23
10	2,324	28,364	95,170	15,154	53.42	31,466	61,846	132,724	16,734	27.05
Probability of Survival			100 percent					100 percent		

TABLE XXXVII

CURRENT AND REAL ENDING NET WORTH AND THE NOMINAL RATE THAT EQUATES BEGINNING AND ENDING NET WORTH FOR THE BASE RANCH AND MANAGEMENT PLAN 2: ECONOMIC SCENARIO II

Simulation Experiment	Economic Scenario	Beginning Net Worth	Ending Current Net Worth	Real Ending Net Worth 4 Percent Annual Inflation	Nominal Rate That Equates Beginning & Ending Net Worth (Percent)
Base Ranch	Base	378,357	313,167	211,564	-1.18
Management Plan 2	Base	378,357	635,672	429,437	5.32
Base Ranch	II	378,357	601,650	406,399	4.75
Management Plan 2	II	378,357	851,674	575,360	8.45

Furthermore, given a higher initial price level, the more productive ranch situation realized a growth in real ending net worth greater than that realized from a fourfold increase in the long-term price trend.

Ordering of Simulation Experiments

Interval preference for ending net worth levels was estimated and used with the evaluative criterion of stochastic dominance with respect to a function. The computer program developed by King and Robinson (1981), SDRF, was used to implement this criterion. The logical foundation of this procedure is explained by King and Robinson (1981) and, more extensively, by Meyer (1977) and reviewed in Chapter II.

The cumulative probability distributions of ending net worth for each of the ranch experiments were ordered (ranked) for several absolute risk aversion intervals. A set of reference levels of absolute risk aversion, which serve as the basis for preference measurements, were assumed. The absolute risk aversion scale assumed was comprised of 2^N reference levels, where N is the number of choices to be made in measuring absolute risk aversion in the range of a particular ending net worth level. Based on the above assumption, a measurement scale for three choices or levels of ending net worth were constructed for eight reference levels, defining seven boundary intervals: (-.0005, -.001), (-.001, 0), (0, .001), (.0001, .0003), (.0003, .0006), (.0006, .0010), and (.0010, .0050). For each comparison made, at least one pair of distribution for which these intervals serves as the boundary interval were identified to construct a hierarchy of choices for the boundary intervals. In field or extension application, these are used to construct the hierarchy of questions or choices for preference measurement questionnaires. The first choice of the hierarchy was assumed to focus on the boundary interval at the center of the measurement scale--i.e. (.0001, .0003). Subsequent choices focus on boundary intervals at the center of the region of absolute risk aversion space consistent with prior choices. If distribution A is the first choice of preference, for example, then the next choice focuses on the interval (.0006, .0010). Because levels of absolute risk aversion less than .0001 would be inconsistent with the first choice, a comparison which focuses on an interval below that level provides no new information.

Direct interval measurements for three outcome levels for each of the following comparisons were determined for the overall range of ending net worth. For each interval measurement, the lowest and highest values of the range of ending net worth levels for which measurement holds and the lower and upper bound levels of absolute risk aversion were specified.

To facilitate the following discussion, the distribution for each simulation experiment is numbered. Figure 33 presents the cumulative probability distribution of ending net worth for the Base ranch situation and the three proposed management plans. Distribution 3, clearly dominates distribution 1, 2, and 4 by the criterion of first degree stochastic dominance, since it is always below and to the right. The same can be said for distribution 4 when compared to distribution 1 and 2. Assuming positive marginal utility, the Base

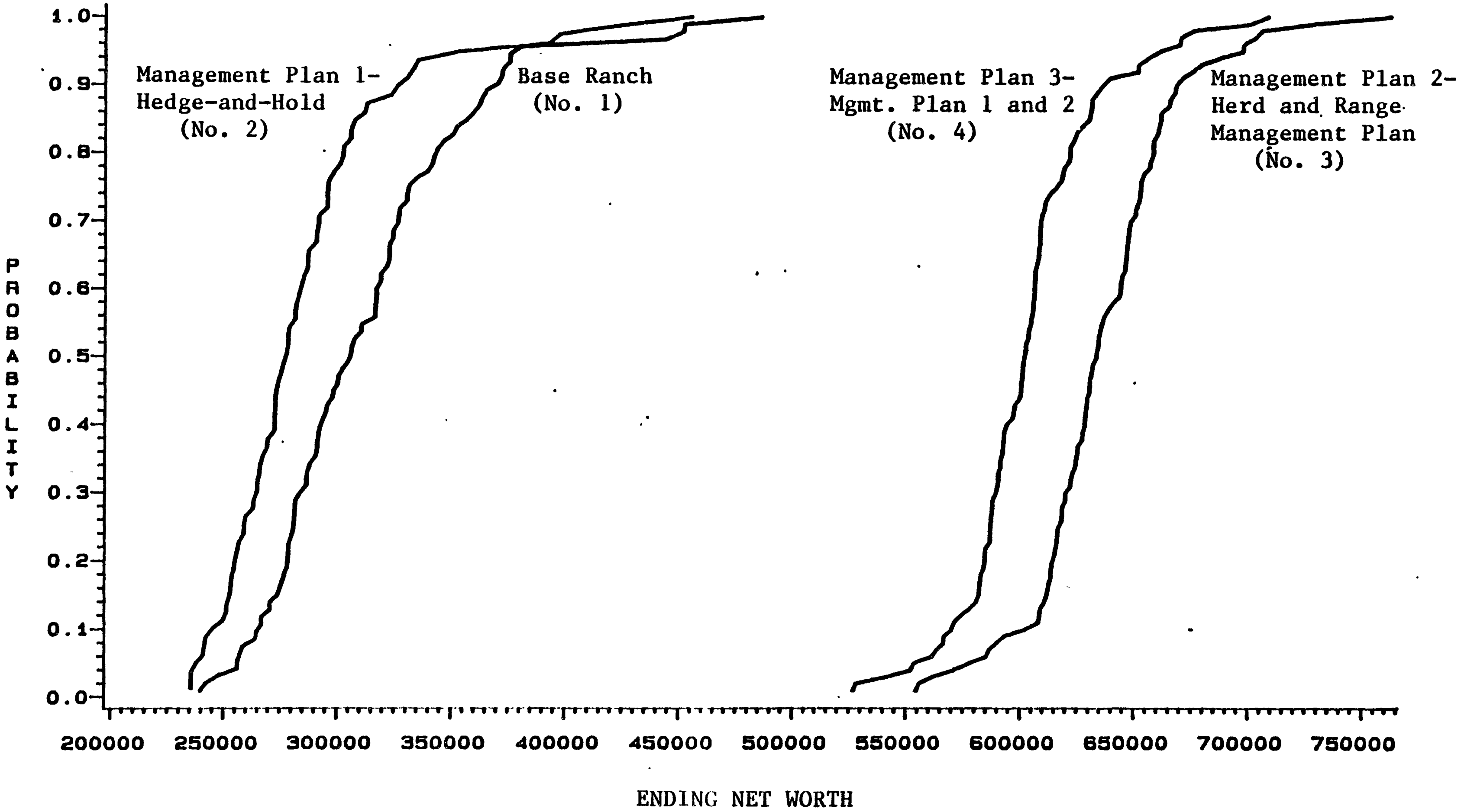


Figure 33. Cumulative Probability Distribution of Ending Net Worth for the Base Ranch and Management Plans 1, 2, and 3

Ranch situation dominates Management Plan 1 under the criterion of second degree stochastic dominance (equation 10, Chapter II).

Table XXXVIII presents the preference ordering of the Base ranch and the alternative Management Plans 1, 2, and 3 for the interval boundaries previously defined under the stochastic dominance with respect to a function criterion. The ordering holds for all intervals defined. As expected, Management Plan 2, distribution 3, is unanimously preferred over the Base ranch and Management Plans 1 and 3. Meyer (1977) has shown that applying stochastic dominance with respect to a function with a risk aversion coefficient interval extending from negative infinity to positive infinity is equivalent to applying first degree stochastic dominance. This means that none of the distribution of ending net worth presented here will belong to a stochastic dominance with respect to a function efficient set unless it is a member of the first degree stochastic dominance efficient set.

Figure 34 presents the cumulative probability distribution of ending net worth for the Base ranch and Management Plan 2 under Economic Scenario I. Distribution 5 dominates distributions 1 and 3 by the criterion of first degree stochastic dominance. Assuming positive marginal utility, distribution 6 dominate distribution 5 by the criterion second degree stochastic dominance, since the area under the cumulative distribution 6 is always less than or equal to that under distribution 5. Table XXXIX presents the preference ordering for the Base Ranch and Management Plan 2, for Economic Scenario I, under the criterion of stochastic dominance with respect to a function. Management Plan 2 - Economic Scenario I is preferred by all classes of individuals whose risk preference interval fall between -.0005 to .0050.

TABLE XXXVIII

STOCHASTIC DOMINANCE WITH RESPECT TO A FUNCTION PREFERENCE ORDERING FOR THE BASE RANCH AND MANAGEMENT PLANS 1, 2 AND 3

Distribution Name	Dist. No.	Distribution Name and Number: Base Ranch No. 1	Mgt. Plan 1 Hedge & Hold No. 2	Mgt. Plan 2 Herd & Range Mgt No. 3	Mgt. Plan 3 Mgt. Plan 1 & 2 No. 4
		Preference Ordering[a]			
Base Ranch	1	NA	1 < 2	1 < 3	1 < 4
Mgt. Plan 1 (Hedge-and-Hold)	2	2 > 1	NA	2 < 3	2 < 4
Mgt. Plan 2 (Herd and Range Mgt.)	3	3 > 1	3 > 2	NA	3 > 4
Mgt. Plan 3 (Mgt. Plan 1 and 3)	4	4 > 1	4 > 2	4 < 3	NA

[a](>)-First distribution name preferred to the second ($\not>$)- the two distributions cannot be ordered, (<)-second distribution is preferred to the first, and NA-not applicable.

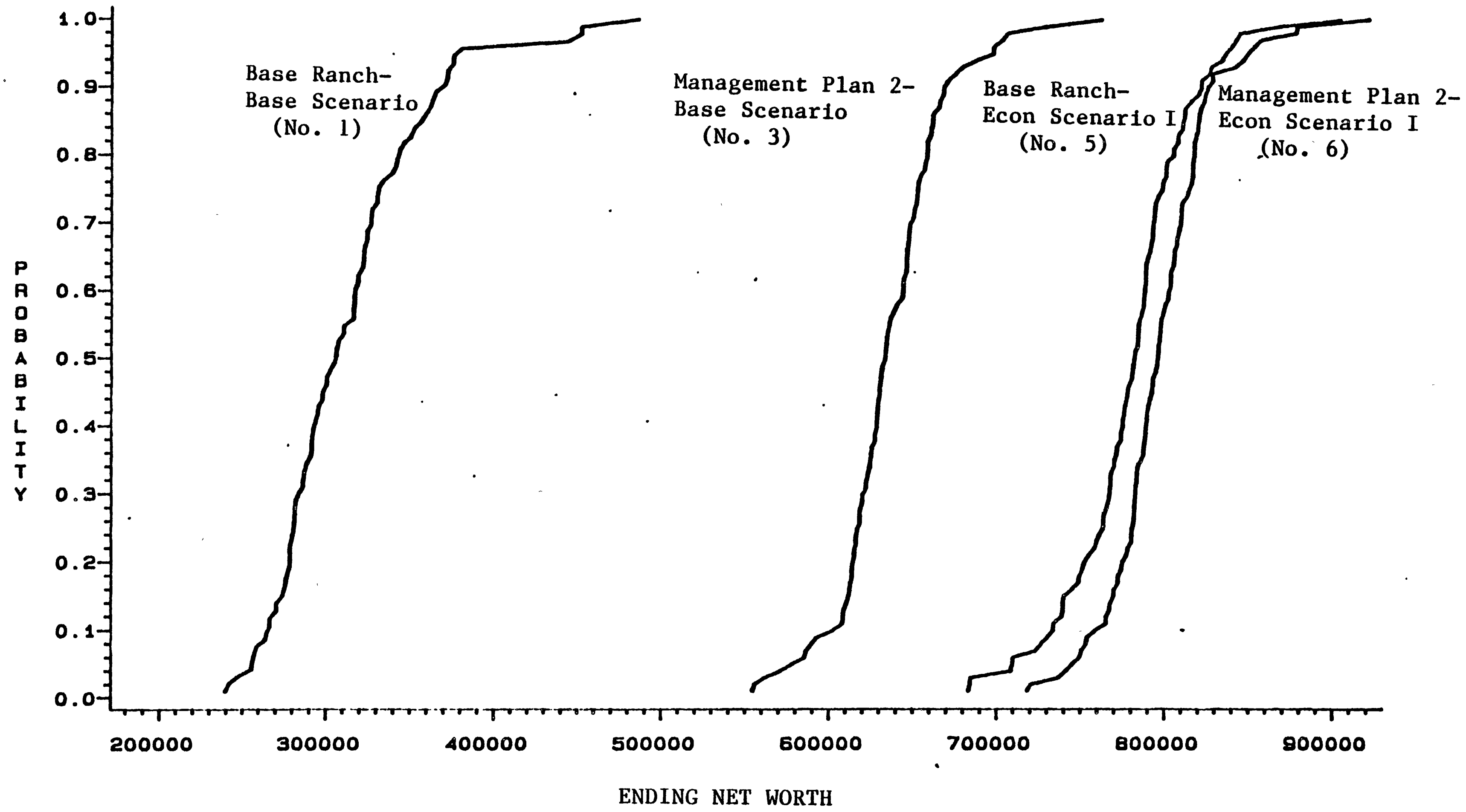


Figure 34. Cumulative Probability Distributions of Ending Net Worth for the Base Ranch Management Plan 2-Economic Scenario I

TABLE XXXIX

STOCHASTIC DOMINANCE WITH RESPECT TO A FUNCTION PREFERENCE ORDERING FOR THE BASE RANCH AND MANAGEMENT PLAN 2 : ECONOMIC SCENARIO I

Distribution Name	Dist. No.	Distribution Name and Number: Base Ranch Base Scenario No. 1	Mgt. Plan 2 Base Scenario No. 3	Base Ranch Econ Scenaro I No. 5	Mgt. Plan 2 Econ Scenario I No. 6
		Preference Ordering			
Base Ranch Base Scenario	1	NA	1 < 3	1 < 5	1 < 6
Mgt. Plant 2 Base Scenario	3	3 > 1	NA	3 < 5	3 < 6
Base Ranch Econ Scenario I	5	5 > 1	5 > 3	NA	5 < 6
Mgt. Plan 2 Econ Scenario I	6	6 > 1	6 > 3	6 > 5	NA

Figure 34 presents the cumulative probability distribution of ending net worth for the Base ranch and Management Plan 2, for Economic Scenario II. All distributions in Figure 35 can be ordered using first degree stochastic dominance criteria. Table XL presents the results of the stochastic dominance with respect to a function criterion for Economic Scenario II.

Even though most of the ranch situations simulated here could have been ordered with first or second degree stochastic dominance, stochastic dominance with respect to a function was include to provide a more complete, conceptual and methodological framework with which to evaluate the survivability of a ranch situation in the Southern Plains study area. The Base Ranch and proposed management plans and economic scenarios are but a few of the many possible management plan - economic scenario ranch situations that could be simulated, evaluated and ordered using the criterion of stochastic dominance with respect to a function.

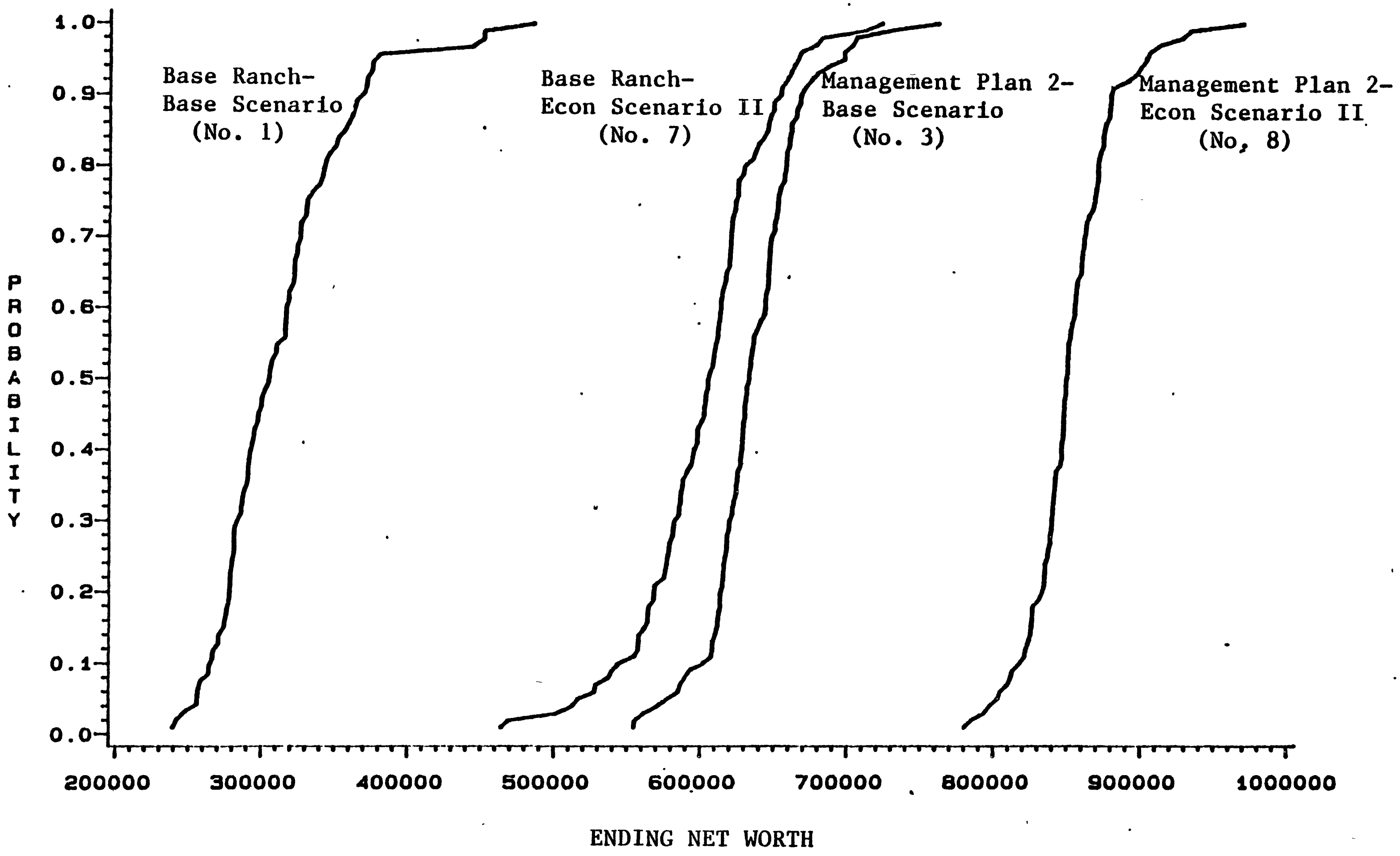


Figure 35. Cumulative Probability Distribution of Ending Net Worth for the Base Ranch and Management Plan 2-Economic Scenario II

TABLE XL

STOCHASTIC DOMINANCE WITH RESPECT TO A FUNCTION PREFERENCE ORDERING FOR THE BASE RANCH AND MANAGEMENT PLAN 2 : ECONOMIC SCENARIO II

Distribution Name	Dist. No.	Distribution Name and Number			
		Base Ranch Base Scenario No. 1	Mgt. Plan 2 Base Scenario No. 3	Base Ranch Econ Scenaro II No. 7	Mgt. Plan 2 Econ Scenario II No. 8
		Preference Ordering			
Base Ranch Base Scenario	1	NA	1 < 3	1 < 7	1 < 8
Mgt. Plant 2 Base Scenario	3	3 > 1	NA	3 < 7	3 < 8
Base Ranch Econ Scenario I	7	7 > 1	7 > 3	NA	7 < 8
Mgt. Plan 2 Econ Scenario I	8	8 > 1	8 > 3	8 > 7	NA

CHAPTER VII

SUMMARY

The Problem

The continued existence of a ranch is not dependent on producing more beef per head or per acre, but on the managers ability to produce that beef while receiving an acceptable return to his resources. This study developed a method to examine the economic survivability of Southern Plains ranches for various herd management alternatives under uncertainty.

Product price variability has moderated in the past few years, but at a relatively low level compared to the late 1970's. Conversely, the prices paid by ranchers has continued to increase at a steady rate. The stagnent demand for beef offers little hope for any near future increases in the price of beef.

Low income levels, high debt and declining land values have added substantially to the financial problems of the rancher. Borrowed funds to purchase additional production inputs in the late 1970's when beef cattle price were unusually high are fixed commitments and must be paid. Many producers are being forced to sell their breeding herds and other assets to meet these immediate commitments.

Many procedures exist which will accurately calculate the effect of alternative management decisions, if cash benefits and cost associated with these alternatives are known with certainty. A method of realistically incorporating risk associated with beef range livestock production into the analysis of capital investments is needed.

Purpose of Study

The major purpose of the study is to develop a conceptual and methodological framework, an tool, to analyze the survivability of a ranch unit in the uncertain ranch business environment. It is intended to provide knowledge concerning risk and feasibility for different ranch-management plan situations under stochastic conditions.

Specific objectives are:

1. To develop a conceptual and methodological framework, using Monte Carlo simulation techniques, to estimate the potential survivability of a ranch situation under uncertainty.

2. To evaluate the survivability of a representative ranch situation.

3. To evaluate selected management plans and alternative economic scenarios for the representative ranch situation.

Many attempts to include risk in management decisions have been made for farm, farm-cattle, and large corporate firms. Simulation has be a popular method for incorporating variation in whole-firm models. Simulation provides more information to the decision maker than a single-valued estimate of returns. Simulation offers some flexibility in specifying the decision maker's goals. Profit maximization assumption can be relaxed, while Monte Carlo simulation techniques provide probability distributions of key output performance measures. Methodological procedures which permit correlation of variation among variables and probability distributions of selected performance measures that include decision maker's subjective evaluations provide a realistic method for relaxing the assumption of perfect knowledge of future production, income, and expenses.

Conceptual Framework

Stochastic mathematical programming techniques are widely accepted as suitable techniques for evaluating whole-firm decisions under uncertainty. However, the availability of accurate and reliable time series data or gross margins for the enterprise activities are essential to evaluate risk associated with different plans and arbitrary measures of risk may impose limitations on whole-firm analysis. The assumption of linear utility functions impose limitations which may require the decision analyst faced with these problems to simplify the planning problem.

Whole-firm simulation describes a technique for obtaining particular time solution of a mathematical model corresponding to specific assumptions regarding firm model inputs and values assigned to parameters. Monte Carlo simulation techniques offer a method for incorporating uncertainty in the whole-firm decision models. These methods involve specification of an subjective probability distribution for the parameters that most influence whole-firm decisions. Random values drawn for these key parameters are used in a whole-firm simulation to calculate measures of success and survivability. By repeating the analysis a specified number of times, a probability distribution for these measures of success and survivability can be developed. Simulation modeling of stochastic processes permits greater realism in the representation of underlying probability. This study uses a whole-firm Monte Carlo simulation model.

Alternative methods for evaluating whole-firm decisions include the net present value and the internal rate of return. The net present value method incorporates the time value of money and the decision maker's discount rate. The internal rate of return method involves setting discounted net cash flows to zero and solving for the discount rate. Using Monte Carlo simulation techniques, probability distributions for these measures of whole-firm success can be derived.

To obtain more complete information about the effect of a proposed management alternative on the ranch situation under uncertainty, a detailed before and after analysis of the firm can be developed. This approach requires an estimate of cash benefits and costs, financial situation and cash flows associated with the ranch situation. This method allows direct comparison of the measures of success for the ranch situation and the proposed management plan under uncertainty of production and price variables. An obvious disadvantage of this method is the requirement of relatively large amounts of input data.

Decision making under risk is a problem of ordering management alternatives with uncertain outcomes. In most applied decision problems, a unique preference measure represented by the decision maker's utility function is not readily available and utility functions are difficult to estimate. An efficiency criterion is a preference relationship which provides a partial ordering of key measures of management alternatives. First and second degree stochastic dominance are among the simplest and most common efficiency criteria, but are not particularly discriminating evaluative tools.

Stochastic dominance with respect to a function is a more powerful efficiency criterion which orders uncertain management alternatives for classes of decision makers defined by specified lower and upper bounds on the absolute risk aversion function. Stochastic dominance with respect to a function orders management alternatives on the basis of the decision maker's risk aversion interval. The interval measurement can be precise or imprecise as is determined necessary for a particular decision analysis.

Several general approaches for field elicitations of subjective probabilities have been used. The simulation model in this study utilizes stochastic price and production variables that are assumed to be triangularly distributed. The triangular distribution is convenient for use in simulation models and field elicitation of the decision makers subjective probabilities. Triangularly distributed prices and yields are based upon the decision maker's subjective estimate of the minimum, most likely, and maximum value of key price and production variables. The random influence of variables is triangularly distributed and correlated, if necessary based on the correlation coefficient matrix of historic price and production series.

General Model Description

REPFARM, a Fortran whole-firm simulation model was the basis for the simulation model used in this study. Modifications were made in the REPFARM model to allow cattle ranch analysis within a stochastic framework. The model was programmed to calculate stochastic steer calf prices, steer calf sale weights, and weaning percents for five cow-calf, five purchased stocker (or purchased replacement heifers), and five raised stocker (or purchased feeder) enterprises, using a triangular distribution. Additional modifications of the model include the flexibility to annually input; the decision to market steers as calves or retain as stockers, the culling rate for cows and bulls, feeding rates for each class of livestock in each enterprise, the total dry matter per acre, the pounds of dry matter per acre per animal unit month, the acres required per animal unit, the percent dry matter of supplemental roughage, and the rate at which roughage is supplemented for decreases in range forage production below the specified mode. These modifications allow the user to reflect the impact of a management plan on such variable by trending the variables up or down over time. The new model was renamed OKIE to distinguish the modified version.

The major purpose of the whole firm simulator model used in this study is to analyze the impact of selected management plans in an intertemporal and stochastic environment. It is specifically designed to determine the profitability, solvency, liquidity, and the probability of firm survival for alternative management plans-economic scenario combinations. Direct comparison of a representative ranch unit and the selected scenarios will provide an estimate of the net effect of the alternative management plans-economic scenarios on a representative ranch.

The model begins each simulation by reading and processing the data cards and calculates values which do not change in each replication of the planning horizon. They are deterministic and may have trend and cyclic patterns. To efficiently utilize computer time, these values are calculated and stored in arrays, one time, and then added each time the analysis is repeated.

Stochastic steer calf price, steer calf weight, weaning percent, supplemental feed prices and range forage yield are calculated at the start of each iteration. Then annual enterprise costs and receipts are calculated. Family living is paid and taxes are deducted. If net cash income is positive, it is accumulated for future use and/or invested. If it is negative, equity levels are calculated to determine whether funds can be borrowed to meet cash flow deficit.

The planning horizon loop of the ranch situation is repeated for a specified number of iteration loops to provide data necessary for cumulative probability distributions of performance variables such as ending net worth, net cash flow and net present values.

Stochastic variables identified for all simulation experiments included; steer calf prices, steer calf weights, weaning percent, supplemental feed prices and range forage yield.

The state of the system for the base ranch situation is assumed to represent a stable economic environment exhibiting a moderate level of growth overtime. The financial state of the base ranch is assumed to be very favorable, with a beginning net worth of $378,357 and 70 percent equity.

The base cow herd consist of 130 medium framed English type crossbred cattle with 950 lb. mature cows and two year old first calf heifers. Cows were calved in the spring and weaned at approximately 210 days. Steer calves were retained as stockers and heifer calves were sold in the fall. Five hundred head of summer stocker steers were purchased May 1 and marketed September 30 in each year of the base ranch planning horizon. Stocking rates and feeding rates were based on the Oklahoma State University Livestock Budgets.

Labor requirements were based on primary data obtained from personal interviews with cow-calf and stocker cattle producers in the Southern Plains Study Area and Oklahoma State University Livestock Budgets.

Base Ranch Analysis

The purpose of the Base Ranch simulation experiment in this study is to demonstrate the model's ability to provide evaluative information of ranch survivability in the Southern Plains. Simulation results are first evaluated for the Base Ranch situation. Additional management plans and economic scenarios are developed for the Base Ranch situation. Simulation experiments are made for the alternative management plans. The simulation is then repeated for the Base Ranch and a selected management plan for alternative economic scenarios. Simulation results for each experiment are evaluated to determine the net effect on the Base Ranch situation survivability.

Exogenous system inputs were assumed to have triangular probability distributions and were correlated as deemed appropriate.

The price and production variables generated in the model appear to be accurate estimates of the specified population of random variables.

Survivability of the ranch is measured in several ways. The profitability of the ranch over the planning horizon is represented by net present value. Beginning and ending net worth provide a measure of the solvency of the ranch. Real ending net worth compared to beginning net worth measures real firm growth and overall profitability. Annual cash flow surpluses and deficits indicate the ranch's liquidity and required credit. A probability measure based on the number of solvent and insolvent iterations for each year of the planning horizon provides a measure of overall survivability. A ranch has failed the survival test when the long-term equity ratio is below .35. The ranch can no longer borrow funds to meet negative annual cash flow.

The base ranch exhibited negative expected net present value for all iterations of the analysis. Expected Ending net worth adjusted for unrealized capital gains, depreciation recapture and contingent liabilities decreased $65, 190 over the ten year planning horizon. No firm growth was realized. Mean cash flow were negative for all years of the planning horizon. The negative pressures on net worth throughout the planning horizon failed to provide needed equity and financial flexibility to support deficits as the ranch became prone to insolvency in the latter years of the planning horizon.

Financial failure occurred in the simualtion model when long-term equity ratio is below .35 and the intermediate term equity ratio is below .40. Financial failures occurred in years 7, 8, 9, and 10. The probability of survival for the Base ranch situation, for the ten year planning horizon, is 93 percent.

The results of the Base Ranch situation does indicate the importance of cash flow. Without some positive change in the economic environment and/or the system performance, the probability of ranch survival is pessimistic.

Analysis of Selected Management Plans and Economic Scenarios for the Representative Ranch

The simulation model used in this study does not simulate day to day, week to week or month to month decisions inherent in most management alternatives. However, accurate specification of changes in production and cost over time, resulting from a proposed management plan, provides useful evaluative information.

Management Plans

Price variability makes effective production and marketing decisions very difficult. Hedging is often recommended to alleviate beef price risk. A hedge-and-hold marketing plan, Management Plan 1, was developed for use in the model. The plan reduced the variability of ending net worth, net present value, and annual net cash flow, compared to the Base ranch situation. However, the change of firm survival diminished greatly. Results of the hedge-and-hold management plan indicate that in the absence of formulating realistic price expectations with regards to buying and selling cattle over time (multiple hedging) such tools may not be effective as long run stratagies. If a hedging strategy involves just hedge-and-hold over time, then hedging should not be used at all. The chance of survival for the Management Plan 1 situation is 79 percent.

Grazing systems depend on the principles of proper forage use, proper season of use, proper grazing distributions, and proper class and kind of livestock. Management Plan 2, a grazing system management plan, yielded substantial increases in profitability compared to the Base ranch situation. Increased range forage yields coupled with decreased variability of range forage yield reduced the cost of supplemental feeding in drought years. Gains in receipts were realized from increased weaning weights due to the management of the cow herd in a deferred-rest rotation grazing system and increased production per acre of summer stockers due to the intensive-early grazing system.

Management Plan 3, the combination of the hedge-and-hold marketing plan and the grazing system plan, yielded the lowest variability in ending net worth and net present value but decreased the mean values of these variables compared to Plan 2. Results of Management Plan 3 indicate the importance of developing a production and marketing plan that work together in achieving long-term goals.

Economic Scenarios

Net worth grows by the retention of profits and capital gains in the firm. The decline in land values experienced in recent years has supressed capital gains and eroded producers' expectations for growth in equity over time. Firm growth now depends more on the retention of profits.

Adjustment in the current long term trend of beef livestock prices, Economic Scenario I, indicates the Base Ranch situation would require a tenfold increase in the current long-term price trend to yield at least a 3.5 percent growth in real ending net worth compared to only 4 fold increase in the current long-term price trend for Management Plan 2 situation to yield a comparable growth in real ending net worth. The more productive ranch situation, Management Plan 2, required a less improvement in the long-term trend of beef prices to obtain a desired rate of growth.

The beef livestock industry has managed to survive over the years in the absence of agricultrual programs designed to support product price. However, in recent years, there has been so much concern over the current level of beef prices, that policy makers have considered the possibility of subsidizing product prices in the beef livestock industry.

A shift up in the current price level, Economic Scenario II, indicates that the probability of survival of the Base ranch would improve from 93 percent to 100 percent for the ten year planning horizon and that the profitability of Management Plan 2 would be greatly improved. Net cash flows improved considerably for both the Base and Management Plan 2 situation due to the intercept shift in model steer calf price level, profitability increased at an increasing rate for the more productive ranch situation, Management Plan 2.

Interval preference for ending net worth levels were estimated and used with the evaluative criterion of stochastic dominance with respect to a function to order the ranch simulation experiments. The distribution of net worth for the simulation experiments were compared for several classes of decision makers whose preference intervals was defined by the upper and lower bounds of the absolute risk aversion function. For each comparison, the efficient set of ranch situations held for all classes of decision makers.

Conclusions

The simulation model described in Chapter III is designed to relax the limiting assumption of perfect knowledge of future prices and production levels. Variation in these values can be specified by the decision maker. A decision maker has more accurate estimate of profitability, solvency, liquidity and chance of survival over time in an uncertain environment. However, the relatively large amount of input data required to obtain these results is a disadvantage for applied extension use of the model. Beginning net worth, operating and fixed cost, gross income and additional production information must be provided by the decision maker.

Repeatable stochastic variation in steer calf prices, steer calf sale weight, weaning percent, supplemental feed prices and range forage yields provides a method for analyzing whole-ranch decision problems in a stochastic environment. The simulation model can be used to determine the comparative effects of alternative management plans-economic scenarios on the profitability, solvency, liquidity, and chance of survival for a ranch situation in the Southern Plains.

Additional Research Needed

The model developed in this study evaluates the survivability for a single representative ranch situation in the Southern Plains area. Because emphasis placed on developing the conceptual and methodological framework, relatively few management plan-economic scenario situations were evaluated. Given a workable Monte Carlo simulation model for whole-ranch analysis, many questions are left unanswered. For example, what is the chance of survival of a more profitable representative ranch situation with a lower level of beginning equity? What are the effects of different owned and leased land basis for a representative ranch situation? What effect on survivability would refinancing existing debts at lower rates have on the representative ranch situation? What would be the effect of a better or worse economic scenario?

Results of this study indicate increases in livestock production per acre or per head may play important roles in terms of individual ranch survival and growth. More range and cattle production management alternatives need to be evaluated and ranked for several representative ranchs situations. One example is to evaluate the effect of different mix and type of cattle on the survivability of a ranch situation. Another example would be to quantify over time production, cost, and returns of an integrated grazing management system with cattle and sheep. Detailed evaluation of the effects of different cross breeding, artificial insemination, replacement heifer and feed reserve programs is also needed. Cyclical, seasonal, and long-term trend price estimates provide information for research evaluating multiple hedging strategies over time, under uncertainty. A detailed study of the relationship of ranch firm growth to capital structure (loan limits and interest rates)and to managerial levels would be useful to economists, policymakers, and lending institutions. The possibility of incorporating a linear programming model that can be used to maximize or minimize numerous livestock enterprise objective functions for each year of the stochastic simulation should also be considered.

The model can be used to determine the probable chance of survival of a ranch situation over time and the relative desirability of alternative management plans. Different financial, marketing and production decisions can be analyzed to determine the profitability and chance of survival under uncertainty over time. Similarly, the performance of a ranch situation can be evaluated under different economic environments.

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