A SIMULATION ANALYSIS OF A SOUTHERN PLAINS LIVESTOCK RANCH UNDER UNCERTAINTY

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CHAPTER I

INTRODUCTION

The Problem Situation

The income and financial situation in American agriculture became highly fragile in about 1980. Rapidly growing land values and expectations of continued growth in operating income and capital gains to farm assets were capitalized into land prices. Land prices have subsequently declined by 50 percent or more in some areas. Barry, Batte, Eidman and Reid (1986) reported that the percent of farms with debt-to-asset ratios above 40 percent increased from 17.7 to 22.9 percent. In addition to financial restructuring, farmers and ranchers need ways to increase cash flow and assure minimum returns sufficient for business survival. Thus, analysis of production and marketing strategies which improve the level and security of income is a prime research topic.

A steadily rising cost of production, lower product prices received by farmers and ranchers and declining asset values have created persistent economic pressure and financial difficulties for Southern Plains ranchers. A recent financial stress study by Jolly, Paulsen, Johnson, Baum and Prescott (1985), using debt-to-asset (D/A) ratio analysis shows that the intensity of financial stress is greatest in Southwest, Northeast, The Pacific, The Delta and The Southern Plains regions. In these regions nearly 19 percent of all farm operators had D/A ratios exceeding 40 percent and over 50 percent had negative cash flows. These difficulties have caused livestock producers to examine a variety of strategies as well as reorganization of the available resources in attempts to reduce risk and increase income.

In livestock enterprises, production risks include death rates of calves and mature cows, calving and weaning percentage and variation in the weight of calves produced and stocker rate of gain. (Trapp, 1986). Inflation, weather, insect, disease, technological advances, institutional changes, and unpredictable prices of inputs and outputs also create uncertainty in evaluating whole-firm decisions. It is difficult for ranchers to make decisions on production levels, technologies, and production and marketing practices that provide the best opportunity to compete, gain profit, and survive in the business.

Helmers and Atwood (1983) observed that livestock have tended to receive less emphasis in risk analysis compared to crop production. For instance, although data for prices of both crop and livestock products are readily available, production variability data for livestock enterprises are the most limiting factor when constructing crop and livestock variability measures. In this regard, Walker (1983) also noted that records and secondary data are not available for estimating variability of livestock enterprises at the firm level.

Much of the uncertainty in ranchers' income can be attributed directly to market risk or the fluctuation in cattle prices. Therefore, a proper accounting of price fluctuation is essential to determining the economic feasibility of range-beef production practices. Cycles in cattle inventories provide much of the impetus in the long run behind fluctuations in beef cattle prices. The length of a cycle is measured between successive identical stages of the cycle, such as the highest or lowest points of the cattle numbers or their prices. Historically, cattle price cycles have averaged 12 to 14 years but in more recent periods the cycle seems to be shortening to as few as 8 to 9 years (Trapp, 1986). The shortening of the cycle may be due to an improvement in physical herd management such as feeding and breeding. However, it is more likely due to the greater attention to changing economic conditions and responding to these changes to maximize profits or minimize losses.

Trapp (1986) developed an optimal flexible culling and replacement strategy for coping with cyclical cattle prices. To accomplish this, however, the feeder cattle price cycle must be anticipated by some four to six years. Both feeder cattle producers and cattle feedlot operators can benefit from a close analysis of the cattle cycle in which they are presently operating. Even though there are seasonal price variations, marketing decisions can be improved if managers know that they are in the downward side of a cycle, upward trend in the cycle, or nearing the peak of the cycle.

Vantassell (1987) studied three major business risks faced by Texas ranchers including: brush encroachment, scant and erratic rainfall, and fluctuating livestock prices. The three problems are interactive and serve to make the decision-making environment very uncertain and difficult. The cattle cycle is an important factor in determining the feasibility of range improvement practices.

Forage yield variation as a result of variability in the amount of rainfall also creates a major source of uncertainty to the rancher's decision-making process. A low level of precipitation usually results in decreased stocking rates, supplemental feeding, or leasing additional land to compensate for the reduced quality and quantity of forage.

Problem Statement

These apparent severe economic problems of farm and ranch firms encourage the researcher to undertake business analyses as close to the real decision environment as possible. Stochastic elements of livestock production and prices need to be generated and included in ranch analyses throughout the planning horizon. The rate of livestock weight gain is influenced by stocking rates and feeding practices. The gain, combined with price level, determines the receipts from sales at the end of the production period. Therefore, practices which can improve the gain can help the producer in improving the final sales. Similarly, marketing strategies may prove beneficial for the producers to reduce price risk and improve the distribution of returns.

Objectives of the Study

The major purpose of this study is to provide the tools for analyzing income potential and survivability of a ranch unit in an uncertain business environment. The model developed in this study is intended to evaluate and provide alternative strategies for representative ranching and livestock farming operations with different financial situations. Specific objectives of the study are:

1. To modify the available computerized firm simulator (FLIPSIM V) through the expansion of the livestock section to simulate a representative ranch which is subject to stochastic conditions.

2. To evaluate alternative production and marketing strategies related to the decision setting faced by ranchers, including opportunities to forward price and use within-year flexibility to adjust decisions.

3. To estimate and evaluate the ranch's financial performance as a decision aid for ranch analysis.

4. To evaluate growth potential and survivability of the representative ranch using results from runs for alternative scenarios.

Area of Study

Twelve counties representing the Southern Plains region in the Colorado-Oklahoma-New Mexico-Texas areas were selected to develop a representative ranch unit for this study (Gutierrez, 1985). A representative ranch unit was identified by the type of farm and production in the region. Figure 1 shows the study area within the Southern Plains region covering the twelve counties. Some selected farm data, which were chosen for developing the representative Southern Plains ranch for the twelve counties under study, are presented in Table I (Gutierrez, 1985.)

Organization of Remaining Chapters

The theoretical background and literature review of stochastic processes used for modeling random variables in whole-ranch simulation, as well as various risk programming models and their relevant applications, are discussed in Chapter II. Chapter III presents the conceptual framework and data development for this study. Chapter IV discusses the stochastic processes used for modeling random variables in whole-ranch simulation, and the performance measures for the representative ranch unit. The description of FLIPSIM V as well as the modified subroutines for the whole-ranch simulation model used to provide comparative measures of profitability, solvency, liquidity and survivability for the representative ranch unit are also provided in this Chapter.

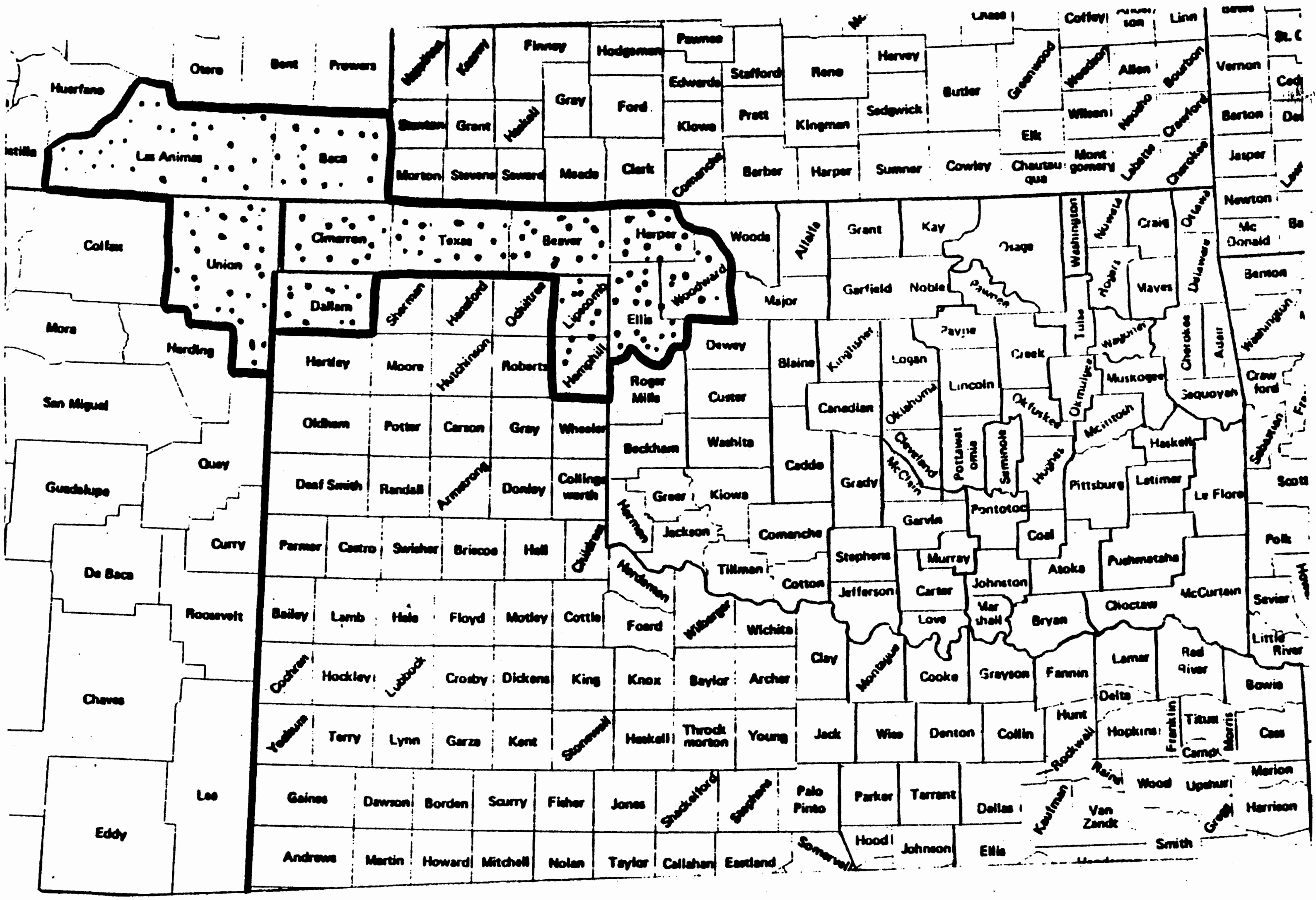


Figure 1. Map of the Southern Plains Area Under Study (dotted area)

TABLE I

SELECTED FARM DATA IN THE TWELVE COUNTIES UNDER STUDY

State and County	Number of Farms	Acres in Farms	Average Farm Size	Percent Land Area	Cropland Used for Pasture
Colorado					
Baca	643	1,283,371	1,996	78.5	35,275
Las Animas	484	2,137,550	4,416	70.0	18,534
Oklahoma					
Beaver	852	1,026,028	1,204	88.7	65,783
Cimarron	458	1,080,087	2,358	91.6	-
Ellis	612	661,929	1,082	83.9	-
Harper	529	598,517	1,131	90.0	45,507
Texas	795	1,148305	1,444	88.0	-
Woodward	733	714,512	975	89.9	47,007
New Mexico					
Union	427	2,371,067	5,553	96.7	20,373
Texas					
Dallam	378	841,456	2,226	87.3	-
Hemphill	221	618,105	2,797	100.0	22,533
Limpscomb	294	539,793	1,836	90.4	-
TOTAL	6,426				

SOURCE: U.S. Department of Commerce (1982)

The implementation, analysis, and results of this study regarding risk management strategies used to compare different financial situations, production decisions, and marketing decision making for the representative ranch are presented in Chapter V. Finally, Chapter VI concludes and summarizes the findings in this study.

CHAPTER II

THEORETICAL BACKGROUND AND LITERATURE REVIEW

Firm Responses to Risk

Robison and Barry (1987) observed that adjusting output is not always a possible risk response for a perfectly competitive firm because production processes already underway must be continued until marketing time. Similarly, economies of size may dictate continued production at a particular time. Hence, another type of risk response is needed, such as trading the risky asset for a safe one. However, the cost of exchanging risk in this manner is a lower return on the safe asset than is expected on the risky asset. Futures markets, on the other hand, allow firms to shift risk through the process of hedging without having to adjust output.

Reducing the likelihood of business and financial risks, transferring risks to other economic units, and increasing the firm's capacity to bear the consequences of risk are among risk responses expressed by firms. However, a firm's financial responses to risk are distinguished from those in production and marketing by their emphasis on a firm's risk bearing capacity (Barry and Baker, 1984). The following discusses the distinction of the two sources of risks.

Business Risk

Gabriel and Baker (1980) suggested that there is a trade-off between business risk and financial risk in the risk behavior of farmers. A decline in business risk would lead to the acceptance of greater financial risk. Business risk is the risk inherent in the firm, independent of the way it is financed. It is generally reflected in the variability of net operating income or net cash flows, and may be evaluated at a point in time based on the probability distribution of net cash flows.

Two major external sources of business risk in the agricultural firm include: (1) the market which produces price variability for both input and output, and (2) the biophysical environment which produces yield or production variability.

Furthermore, Robison and Barry (1987) described hypotheses about the firm's production and marketing decisions concerning output level (q) and its amount (h) of forward selling as follows:

$$\pi = (p+\epsilon)(q-h) + p_f h - C(q) - B \quad (2.1)$$

with expected profit:

$$E(\pi) = p(q-h) + p_f h - C(q) - B \quad (2.2)$$

and variance of profits:

$$\sigma^2(\pi) = (q-h)^2 \sigma_\epsilon^2 \quad (2.3)$$

where:

π	=	profits
$(p+\epsilon)$	=	current spot price with expected value p and variance σ_ϵ^2
q-h	=	future output sold at spot price
p_f	=	futures price
C(q)	=	variable cost to produce q
B	=	fixed costs

However, when output levels (q) are stochastic, the firm's environment is more complex. In the above case hedging reduces price risk but not output risk.

Financial Risk

Gabriel and Baker (1980) defined financial risk to be the added variability of the net cash flows to the owners of equity that results from the fixed financial obligations associated with debt financing and cash leasing. The financial risk (FR) can be represented as:

$$FR = \{\sigma_2/(cx - I)\} - (\sigma_1/cx) \quad (2.4)$$

where:

σ_1 = standard deviation of net cash flows without debt financing

σ_2 = standard deviation of net cash flows with debt financing but before the deduction of debt servicing payment

cx = expected net cash flows without debt financing

I = fixed debt servicing obligation

Assuming no leverage induced changes in business risk, the total risk (TR) is defined as:

$$TR = \{\sigma_2/cx\} \{cx/(cx - I)\} \quad (2.5)$$

Barry (1983) and Barry and Baker (1984) show another approach in defining the total risk where business risk (BR) and financial risk (FR) combine to determine total risk (TR) in a multiplicative way as:

$$TR = (BR) (FR) \quad (2.6)$$

Following Eidman (1983), if financial risk is an important source of total risk and when the trade-offs between business risk and financial risks are important to producers, consideration of financial risk will be important in modeling farm firms. Thus the major concern is with estimating total risk as measured by $\sigma_2{}^2$ and other moments of the distribution and by incorporating the appropriate estimates in the usual programming and simulation models of farm firms. Furthermore, business risk and financial risk can be calculated based either on net operating income or net cash flows. The calculations based on net operating income can be represented by the following equations:

$$EBIT = \sum_j (P_j - V_j)\, X_j - F - D - L \tag{2.7}$$

$$EAIT = EBIT - I - T \tag{2.8}$$

where:

P_j	=	average price per unit of product j
X_j	=	amount of product j sold
V_j	=	average variable cash cost per unit of product j
F	=	fixed cash cost of operating the firm
D	=	the economic depreciation
L	=	the minimum family withdrawal for consumption
EBIT	=	operating earnings before interest and taxes
I	=	interest on debt capital
T	=	income tax payment
EAIT	=	operating earnings after interest and taxes

In comparing the two approaches, it can be seen that the first one removes depreciation, but does not remove principal payments. The opposite is true for the second approach. If depreciation is a constant, all moments of the distribution of business risk except the mean will be the same whether they are based on variation in EBIT or variation in NBPT. Similarly, if principal payments are constant, all moments of total risk except the mean will be the same whether they are based on variation in EAIT or NAPT.

Since the variability of EBIT depends on the variability of P_j, X_j, and V_j, the probability distribution of EBIT can be considered as a measure of business risk. An alternative way is with data on net cash flow as presented in the following equations:

$$NBPT = \sum_j (P_j - V_j) X_j - F - L \qquad (2.9)$$

$$NAPT = NBPT - I - P - T \qquad (2.10)$$

where:

NBPT = net cash flow before debt servicing payments and taxes

NAPT = net cash flow after debt servicing payments and taxes

P = required principal payments

Therefore, selection of consistent methods to calculate business risk and financial risk is important when these measures are expressed as a ratio of the standard deviation divided by the expected value.

Risk Analysis for Farms and Ranches

Current problems in farm and farm-related businesses encourage study of how firms do or can operate through time to attain goals. An example of the situation, given by Helmers and Atwood (1983), shows that the existence of profit potential can lead the firm to expand and have the means to increase net worth. At the same time, however, growth can increase the vulnerability of the firm to financial insolvency if the firm expands using debt resources. Agricultural producers view their business environment in a multiperiod fashion where safety-first considerations are emphasized. However, many analyses do not consider the time dimension, such as the path of firm returns across time. On the other hand, a normative or positive analysis is difficult to conduct without considering the order that events affecting the firm occur in time. Therefore, during the analysis it is important to integrate income, balance sheet, and cash flow considerations across time (Walker, Bernardo, and Gutierrez, 1986).

The existence of farm and ranch firms in a continually changing environment and imperfect knowledge makes subsequent decisions directly affected by the previous decisions. Gutierrez (1985) considered this reason to suggest that many ranch management decisions can only be evaluated properly in terms of the whole-ranch situation across time.

Risk Attitudes

To understand the effects of direct risk attitudes on decision choices in a risky environment, it is important to know a decision maker's risk attitude as reflected by the characteristics of his utility function, U(y). The general distinction commonly made between the risk attitudes of individual decision makers is based on the shape of their utility functions defined with respect to wealth or monetary outcome.

Robison and Barry (1987), for example, suggested the bending rate as a measure of risk attitude. A unique measure of the direction of bending of U(y) and the rate of change in the slope of the function is the absolute risk aversion function. Pratt (1964) defined this measure as:

$$R(y) = -\{U''(y)\}/\{U'(y)\} \tag{2.11}$$

where U'(y) and U"(y) are the first and second derivatives of Von Neuman-Morgenstern utility function U(y).

Following King and Robison (1981), 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 implies a concave utility function. $R(y) > 0$ implies the decision maker is risk averse. Similarly for $R(y)=0$ for risk neutral, and $R(y) < 0$ for risk preference decision makers. As an example, $R(y)$ within an interval of 0.001 to 0.01 is considered to exhibit a risk averse decision maker.

The rate of bending of function $R(y)$ has proven useful in classifying decision makers' risk attitudes. For example, the sign of $R'(y)$ indicates how risk attitude changes as y increases. If $R'(y) < 0$, that is the most usual assumption, decision makers are said to display decreasing absolute risk aversion (DARA). Similarly, $R'(y)=0$ indicates constant absolute risk aversion (CARA), and $R'(y) > 0$ indicates increasing absolute risk aversion (IARA).

Decision Models

Static economic analysis is based on the assumption of certainty about the environment and an objective of profit maximization. These concepts are extended when risk is introduced into the decision-makers' perception about their attitude toward risk. Some empirical studies which analyzed production, marketing, and financial alternatives under risky environments are presented along with the appropriate mathematical formulation in this section.

Safety First Rules. Safety first rules specify that a decision maker first satisfies a preference for safety, or a risk constraint, in selecting among action choices, and then follows a profit-oriented objective (Young, 1984). This concept is often implied as a chance of loss and the model is specified as:

$$P(\pi < d) < \alpha \qquad (2.12)$$

where π is stochastic income for an action and d is a threshold or disaster level of income to be met with probability α. Figure 2 illustrates chance of loss (α_i) as a measure of risk (π<d).

Expected Utility Maximization. Following Selley (1984), the theory of profit maximization is extended to incorporated risk by assuming that decision makers are maximizing expected profit. In a discrete distribution, it is defined as:

$$E(M) = \sum_{k} M_k P(M_k) \tag{2.13}$$

where M_k is k^{th} level of profit, $P(M_k)$ is probability of k^{th} level of profit, and E(M) is the expected profit.

Moreover, expected profit maximization assumes that the decision maker's satisfaction is measured by the level of profit, although this assumption is inappropriate for the decision maker with diminishing marginal utility for profit. In fact, maximization of expected profit is a special linear case of the more general maximization of expected utility such as:

$$E\{U(M)\} = \sum_{i} U(M_i) P(M_i) \tag{2.14}$$

which is also represented by Young (1984), in the following relationship:

$$(EU)_j = \sum_{i=1}^{n} U\{\pi(\theta_j, a_j)\} P(\theta_j) \tag{2.15}$$

where $\pi(\theta_j, a_j)$ represents the income level of the i^{th} state of nature (θ_j), and j^{th} action (a_j); $U\{\pi(\theta_j, a_j)\}$ represents the utility equivalent of this income level, and $P(\theta_j)$ denotes the probability of occurrence of the i^{th} state of nature.

For a linear utility function such as $U(M_i) = a + bM_i$, the expected utility can be expressed as:

$$E\{U(M)\} = \sum_{i} U(M_i) P(M_i) \tag{2.16a}$$

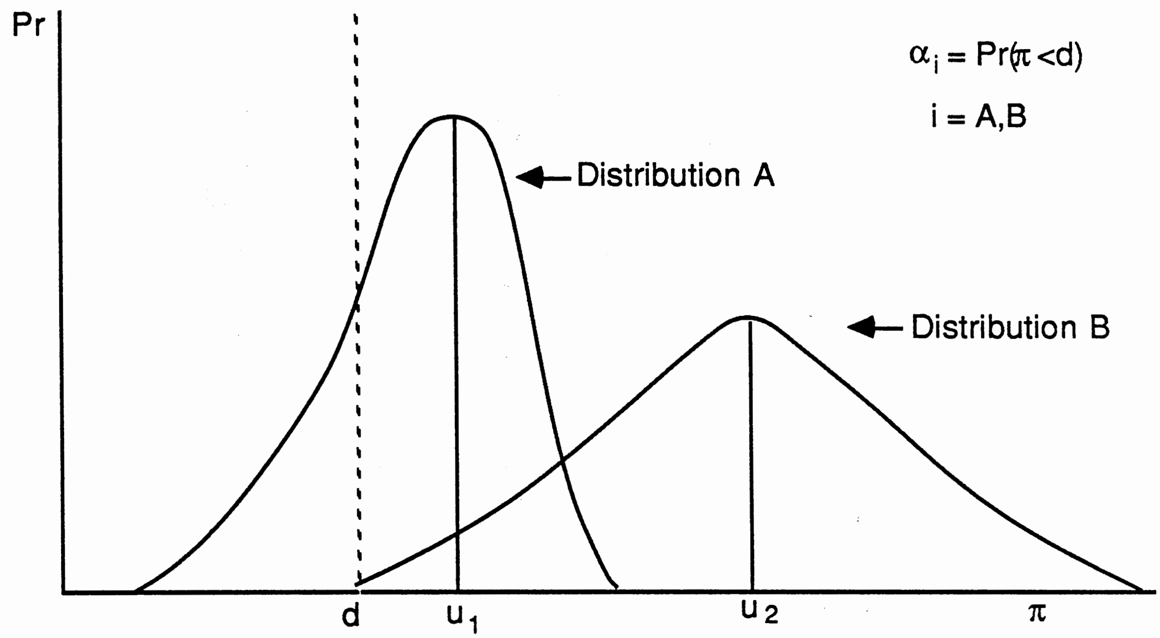


Figure 2. Chance of Loss as a Measure of Risk with $\alpha_A > \alpha_B$

$$= \sum_i (a + bM_i) P(M_i) \tag{2.16b}$$

$$= \sum_i P(M_i) + b \sum_i M_i P(M_i) \tag{2.16c}$$

$$= \quad a + b\, E(M) \tag{2.16d}$$

Therefore, maximizing {a + b E(M)} for b > 0 is equivalent to maximizing E(M) in equation (2.13).

Mean-Variance Models. Markowitz (1959) developed the mean-variance (EV) model as the efficient set of farm plans that can be derived from quadratic programming. He first defined the variance of total gross margin as:

$$V = \sum_i \sum_k X_j X_k \sigma_{jk} \tag{2.17}$$

where X_j denotes the level of the j^{th} farm activity, and σ_{jk} denotes the covariance of gross margins between the j^{th} and k^{th} activities (σ_{jk} = variance, when j=k).

To obtain the efficient EV set, it is required to minimize V for each possible level of expected income E, while retaining feasibility with respect to the available resource constraints. The relevant programming model is:

$$\min V = \sum_i \sum_k X_j Xk\, \sigma_{jk} \tag{2.18}$$

$$\text{such that: } \sum_i c_j X_j = \tau \tag{2.19}$$

$$\sum_i aij\, X_j < b_i \text{ for all i} \tag{2.20}$$

$$X_j > 0 \text{ for all j} \tag{2.21}$$

where c_j denotes the expected gross margin of the j^{th} activity, and τ is a scalar. The model is solved by a quadratic programming algorithm since equation (2.18) is quadratic in X's.

Scott and Baker (1972) presented the quadratic programming-risk aversion model in the matrix notation as:

$$\text{Maximize } Z = U'X - \delta \; X'WX \tag{2.22}$$

$$\text{subject to } AX < B \tag{2.23}$$

where:

U = a vector of mean incomes for the activities

X = a vector of activities

δ = a scalar for risk aversion coefficient

W = the variance - covariance matrix of the activity incomes

A = the matrix of input-output coefficient for the activities, and

B = the vector of resource restrictions

When δ is zero, the solution gives the combination producing the maximum mean income possible with the given restriction set and is the same as the linear programming solution.

When δ is large, only a small income is produced, low levels of activities are activated, and most resources are idle. Parameterizing δ will give the (EV) efficient frontier.

<u>Mean-Absolute Deviation Model</u>. Hazell (1971) developed a procedure for determining a risk efficient set through the minimization of the total absolute deviation (MOTAD), as the objective function in a linear programming model. It is also called EA criterion for the income-mean absolute deviation. The following is the mathematical formulation for MOTAD:

$$\min \sum_{k=1}^{n} M_{k-} \tag{2.24}$$

subject to:

$$\sum_{i=1}^{n} (C_{kj} - g_j) X_j - M_k -> 0 \text{ for all } k \tag{2.25}$$

$$\sum_{i=1}^{n} e_j X_j = \tau \qquad 0 < \tau < E_{max} \tag{2.26}$$

$$\sum_{i=1}^{n} a_{ij} X_j < b_j \qquad \text{for all i} \qquad (2.27)$$

$$X_j, M_k^- \geq 0 \qquad \text{for all k, j} \qquad (2.28)$$

where:

M_k^- = absolute values of the total gross margin deviations

n = number of years of sample deviation

c_{kj} = the gross margin for the j^{th} activity on the kth sample observation

g_j = the sample mean of gross margin for the j^{th} activity

X_j = the level of the j^{th} activity

e_j = the expected gross margin of the j^{th} activity

a_{ij} = the requirement of activity j^{th} from resources i

τ = the expected total gross margin which can be specified between zero and maximum expected total gross margin, E_{max}, at the basic linear programming solution.

Mapp, Hardin, Walker, and Persaud (1979) presented the MOTAD model for developing risk efficient farm plans, using matrix notation as:

$$\text{Minimize } \Sigma d^- \qquad (2.29)$$

$$\text{Subject to:} \quad AX < B \qquad (2.30)$$

$$DX + Id^- > 0 \qquad (2.31)$$

$$C'X = \tau \qquad (2.32)$$

$$X, d^-, \tau > 0 \qquad (2.33)$$

where:

X = activity levels

A = resource requirements

B = resource availabilities

C = gross margin expectations

D = the matrix of deviations

d^- = yearly total negative deviations over all activities

Tauer (1983) proposed Target MOTAD, as a modification of the MOTAD. Here returns are defined as the product of the sum of the expected return of activities and individual activity level, and risk is measured as the expected sum of the negative deviations of the solution results from target return level. Target MOTAD model is formulated as:

$$\max E = \sum c_j X_j \quad (2.34)$$

subject to:

$$Y_o - \sum_i c_{jt} X_j - Zt - < 0 \text{ for all } t \qquad (2.35)$$

$$\sum_t P_t Z_t - = \tau \qquad (2.36)$$

$$\sum_j a_{ij} X_j < b_i \quad \text{for all } i \qquad (2.37)$$

$$X_j, Z_t- > 0 \qquad \text{for all } j, t \qquad (2.38)$$

The Z_t^- variables in (2.35) measure the value of any deviations in income below the target. By parameterizing τ, a set of efficient farm plans is obtained which for any given level of compliance with the target income, measured by $\sum p_t Z_t^-$, have the maximum possible value of E. Farmers who are most concerned about survival might well choose the plan having the smallest possible value of $p_t Z_t^-$.

Pederson and Bertelsen (1986) represented the Target MOTAD model in matrix notation as:

$$\text{maximize} \quad E(R)X = RX \qquad (2.39)$$

$$\text{subject to:} \quad AX < B \qquad (2.40)$$

$$RX + d^- > T \qquad (2.41)$$

$$Pd^- < D \qquad (2.42)$$

$$X, d^- > 0 \tag{2.43}$$

where:

X	=	n x 1 vector of activity levels
R	=	1 x n vector of expected returns for each activity
A	=	k x n vector of resource requirements
B	=	k x 1 vector of resource constraints
T	=	m x 1 vector with each element equal to the target
R	=	m x n matrix of returns for each activity
d^-	=	m x 1 vector of negative deviations from target
P	=	1 x m vector of probabilities for each target
D	=	a scalar parameterized from zero to large number
n	=	number of activities
m	=	number of observation
k	=	number of constraints

Simulation Models

Banks and Carson (1984) define simulation as the imitation of a real-world process or system over time which generates an artificial history of a system. The observation of that artificial history draws inferences concerning the operating characteristics of the real system. Furthermore a system is defined as a group of objects that are joined together in some regular interaction or interdependence toward the accomplishment of some purposes. An entity is an object of interest in the system, and an attribute is a property of an entity. The state of a system is defined to be that collection of variables necessary to describe the system at any time, relative to the objectives of the study. An event is defined as an instantaneous occurrence that may change the state of the system. The term endogenous is used to describe activities and events occurring within a system, and the term exogenous is used to describe activities and events in the environment that affect the system. Simulation is used as an analysis tool for predicting the effect of changes to an existing system and as a design tool to predict performance of a new system under varying sets of circumstances.

A simulation model seeks to duplicate the behavior of the system under investigation by studying the interactions among its components. The output of the simulation model is normally presented in terms of selected measures that reflect the performance of the system. Simulation runs may be treated as statistical experiments.

Manetsch and Park (1974) define simulation as a technique for obtaining a particular time solution of a mathematical model corresponding to specific assumptions regarding model inputs and values assigned to parameters. Unlike mathematical models, where the output of the model represents a long-run steady-state behavior, the results obtained from running simulation models are observations from a distribution of such observations. This means that any inference regarding the performance of the simulated system must be subject to all the appropriate tests of statistical analysis. By expressing the interactions among the components of the system as mathematical relationships, the necessary information can be gathered in very much the same way as for the real system.

Mapp and Helmers (1984) suggested that probabilistic results from simulation may be presented to decision makers to show the likelihoods that risk management strategies will maintain income above a critical level. An elicited utility function or subjective evaluation by the producer may be used to select desirable outcomes, or stochastic dominance criteria may be used to identify risk efficient farm plans.

Gutierrez (1985) demonstrated and implemented some modifications on simulation model REPFARM, an earlier version of FLIPSIM V, to allow cattle ranch analysis within a stochastic framework using triangular distributions. The modifications include: stochastic steer calf prices, steer calf sale weights, and weaning percents for five cow-calf and five stocker enterprises. Interval preferences for ending net worth levels were estimated and used with the evaluation criterion of stochastic dominance with respect to a function used to order the ranch simulation results. The distribution of net worth from the simulation experiments were compared for several classes of decision makers whose preference intervals are defined by the upper and lower bounds of the absolute risk aversion function.

Vantassel (1987) used financial and accounting routines of FLIPSIM V to accommodate a simulation model RANGE which is basically driven by a simulated climatic environment that directly influenced cattle supplementation levels, cow and calf weights, weaning dates, and range conditions. The model assessed cumulative environmental conditions at selected decision dates and assigned cattle production parameters depending upon certain decision criteria. The resulting combined model RANGE and FLIPSIM V is a new model called RANSIM. Cash receipts, variable expenses, and financing requirements were passed from RANGE to FLIPSIM V, while overall financial conditions of the ranch were passed back to RANGE from FLIPSIM V for use in decision analysis.

Comparison of Alternative Models

Following Taha (1982), a distinct difference exists between the optimization of well-defined mathematical models and simulation models. In a mathematical model, the optimization problem is expressed in terms of explicit mathematical functions of the decision variables. The optimization problem is then solved to yield the values of the decision variables that optimize the model's objective function. In this respect, the optimum values of the decision variables are the output of the mathematical model. Simulation models, on the other hand, usually are not constructed in the framework of an optimization process. A simulation model merely measures the output of the system for predetermined values of the decision variables. This means that the values of the decision variables are considered part of the input data. The implementation of an optimization process within the context of simulation can be achieved by systematically changing the values of the decision variables and then measuring the output by making proper simulation runs. The nature of simulation, therefore, allows greater flexibility in representing complex systems that are normally difficult to analyze by standard mathematical models. However, the development of a simulation model is costly and time-consuming, particularly during the process of optimizing the simulated system.

In general, non-optimizing procedures such as simulation have more flexibility in the representation of the whole-farm problem over time and may be an appropriate tool compared to the optimization procedures described in the preceding section. Simulation offers the phenomena of modeling feedback and adaptive control processes that characterize many risk responses. Hence, solutions can be revised by adding new information into the model. Since many risk analyses are concerned with identifying actions that will be optimal according to some criteria, the stochastic dominance criteria discussed earlier can be used to order the simulation results into efficient and inefficient sets for a more orderly selection of an optimal solution by a decision maker.

According to Anderson, Dillon and Hardaker (1977), simulation will not be essential when all the distributions are normal, as has often been presumed in empirical studies, since computing the means and variances analytically describe the environment succinctly and completely. On the other hand, in the many situations when risk is other than normal and utility is other than quadratic, appraisal only by means and variances and covariances may not be adequate to indicate optimal decisions. Continuous and discrete distributions other than the normal are readily accomodated in stochastic simulation and can range from convenient theoretical distributions such as the Beta, Gamma, and Poisson to quite arbitrary empirical distributions. Clements, Mapp, and Eidman (1971) provided a procedure for correlating events in farm firm simulation analysis.

In many risk applications, simulation techniques have been used to understand the impacts of uncertain yields and prices on farm income, net worth, short and long-term credit requirements, or consumption in a given year. Simulation models may contain linear programming components to determine optimal production plans and to simulate the organizations operating under risky conditions. The impact of risk responses such as crop insurance, disaster or deficiency payments, or hedging and forward contracting may be evaluated under different assumptions about beginning net worth, critical debt-to-asset ratios, or future economic conditions (Mapp and Helmers, 1984).

Simulation modeling of stochastic processes permits greater realism in the representation of underlying probabilities of diverse random variables. In relation to this aspect of simulation, Trapp and Walker (1985) demonstrated a means to provide the required realism and flexibility needed in the application of the production theory through biophysical simulation modeling for beef cattle production.

Estimating Distribution Functions

Production Distribution. Taylor (1984) presented a hyperbolic trigonometric (HT) transformation procedure for empirically estimating a cumulative probability distribution function (cdf) for cotton and corn yields conditional on the fertilizer levels. The probability density function (pdf) can be obtained by differentiation. The transformation of a hyperbolic tangent is given by the following expression:

$$F(Y|X) = 0.5 + 0.5 \tanh [P(Y,X)] \tag{2.44}$$

where F(Y|X) is the cdf of Y conditional on X, and P(Y,X) is a polynomial function of Y and X or a polynomial function of a transformation of Y and X such as lnY and lnX. For any value of P(Y,X), transformation of (2.44) constraints F(Y|X) to the interval zero-one. Figure 3 shows that since tanh u has one inflection point, the transformation allows for the traditional bell-shaped pdfs.

The differentiation of (2.44) with respect to Y, for the maximum likelihood estimation, gives the conditional pdf such as:

$$f(Y|X) = 0.5\, P'(Y,X)\, \text{sech}^2 [P(Y,X)] \tag{2.45}$$

where f(Y|X) is the conditional pdf and P'(Y,X) is the derivative of P(Y,X) with respect to Y.

The transformed cdf can be fitted with ordinary least squares (OLS) regression. Although OLS estimates are biased and inconsistent, they are usually very close to ML estimates, therefore, the use of OLS estimates as starting values facilitates the numerical search procedures to obtain ML

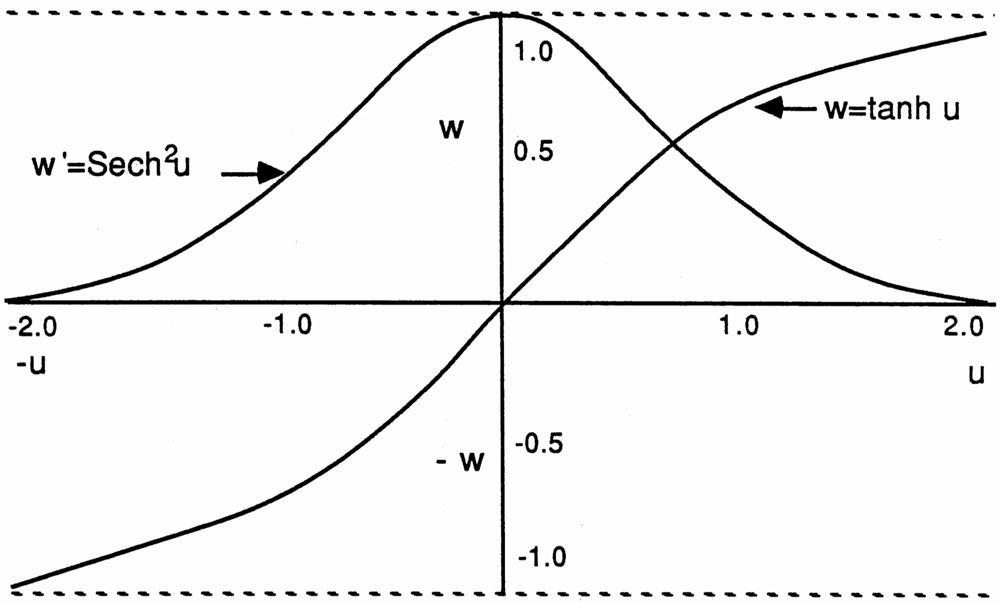


Figure 3. The Hyperbolic Tangent and Its Derivative, the Square of the Hyperbolic Secant

estimates which have desirable asymptotic properties. The advantage of this procedure as compared to alternative procedures for fitting probability functions is that it yields an explicit expression of the cdf and thus the pdf.

As in many empirical decision analyses, the expected value of Y given X is particularly desirable, such as the estimation of the production function of pasture yield conditional upon rainfall. Once the parameters of P(Y,X) are obtained, the conditional expectation of Y can be presented by:

$$\int_{-\infty}^{\infty} E(Y|X) = y[0.5\, P'(y,X)\mathrm{sech}^2\, [P(y,X)]\, dy \qquad (2.46)$$

Following Anderson, Dillon, and Hardaker (1977), variates of any distribution can in principle be sampled in the inverse cdf method by projecting a uniform variate on the cumulative probability scale through the cdf to the scale of the specified random variable. The projection process is illustrated graphically in Figure 4, where for a particular value of a uniform variate such as d, the corresponding variate of the specified random variable is e.

Price Distributions. Alternative price distributions have been considered in several studies using Monte Carlo simulation. Bailey, Brorsen, and Richardson (1984) used an autoregressive moving-averages (ARMA) model approximated by a higher order of autoregressive (AR) for estimating cash and futures cotton price distribution. Gutierrez (1985) in simulation model REPFARM and Vantassel (1987) in RANSIM used a harmonic sine-cosine function developed by Franzmann and Walker (1972) for estimating livestock price distributions for the planning horizon. Park and Tomek (1988) provided results from incorporating composit price forecasting in a Monte Carlo simulation for predicting slaughter steer and soybean oil prices. These applications considered that the time series model component provided an estimate of

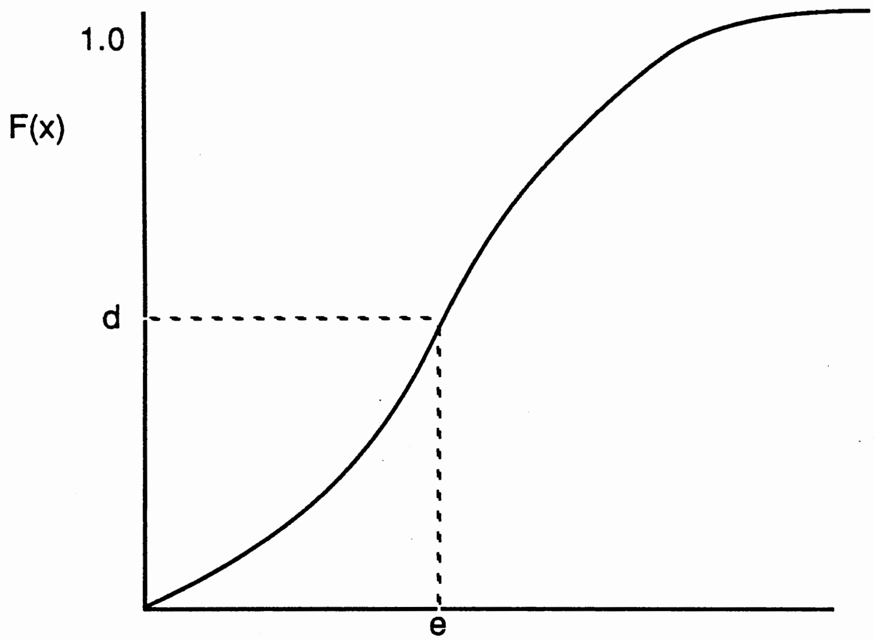


Figure 4. Projection Process on CDF for Drawing Random Variates

average prices, while the covariance component provided a multivariate probability distribution about the means.

A number of other studies, such as those done by Leuthold, MacCormick, Schmidtz, and Watts (1970), Brandt and Bessler (1981), Rausser and Carter (1983), Helmers (1979) and Bailey, Brorsen, and Richardson (1984), have used time series models to forecast daily cash and futures prices. The first four studies were interested only in deterministic forecasts while the latest incorporated futures prices into a firm level simulation model using daily average futures price.

In regard to the time series model, Hanke and Reitsch (1981) classified and described time series forecasting models into six different methods as follows:

(1) Decomposition method. This method incorporates explanatory forecasting that assumes a cause and effect relationship between time and the output of a system. The system is decomposed into four components such as trend, seasonal, cyclical and irregular.

(2) Method of moving-averages. This method eliminates randomness in a time series and forecasts based on projection from time series data smoothed by a moving average, taking into account trends, seasonal, cyclical, and irregular variations.

(3) Exponential smoothing method. This method is similar to moving averages but averages are weighted exponentially, giving more weight to the most recent data.

(4) Autoregressive models. In these models economic variables are employed in order to account for relationships between adjacent observations in a time series.

(5) Method of adaptive filtering. This method is similar to moving averages and exponential smoothing, but uses the iterative method to determine the best weights.

(6) The Box-Jenkins (ARIMA) techniques. These techniques do not assume any particular pattern in the historical data of the series to be forecasted and also use an iterative approach to identify a possibly useful model from a general class of models.

Autoregressive moving-average (ARMA) models, such as the Box-Jenkins techniques, are a specialized but highly powerful class of linear filtering techniques by which a random input is filtered so that the output represents the observed or transformed time series. Lavenbach and Cleary (1984) believed that autoregressive (AR) models were used by Yule in 1927, the moving-average (MA) model was introduced by Slutsky in 1937, while the autoregressive moving-average (ARMA) theory, in which these models are combined, was developed by Wold in 1954.

The ARIMA (Autoregressive Integrated Moving-Average) models have also proved to be excellent forecasting models for a wide variety of time series where in many studies, according to Makridakis, Wheelright, and McGee (1983), simple ARIMA models have frequently outperformed larger, more complex econometric systems for a number of economic series.

Many studies above observed that the best results from the application of the time series model are usually obtained when at least five to ten years of monthly data are available, particularly if the series exhibits strong seasonality.

Time series models of cash and futures prices appear a feasible choice to model the underlying stochastic process. The cash and futures prices are expected to be intertemporally correlated and the autocovariance function of a variable is a combination of both intertemporal decay and truncation. For example, autocovariance becomes zero after (p) time period. According to Hanke and Reitsch (1981), the model may be expressed as an autoregressive moving-average, ARMA (p,q) as follows:

$$Y_t = \Sigma\, a_i\, Y_{t-i} + \Sigma\, b_j\, e_{t-j} + u_t \qquad (2.47)$$

which is a combination of an autoregressive model (AR) of the form:

$$Y_t = \Sigma\, a_i\;\, Y_{t-i} + e_t \qquad (2.48)$$

and a moving average model (MA) of the form:

$$Y_t = \Sigma\, b_j\;\, e_{t-j} + e_t \qquad (2.49)$$

where:

Y_t = dependent variable

Y_{t-i} = independent variables that are dependent variable lagged p-time periods

a_i = regression coefficients

e_t = residual term that represents random events not explained by the model

b_j = weights

e_{t-j} = previous values of the residuals of q-period

u_t = error term

Furthermore, a general ARIMA model involving seasonal effects can be represented by ARIMA (p,d,q) (P,D,Q), suggested by Makridakis, Wheelwright, and McGee (1983), as follows:

$$\text{ARIMA } (p,d,q)\ (P,D,Q)^s \qquad (2.50)$$

where:

p = period of nonseasonal autoregressive (AR)

q = period of nonseasonal moving-averages (MA)

d = degree of nonseasonal differencing

P = period of seasonal autoregressive (SAR)

Q = period of seasonal moving-averages (SMA)

D = degree of seasonal differencing

s = number of periods per season

A useful notational device in representing the ARIMA model is the backward shift operator, B, which is convenient for describing the process of differencing, expressed as follows:

$$B\,Y_t = Y_t - 1 \qquad (2.51)$$

Where B, operating on Y_t, has the effect of shifting the data back one period. For example, a data series that is collected quarterly, with AR(1), MA(1), SAR(1), SMA(1), with first degree nonseasonal differencing first degree seasonal differencing, and number of periods per season equal to 4, can be represented in the general ARIMA model with seasonal effect of the form ARIMA $(1,1,1)(1,1,1)^4$ as follows:

$$(1\text{-}\alpha B)\ (1\text{-}\beta B^4)\ (1\text{-}B)\ (1\text{-}B)^4\ Y\text{-}t = (1\text{-}\tau B)\ (1\text{-}\delta B^4)\ e_t \qquad (2.52)$$

where the terms within brackets on the left side of the equation represent nonseasonal AR(1) with coefficient α, seasonal SAR(1) with coefficient β, nonseasonal difference, and seasonal difference, respectively. Terms within brackets at the right side of the equation represent the nonseasonal MA(1) with coefficient τ, and seasonal SMA(1) with coefficient δ, respectively.

Equation (2.52) can be written in the general unscrambled form by multiplying out all terms, hence eliminating the B operators, as follows:

$$Y_t = (1+\alpha)\ Y_{t-1} + (1+\beta)\ Y_{t-4}\ (1+\alpha+\beta+\alpha\beta)\ Y_{t-5} + (a+\alpha\beta)\ Y_{t-6}$$
$$-\beta Y_{t-8} + (\beta+\alpha\beta)\ Y_{t-9} - \alpha\beta\ Y_{t-10} + e_t - \tau\ e_{t-1} - \delta e_{t-4} + \tau\ \delta e_{t-5} \qquad (2.53)$$

Box and Jenkins (1976) suggested a procedure that involves three separate stages for applying ARIMA techniques: 1) model identification, 2) model estimation and testing, and 3) applying the model.

The identification stage determines whether or not the series is stationary. Non-stationary data can be in terms of mean or both mean and variance. Figure 5 through 7 illustrate the time series data showing a random process (Figure 5), a process that is non-stationary in the mean (Figure 6), and a process that is non-stationary in both the mean and the variance (Figure 7). The stationarity condition can be obtained through the differencing method at a specified degree to the non-stationary data. That is, a new series is created with a new observation where $Y_t = Y_t - Y_{t-d}$, where d is the specified degree of differencing. Once the stationary series has been obtained, the form of the model to be used must be identified by comparing the autorelation function (ACF) and partial autocorrelation function (PACF) plots of the data to be fitted. Furthermore, plots of the ACF and PACF can visually be checked for tentatively determining the order of AR and MA processes, for example, a 95% confidence level of the series can be considered random if the calculated autocorrelation coefficients are within $0.0 \pm Z\ (1/\sqrt{N})$, where N is the total number of observations.

The stage of model estimation and testing of model adequacy includes the estimation of the parameters of the model as well as checking for adequacy of the model before it is used for forecasting. The model is considered adequate if only a very few error term autocorrelations are significantly different from zero. If these autocorrelations are large, the procedure should return to the first stage. Adequacy checking for the model can also be implemented by a Chi-square (X^2) test on the autocorrelations of the residuals. The test statistic is as follows:

$$Q = (N - d) \Sigma \phi^2_i (e) \qquad (2.54)$$

which is approximately distributed as a Chi-square with k-p-q degrees of freedom, where in this equation:

N = length of time series

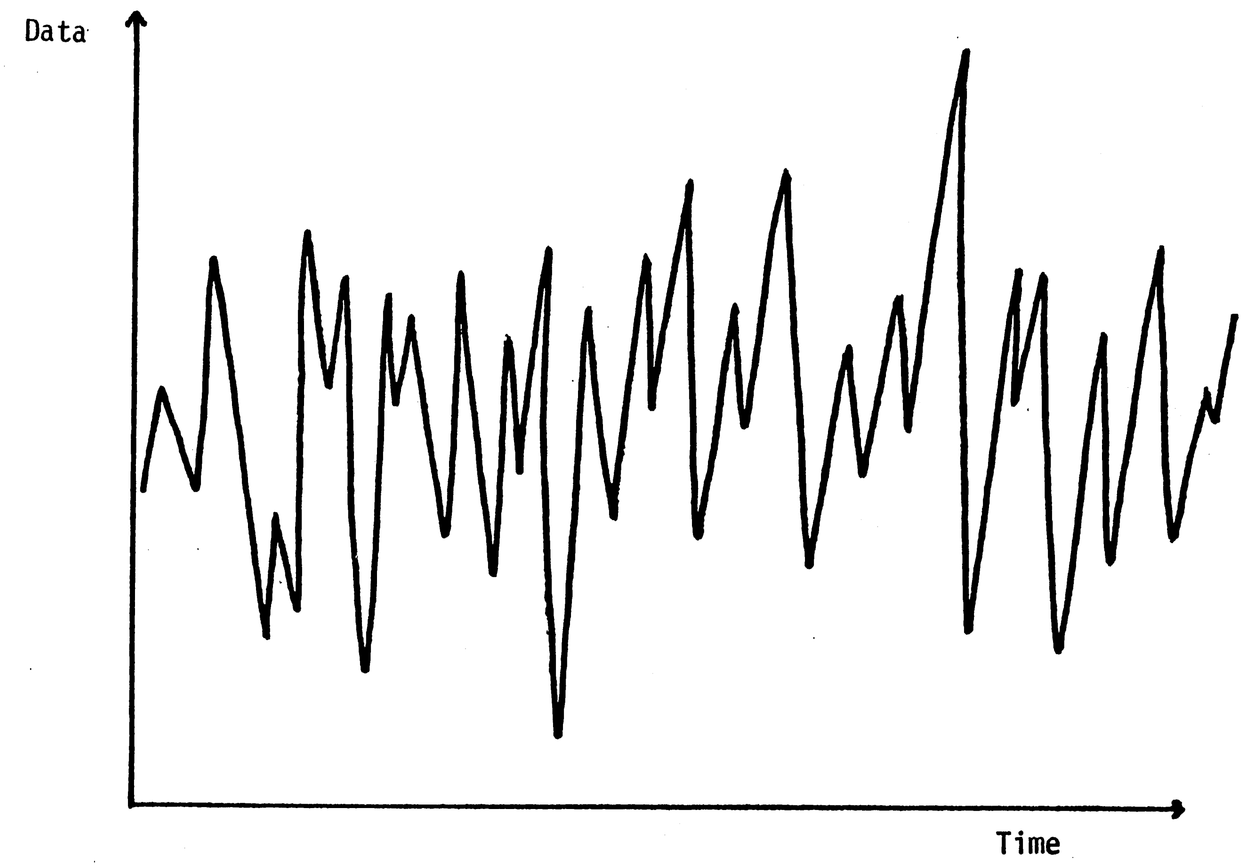


Figure 5. Illustration of Time Series Data Showing a Random Process

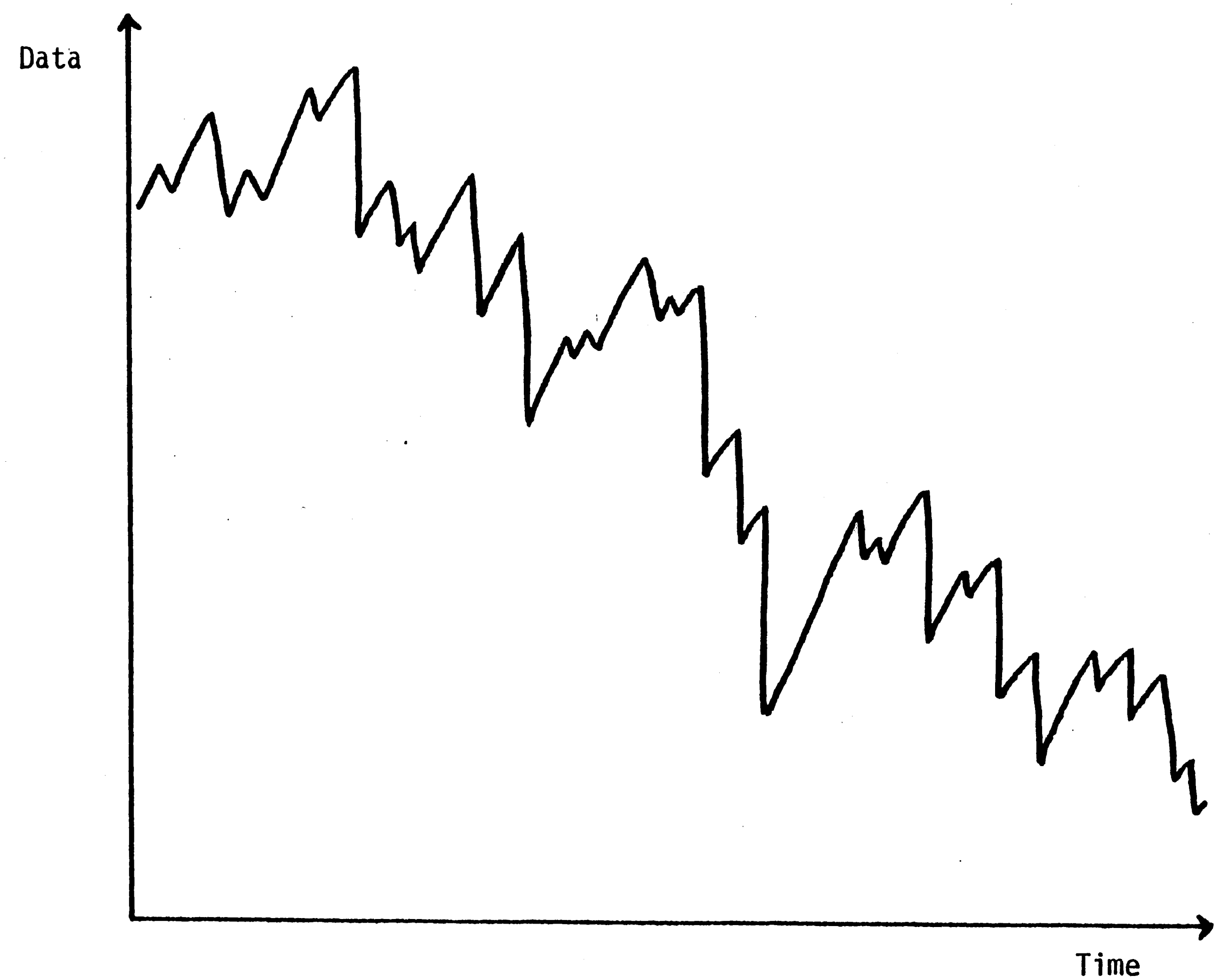


Figure 6. Illustration of Time Series Data Showing a Non-Stationary Process in the Mean

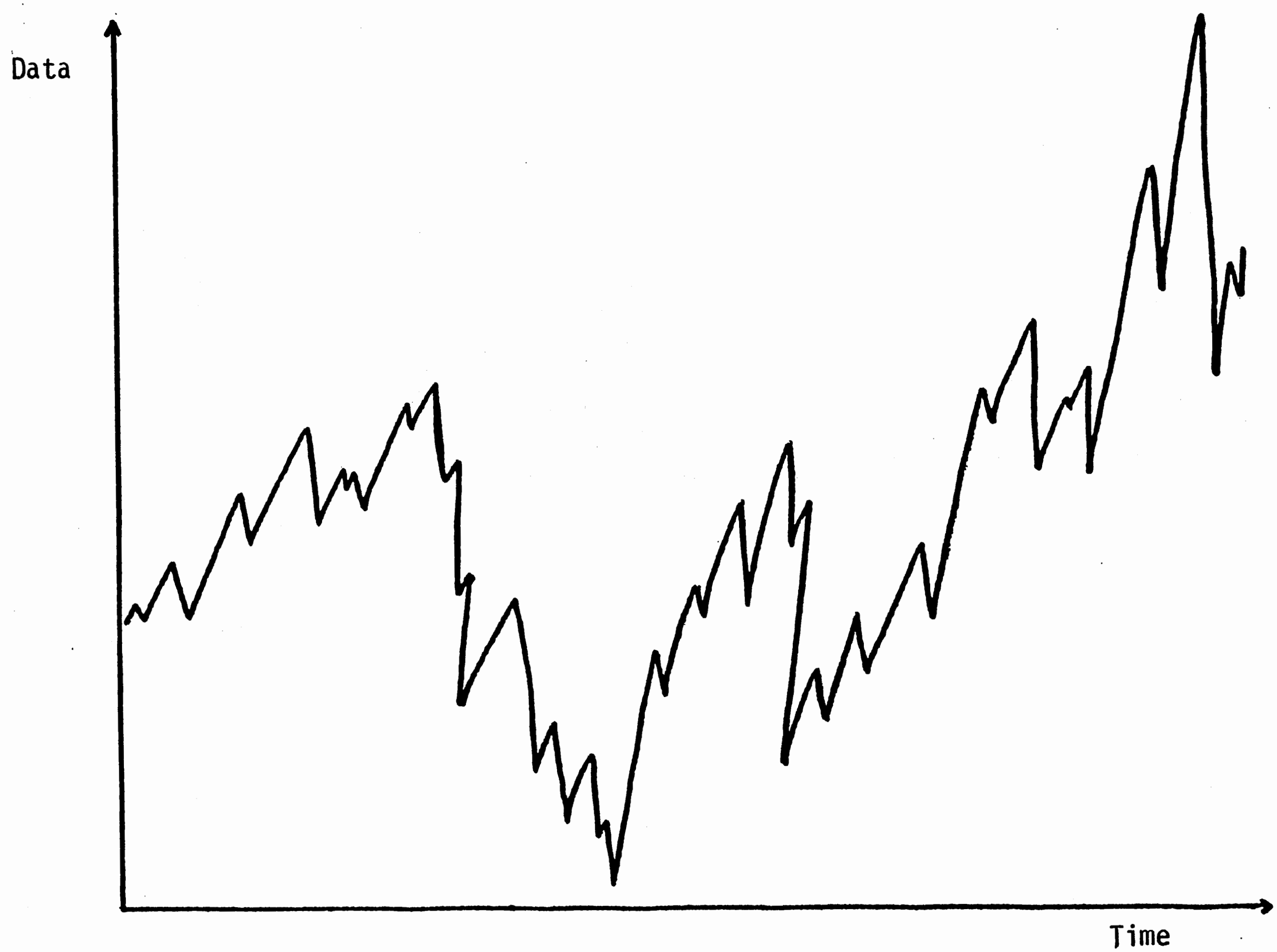


Figure 7. Illustration of Time Series Data Showing a Non-Stationary Process in Both Mean and Variance

k = first k autocorrelations being checked

p = number of autoregressive (AR) terms

q = number of moving average (MA) terms

ϕ_i (e) = sample autocorrelation function of the i^{th} residual term

d = degree of differencing to obtain a stationary series

If the calculated value of $Q > X^2$ for k-p-q degrees of freedom, the model is considered inadequate and the procedure should return to the first stage until a satisfactory model has been found.

In the forecasting stage, the procedure first compares several models that are considered adequate. For example, if AR(1) is considered adequate, we should try ARMA (1,1) without differencing and ARMA(1,1) with differencing. The three models are compared in terms of Chi-square (Q) tests on residuals, degrees of freedom, forecast error, range of residuals, variance of residuals, autoregressive (AR) parameters and moving average (MA) parameters. The simpler model (parsimony) should be chosen if comparisons are approximately equal.

In the proposed study, cash price and futures price forecasts are needed. The basis, the difference between the current cash price and the futures price, can also be treated as a random variable. The evaluation of cattle marketing alternatives (cash sales, simple hedging and multiple hedging) requires combinations of current cash and futures prices and forecasts of the basis for the transaction months. For example, the current futures price for the contract at or beyond the actual marketing date and an estimate of the basis at the time of the cattle cash sale are needed. Furthermore, if a multiple hedging strategy is selected, a prospective price movement needs to be forecasted to decide whether the hedge should be delayed when prices are trending upward.

Ordering Risky Choices

A complete ordering of risky choices requires substantial information about risk attitudes but also increases the chances of ordering errors if the attitudinal information is in error. A partial ordering of risky choices requires less comprehensive information about risk attitudes, and reduces the chances of ordering errors. Therefore, the ordering concept involves a trade-off between the completeness of ordering and the possibility of ordering errors (Robison and Barry, 1987).

Following King and Robison (1984), the expected utility model provides a choice criterion of expected utility maximization that integrates information about a decision maker's preference choice under uncertainty. A set of restrictions on the utility function defines an efficiency criterion for a particular class of decision makers. Only minimal information is required to order alternatives if these restrictions are rather general in nature. By eliminating some of the alternatives, a decision maker can make a final choice from the efficient alternatives. Efficiency criteria with few restrictions on preferences may not eliminate many choices, while criteria that identify small efficient sets usually require more specific information about preferences. Hence, efficiency criteria help resolve some of the problems of single-valued utility functions.

First Degree Stochastic Dominance (FSD). FSD is the simplest and most widely applicable efficiency criterion, and holds for all decision makers with positive marginal utility. That is, all who prefer more to less. Under this criterion, an alternative outcome defined by a cumulative distribution function F(y), is preferred to a second alternative with cumulative distribution function defined by G(y) as long as:

$$F(y) \leq G(y) \tag{2.55}$$

for all possible values of y and if the inequality is strict for some value of y. However, the usefulness of the FSD is limited by the fact that this criterion often eliminates few choices from consideration.

The class of decision makers ordered by FSD is assumed to have positive marginal utility, U'(y) > 0, which has no bounds on the absolute risk aversion function because U"(y) can take any value. Therefore, the kind of decision making class that is consistent with FSD is defined as:

$$-\infty < R(y) < \infty \tag{2.56}$$

Second Degree Stochastic Dominance (SSD). The SSD set is more discriminating than FSD and holds for all decision makers whose utility functions have positive, nonincreasing slopes at all outcome levels, that is the risk averse decision makers. Under SSD set, an alternative with the cumulative distribution function F(y) is preferred to a second alternative with cumulative distribution function G(y) if:

$$\int_{-\infty}^{y} F(y)\, dy \leq \int_{-\infty}^{y} G(y)\, dy \tag{2.57}$$

for all possible values of y, and if the inequality is strict for some value of y.

Since SSD requires U'(y) > 0, and U"(y) < 0 the function R(y) and the applicable class of decision makers are limited to the risk averse class with R(y) > 0, hence:

$$0 < R(y) < \infty \tag{2.58}$$

Mean-Variance and Mean-Absolute Deviation Criteria. The most familiar and widely used efficiency criterion is the mean-variance (EV) criterion introduced by Markowitz (1959). This criterion requires the risk averse class of decision makers as in SSD. In addition to that, it requires the distribution of outcome to be normal or decision makers with quadratic utility functions. The EV criterion will generate an efficient set that is identical with the SSD set if the two requirements above are met.

The Hazell's MOTAD criterion is considered as an approximation to the EV efficiency through modeling with linear programming and the two criteria are similar when the distributions being ordered are approximated normal. The MOTAD efficiency holds for risk averse decision makers, although there are no direct links, analytically, between this criterion and the form of utility function.

Stochastic Dominance With Respect to a Function (SDRF). The previous efficiency criteria are considered to have low discriminatory power in the sense that one of them will reliably reduce a large number of choices to an efficient set that can be ordered directly by the decision maker. For example, both SSD and EV criteria are unrealistic for the non-risk averse class of decision makers (King and Robison, 1984).

A more discriminating efficiency criterion that allows for greater flexibility in representing preferences is called the SDRF. It establishes the necessary and sufficient conditions under which an alternative with the cumulative distribution function defined by F(y) is preferred to G(y) by all individuals whose absolute risk aversion functions lie between lower and upper bounds, $R_1(y)$ and $R_2(y)$. Hence, the solution procedure requires a utility function $U_o(y)$ which minimizes:

$$\int_{-\infty}^{\infty} \{ G(y) - F(y) \} U'(y) \, dy \qquad (2.59)$$

subject to:

$$R_1(y) \leq -U''(y)/U'(y) \leq R_2(y) \text{ for all } y \qquad (2.60)$$

where F(y) and G(y) are cumulative distribution functions.

Equation (2.59) equals the expected utility associated with G(y) minus the expected utility corresponding to F(y), and the minimization process requires the difference between the expected utilities of the two choices to be as small as possible. Therefore, all other decision makers with risk aversion functions within the defined absolute risk-aversion interval would have a difference in expected utility greater than the amount calculated.

Given this condition, the following preference orderings can be specified for the particular set of decision makers defined by $S\{R_1(y), R_2(y)\}$.

If the minimum of this difference is positive, then F(y) is unanimously preferred to G(y) for the particular set of decision makers.

If the minimum is zero, then the decision makers in the particular set are said to be indifferent between the two activities and they cannot be ordered.

If the minimum is negative, then the particular set of decision makers does not unanimously prefer F(y) to G(y). When this situation occurs, equation (2.59) is changed to:

$$\int_{-\infty}^{\infty} \{ F(y) - G(y) \} U'(y)\, dy \tag{2.61}$$

and it is minimized subject to the relation in (2.60) to determine whether G(y) is unanimously preferred to F(y) for the same set of decision makers. If G(y) is shown not to be unanimously preferred or indifferent to F(y), that is, equation (2.57) is also negative, then the two activities cannot be ordered.

Equation (2.59) is equivalent to measuring the difference between expected utility for distribution G(y) and F(y), and the solution to this problem requires the optimal control technique. Meyer (1977) reformulated the above problem into an optimal control framework using the absolute risk aversion function, $R_o(y)$ as the control variable and U'(y) as a state variable.

This chapter provides a summary of the theoretical and empirical concepts and procedures for analyzing the problem described in Chapter I to achieve the objectives of the study. Sources of risks in the farm firm, firm responses to risks characterized by the decision maker preferences about distribution of outcomes and various risk models provide a framework for constructing a model. The distribution of both livestock prices and production are important in determining enterprise receipts. By taking uncertainty into account in the model building, the respecting distributions of returns explains how the variable in question behaves throughout the planning horizon. The next chapter uses the procedures described in Chapter II to outline a model and develop data for the study.

CHAPTER III

CONCEPTUAL FRAMEWORK AND DATA DEVELOPMENT

Cattle Production System

The beef cattle production system in the U.S. can be divided into three stages: cow-calf production, an intermediate pasture-forage based growing phase, and confined feedlot finishing. The first stage entails production of a weaned calf by cow-calf operators who breed cows to produce calves. At weaning, all male calves and those heifers not required as beef cow replacements are usually sold. The next stage is a period in which calves consume pasture and roughage with little or no concentrate feed. This stage is called stocker cattle production. Calves typically graze high quality forages for four to nine months. The third stage is feeding cattle in a confined feedlot. Cattle consume a ration which contains a high proportion of concentrate feed such as corn, they are fed a minimum of 100 days to 200 days depending upon their weight at the time of placement, and then slaughtered. A combination of the above enterprises is possible, for example, a stocker operation can be established by either retaining calves at weaning from cow-calf production or by purchasing newly weaned calves (Johnson, Spreen, and Hewitt, 1986).

Simulation Analysis

The simulation analysis such as described in Chapter II is chosen for use in this study based on advantages reported by many risk management studies.

For example, the ability to more fully represent the essential characteristics of the cattle production system under study allows the investigator to review problems as they exist rather than as some predetermined analytical structure admits (Johnson and Rausser, 1977). It also provides an instrument for dealing with the dynamic and stochastic physical and economic environment in which farm producers operate. Although the flexibility and autonomous analytical structure of simulation modeling may relinquish the advantage of determining an optimal solution, it does provide an estimate of the more likely answer through the use of probability distributions. Therefore, a representation of possible outcomes which could result from actual performance is supplied and the minimum levels of success for performance variables of interest can be assigned.

The whole-firm approach is needed to encompass the level of total income and balance sheet position resulting from alternative decisions. Simulation offers an easier technique than risk programming to maintain balance sheet information in a dynamic setting. However, the lack of an optimization process in simulation is a disadvantage compared to risk programming.

A dynamic, Monte Carlo simulation model is used to evaluate alternative strategies for livestock ranchers in this study. The firm level model recursively simulates the annual production, financial management, growth and income tax functions of a farm over a ten year planning horizon. The ten year planning horizon (1988-1997) is replicated for 50 iterations with different random monthly livestock weight gains as well as monthly cash and futures livestock prices for each iteration. The cumulative density functions for selected output variables are developed using the values observed for all iterations. The strategies are compared based on their impacts on the typical farm, such as probability of survival, probability of success, after tax net present value, present value of ending net worth and ending leverage ratio. The cdf's are compared using stochastic dominance with respect to a function (SDRF) to evaluate the relative desirability of each strategy based on alternative risk attitudes of the ranchers.

FLIPSIM V (Richardson and Nixon, 1986) was selected as the simulation model used in this study. The model has numerous subroutines that perform calculations which are called once each year of the planning horizon. This part of the model, the subroutines, are of primary interest to the analyst since it is where the calculations are performed. Furthermore, the model provides a starting point for analysts for some possible modifications on a particular problem to be addressed. For example, one potential area for expansion and modification in the model is the livestock section for simulating a ranch which is subject to random livestock production, as well as random livestock prices. In livestock enterprises, individual variables such as rate of gain, amount of feed fed, death loss, calving rate and price level can be considered in the model with appropriate covariances.

The Random Variables

FLIPSIM V is modified in this study to allow the analyst to use either yearly or within-year decisions. For example, the within-year adaptive decision allows the analyst to make an adjustment at the end of the first three months of steer grazing based on information for the first three months. If the stochastic steer weight gain in the first period is less than the least expected weight gain among the stocking rate levels, the program will read an option card to determine if the analyst wants to feed supplement or sell some animals to lower the stocking rate. The model also allows the analyst to select one of the available livestock marketing strategies, such as cash sales, simple hedging, strategic hedging, and multiple hedging. Using basis and cash price information for predicting futures prices, a hedging routine will calculate the necessary rules for placing and lifting a hedge. Chapter IV explains the procedure in more detail. This chapter provides data development for the modified FLIPSIM V model.

Livestock Weight Gain.

The procedure for estimating conditional distribution functions addressed by Taylor (1984) was used in this study to estimate the distribution of steer weight gain conditional upon the level of stocking rate. Data series for steer weight gain with alternative stocking rates are required to construct the maximum likelihood estimation (MLE) of the conditional probability distribution functions using a hyperbolic tangent transformation.

Steer weight gain data were taken from a study done by Rodriguez (1986) in Baca county, Southeastern Colorado in the area of study. Rodriguez and Bartlett (1988) validated the RANGES model, developed by Gilbert (1975), using nine years of historical weather data to generate 50 years of simulated continuous grazing at low (2.11 ha/head), medium (1.88 ha/head), and high (1.66 ha/head) stocking rates. For the treatments, 60, 67, and 76 head of steer calves were put in a 312 acre pasture on May first for the period of 168 days.

The 50 years of simulated data were used in this study for estimating the conditional probability density function using Taylor's hyperbolic tangent procedure. A conditional distribution function was estimated for three production periods considered in this study, (1) the first three months, (2) the last three months, and (3) the whole six months of the production period.

The estimation procedure was performed outside the FLIPSIM V using the Fortran program SECANT (Taylor, 1987). The following are the steps recommended to obtain the maximum likelihood estimates (MLE) of the parameters characterizing a polynomial function, P(Y,X), where Y is the observation on livestock weight gain and X is the particular level of stocking rate:

(1) Specify which polynomial terms (Intercept, Y, Y^2, Y^3, X, X^3, XY, and XY^2) to include in P(Y,X) using a stepwise top-down approach by including all terms initially and deleting insignificant term(s) in a backward stepwise.

(2) Use ordinary least square (OLS) to obtain preliminary estimates of ß's, the parameter vector characterizing P(Y,X). These estimates are used only as the starting values in numerical search routines used to solve the maximum likelihood problem. The OLS estimates are obtained by transforming (2.44) into:

$$Z = 0.5 \ln [\{F(Y|X)\}/\{1-F(Y|X)\}] = P(Y,X) \quad (3.1)$$

(3) To obtain the maximum likelihood estimates (MLE) of these ß's, a microcomputer package developed by Taylor (1987), was used to numerically give a local optimum of the likelihood function. The input for this program is the set of observations on the steer weight gain (Y); the stocking rate level (X); the number of polynomial terms to include (maximum of ten); codes for the included polynomial terms; and the OLS's ß estimates as starting values in numerical search. Output from this procedure includes: the estimated ML's ß, the asymtotic covariance matrix, asymptotic t-values, the parameter correlation matrix, and the value of the log-likelihood function evaluated at the ß's.

(4) Examine asymptotic t-values for individual ß's to determine polynomial term(s). A likelihood ratio test can be used to decide which polynomial term(s) to include or to exclude in P(Y,X). For example, if m is the number of parameters in the null hypothesis specification of P(Y,X) then m' < m

is the number of parameters in the alternative specification of P(Y,X). The likelihood ratio test, as suggested by Taylor (1984), will be based on:

$$R = -2 \ln L(\beta) + 2 \ln L(\beta') \quad (3.2)$$

where L(ß) is the value of the likelihood function for the m parameter model and L(ß') is from the m' parameter. R is asymptotically distributed as Chi-square with (m-m') degrees of freedom. If calculated Chi-square < Chi-square table, the deleted polynomial term(s) is (are) not significant.

Once the parameters of P(Y,X) have been obtained from the MLE, the estimated conditional cumulative distribution function (2.44) and its estimated conditional probability density function (2.45), presented in Chapter II, are obtained.

According to Taylor (1987) the hyperbolic tangent procedure for empirically estimating a cdf may be viewed as somewhat subjective, but its use is no more subjective than estimating any polynomial function where the degree of the polynomial is unknown. Although it is an approximation, it has several advantages, such as: (1) easier to use compared to procedures with equal flexibility, (2) the procedures have the flexibility to closely approximate common theoretical probability distributions, as well as fit data for many unconventional distributions, (3) the procedure can be used to estimate conditional cdfs, which is not possible with most other procedures in their current stage of development, and (4) with the ML approach, smoothing of data is controlled by traditional asymptotic statistical tests (Taylor, 1984).

Final ML estimations and accompanying asymptotic t-statistics, in the parentheses, for the conditional cumulative distribution function of the first three months (3.3), the last three months (3.4), and the whole six months of grazing (3.5), respectively, are as follows:

$$F(Y|X) = 0.5 + 0.5 \tanh \underset{(-4.55)}{[-19.33} + \underset{(4.43)}{44.79\,Y} \underset{(-4.71)}{-37.23\,Y^2}$$

$$+ \underset{(5.33)}{10.78\,Y^3} \underset{(-0.02)}{-0.17\,XY^2}] \qquad (3.3)$$

$$F(Y|X) = 0.5 + 0.5 \tanh \underset{(-9.38)}{[-1.64} + \underset{(3.75)}{0.39\,Y^2} + \underset{(4.87)}{0.41\,Y^3} + \underset{(4.46)}{0.20\,XY}] \qquad (3.4)$$

$$F(Y|X) = 0.5 + 0.5 \tanh \underset{(-6.34)}{[-2.07} + \underset{(2.81)}{5.21\,Y} \underset{(-2.99)}{-2.02\,Y^2}$$

$$+ \underset{(4.23)}{0.22\,Y^3} \underset{(-2.38)}{-2.41\,XY} + \underset{(2.15)}{0.77\,XY^2}] \qquad (3.5)$$

where F(Y|X) is the cumulative distribution of Y conditional on X; Y is steer weight-gain in the period, X is stocking rate, and tanh is the hyperbolic tangent operator. Figures 8, 9, and 10 present the respective cumulative distribution function for the first three months, the last three months, and the whole six month production period at three different stocking rates (STR).

Probability density functions for the three production periods were derived by differentiating (3.3), (3.4), and (3.5) with respect to Y, the steers' weight-gain, as presented in (2.45), as follows:

$$f(Y|X) = 0.5\,(44.79 - 74.47\,Y + 32.34\,Y^2 - 0.33\,XY)\,\mathrm{sech}^2\,[-19.33 + 44.79\,Y - 37.23\,Y^2 + 10.78\,Y^3 - 0.17\,XY^2] \qquad (3.6)$$

$$f(Y|X) = 0.5\,(0.79\,Y + 1.21\,Y^2 + 0.20\,X)\,\mathrm{sech}^2\,[-1.64 + 0.39\,Y^2 + 0.41\,Y^3 + 0.20\,XY] \qquad (3.7)$$

$$f(Y|X) = 0.5\,(5.21 - 4.04\,Y + 0.67\,Y^2 - 2.41\,X + 1.55\,XY)\,\mathrm{sech}^2\,[-2.07 + 5.21\,Y - 2.02\,Y^2 + 0.22\,Y^3 - 2.41\,XY + 0.77\,XY^2] \qquad (3.8)$$

where f(Y|X) is the probability density function (pdf) of Y conditional on X; Y is steer weight-gain, X is stocking rate, and sech^2 is the square of the hyperbolic secant. Figures 11, 12, and 13 present the corresponding graphs of the pdf's

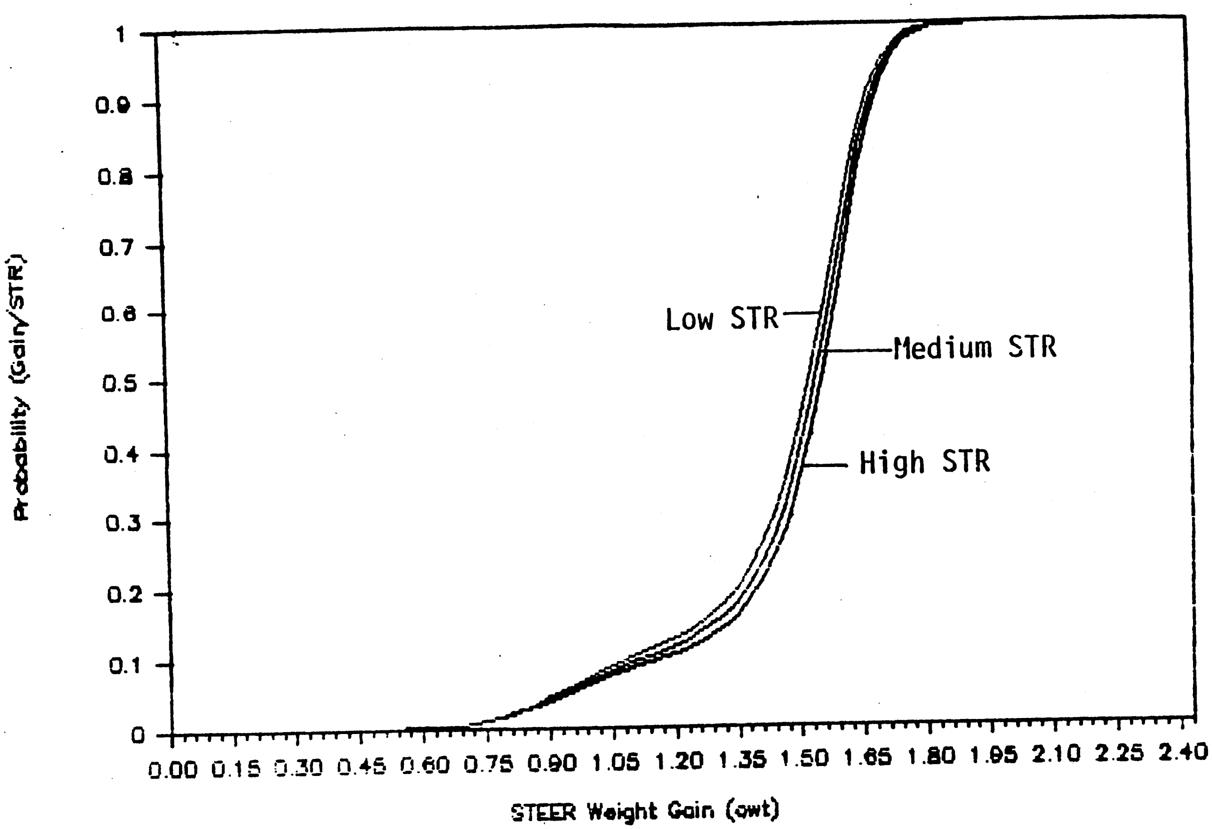


Figure 8. Cumulative Distribution Function of Weight Gain Conditional on Stocking Rate for the First Three Months of Production Period

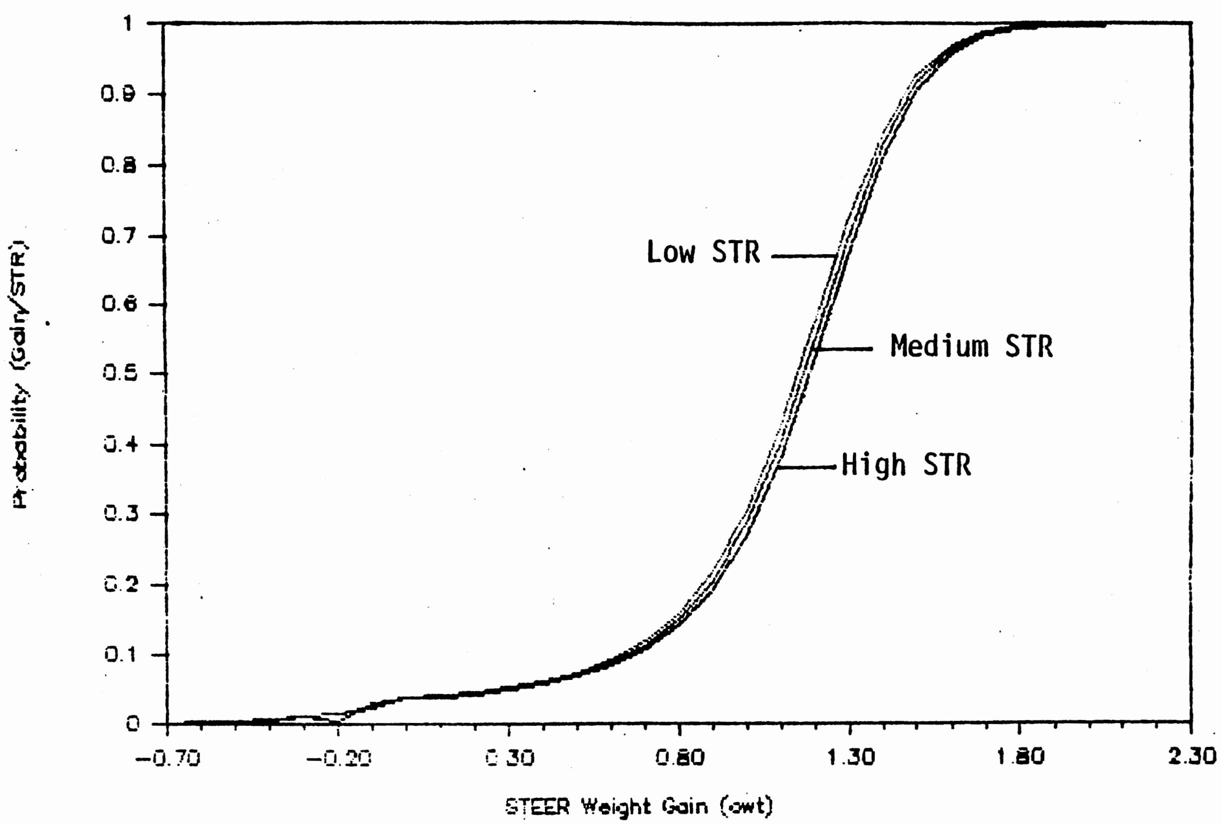


Figure 9. Cumulative Distribution Function of Weight Gain Conditional on Stocking Rate for the Last Three Months of Production Period

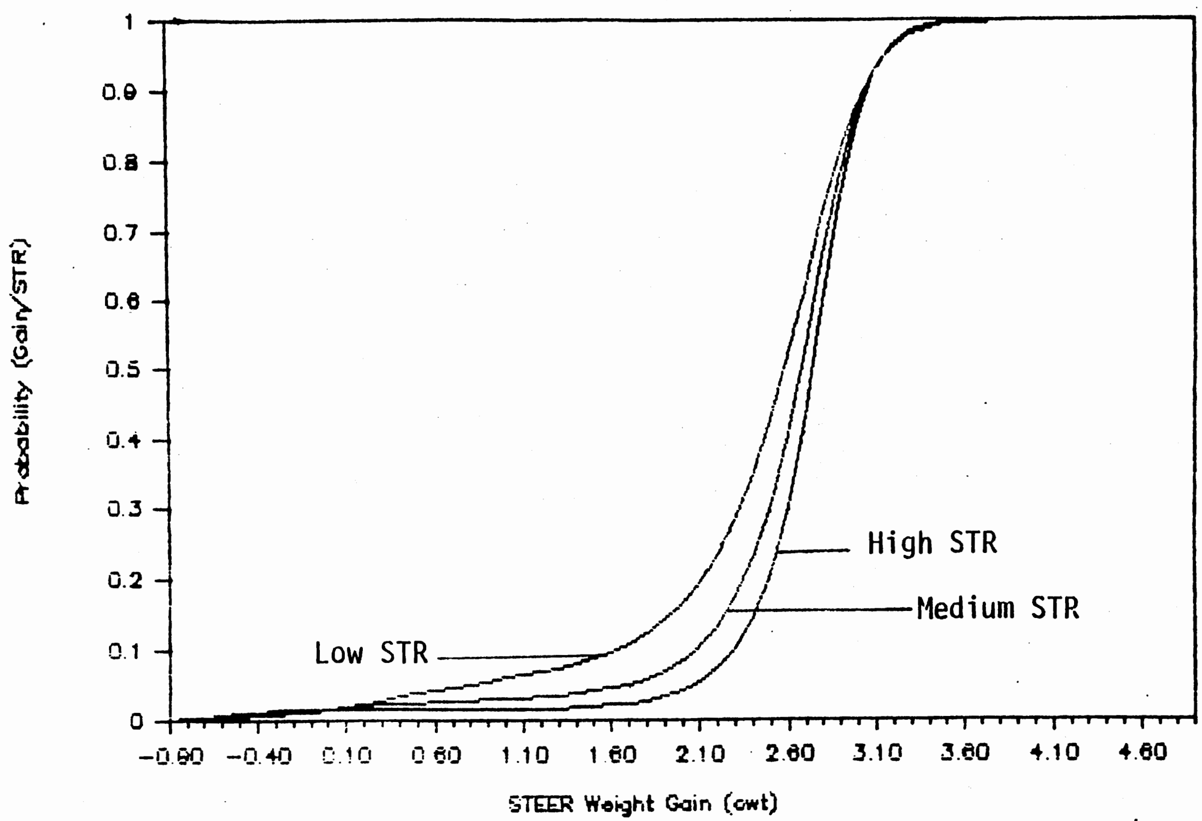


Figure 10. Cumulative Distribution Function of Weight Gain Conditional on Stocking Rate for the Whole Six Months of Production Period

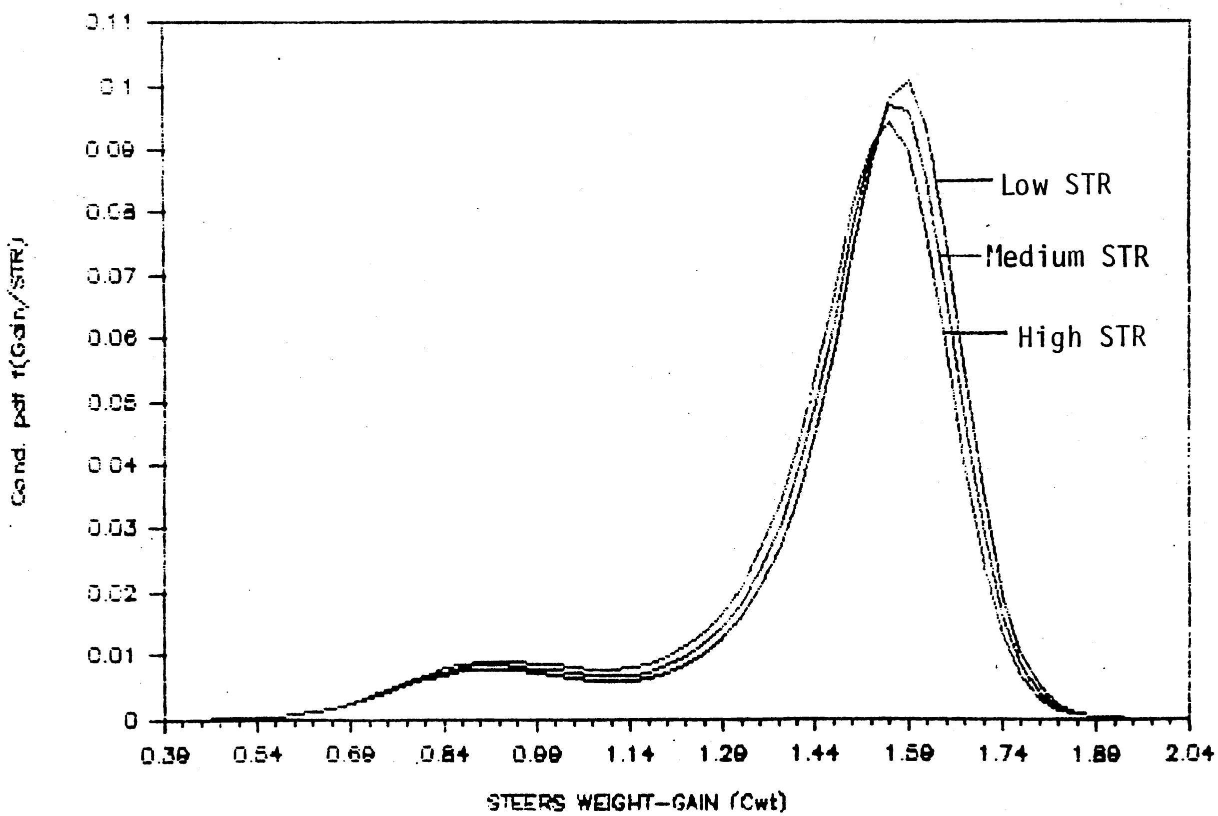


Figure 11. Probability Density Function of Weight Gain Conditional on Stocking Rate for the First Three Months of Production Period

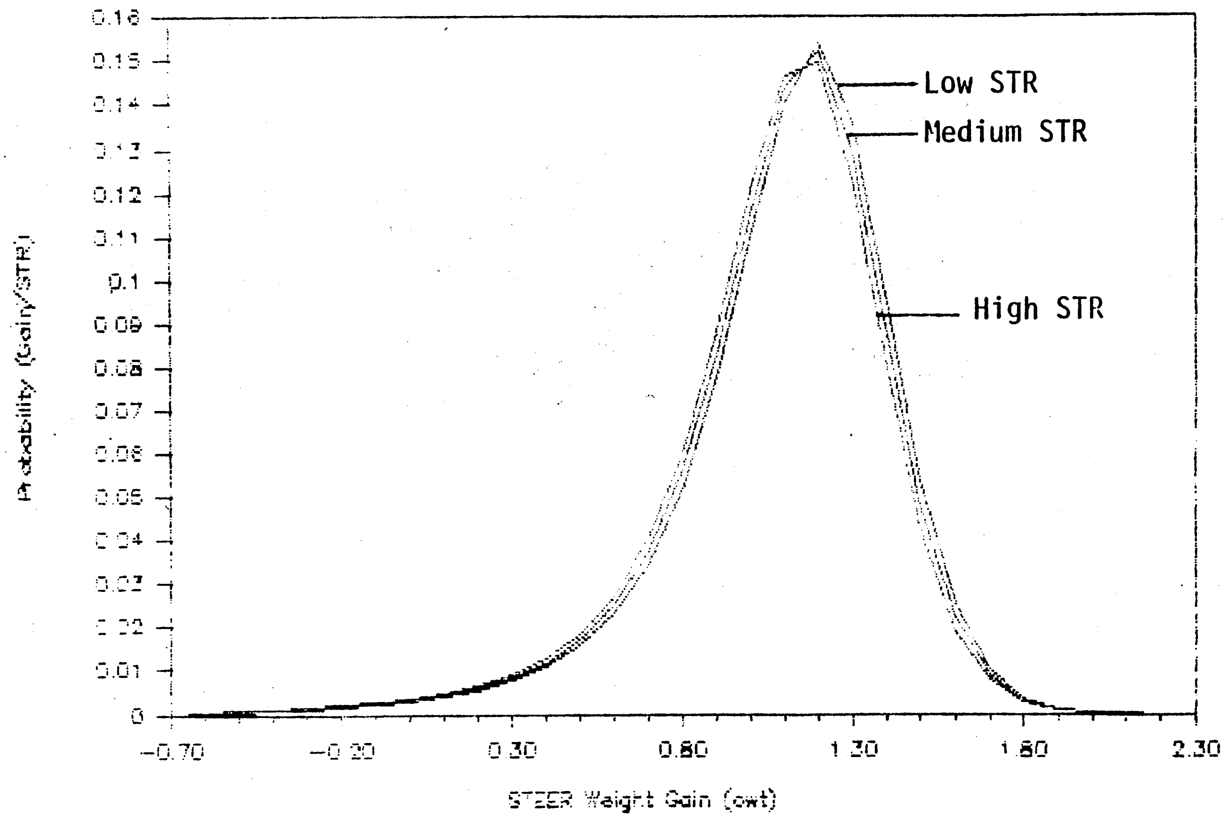


Figure 12. Probability Density Function of Weight Gain Conditional on Stocking Rate for the Last Three Months of Production Period

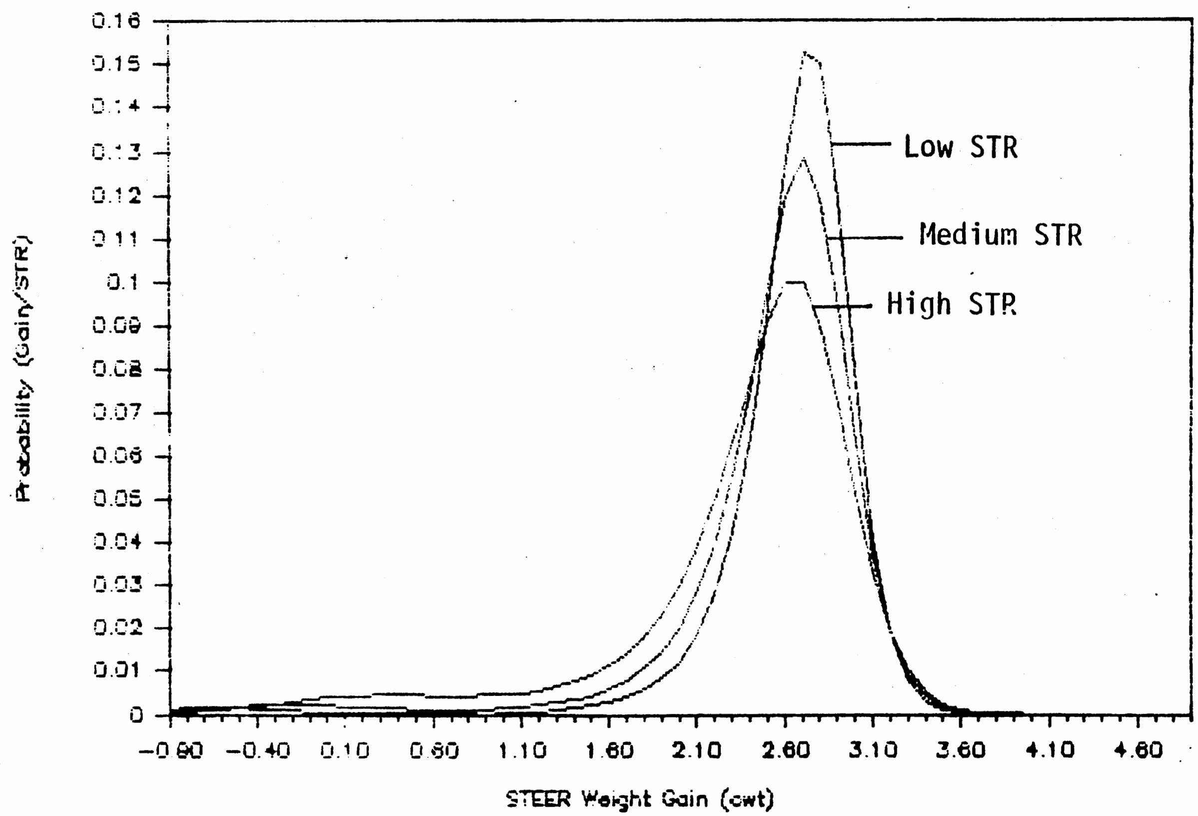


Figure 13. Probability Density Function of Weight Gain Conditional on Stocking Rate for the Whole Six Months of Production Period

for the first three months, the last three months, and the whole six-month grazing period at three different stocking rates. Furthermore, Table II presents the minimum, maximum, and the expected steer weight-gain conditional on stocking rate from the respective density functions for the three production periods. The gain distribution of the whole six-month period has expected weight gain of 264.75, 254.56 and 239.51 lbs. for the low, medium, and high stocking rates, respectively. In addition, the gain distribution from the first (last) grazing period shows the expected weight gain of 149.66 (107.15), 148.06 (108.85) and 146.42 (110.60) lbs. for the low, medium, and high stocking rates.

Livestock Prices.

Estimation of the stochastic livestock cash and futures prices ideally involves estimating the multivariate probability density function for monthly cash and futures prices. For this purpose, the use of time series techniques is most promising (Bailey, Brorsen, and Richardson, 1984). This study considered several possible autoregressive models such as pure autoregressive (AR), pure moving-average (MA), a mixed autoregressive moving-average without differencing (ARMA) and mixed with differenced series (ARIMA) models.

From the eight cash and hedging strategies described by Brown and Purcell (1978), three are considered in this study.

(1) Cash sales (no hedge) strategy. Steers are sold at the end of its production period in the cash market.

TABLE II

MINIMUM, MAXIMUM, AND EXPECTED STEER WEIGHT GAIN FROM THE HYPERBOLIC TANGENT DISTRIBUTION FUNCTION FOR THE THREE PRODUCTION PERIODS

Period		Stocking Rates (Ac/Hd)* Low	Medium	High
Whole six months				
Minimum	(lbs/Hd)	-70.00	-80.00	-90.00
	(lbs/Ac)	-13.45	-17.16	-21.90
Maximum	(lbs/Hd)	400.00	410.00	420.00
	(lbs/Ac)	76.84	87.95	102.20
Mean	(lbs/Hd)	264.75	254.56	239.51
	(lbs/Ac)	50.86	54.61	58.28
First three months				
Minimum	(lbs/Hd)	39.00	39.00	39.00
	(lbs/Ac)	7.49	8.37	9.49
Maximum	(lbs/Hd)	198.00	198.00	198.00
	(lbs/Ac)	38.04	42.47	48.18
Mean	(lbs/Hd)	149.66	148.06	146.42
	(lbs/Ac)	28.75	31.76	35.63
Last three months				
Minimum	(lbs/Hd)	-70.00	-70.00	-70.00
	(lbs/Ac)	-13.45	-15.02	-17.03
Maximum	(lbs/Hd)	230.00	230.00	230.00
	(lbs/Ac)	44.18	49.34	55.96
Mean	(lbs/Hd)	107.15	108.85	110.60
	(lbs/Ac)	20.58	23.35	26.91

* Low = 5.2056, Medium = 4.6618, High = 4.1097, Mean = E (Weight gain| Stocking Rate).

(2) When the steers are purchased in early May, a hedge is placed by selling a contract. The hedge is lifted (late October) by purchasing a contract, and the cattle are marketed in the cash market.

(3) A variation of strategy (2) is evaluated. At the end of each month during the production period, a comparison is made between futures prices and the break-even cost (BEC) and a hedge is placed the first time the futures price for the month exceeds the specified price objective (or profit objective). The profit criterion for placing a hedge, as suggested by Anderson (1987), compares breakeven cost (BEC) of producing steers to a current month's futures price for a particular steer weight. Table III shows the components of the break-even cost (BEC). The hedge is held for the entire production period and lifted when the cattle are marketed. The cattle is kept unhedged if the futures price is still less than the price objective.

(4) A hedge is placed when the moving averages of futures prices indicate a downturn in prices. The hedge is retained as long as the futures price for the month lies below the three-month moving averages (see Figure 14). The hedge is lifted when the moving averages cross, signaling an upturn in prices. The cattle remain unhedged as long as the futures price for the month lies above the three-month moving averages. If the futures price for the month crosses the three-month moving average from above, the hedge is again placed. The hedge is held until an upward trend is designated by the averages.

TABLE III

COMPONENTS OF PER HEAD STEER COST AND AND RETURN BUDGET[a]

Item		Cost
Steer Purchase	470 lbs. at $.85	$399.50
Pasture & Labor[b]	$25,000/yr	18.50
Feed and Hay		25.00
Vet and Medicine		10.00
Death Loss	at 3%	19.00
Marketing and Hauling		5.00
Interest	12%/yr	28.32
TOTAL COSTS		505.32
BREAK-EVEN COST/CWT	$505.32 ÷ 750	$67.37

[a] Adapted from Anderson, K. (1987)
[b] Family living

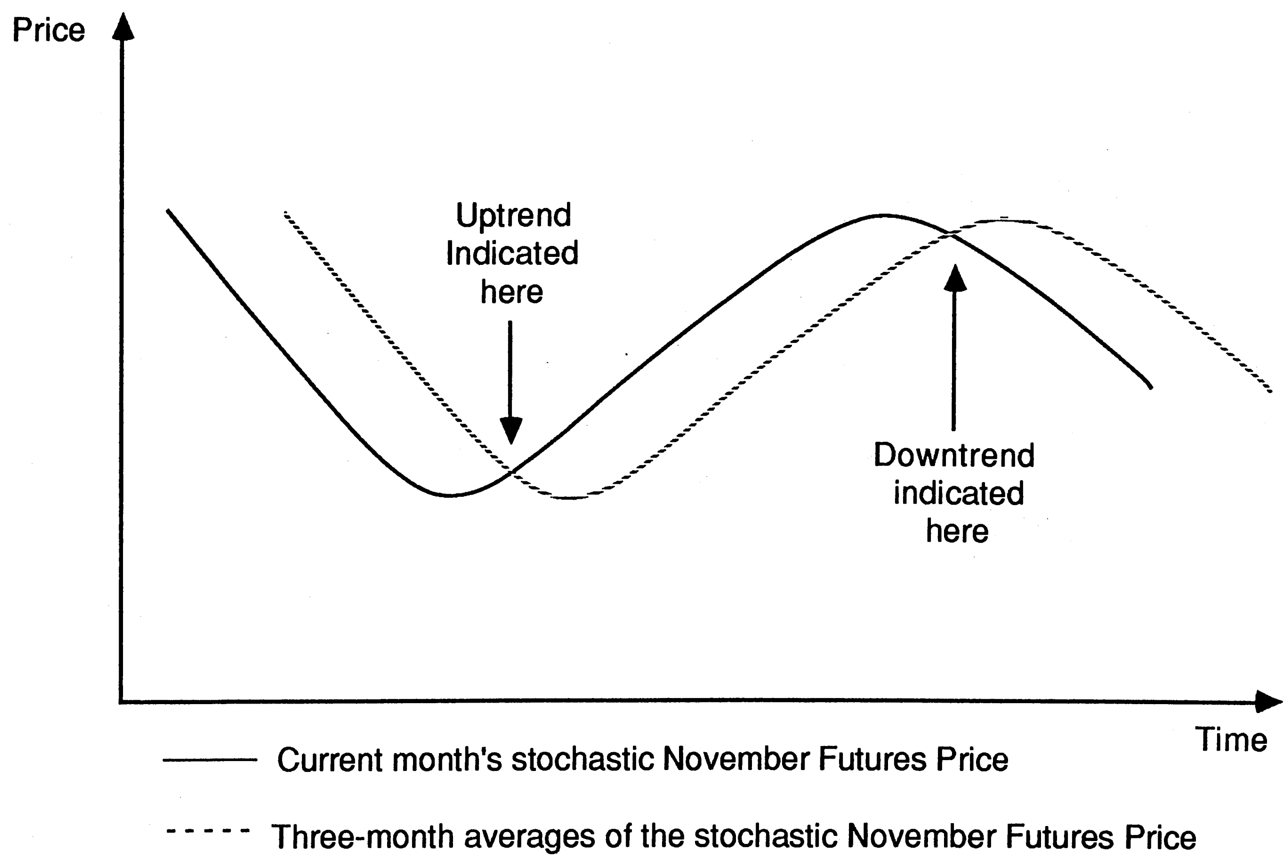


Figure 14. Illustration of Crossing Action of Three Month Moving Averages

When the analyst hedges a contract transaction a cost is incurred. Brokerage fees and interest costs are minimal. However, these small costs may be the difference in making the right decision. The brokerage fee per cwt. is calculated by dividing the brokerage fee by the contract size. For example, for a $75.00 (full service broker) brokerage fee (including a sell and a buy transaction), the brokerage cost per cwt for feeder cattle is $75.00/440 cwt ($0.17), since the contract size for feeder cattle with CME is 44,000 lbs. Anderson (1987), in his study of Oklahoma feeder cattle markets, observed that the discount broker fee is around $16.00 to $50.00 and a full service broker charge between $50.00 per contract and $100.00.

Interest costs require an estimate of the average margin requirement, the brokerage fee, and the amount of time (in months) before the hedge is lifted. Interest costs per cwt. are determined by dividing the interest cost per contract by 440 cwt. Therefore, for a six-month period of hedging with an annual interest rate of 12% (1% per month) and $2,000.00 average margin requirement, the total investment is $2,075.00 (margin + brokerage) and the total interest cost is $124.50 ($2,075.00 x .06). The interest cost per cwt is $0.28 ($124.50/440 cwt), hence, total brokerage fee and interest costs are $0.45 per cwt ($0.17 + 0.28).

Random monthly cash-futures bases and cash cattle prices were generated using a mixed autoregressive integrated moving average (ARIMA) time series model and the correlation matrix from that model. The time series component provides an estimate of average monthly prices and the correlation component provides a multivariate probability distribution about the means. The stochastic futures prices are estimated as the difference between the stochastic cash prices and the appropriate basis.

Monthly cash and futures prices from January 1978 through December 1987 were used to estimate the time series model. The model was estimated by using the following relationships for forecast cash prices and forecast basis:

$$FCASH_t = CASH_{t-1} + \Sigma\, a_i\, CASH_{t-i} + \Sigma\, b_j\, e_{t-j} + u_i \tag{3.9}$$

$$FBASIS_t = BASIS_{t-1} + \Sigma\, c_i\, BASIS_{t-i} + \Sigma\, d_j\, e_{t-i} + u_2 \tag{3.10}$$

where:

$FCASH_t$ = forecast cash price at period t

$CASH_t$ = actual observed cash price at period t

$FBASIS_t$ = forecast basis at period t

$BASIS_t$ = current t^{th} month's basis (cash price minus futures price)

a_i = AR coefficient for CASH

b_j = MA weights for CASH

c_i = AR coefficient for BASIS

d_j = MA weights for BASIS

e = the residuals from a linear and deseasonalized trend model for the basis and cash price

u_1, u_2 = white noise

Error terms u_1 and u_2 were used to estimate the correlation matrix for the errors associated with (3.9) and (3.10). These equations together with their correlation matrix were used to generate multivariate empirical estimates of monthly values for $FCASH_t$ and $FBASIS_t$.

These random values were then used in the following identities to develop stochastic forecast monthly futures prices:

$$FUTURES_t = FCASH_t - FBASIS_t \tag{3.11}$$

where:

$FCASH_t$ = forecast cash price at period t

$FBASIS_t$ = forecast basis at period t

$FUTURES_t$ = forecast futures price at period t

Livestock price data from four steer weight classes, within the range of the possible steer weights generated by the pasture gain distribution functions (400-500 lbs., 500-600 lbs., 600-700 lbs., and 700-800 lbs.) were considered in developing the price forecast model for the basis, cash, and futures prices. Monthly cash price data are taken from Oklahoma City feeder cattle prices reported for each month from January 1978 through December 1987, and the futures prices data were taken from the reported Chicago Merchantile Exchange's weekly Tuesday closing average for each month during the same period as cash prices. Figures 15 through 18 show the historical cash and future prices for each class of weights. The graphs of current months' bases and the difference between the current cash and futures prices are presented in Figures 19 through 22.

The parameter estimation procedures and diagnostic checking for model adequacy, suggested by Box and Jenkins (1976), resulted in an ARIMA (p,d,q) $(P,D,Q)^s$ specification which includes seasonal terms for both autoregressive (SAR) and moving averages (SMA). The estimated ARIMA parameters for cash price series with their statistics are presented in Table IV.

Cash prices for the three classes of steers weights (400-500 lbs., 600-700 lbs., and 700-800 lbs.) followed the form of ARIMA (1,1,1) (22,0,22), while the cash price for 500-600 lbs. of steer weight followed the form of ARIMA (1,1,1) (22,0,0). The ARIMA expressions for forecast cash prices, as described in Chapter II, for steer weight classes 400-500 lbs., 500-600 lbs., 600-700 lbs., and 700-800 lbs. are expressed respectively, using the backshift operator (B), as:

$$(1-0.026B)(1+.756B)(1-B)\ CASH_t = (1+.282B)(1-.867B)\ e_t \qquad (3.12)$$

$$(1+.103B)(1+.651B)(1-B)\ CASH_t = (1-.896B)\ e_t \qquad (3.13)$$

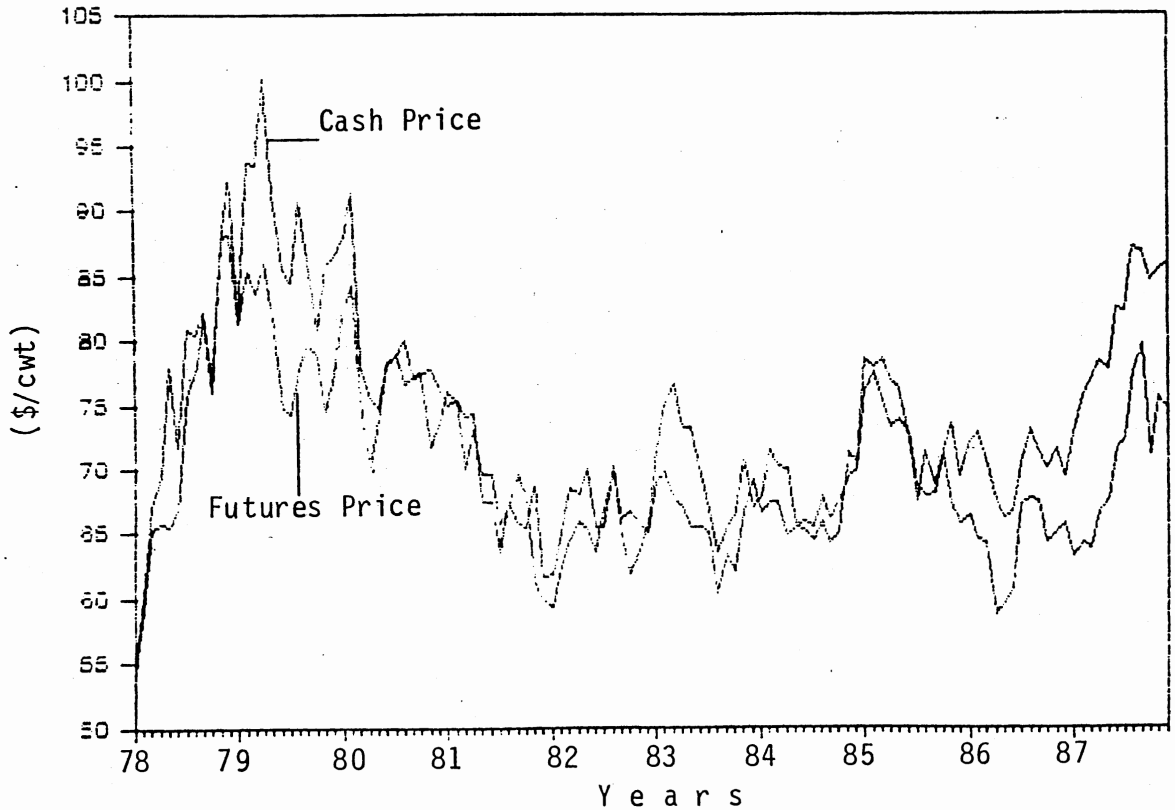


Figure 15. Historical Monthly Cash and Futures Prices for 400-500 lbs. Steers, January, 1978 Through December, 1987

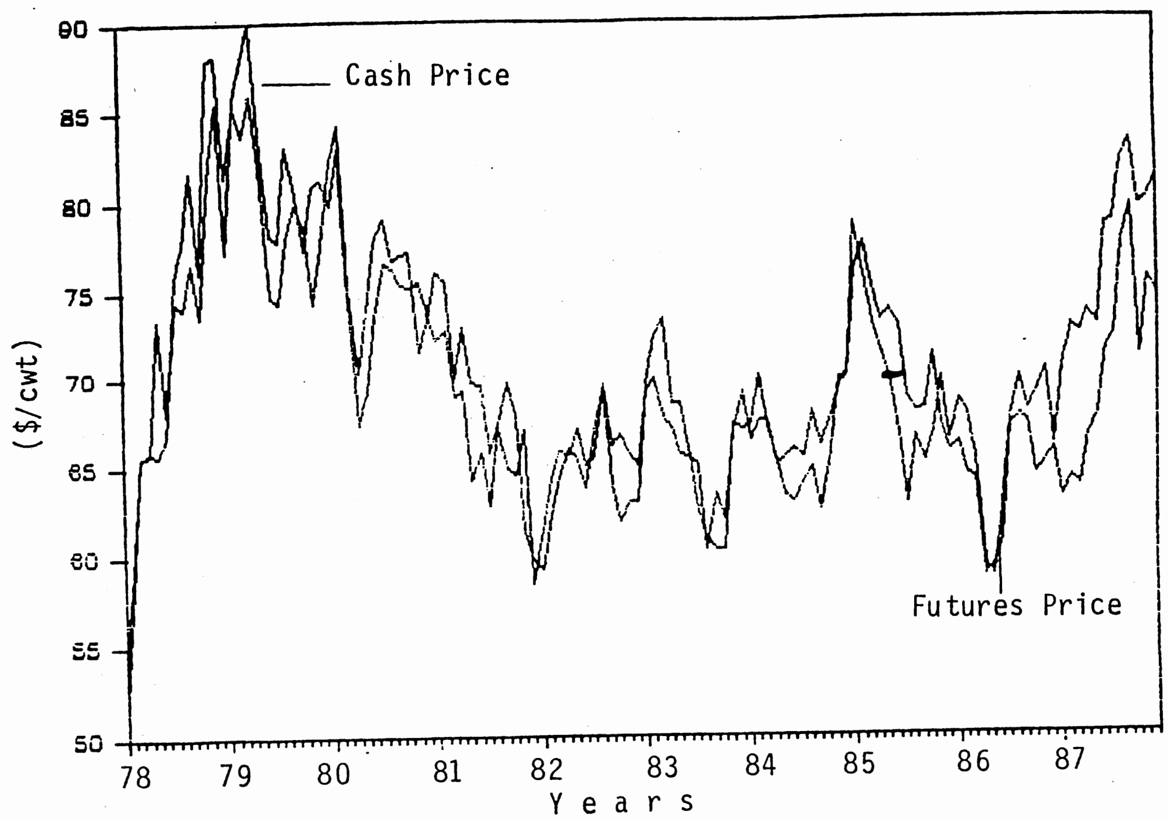


Figure 16. Historical Monthly Cash and Futures Prices for 500-600 lbs. Steers, January, 1978 Through December, 1987

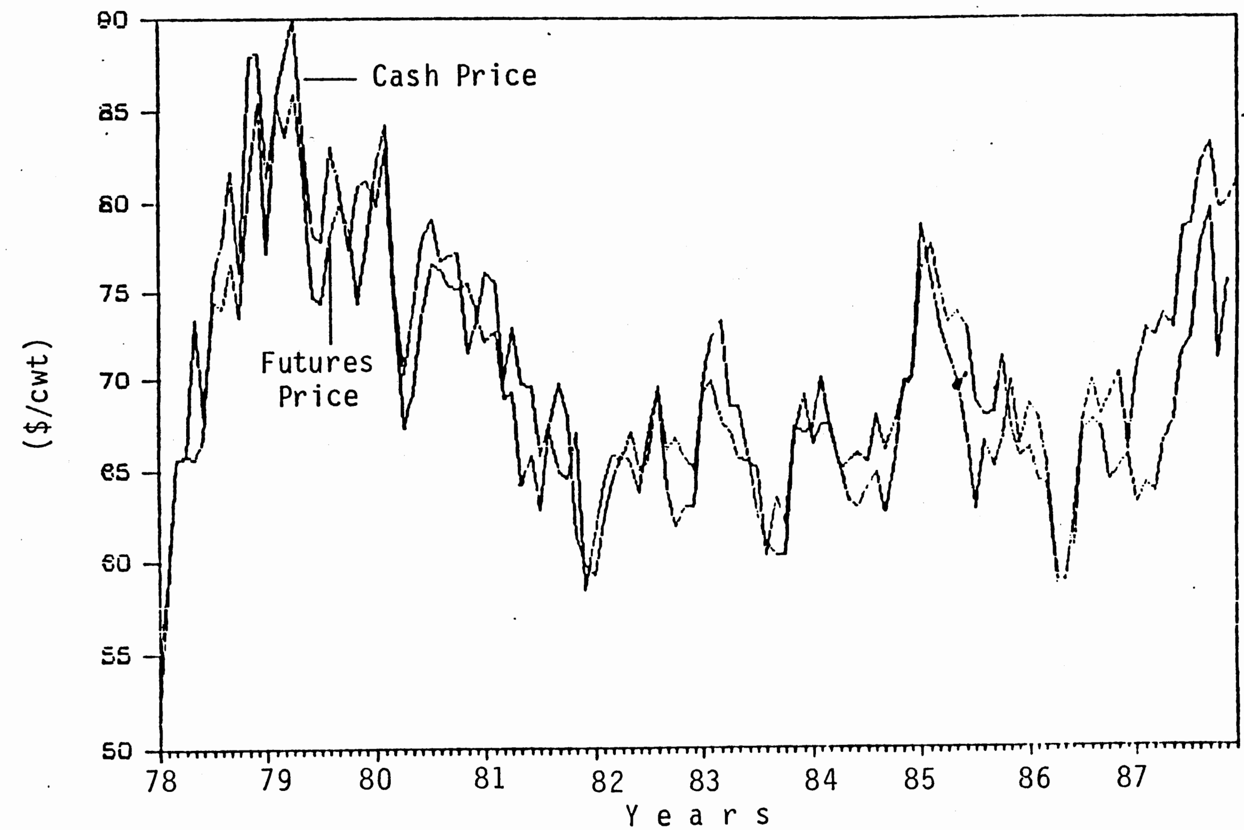


Figure 17. Historical Monthly Cash and Futures Prices for 600-700lbs. Steers, January, 1978 Through December, 1987

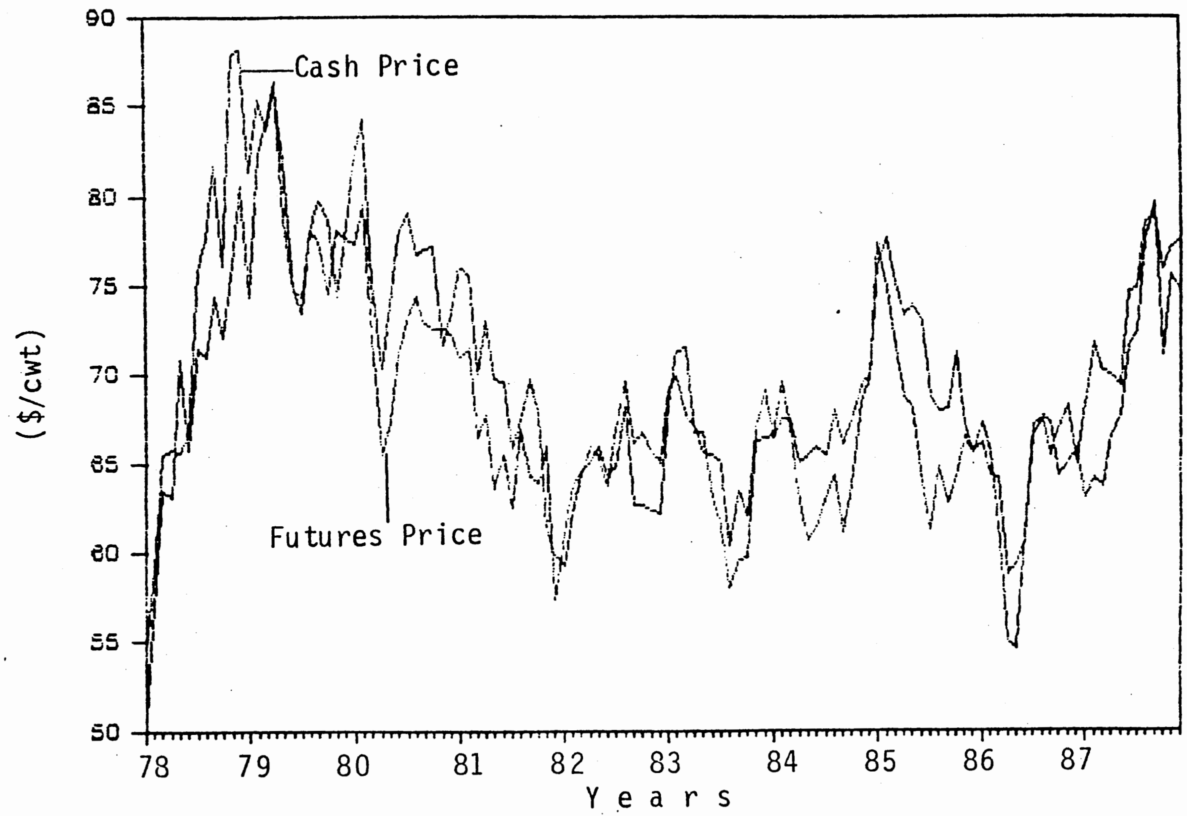


Figure 18. Historical Monthly Cash and Futures Prices for 700-800lbs. Steers, January, 1978 Through December, 1987

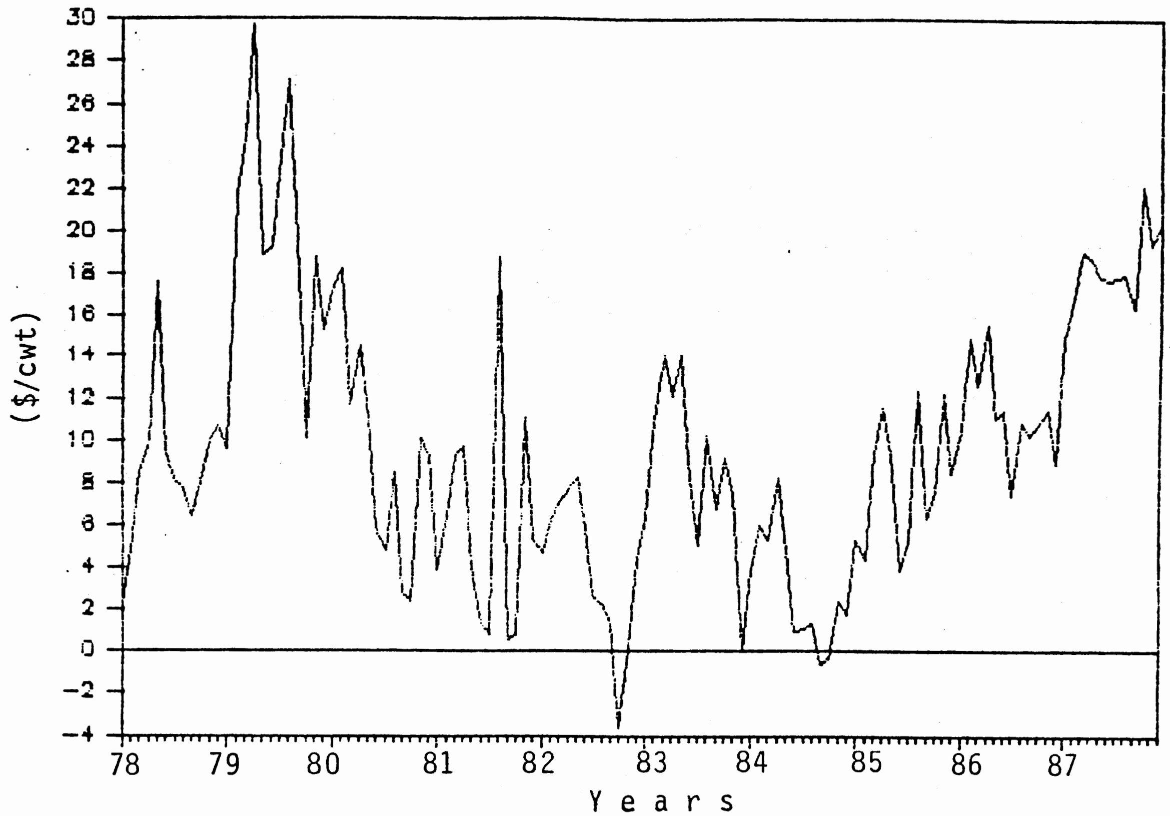


Figure 19. Historical Monthly Basis for 400-500 lbs. Steers from January, 1978 Through December, 1987

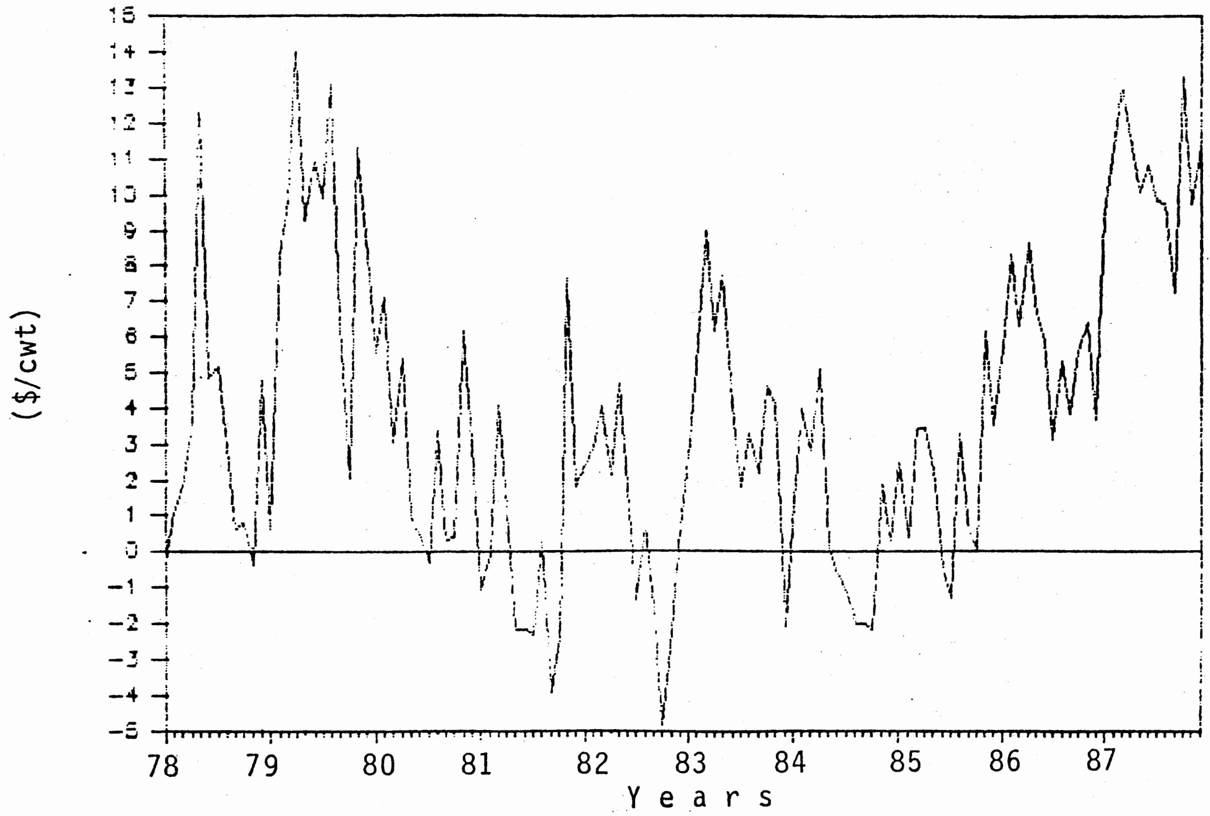


Figure 20. Historical Monthly Basis for 500-600 lbs. Steers from January, 1978 Through December, 1987

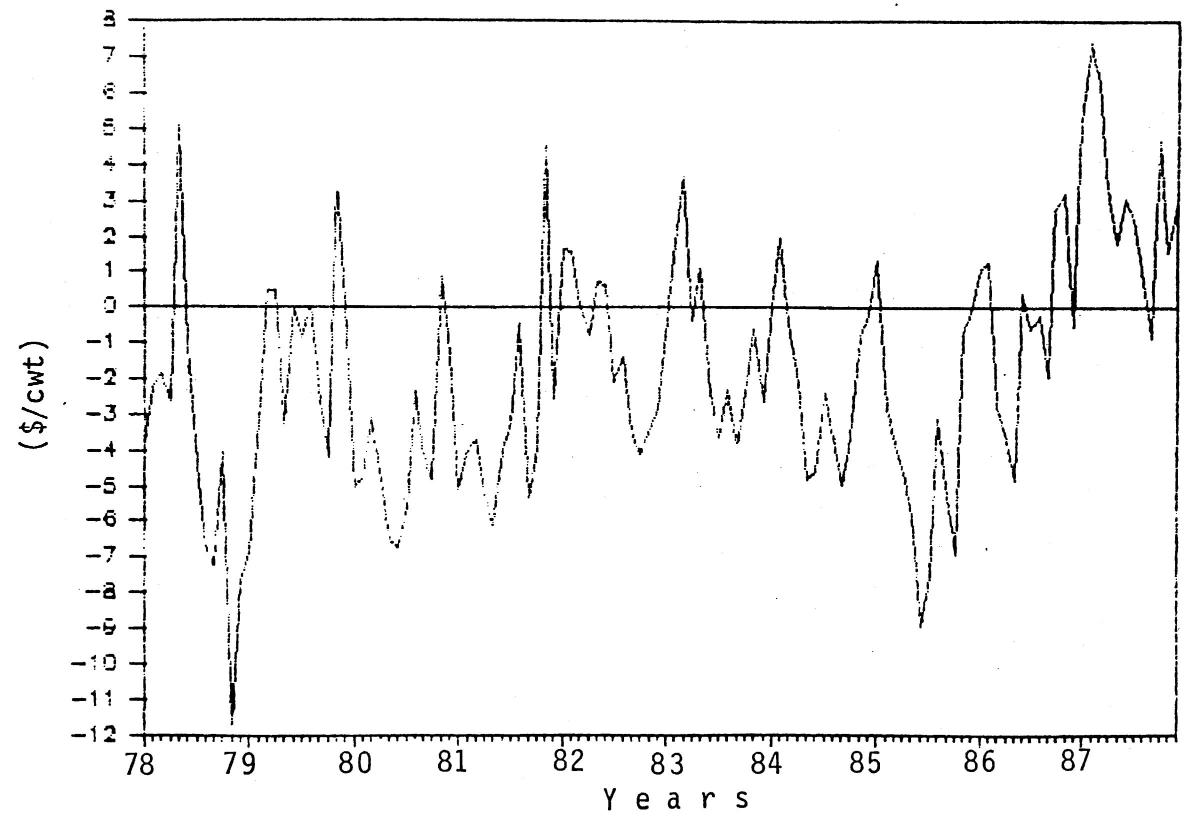


Figure 21. Historical Monthly Basis for 600-700 lbs. Steers from January, 1978 Through December, 1987

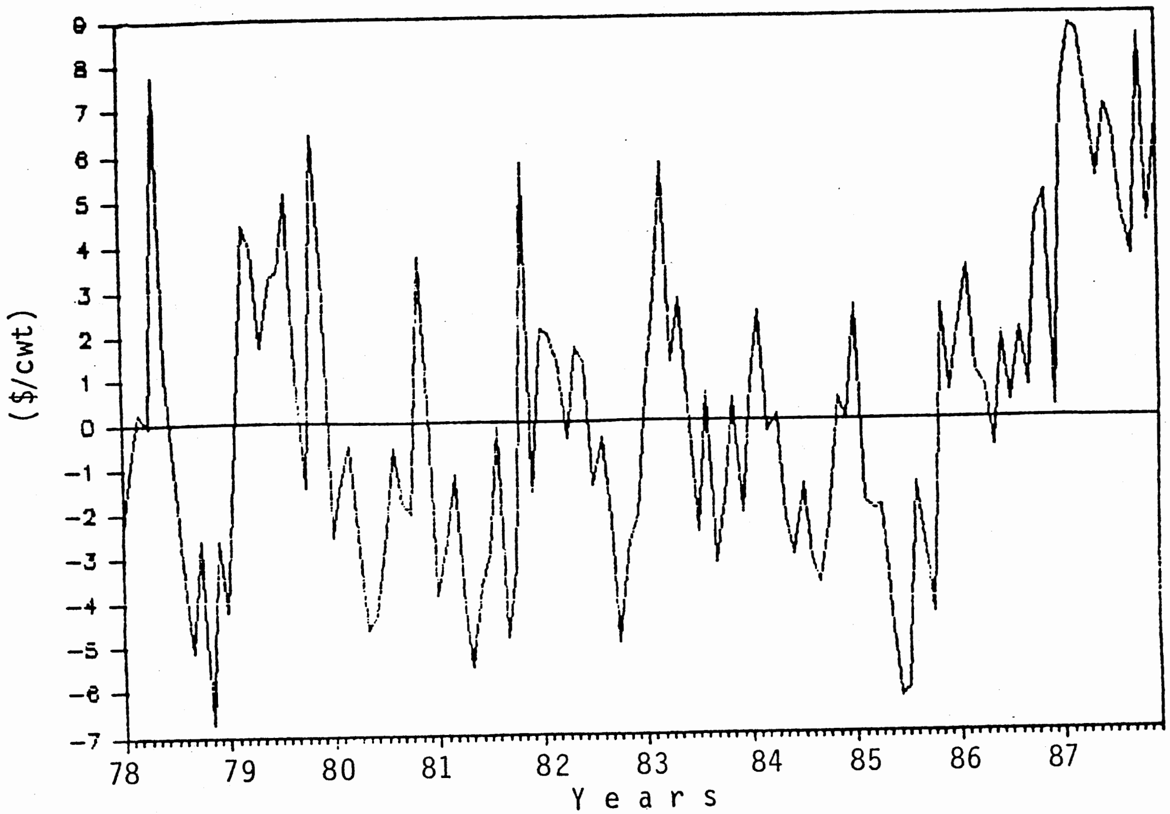


Figure 22 Historical Monthly Basis for 700-800 lbs. Steers from January, 1978 Through December, 1987

TABLE IV

ESTIMATED ARIMA MODEL PARAMETERS WITH THEIR STATISTICS FOR THE DIFFERENCED MONTHLY CASH PRICES SERIES, JANUARY 1978 - DECEMBER 1987*

ARIMA Variables	Steers Weight (Lbs.) 400-500	500-600	600-700	700-800
AR(1)	0.0262	-0.1031	-0.5000	0.2098
	(0.352)	(-2.227)	(-3.619)	(1.663)
SAR(22)	-0.7566	-0.6509	-0.6215	-5.862
	(-7.802)	(-7.327)	(-6.326)	(-5.862)
MA(1)	-0.2824	-	0.2636	-0.1920
	(-2.433)	-	(1.3533)	(-1.122)
SMA(22)	0.8672	0.8962	0.8265	0.8604
	(6.544)	(6.931)	(6.109)	(1.663)
D.W. Stat.	1.7997	1.8157	1.5869	1.7847
Q-Stat.	33.6507	34.4386	46.2453	46.4968

* First 24 original observations were lost due to the first difference (1), AR(1), and SAR(22) lags. The t-statistics are in parenthesis.

$$(1+.500B)(1+.621B)(1-B)\ CASH_t = (1-.263B)(1-.826B)\ e_t \qquad (3.14)$$

$$(1-.210B)(1+.609B)(1-B)\ CASH_t = (1+.192B)(1-.860B)\ e_t \qquad (3.15)$$

Figures 23 through 26 show the actual observation on monthly cash prices as well as their reconstruction from the ARIMA model for each class of steer weight of the original observation from 1980-1987. The estimated ARIMA parameters for the bases, with their statistics, are presented in Table V.

The ARIMA expressions for the respective bases, using the backshift operator (B), are presented in equations (3.16) through (3.19) as follows:

$$(1-.457B)(1+1.00B)(1-B)\ BASIS_t = (1-.914B)\ e_t \qquad (3.16)$$

$$(1+.309B)(1+.720B)(1-B)\ BASIS_t = (1-.897B)\ e_t \qquad (3.17)$$

$$(1+.408B)(1+.646B)(1-B)\ BASIS_t = (1-.897B)\ e_t \qquad (3.18)$$

$$(1+.206B)(1+.410B)(1-B)\ BASIS_t = (1-.830B)\ e_t \qquad (3.19)$$

Figures 27 through 30 show the actual monthly bases and their reconstruction from the ARIMA model for each class of steer weight from 1980-1987.

Production Parameters and Input Prices.

A rancher can make a decision based on his own evaluation of the variation in steer prices, feed supplement prices, and steer weights. Table VI presents several possible feed supplement formulas with their effects on weight gains for the summer stockers grazing native pasture. The data were taken from studies done by Lusby, Horn, and Dvorak (1981), Lusby and Horn (1983), McCollum, Gill, and Ball (1985), and Cantrell, Bryan, and Lusby (1985). However, only Treatment A in Table VI was selected as the feed supplement formula for this study since it has the highest weight gain response (1.97 lbs./head/day) compared to other treatments.

TABLE V

ESTIMATED ARIMA MODEL PARAMETERS WITH THEIR STATISTICS FOR THE DIFFERENCED MONTHLY BASES SERIES, JANUARY 1980 - DECEMBER 1987*

ARIMA	Steers Weight (Lbs.)			
Variables	400-500	500-600	600-700	700-800
AR(1)	-0.4576	-0.3091	-.04082	-0.2059
	(-9.51)	(-6.51)	(-8.04)	(-3.31)
SAR(22)	-1.0029	-0.7206	-0.6463	-0.4105
	(-11.0)	(-8.51)	(-7.98)	(-4.77)
MA(22)	0.9140	0.8974	0.8978	0.8301
	(8.078)	(7.666)	(8.512)	(7.299)
D.W. Stat.	1.9879	2.0422	2.0959	2.2206
Q-Stat.	44.9086	37.1745	33.8458	27.1876

* First 24 original observations were lost due to the first difference (1), AR(1), and SAR(22) lags. The t-statistics are in parenthesis.

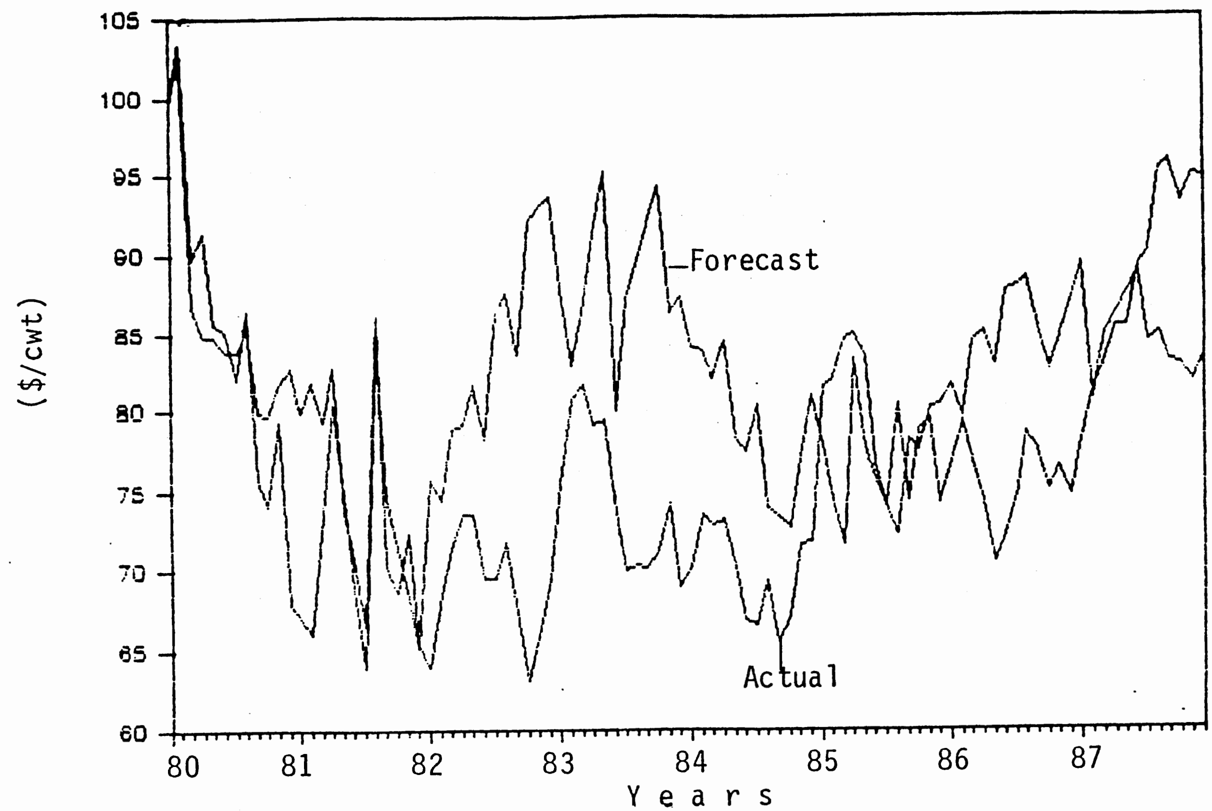


Figure 23. Actual and ARIMA Forecast Monthly Cash Prices for 400-500 lbs. Steers Weight, 1980-1987

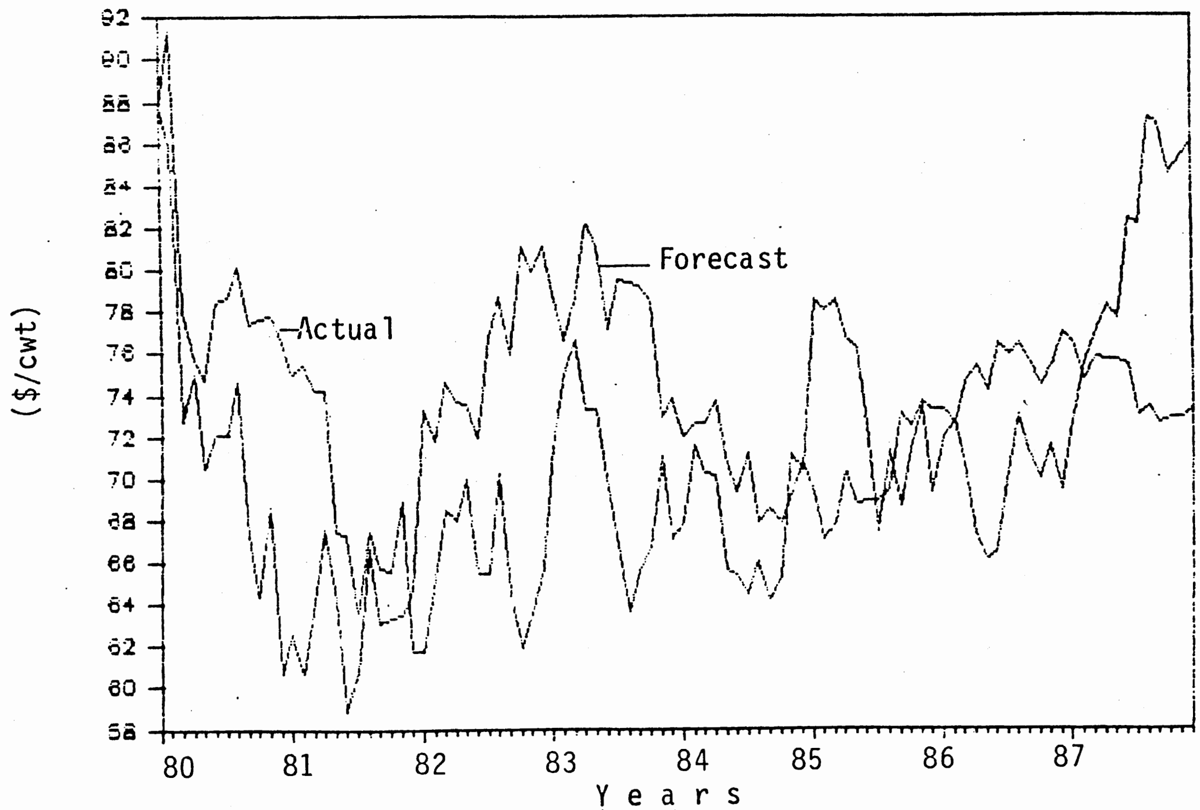


Figure 24. Actual and ARIMA Forecast Monthly Cash Prices for 500-600 lbs. Steers Weight, 1980-1987

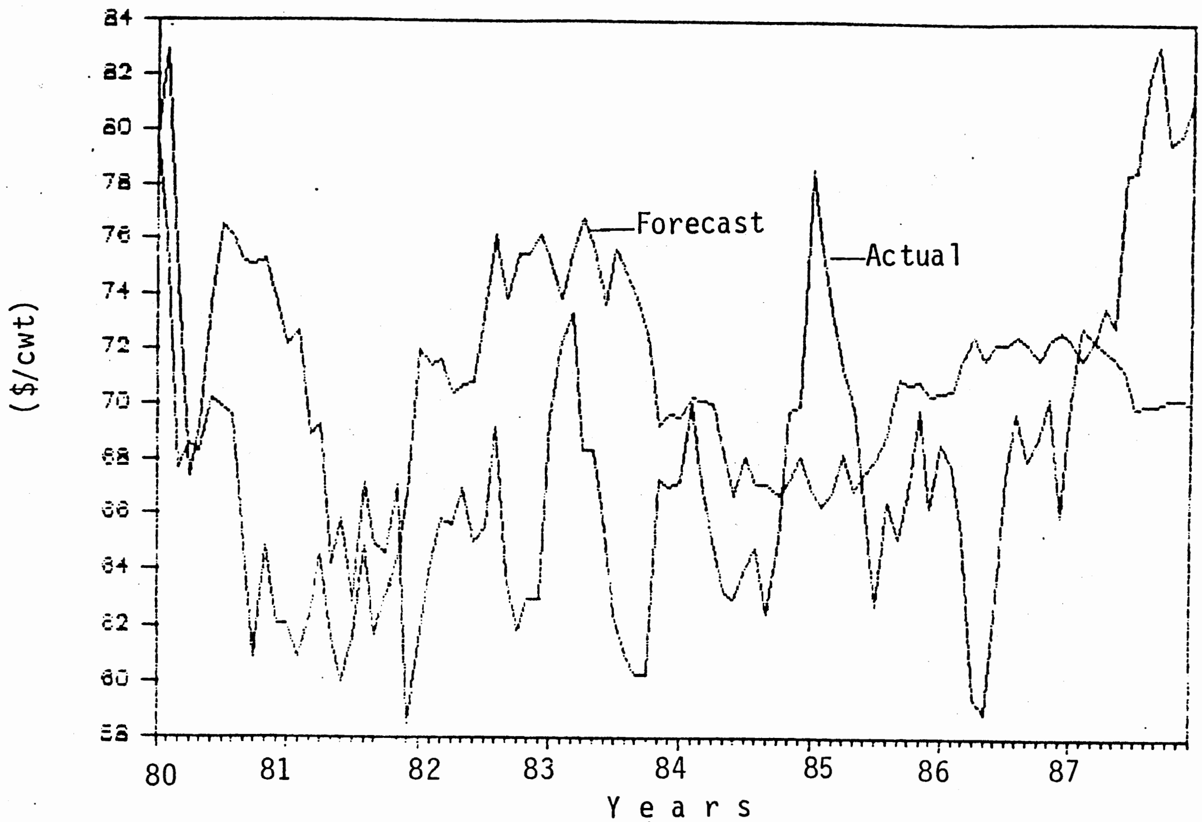


Figure 25. Actual and ARIMA Forecast Monthly Cash Prices for 600-700 lbs. Steers Weight, 1980-1987

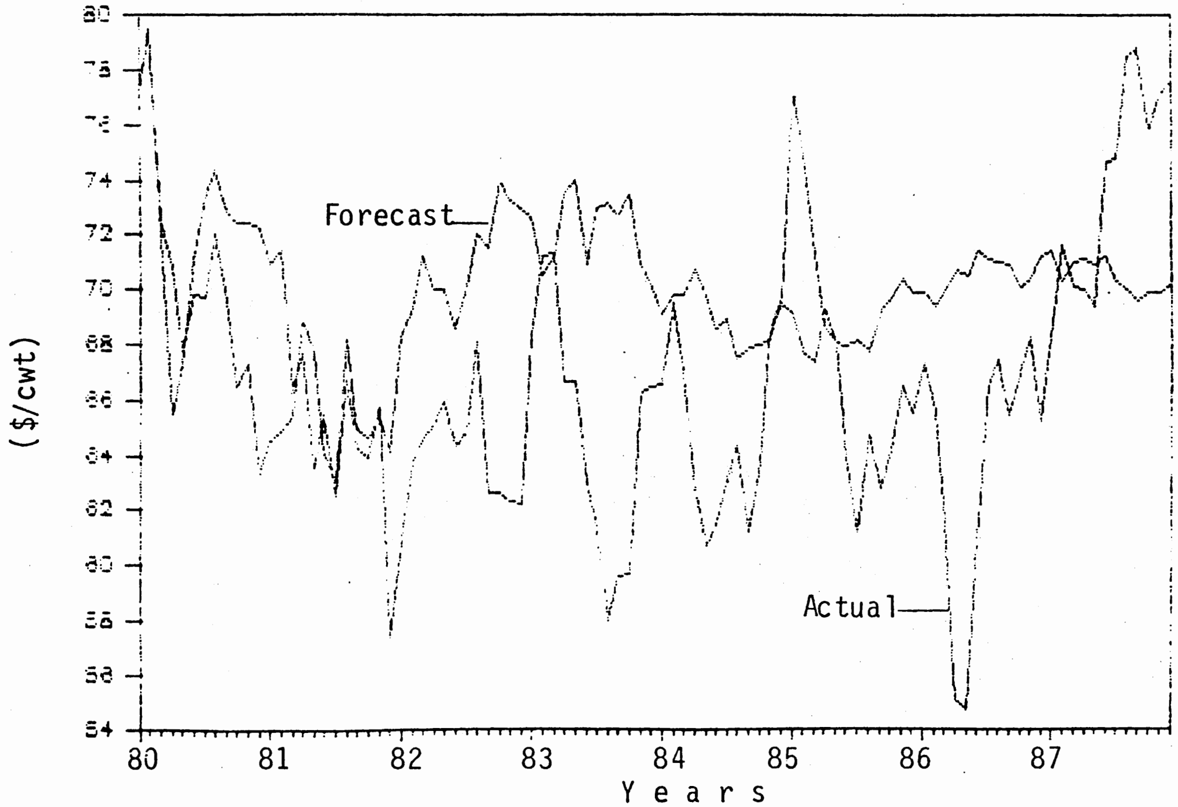


Figure 26. Actual and ARIMA Forecast Monthly Cash Prices for 700-800 lbs. Steers Weight, 1980-1987

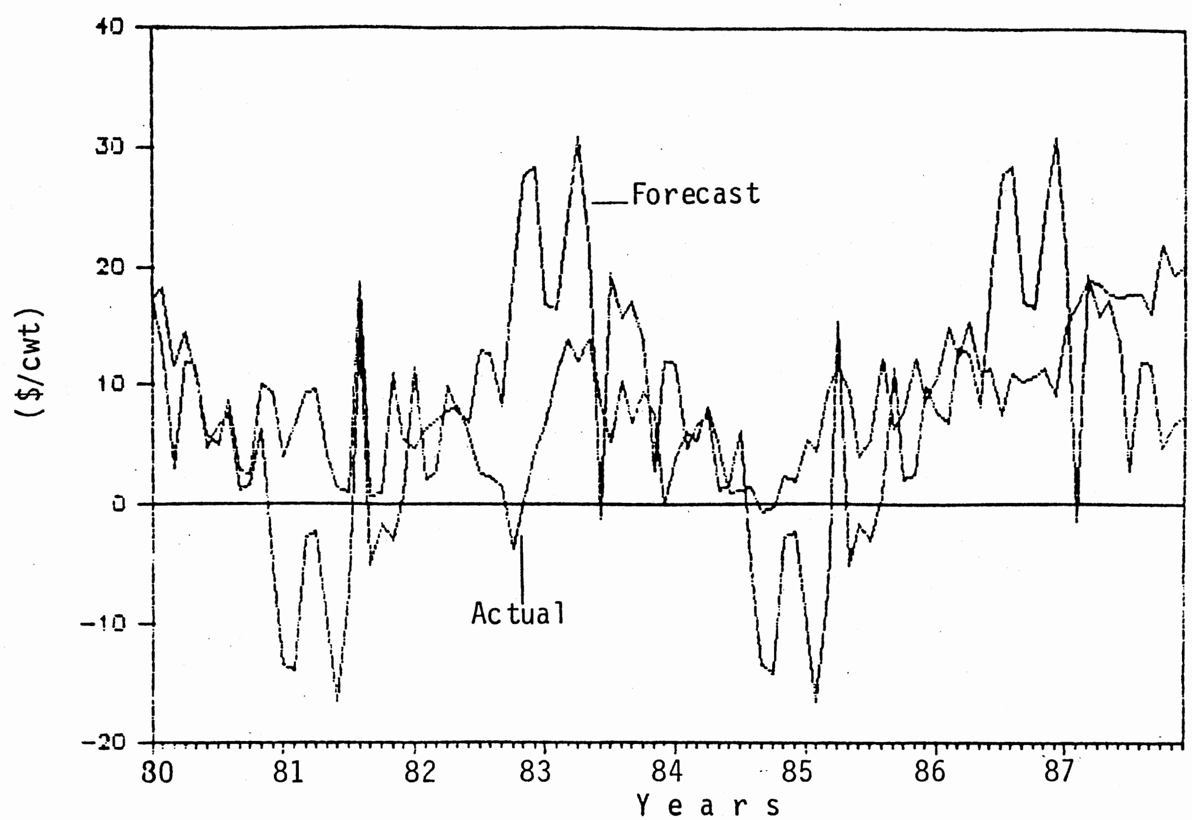


Figure 27. Actual and ARIMA Forecast Monthly Basis for 400-500 lbs. Steers Weight, 1980-1987

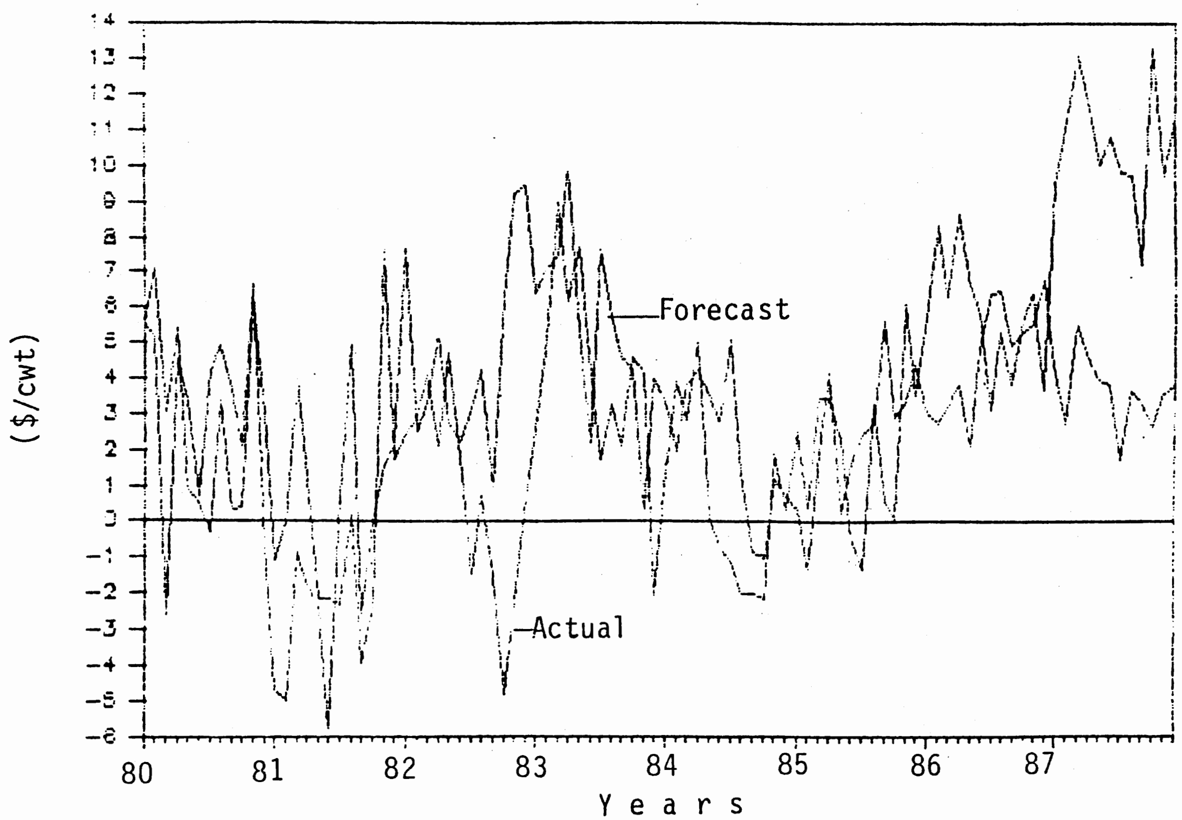


Figure 28. Actual and ARIMA Forecast Monthly Basis for 500-600 lbs. Steers Weight, 1980-1987

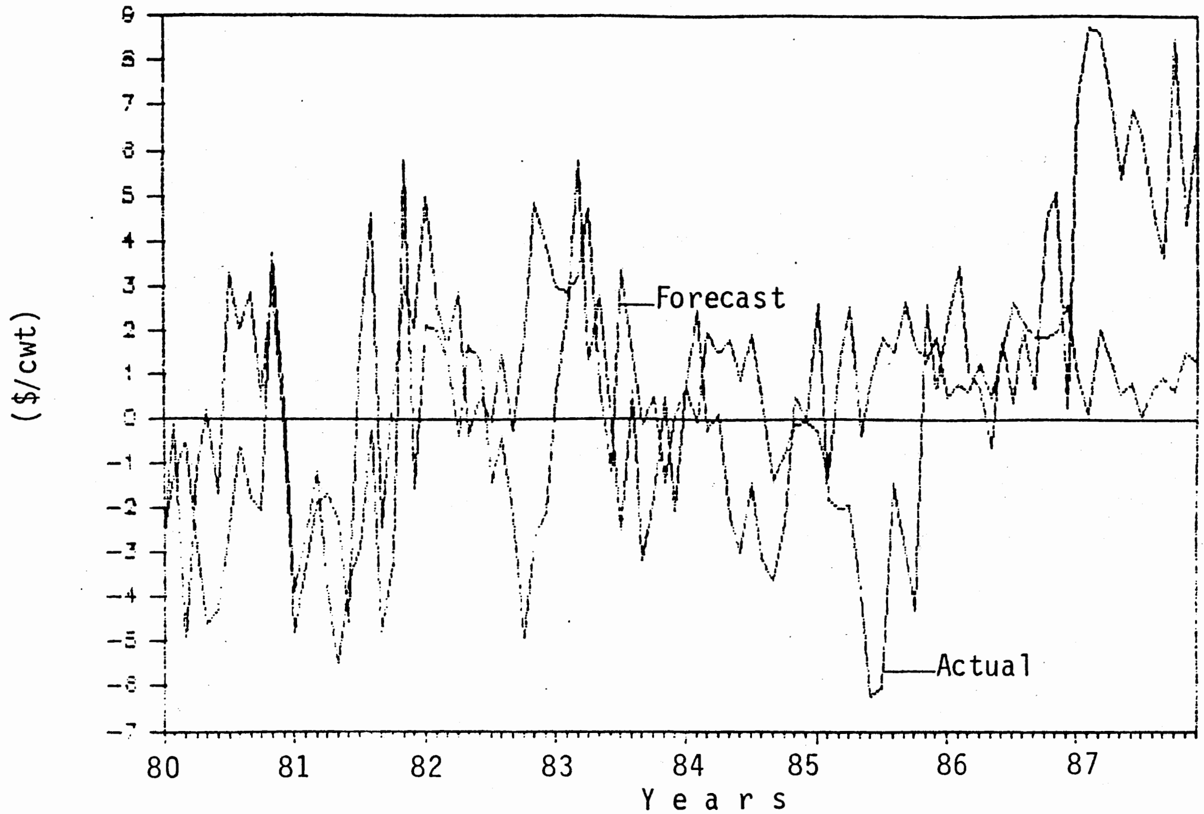


Figure 29. Actual and ARIMA Forecast Monthly Basis for
600-700 lbs. Steers Weight, 1980-1987

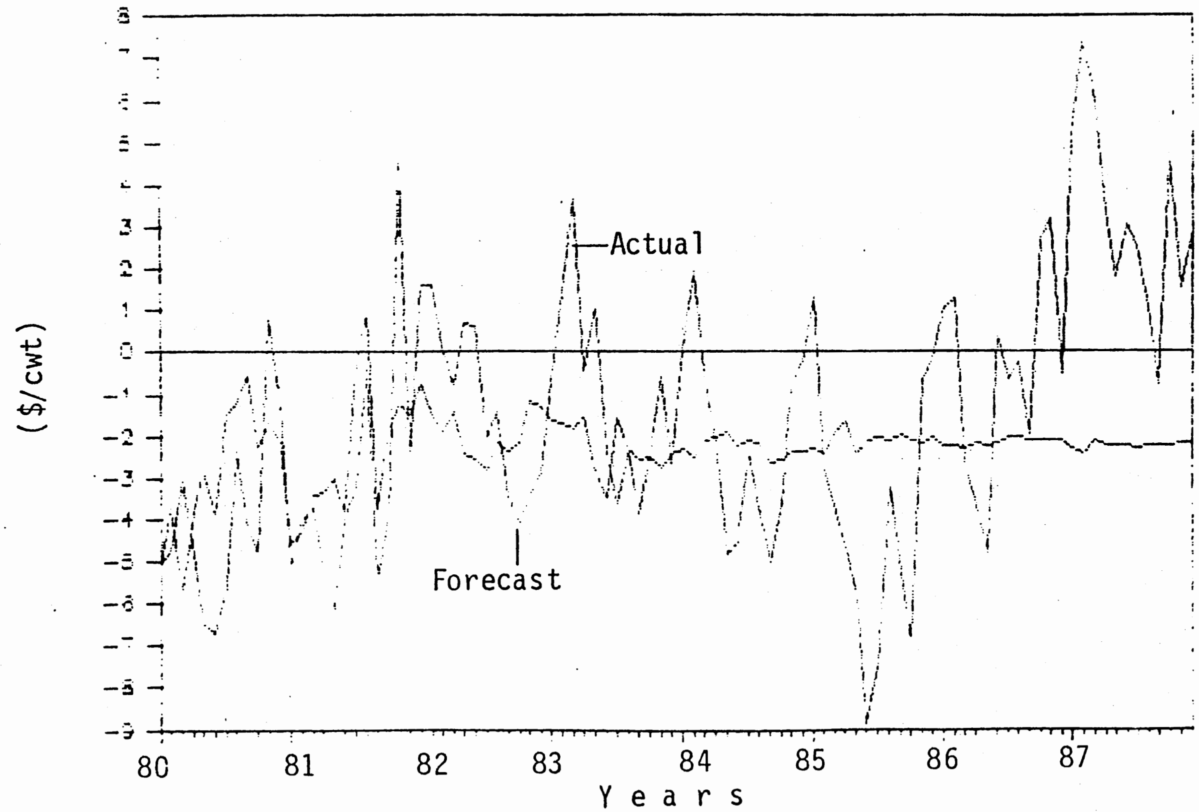


Figure 30. Actual and ARIMA Forecast Monthly Basis for 700-800 lbs. Steers Weight, 1980-1987

TABLE VI

INGREDIENTS OF SEVERAL FEED SUPPLEMENTS RESULTING IN HIGHEST GAINS FROM SOME STUDIES ON STEERS GRAZING NATIVE PASTURE FROM EARLY SUMMER TO LATE FALL IN OKLAHOMA

ITEM	TREATMENTS*			
	A	B	C	D
Amount fed (lbs./day)	1.50	0.80	1.00	1.07
Protein level (%)	43.00	39.00	38.00	44.00
Ingredients (%)				
Soybean meal	95.00	87.50	43.00	-
Soybean meal cube	-	-	-	100.0
Cottonseed meal	-	-	47.00	-
Limestone	2.00	1.50	-	-
Dicalcium Phosp.	3.00	10.00	1.00	-
Molasses	-	-	5.00	-
Fat	-	-	-	-
Vitamin A	-	-	0.16	-
Binder	-	-	3.84	-
Potassium Chloride	-	1.00	-	-
Weight Gains				
Daily (lbs./day)	1.97	1.72	1.39	1.32
Suppl./gain (lbs.)	2.80	2.16	2.60	2.00

* A=Lusby, Horn, and Dvorak (1981); B=Lusby and Horn (1983); C=McCollum, Gill, and Ball (1985); and D=Cantrell, Bryan, and Lusby (1985).

Stochastic supplemental feed prices were generated by the model based on the cost per pound of the supplemental feed (OSU Livestock Budget, 1987), the historical correlation between prices, and the random deviates drawn. Furthermore, the mean of random variables in this model can be trended up or down to reflect variation in the planning horizon.

Stochastic Multivariate Processes.

A multivariate routine for empirically distributed random variables available within FLIPSIM V was used to generate stochastic steer prices and weight variables using factored correlation matrices. However, the distribution of stochastic steer weight gain for the whole six-month period was considered as independent, empirically distributed, conditional upon the stocking rate levels, and following the hyperbolic tangent (HT) function described earlier. The stochastic cash and futures prices are considered as multivariate empirically distributed and the basis is correlated with the cash prices. The stochastic futures prices are derived from identity (3.11). In this process the time series component provides an estimate of average monthly prices and the correlation component provides a multivariate probability distribution about the means. The factored correlation matrix needed for the stochastic process is generated by time series package (TSP) and then factored using MFACTOR1 fortran routine to develop an upper triangular matrix. The dimension of this matrix, 24 by 24, is prepared to account for twelve months of entries for both cash prices and the bases.

The stochastically generated random variables must involve the necessary correlation to reflect their realistic variation. To generate empirically distributed random values for steer weights and prices, a series of independent normal deviates, and the factored correlation matrices are provided as input for the model. According to Clements, Mapp, and Eidman (1971), this correlation coefficient matrix is symmetric about its main diagonal and it is positive definite. Furthermore, this matrix can be factored into its upper triangular matrix which is used in the stochastic process for the random variables. Following Law and Kelton (1982), the deviates are later multiplied by the factored correlation matrices, and the product of the two is uniformly transformed. The transformed values are used in the inverse function to calculate empirically distributed random steer weights and prices.

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

$$DEV = DEV + (CORM * GAUSS) \tag{3.20}$$

where:

DEV = array of empirically integrated variates which is the product of the matrix multiplication of factored correlation matrix and the random deviates.

CORM = upper right triangular factored correlation matrix.

GAUSS = deviates generated by GAUSS random generator.

STOCH subroutine transforms correlated deviates to a uniform (0,1) variates using ERFF function routine in the following equations.

$$E_t = DEV * 0.707106781 \tag{3.21}$$

$$UVAR_t = ERFF(E_t) \tag{3.22}$$

where:

E_t = factor adjusted correlated random deviate in period t.

$UVAR_t$ = uniform factor correlated deviates in period t.

ERFF = error function subroutine that calculates the area from negative infinity to the argument E_t by means of polynomial approximation.

The stochastic values are represented by equation (3.23) as follows:

$$SV_t = (((CDM_{i+1}-CDM_i)*((UVAR_t-PUD)/DELTA))+CDM_i)*EEF \quad (3.23)$$

where:

SV_t = a matrix of stochastic empirically distributed expanded and factored correlated observation in period t

CDM_i = cummulative deviates about mean, i=2,...,12

$UVAR_t$ = uniform factor correlated deviates in period t

PUD = probabilities for a discrete uniform distribution

DELTA = defined as 1/11

EEF = expansion fractions for empirical distribution

Every year in the planning horizon within each iteration loop, if the $UVAR_t$ is between 0 and 1, the model calculates the stochastic values for all variables considered empirically distributed in this study.

Firm Performance Measures

The future flows of annual net cash ranch income are discounted to the net present value (NPV), and the net present values of alternative plans are compared.

$$NPV = \sum_{i=1}^{n} \{(NS)/(1+r)^n\} \quad (3.24)$$

where:

NPV = Net Present Value of income

NS = Net Sum of future income

r = Interest rate

n = Planning Horizon (Years)

The net present value analysis incorporates the time value of money and the decision maker's discount rate to provide information needed for whole-firm comparative analysis. For example, whole ranch analysis under risk will select its alternative strategy with a preferred distribution from among different probability distributions given by each strategy.

Several net present value distributions representing different strategies generated by the model can be ordered for the decision maker to select according to the risk preference. However, a unique preference measure represented by the decision maker's utility function is not readily available in most cases and it is difficult to estimate. An efficiency criterion, a preference relationship that provides a partial ordering of some important measures of alternative strategies, can be used to eliminate some feasible alternative strategies from consideration without requiring detailed information about the decision maker's preference. For example, stochastic dominance with respect to a function described in Chapter II provides a most discriminating efficiency criterion for selecting alternative strategies.

At this point, the required production and price input data for the simulation model FLIPSIM V, are developed. The estimated average monthly cash prices and basis are generated by the time series component (ARIMA), and a factored correlation matrix for monthly cash price and basis is constructed using TSP (Time Series Package) and factored using MFACTOR1 Fortran routine. The factored upper triangular matrix is required for the stochastic process to generate stochastic monthly cash price and basis. The stochastic monthly futures prices needed by the hedging routines are calculated by using the identity relation (3.13). All calculations pertaining to cash prices and the bases are carried out for each steer weight class (400-500 lbs., 500-600 lbs., 600-700 lbs., and 700-800 lbs.) The steer weight gain data were developed for three different stocking rates (low, medium, and high) for the selected steer production period (first three months, last three months, and whole six months.)

Input Data for the Representative Ranch Unit

The representative base ranch selected for this study can be categorized as a large commercial stocker enterprise with 6,926 acres of land and 1,500 head of summer stocker each year for the medium stocking rate, and 1,700 head for high stocking rate assumptions. The beginning inventory of assets and liabilities of the base ranch, presented in Table VII has a 35 percent debt to asset (D/A) ratio. Initial land values were based on a 3.5 percent return to assets and a cash lease cost of $95.00 per cow per year for pasture that could carry one cow unit per 25 acres. The ranch has machinery and equipment that include two pickup trucks, one stock trailer, livestock facilities, and feeding equipment. Building and improvements, fencing, and other permanent facilities were valued at the current market value of $80,000.00 (Gutierrez, 1985).

Financial Assumptions

Table VIII presents the financial assumptions used in this study. All annual interest rates and annual rates of return are increased by 2 percent annually throughout the planning horizon. The annual inflation rate for range land is 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 and 18 years. Long-term financing can be obtained at the specified interest rate (Table VII) if the

TABLE VII

BEGINNING ASSETS AND LIABILITIES FOR THE SOUTHERN PLAINS STOCKER BASE RANCH

Item		35% D/A	65% D/A
Owned land	(Acres)	4,156	4,156
Cash Leased Land	(Acres)	2,770	2,770
Lease Cost	($/Acre)	3.80	3.80
ASSETS			
Beginning Cash Reserve	($)	1,000	1,000
Machinery and Equipment	($)	49,700	49,700
Building and Improvements	($)	80,000	80,000
Market Value of Owned Land	($)	531,216	531,216
Total Assets	($)	661,916	661,916
LIABILITIES			
Livestock Debt	($)	28,351	52,650
Intermediate Term Debt	($)	17,395	32,305
Real Estate Debt	($)	185,925	345,290
Total Liabilities	($)	231,671	430,245
NET WORTH	($)	430,245	231,671
Equity (%)		65.0	35.0
Leverage Ratio		0.358	1.857

TABLE VIII

FINANCIAL ASSUMPTIONS FOR THE BASE STOCKER RANCH FOR THE PLANNING HORIZON

ITEM	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Interest rate on new long-term loan	0.1250	0.1275	0.1300	0.1326	0.1352	0.1379	0.1406	0.1434	0.1462	0.1491
Interest rate on new intermediate-term loan	0.1360	0.1387	0.1414	0.1443	0.1471	0.1501	0.1531	0.1561	0.1593	0.1625
Minimum down on new long-term purchases (% of purchase price)	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
Minimum down on new intermediate-term purchases (% of purchase price)	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
Rate of Return on Cash Reserves	0.0777	0.0792	0.0808	0.0820	0.0841	0.0857	0.0875	0.0892	0.0910	0.0928
Before tax rate of return on off-ranch investments	0.0877	0.0894	0.0912	0.0930	0.0949	0.0968	0.0987	0.1007	0.1027	0.1048
Interest rate on new short-term (operating) debt	0.1250	0.1275	0.1300	0.1326	0.1353	0.1380	0.1407	0.1435	0.1464	0.1493
Interest rate for refinancing long-term debt	0.1450	0.1475	0.1500	0.1526	0.1552	0.1579	0.1606	0.1634	0.1662	0.1691
Interest rate for refinancing intermediate-term debt	0.1460	0.1487	0.1514	0.1543	0.1571	0.1601	0.1631	0.1661	0.1693	0.1725
Escalation rate for cash lease	0.0430	0.0438	0.0447	0.0456	0.0465	0.0474	0.0484	0.0493	0.0503	0.0514

SOURCE: Gutierrez (1985)

long-term equity ratio is above 35 percent. 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 loans are seven and six years. Intermediate-term financing can be obtained at the specified interest rate (Table VIII) if the intermediate-term equity ratio is above 40 percent.

Inflation and Tax Rates

Continuously changing economic situations may be reflected in FLIPSIM by trending costs over time using annual inflation rates. Used machinery, equipment, and annual fixed costs are assumed to be inflated by 3.7 percent, 1.6 percent, and 3.9 percent, respectively. Fuel and lube, pasture cost, variable livestock costs and hired labor are inflated at a rate of 3.6 percent, 3.4 percent, 4.1 percent, and 2.6 percent, respectively.

Family living expenses and off-farm income are inflated by using the consumer price index (CPI), built into the FLIPSIM V model, with an initial CPI of 319.8 increased at 4.5 percent annually.

Table IX presents the annual self-employment tax rates with the maximum income level subject to this tax for the planning horizon. Four personal income tax exemptions are assumed. Rates of 10 percent and a 20 percent marginal income tax are assumed to calculate state income tax, and personal itemized deduction to taxable ranch income, respectively.

The base stocker ranch could neither sell land to avoid insolvency nor buy or lease land when the financial position allows. Operating capital is borrowed for seven months out of the year and a $1,000 cash reserve is required.

TABLE IX

SELF EMPLOYMENT TAX RATE WITH ITS MAXIMUM INCOME LEVEL THAT IS SUBJECT TO THIS TAX

	SELF-EMPLOYMENT	
Planning	Tax Rate	Maximum Income
1988	0.1180	39,600
1989	0.1230	41,700
1990	0.1230	43,800
1991	0.1302	45,900
1992	0.1302	48,200
1993	0.1530	50,500
1994	0.1530	52,700
1995	0.1630	54,800
1996	0.1630	57,000
1997	0.1730	59,300

SOURCE: Gutierrez (1985)

Production and Marketing Decision

The representative ranch with a medium stocking rate has 1,500 heads or 1,700 head for high stocking rate of summer stockers on pasture with a 2 percent annual death loss rate for the entire planning horizon. The production period of the summer stocker system starts in early May and ends in late

October. The ranch buys 470 pound steer calves on about May 1 at a stochastic 400-500 lbs. steer calf price and the steers are put on grazing pasture for 6 months. In addition, the steers are fed approximately 140 lbs. of prairie hay per head during this production period. The ranch operator can make within-year production decisions and use any one of the available marketing strategies described earlier in this chapter. The detailed description of each strategy, which is built into the model, is presented in Chapter IV.

The stochastic stocker weight at the end of the production period is the sum of the initial weight and the weight gain during the production period. The following relations show the stochastic ending weight for a yearly decision (3.25), within-year decision with supplement feed in a bad year (3.26), and within-year decision with a stocking rate adjustment in a bad year (3.27), respectively.

$$SWT_y = IWT + SWGN_y \quad (3.25)$$

$$SWT_{wf} = IWT + SWGN_1 + (SWGN_2 * k) \quad (3.26)$$

$$SWT_{ws} = IWT + SWGN_1 + SWGN_2 \quad (3.27)$$

where:

SWT_y = stochastic ending weight for yearly decision (lbs.)

SWT_{wf} = stochastic ending weight for within year decision with feeding supplement in bad year (lbs.)

SWT_{ws} = stochastic ending weight for within year decision with stocking rate adjustment in bad year (lbs.)

IWT = initial steer calf weight (lbs.)

$SWGN_y$ = stochastic weight gain for entire six months production period (lbs.)

$SWGN_i$ = stochastic weight gain in first three month of the production period (lbs.)

$SWGN_2$ = stochastic weight gain in the last three months of the production period (lbs.)

k = factor for the effect of feeding supplement on the weight gain.

When the two-period decision is selected and a low gain is achieved at the end of the first three-month production period, a conditional decision is made as to whether to feed the animals with supplement, hence increasing production cost, and obtaining a higher gain. The other alternative is to lower the stocking rate by selling some of the animals to obtain higher ending weights for remaining cattle. The criterion for a low gain is when the stochastic weight gain in the first period is lower than or equal to the lowest mean weight gain across stocking rates. A decision for lowering the stocking rate level in the second period will result in a one step lower level than in the first period. For example, high to medium, medium to low, and no change if the original stocking rate was already low.

If the ranch operator selects a within-year decision and experiences a good year, the stochastic ending weight is similar to (3.27), with the same number of stockers for the full summer. On the other hand, if a bad year is encountered, the ranch has the stochastic ending weight as in (3.27) but with fewer stockers due to a stocking rate adjustment achieved by selling some of the animals. However, if the stocking rate level is already low, i.e. at the lowest stocking rate, no stocking rate adjustment will be made. The lowest stocking rate is not evaluated in this study. This study uses a factor k=1.36 to reflect increased weight gain of 136 percent, due to soybean meal supplement, compared to no supplement (Lusby, Horn, and Dvorak, 1981).

Receipts from stocker sales are calculated depending upon the marketing strategy selected. The following relations describe the calculation of receipts from cash sales, simple hedging, strategic hedging, and multiple hedging strategies. Relations (3.28) through (3.36) represent calculation of receipts from different marketing strategies.

$$RECPTS_{cm} = SCPRC_{nv} * SWT_{y} * STKRNO * (1\text{-}DLOSS) \quad (3.28)$$

$$SELFUT_{si} = SFPRC_{my} * EWT_{y} * STKRNO * (1\text{-}DLOSS) \quad (3.29)$$

$$BUYFUT = SFPRC_{oc} * EWT_{y} * STKRNO * (1\text{-}DLOSS) \quad (3.30)$$

$$RECPTS_{si} = SELFUT_{si} - BUYFUT - HEDGCOS + RECPTS_{cm} \quad (3.31)$$

$$SELFUT_{st} = SFPRC_{mo} - EWT_{y} * STKRNO * (1\text{-}DLOSS) \quad (3.32)$$

$$RECPTS_{mt} = SELFUT_{st} - BUYFUT - HEDGCOS + RECPTS_{cm} \quad (3.33)$$

$$SELFUT_{mh} = SFPRC_{mo} * EWT_{y} * STKRNO * (1\text{-}DLOSS) \quad (3.34)$$

$$BUYFUT_{mh} = SFPRO_{mo} * EWT_{y} * STKRNO * (1\text{-}DLOSS) \quad (3.35)$$

$$RECPTS_{mh} = \Sigma\,(SELFUT_{mh} - BUYFUT_{mh} - HEDGCOS)_{mo} + RECPTS_{cm} \quad (3.36)$$

where:

$RECPTS_{cm}$ = receipt from cash market

$SCPRC_{nv}$ = stochastic cash price in November

SWT_{y} = stochastic ending weight

STKRNO = number of stocker

DLOSS = fraction of death loss rate

$SELFUT_{si}$ = selling futures in simple hedging

BUYFUT = buying futures to liquidate position

$RECPTS_{si}$ = receipt from simple hedge strategy

$SELFUT_{st}$ = selling futures in strategic hedging

$SFPRC_{mo}$ = stochastic futures price in month mo (my=may, Oc=October)

$RECPTS_{st}$ = receipt from strategic hedging

$SELFUT_{mh}$ = selling futures in multiple hedging

$BUYFUT_{mh}$ = buying futures in multiple hedging

$RECPTS_{mh}$ = receipt from multiple hedging

HEDGCOS = transaction costs covering placing and lifting a hedge

$RECPTS_{st}$ and $RECPTS_{mh}$ equal $RECPTS_{cm}$ when no single hedge is placed during the entire production period. The same calculations apply for the within period decisions by replacing the stochastic ending weight with SWT_{wf} or SWT_{ws} as presented in (3.26) and (3.27).

Labor Requirement

Family labor of about 240 hours is available monthly without full-time employees. Part-time labor is $5.00 per hour inflated over the planning horizon using the annual rates of change in the CPI. Labor requirements for the summer stocker operation are based on a previous study where monthly labor requirements per head for the six months (May through October) stocker production period are 0.24, 0.24, 0.25, 0.25, 0.25 and 0.31 hours per head, respectively (Gutierrez, 1985).

Fixed Costs

The following fixed cost figures are assumed in this study. Overhead costs of $500 (accountant and legal fees), unallocated maintenance and repair cost ($100), insurance premiums for ranch business ($1,000), accrued taxes (past four-year average appreciation rate for land, 2 percent), return to production assets for ranch (in year t-1 and t-2 are 3.5 and 3.5 percent respective), and after tax discount rate of 8 percent. Overhead costs are calculated annually where the initial value is inflated by annual inflation rates. An after-tax discount rate of 8 percent is used for calculating the net present value (NPV) and the present value of ending net worth (PVENW).

The procedures used for subroutine modification, the input data preparation, and a general description of the FLIPSIM V simulation model are presented in the next chapter.

CHAPTER IV

SIMULATION MODEL

Description of the Simulation Model

The simulation model used in this study is the most recent version of FLIPSIM V. The model allows evaluation of the probable consequences of alternative farm policies and income tax developments on typical or representative farms in a deterministic or stochastic setting. The model provides for multivariate or independent normal, triangular, and empirical probability distributions for crop yields and prices, dairy prices and milk production, and beef prices. However, the model does not allow livestock (non-dairy) production variables such as weight, to vary stochastically as a random variable using one of the distributions. Thus, modifications (as described in this and the preceding chapter) are made to accommodate the livestock analysis.

Capabilities and Uses of the Model

The general description of FLIPSIM V in the following sections is extracted from Richardson and Nixon (1986).

FLIPSIM V simulates the annual production, farm policy, marketing, financial management, growth, and income tax aspect of a farm over a multiple-year planning horizon. The program is capable of simulating a case farm situation for 1 to 10 years. It recursively simulates a typical farm by using the ending financial position for year 1 as the beginning position for the second year. Options for selecting the optimal (profit or utility maximizing) crop mix, using linear programming or quadratic programming algorithm, for years 2 through 10 are included in the model. A simulated farm, from year 1 to 10, is repeated for up to 300 iterations during a stochastic analysis, and at the end of each iteration the model records the results for future analysis. Prior to simulating iterations 2 through 50, the model reinitializes the farm to the beginning situation used for the first iteration. Statistical analysis, development of cumulative probability distributions, and estimates of the probability of solvency of output variables are performed as iterations completed.

The same set of input data for a typical farm can be simulated using deterministic or stochastic values for prices and yields by changing one character on the option card. Similarly, a typical farm can be simulated under two types of depreciation rules with a single change on the option card.

Richardson and Nixon (1986) report that since the first version of this model was released in 1981, FLIPSIM has been used extensively by researchers, such as in cotton farm analysis by Smith in 1982; by Limieux, Richardson, and Nixon in 1982; by Richardson and Nixon in 1982; by Richardson, Nixon, and Smith in 1982; by Bailey in 1983; and by Duffy, Richardson, and Smith in 1984. In other areas such as feed grain and rice farming, the model was used by Ray, Richardson, and Li in 1982; and by Perry, Rister, Richardson, Sij and Grant in 1985.

In livestock research, FLIPSIM has been used with some modification on the livestock section or combined with other routines to provide and allow stochastic livestock production components, such as selling weight, weaning percent, calving percent, and death loss, as well as incorporating exogenous variable such as weather conditions into the model. For example, Gutierrez (1985) used REPFARM, an earlier version of FLIPSIM, with some modification for analyzing management alternatives for a Southern Plains representative ranch. Vantassell (1987) used FLIPSIM V for a ranch business analysis by merging the simulation model RANGE and FLIPSIM V, in which the financial and accounting routines of FLIPSIM V are linked with RANGE to create RANSIM.

The Model Subroutines

The computer program for FLIPSIM V is made up of a series of subroutines that perform specialized operations. A schematic of the order in which these subroutines are called by the main program and the design of the overall computer model is presented in Figure 31. The first part of the model processes the analyst's data for the simulator. The second part consists of subroutines that perform the calculations and are called once each year of the planning horizon. The last part of the model analyzes the stochastic results and prints all output tables. Figure 32 shows the available subroutines as well as their sub-subroutines.

Subroutine ITSUMM calculates the present value of the farm's income stream, as well as the present value of ending net worth and the internal rate of return for the iteration.

Subroutine STAT performs statistical analysis of the output variables. The probability of the farm having a positive net present value is determined by using the cumulative distribution for the net present value. A table summarizing the probability of the firm remaining solvent each year of the planning horizon is printed as the last function of the subroutine.

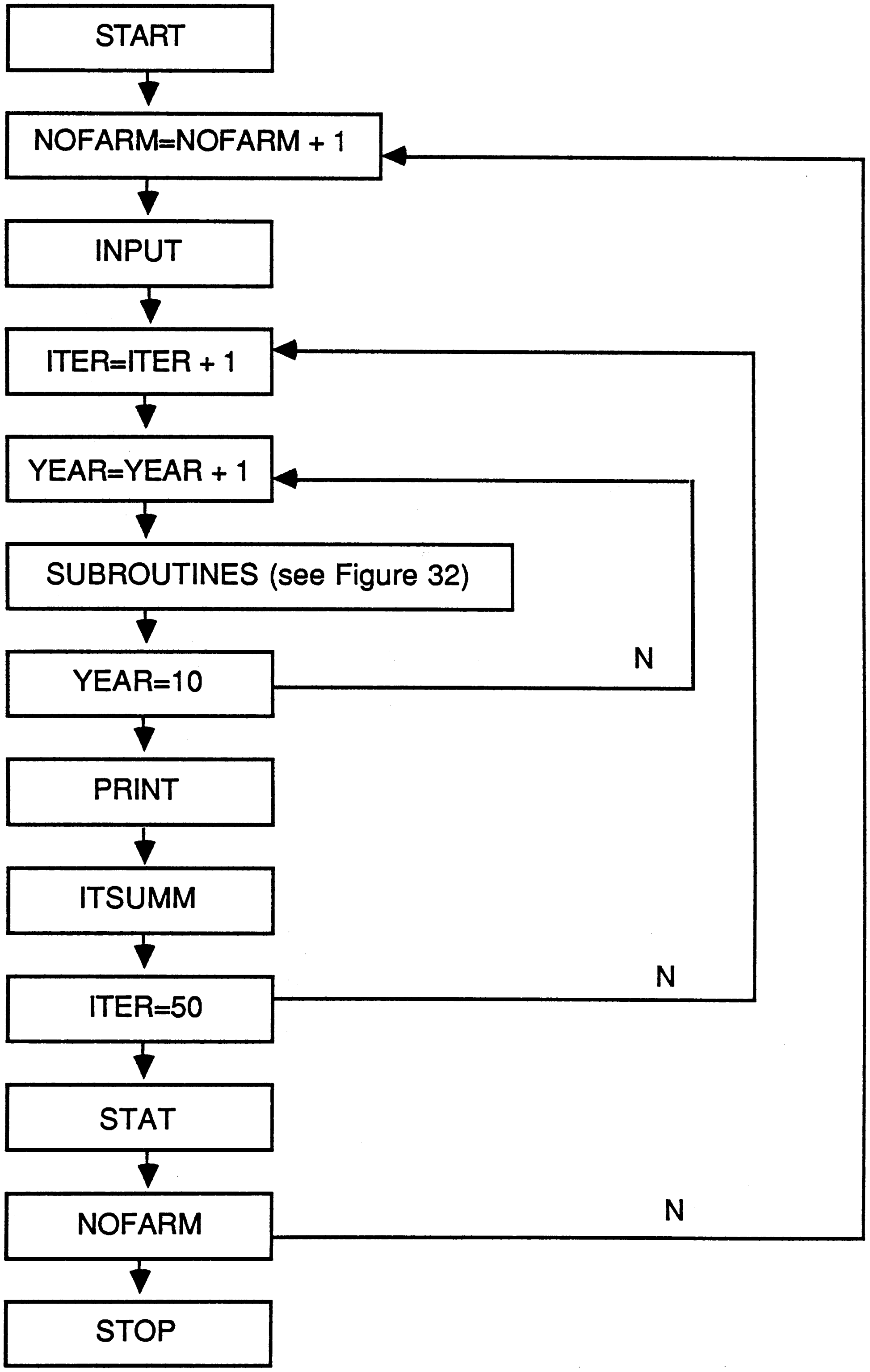


Figure 31. Schematic of the FLIPSIM V Simulation Model

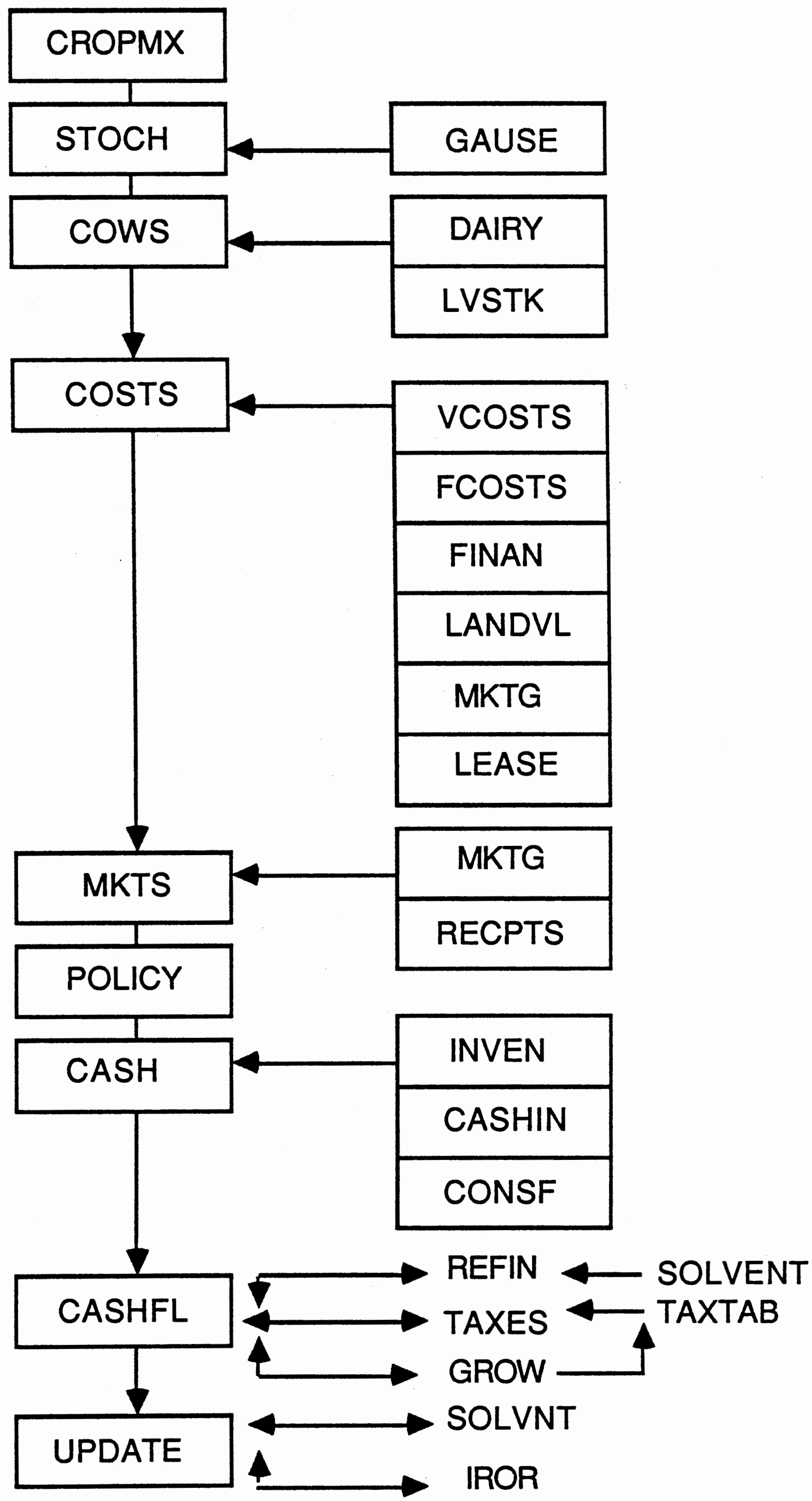


Figure 32. Schematic of Subroutines in FLIPSIM V

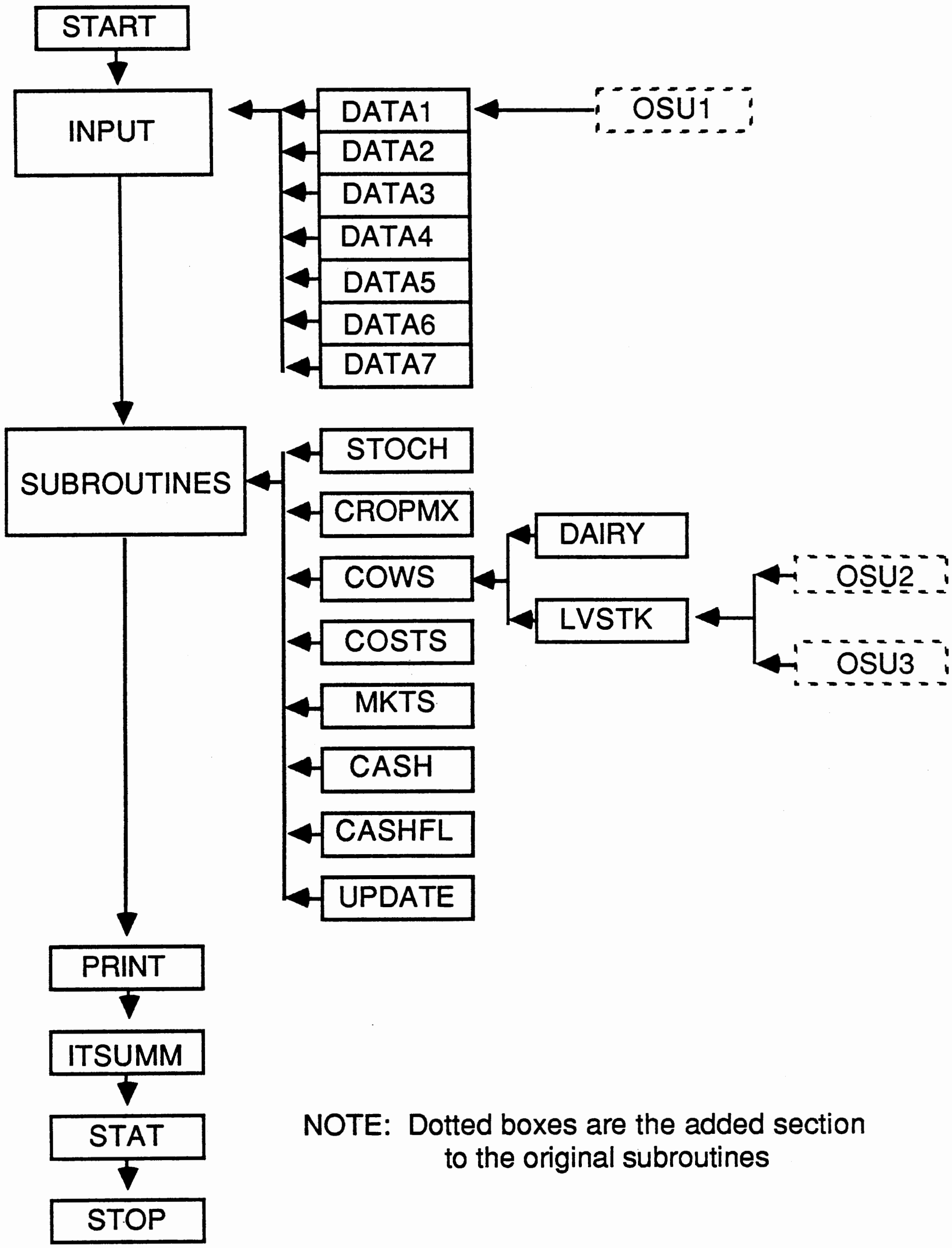
The Modified Subroutines

This study is particularly interested in several subroutines within FLIPSIM V, such as DATA1, STOCH, and LVSTK, for modifications mentioned in Chapter I. Figure 33 is a schematic of modified subroutines from this study.

Subroutine DATA1

Subroutine DATA1 reads all of the input data for the ranch to be simulated and only minor calculations, using the user's input data, are made in these subroutines. This subroutine was extended to create subroutine OSU1 for reading additional input data.

Subroutine DATA1 was modified to include input data cards for additional information required in this study, such as: range for stocking rate levels, break-even cost (BEC) components, annual brokerage fee and average required margins, livestock weight gains, monthly cattle cash prices and bases prices that form futures prices distributions. Also, additional input cards are needed for the factored correlation matrices of steer weight and prices for the stochastic process. Because of the increased size in the input data, mainly due to addition of monthly prices (cash and futures) and monthly basis for every class of steer weights, annual average steer weight generated by the HT function in the program, the size of matrix B(I,J) for the beef enterprises is expanded from B(27,110) to B(27,320). Furthermore, the format for reading the option card was changed to include additional options needed for this study, such as production decision and marketing strategy options, by taking advantage of the reserved, but unused, option numbers 52 to 59.



NOTE: Dotted boxes are the added section to the original subroutines

Figure 33. Schematic of the Modified Subroutines

Option 52 is used for production decision alternatives, either as a yearly decision (Option 52=0) using the whole six-month steer weight gain distribution, or within-year decision (Option 52=1) using both steer weight gain distributions in the first three months and last three months of the production period. The within-year decision alternative allows for changing the stocking rates or feeding supplements at the end of the first period when a bad year is experienced.

Option 53 is used for alternative steer marketing strategies where input numbers 0, 1, 2, and 3 correspond to cash sales, simple hedge, strategic hedge, and multiple hedge, respectively.

Finally, option 54 is used for designating choices of stocking decision alternatives, where input values of 0 and 1 refer to feeding supplement, and changing stocking rate by selling some steers, respectively. The schematic of stocker production alternatives resulting from yearly decisions and within-year decisions are presented in Figures 34 and 35.

The original card 44 is reassigned as card 44-A with three additional entries (originally blanks) for specification of the stocking rate interval. Additional cards 44-B through 44-E are prepared for input data on break-even costs components, annual brokerage fee, and average margin requirement for the contract, and average annual steer weight gain in the first and the last production period at low, medium, and high stocking rates. Furthermore, the original card 47 is reassigned as card 47-A and additional card 47-B through 47-J are prepared for the average monthly steer cash prices, basis, and future prices for all four classes of steer weights (400-500 lbs., 500-600 lbs., 600-700 lbs., and 700-800 lbs.).

The original card 48 (used for the factored matrix of livestock prices) is reassigned as card 48-A and additional card 48-B allows input of the factored

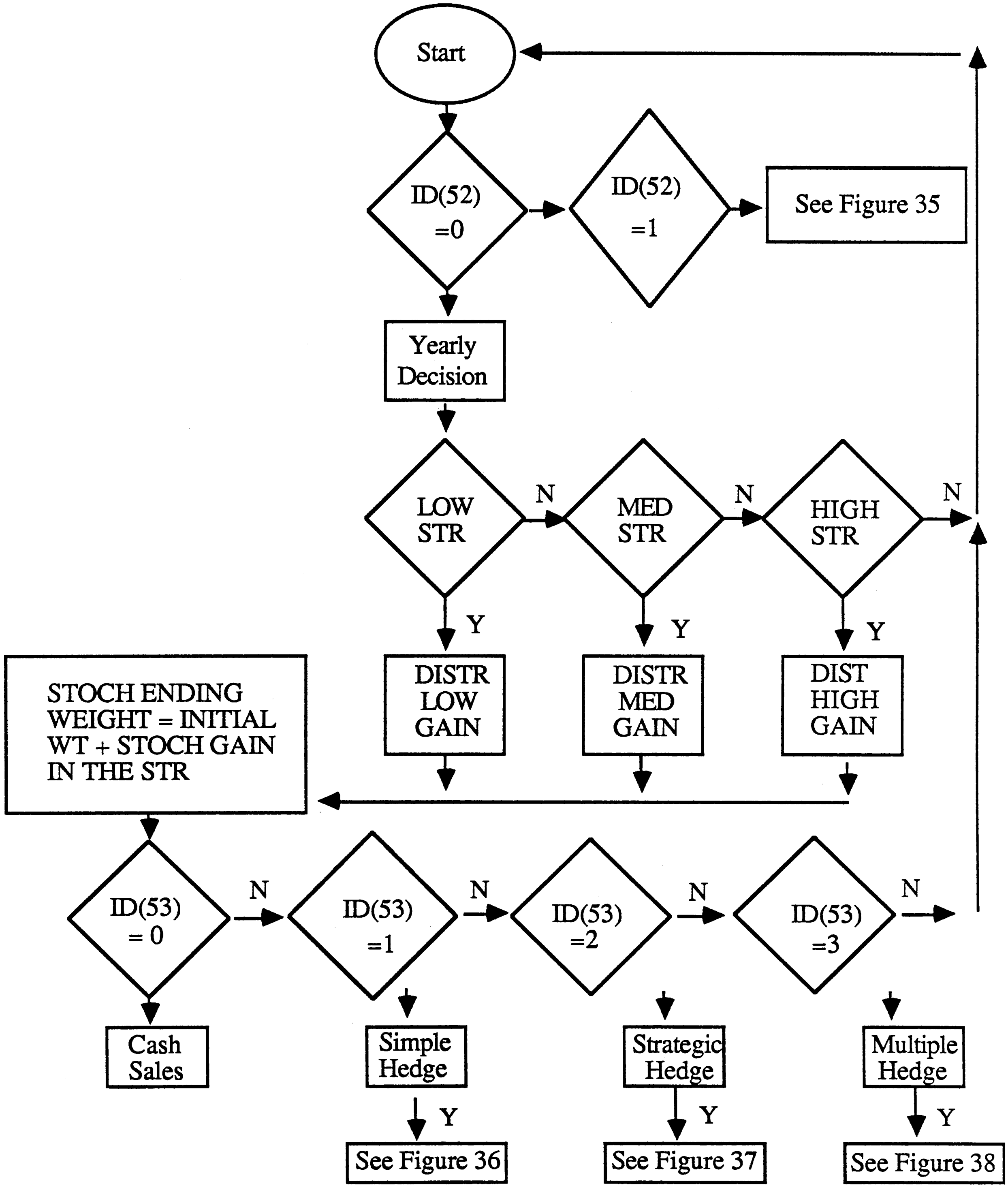


Figure 34. Schematic of Yearly Stocker Production Decision

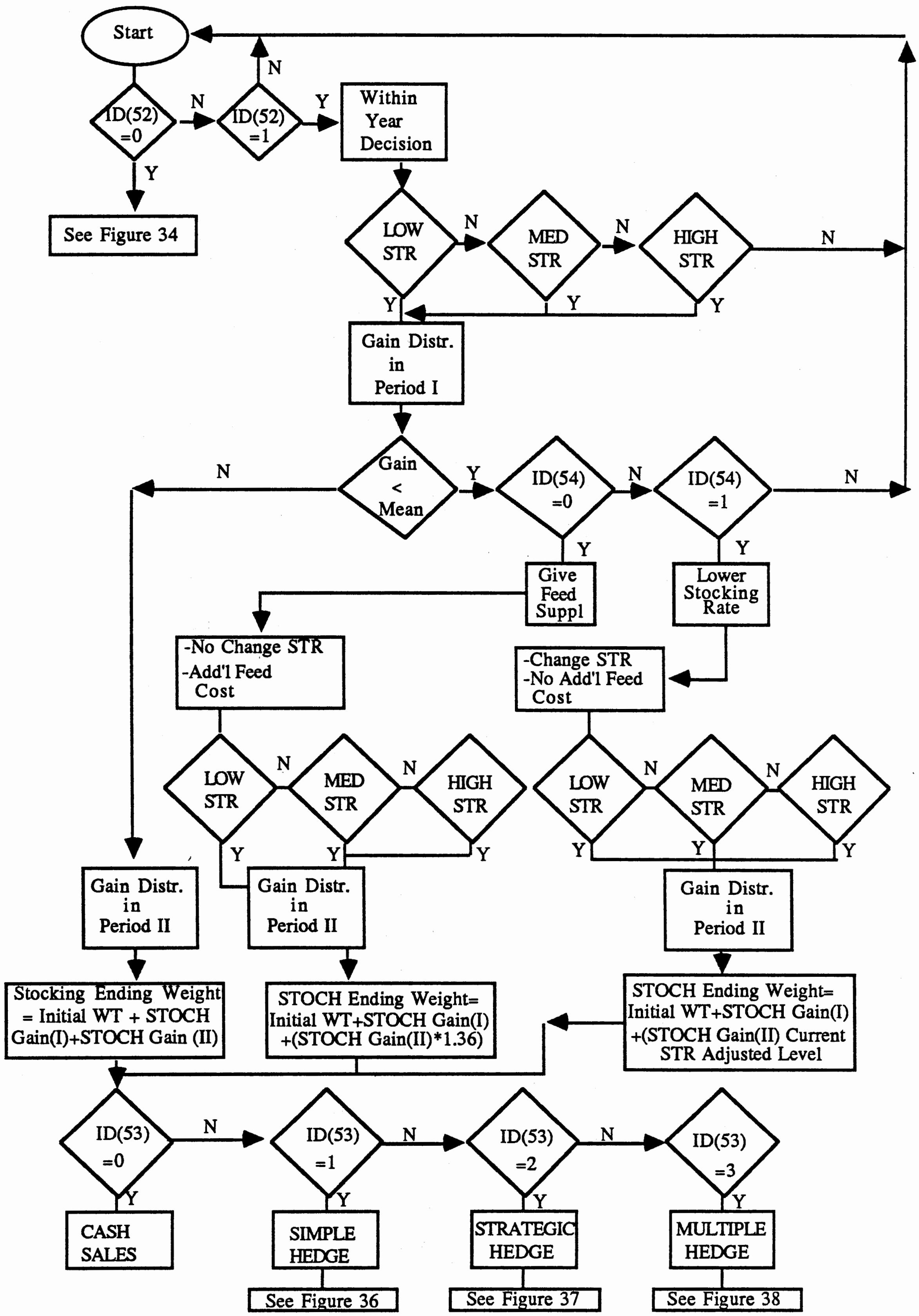


Figure 35. Schematic of Within-Year Stocker Production Decision

correlation matrix of steer cash prices and bases for all steer weights classes, and factored correlation matrix of steer weight gains in the first period and the last period at their levels of stocking rate. In addition to the original card 50, which is reassigned as card 50-A, for the historical probability distribution functions, cards 50-B through 50-E are included to input the historical pdf's for the steer weight gains from the first and the last production periods as well as the historical monthly steer cash prices and the bases.

The available hedging strategies that require monthly information on the cash and futures prices and hence, the basis, are offered only when the analyst decides to use a marketing strategy other than cash sales. The schematic hedging strategies introduced into the model are presented in Figures 36 through 38.

Subroutine DATA3 processes the input data to develop necessary values that are either not provided by the analyst or are provided in a different form than the model requires. Subroutine DATA4 prints the summary of the options selected for the particular analysis. Subroutines DATA5 and DATA6 print a summary of all input data except the dairy herd data.

At the end of a deterministic (but not for stochastic runs) simulation, the model prints the output for the analysis as well as all intermediate results generated by the model.

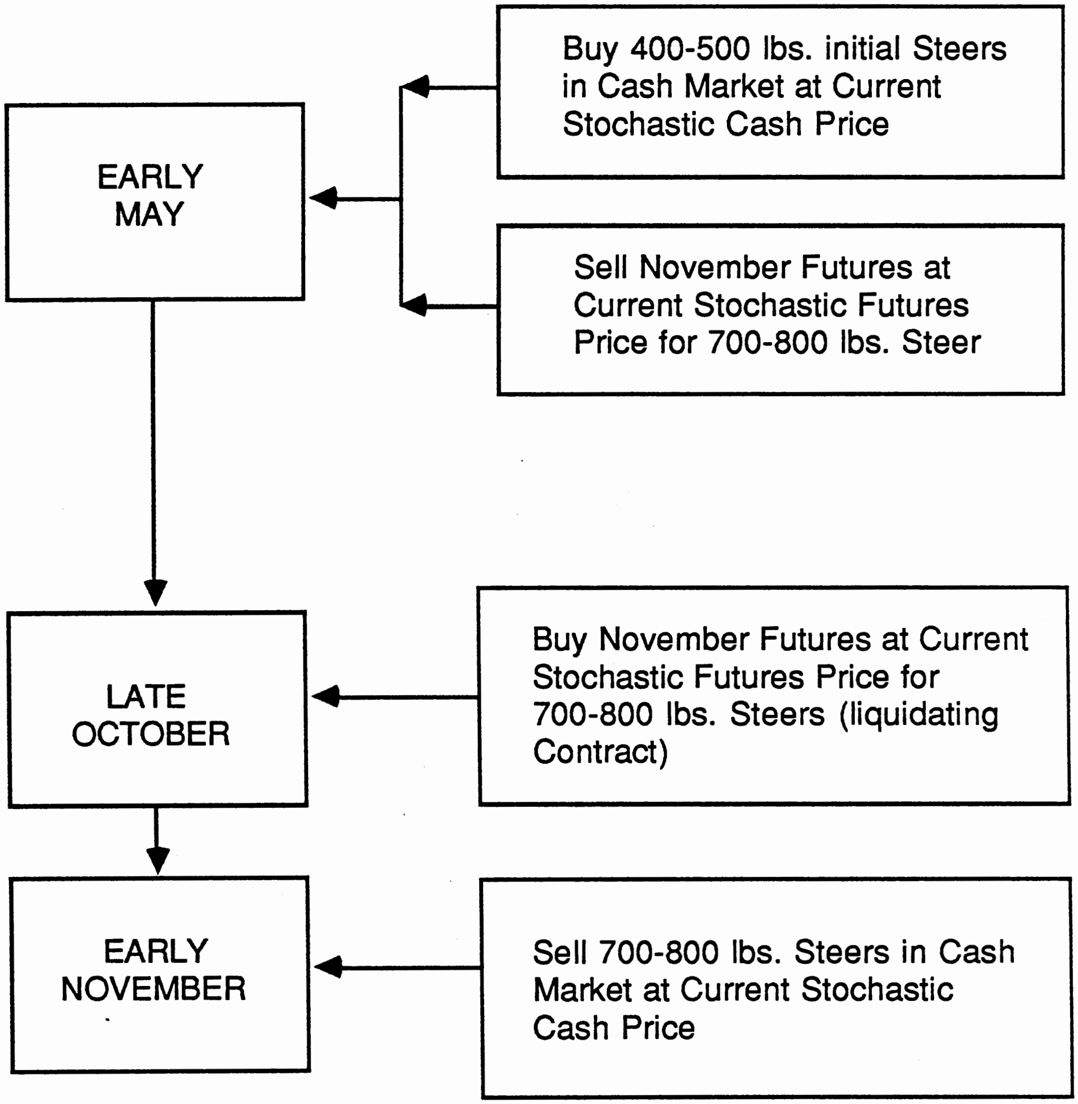


Figure 36. Schematic of Simple Hedging Strategy

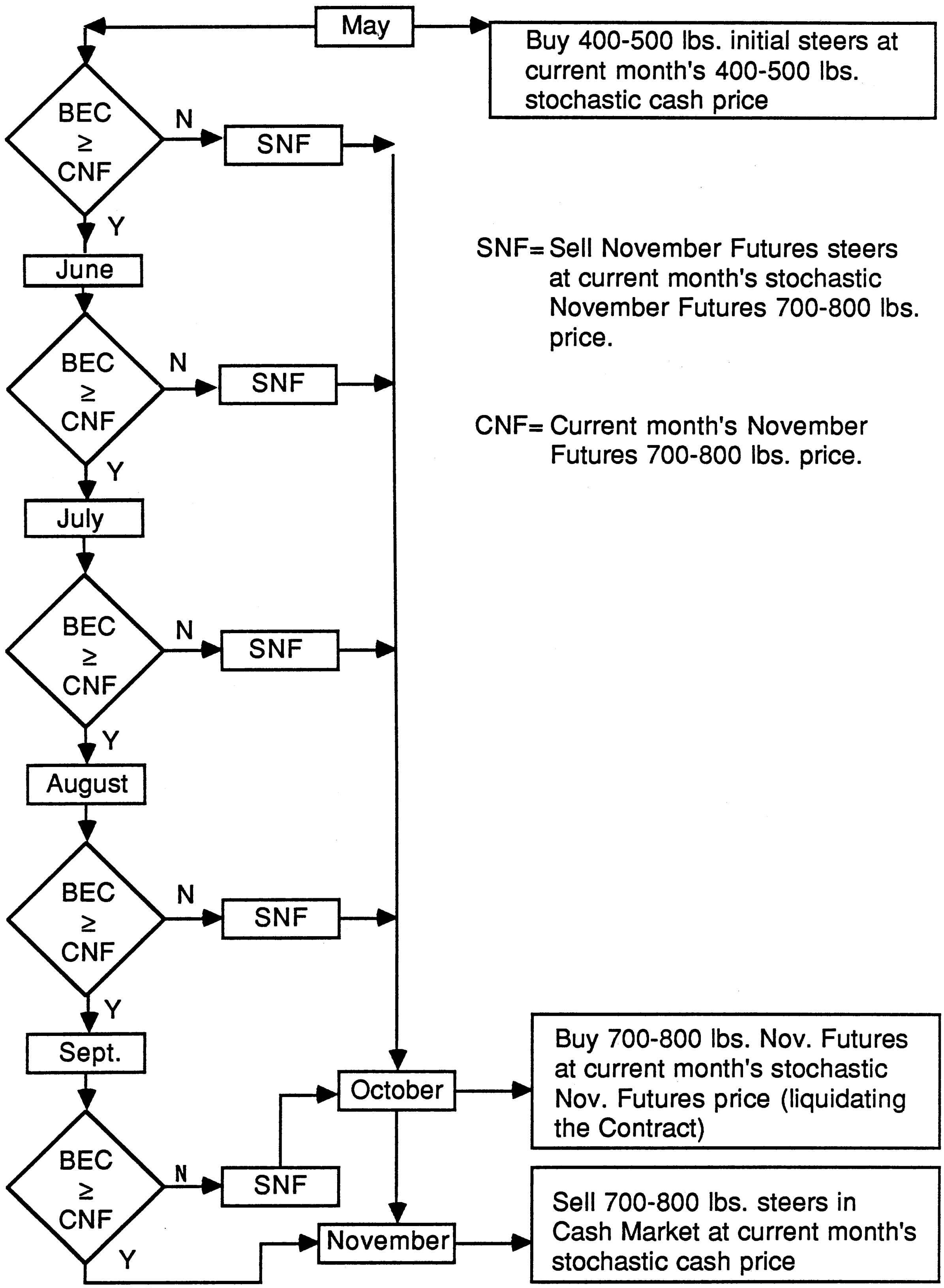


Figure 37. Schematic of Strategic Hedging

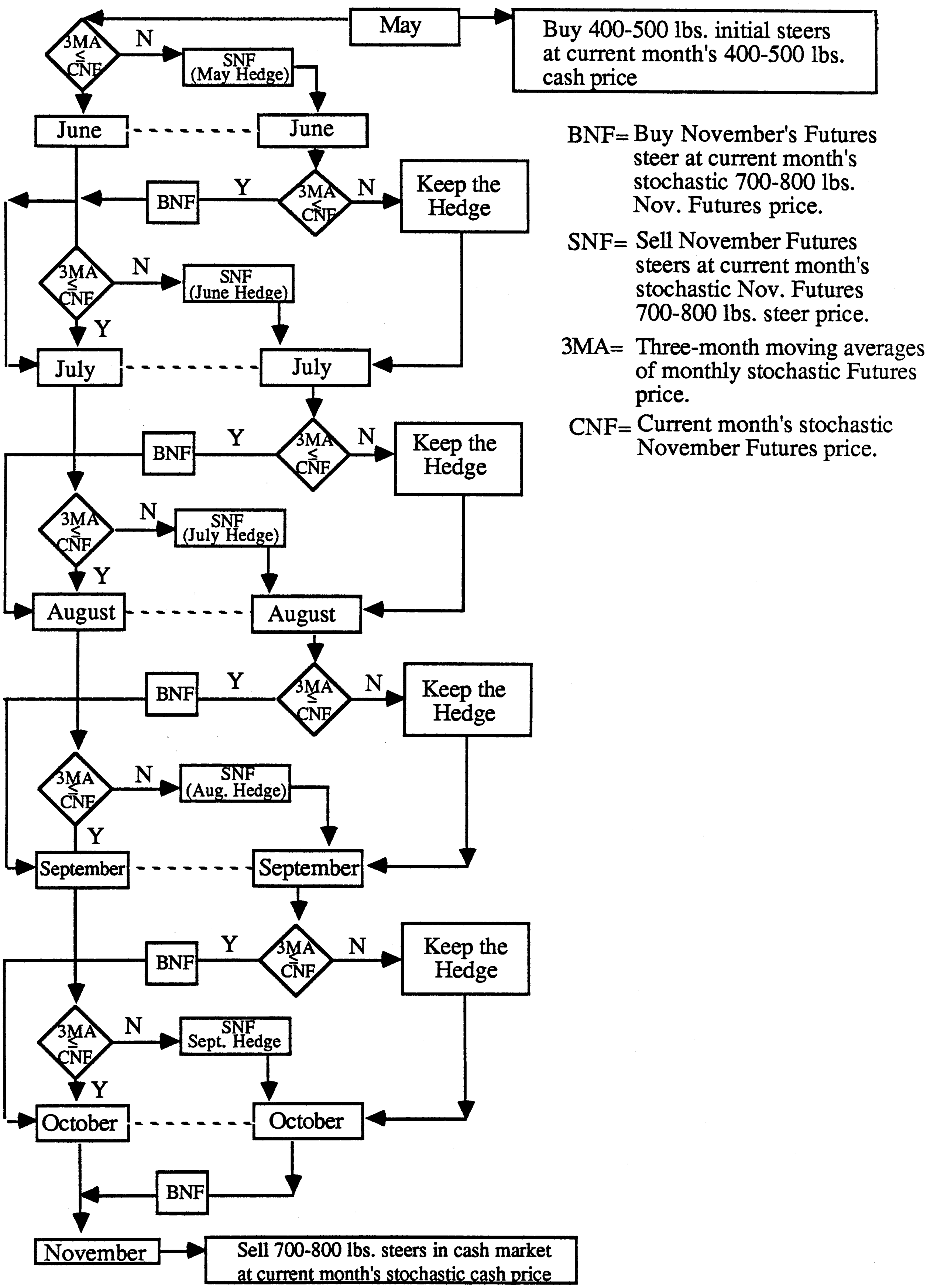


Figure 38. Schematic of Multiple Hedging Strategy

Subroutine STOCH

Subroutine STOCH is the first subroutine called each year of the planning horizon. In the original routine, it determines annual crop yields, crop prices, livestock prices, and dairy production values. Since it does not determine livestock yields, a modification was made to include stochastic livestock weights at different periods. In the stochastic mode, the model generates random values for yields and prices each year from the independent or multivariate normal, triangular, or empirical probability distribution specified by the analyst. This study uses and develops the available multivariate empirical routine for livestock weight, cash prices, and bases price probability distributions.

The calculation of a stochastic steer weight-gain was added to subroutine STOCH using the results from the hyperbolic tangent conditional distribution described in Chapter III. The steer weight gain distribution between periods (first three months and last three months) is assumed to be multivariate. If the model runs the whole six-month period (it is considered as the second period), the entries for the first period will be identical. Moreover, the stochastic monthly futures steer prices for four different steer weight classes are derived from the stochastic monthly cash prices and the monthly basis which are calculated by the mutivariate empirical distribution routines in which monthly cash prices are correlated with the monthly bases. A three-month moving average routine was developed for use as a decision criterion in the multiple hedging strategy. These procedures require expansion of the size of the matrix VC(I,J) from VC(20,142) to VC(24,350) to provide spaces for a factored correlation matrix of monthly cash prices and basis. In this regard the intermediate matrix size for the generated random deviates XB(I,J) is also changed from XB(20,20) to XB(24,24). The monthly hedging costs and the cost of feeding supplement are developed within this subroutine. The monthly hedging cost assumes a 12 percent annual interest rate in calculating interest charges on the brokerage fee and the average margin requirement for each contract made in the specified month.

Subroutine LVSTK

All the calculations for a beef enterprise are made in the LVSTK subroutine. In the original routine, a beef enterprise can consist of a mother cow herd, replacement heifers, and herd bulls, as well as stocker or feeder cattle. The modified routine uses the fourth livestock enterprise reserved by the original (unmodified) model for the stocker enterprise, as the primary enterprise of interest in this study. A summer stocker operation is the central focus of the study. The modified model still uses the old input code so that the order of the livestock enterprise and all other modified codes are later repositioned to their original place, hence other subroutines, that are not modified, still call the same code as in the original model.

Major modification done in this study took place in the LVSTK subroutine. All routines for marketing strategies are developed in this subroutine and are still intact with old codes for livestock receipts formula in their place. Hence, the modified program statement can be directed to these codes for later use as in the original model.

Subroutine LVSTK was extended to create subroutines OSU2 which handles marketing strategies for stocker yearly production decisions and stocker within-year decisions to feed supplement. Subroutine OSU3 was created to handle marketing strategies under the within-year stocker production decision with a stocking rate adjustment in bad year.

Annual cash costs for each livestock category are provided by the analyst along with an annual inflation rate for updating these costs over time. Total annual cash cost, by livestock category, is the product of the inflated variable cost and the number of head in the respective category. For a stocker herd, the model calculates the cost of buying the stockers based on the stochastic 400-500 lbs. price and purchase weight for weaned steer calves. The stockers are assumed to be bought, fed, and sold all in the same income tax year.

Interaction between the beef herd and crop production is handled in the LVSTK and RECPTS subroutines. The model calculates the total quantity of each crop fed to the stocker herd each year. The modified model uses dummy crops enterprises for prairie hay and soybean meal. These crops do not have yield, hence, they have to be bought for cattle feed. Annual feed requirements per head for each crop are multiplied by the number of head in that category to calculate total feed requirements. The total quantity of each crop fed to the beef herd is calculated by summing the crop's total feed requirements over the beef categories. Cash receipts for the individual beef categories are calculated using the number of animals sold, their stochastic sale weights, and their stochastic prices. Cash receipts for stocker cattle are reduced to reflect the average annual death loss fractions, hedging, cost and the difference between receipt from futures market and cash sales.

CHAPTER V

ANALYSES AND RESULTS OF THE ALTERNATIVE RANCH PRODUCTION AND MARKETING STRATEGIES

The major purpose of this study is to provide tools for analyzing growth potential and survivability of a Southern Plains ranch unit under uncertainty, particularly for a summer stocker operation. To fulfill this purpose, the study modified the available computerized firm simulator (FLIPSIM V) through the expansion of the livestock section for simulating a representative ranch which is subject to a stochastic stocker production and prices. Two production decisions are considered, including a yearly production decision and a decision which is made within the production period. The performance of the simulator and the empirical results using selected production and marketing strategies are evaluated in this chapter.

Two options for a within-period decision are available when the representative ranch experiences a low steer gain during the first three-month grazing period. The options are (1) feeding a supplement to the animals while maintaining the current level of stocking rate, and (2) the current level of stocking rate is decreased to the next lower specified level by selling some of the animals. Otherwise, neither feed supplement is given nor the current stocking rate level adjusted.

For each year of the stochastic analysis, all ranch situations are simulated over the 1988-1997 planning horizon with 50 replications (iterations) of experiment. Results of the analyses include the impact of various marketing strategies under different production decisions and financial alternatives on the risk, liquidity, solvency, and profitability of the representative ranch.

Production Decisions

The representative ranch's situations were evaluated under three different production decision scenarios - an annual production decision, a within-period decision to feed supplement, and a within-period stocking rate adjustment.

Annual Decision

The yearly production decision assumes that the representative ranch does not make any production adjustment once the animals are put on pasture. Livestock production is measured by the sum of initial weight and the stochastic weight gain during the whole six months of the grazing period. The level of stocking rate is maintained throughout the production period and no feed supplement is given to the animals.

Within-Year Decisions

A within-year decision allows a rancher to reconsider his initial decision on the production management, through feeding supplement or making a stocking rate adjustment when he observes that the animals have achieved a low gain at the end of the first period. A low gain is defined when the stochastic weight gain at the end of the first grazing period is less than the expected weight gain across stocking rates. The within-year decision assumes that the representative ranch uses the above information as an initial situation for the next (last) three-month grazing period. The final steer weight for the within-year decision is the sum of the initial steer weight, stochastic steer weight gain in the first period, and stochastic steer weight gain in the last period.

The within-year decision to feed protein supplement allows the ranch to augment the pasture when the animals experience a low gain during the first period. In this scenario, the ranch incurs additional cost for the feed supplement and maintains the original level of stocking rate. Therefore, the same number of animals are raised but with higher expected weight gain at the last three months of the grazing period. For example, the stochastic steer weight gain achieved the last period is multiplied by a factor of 1.36 (see Lusby, Horn, and Dvorak, 1981) to reflect the added gain due to feeding soybean meal and hay as supplement. This factor can be any appropriate number depending upon the kind of feed supplement used and the expected response.

The within-year stocking rate adjustment decision allows the representative ranch to adjust the current stocking rate level. Under this scenario, when the animal experiences a low gain in the first period, the rancher adjusts the current stocking rate level through selling some of the animals. The number of animals sold is the difference between the current stocking rate and the next lower specified stocking rate level. For example, this study defines 5.21, 4.66, and 4.11 acres per head as a low, medium, and high stocking rate level, respectively. Therefore, with 1,500 head of initial summer stocker placed on the 6,926 acres of land, the study assumes a medium initial stocking rate level. Under this scenario the rancher sells about 157 head to move from a medium to low stocking rate. No additional feed supplement cost is involved and the cash receipts from selling the 157 animals are added to the ranch's cash receipts. Since no feed supplement is given, the final steer weight of the individual animal is the summation of the initial steer weight of 470 lbs., weight gain in the first period, and weight gain in the last period at the new stocking rate level, without a multiplier factor. Therefore, with an initial 1,500 steers, the number of animals at the end of the production period is less than for the feeding scenario. This situation suggests that the stocking rate adjustment strategy will generate lower average annual ranch receipts.

Analysis and Results for the Medium Initial Stocking Rate

Each of the marketing strategies described in Chapter III is evaluated by selected financial measures to determine the ranch's performance under annual and within-year production decisions. The selected financial measures used are the average annual net ranch income (NRI) and the present value of ending net worth (ENW). NRI is calculated as the sum of the net cash ranch income and the total non-cash adjustment to income. Depreciation and changes in the value of livestock and crops stored are the components of non-cash adjustments to income. Other adjustments to NRI, such as depreciation recapture and realized capital gains, are summed for later use. The results representing the ranch's profitability, liquidity, solvency, and risk under 35 and 65 percent initial debt to asset ratios, are presented in Table X and Table XI, respectively.

TABLE X

THE IMPACT OF PRODUCTION DECISIONS AND MARKETING STRATEGIES ON FINANCIAL MEASURES WITH 35 PERCENT INITIAL D/A

Financial Measures			Marketing Strategies			
			Cash Sales	Simp. Hdg.	Stra. Hdg.	Mult. Hdg.
Yearly Decision:						
				($)		
ENW	Mean	($)	218560.87	31672.08	578230.87	58861.48
	Minimum	($)	-392685.80	-1428812.00	-376449.93	-1061455.00
	Maximum	($)	1074657.00	1403930.00	1978457.00	1990044.00
	Coef. Var.	(%)	192.91	2104.58	113.61	1350.54
NRI	Mean	($)	8842.69	-109038.00	64899.46	-51981.04
	Minimum	($)	-322277.18	-871426.06	-313672.12	-610435.25
	Maximum	($)	173240.37	225445.50	391542.75	385992.50
	Coef. Var.	(%)	1247.98	-237.35	278.66	-475.94
Probability of:						
				(%)		
	Survival		48%	34%	68%	30%
	Econ. Success		46%	36%	66%	34%
Year in Operation			7.24/10	5.22/10	7.62/10	5.20/10
Within Year with Feeding:						
				($)		
ENW	Mean	($)	493665.43	678480.81	1667153.00	-124228.75
	Minimum	($)	-192838.56	-672592.75	930198.50	-1307825.00
	Maximum	($)	1369705.00	2148232.00	2357907.00	1932177.00
	Coef. Var.	(%)	85.81	115.89	19.33	-708.35
NRI	Mean	($)	71120.12	77283.25	298913.81	-123159.00
	Minimum	($)	-158736.37	-470627.75	132593.56	-676767.30
	Maximum	($)	1369705.00	2148232.00	2357907.00	1932177.00
	Coef. Var.	(%)	131.27	229.14	22.24	-230.25
Probability of:						
				(%)		
	Survival		72%	72%	100%	34%
	Econ. Success		70%	70%	100%	34%
Year in Operation			8.70/10	7.82/10	10.00/10	5.18/10

TABLE X (Continued)

Financial Measures			Marketing Strategies			
			Cash Sales	Simp. Hdg.	Stra. Hdg.	Mult. Hdg.
Within Year with Stocking Adjustment:						
					($)	
ENW	Mean	($)	164389.87	302106.37	1395810.00	-77546.62
	Minimum	($)	-342327.18	-977905.25	662723.75	-1001960.87
	Maximum	($)	1251409.00	1913120.00	2192943.00	1619233.00
	Coef. Var.	(%)	216.58	254.74	25.2	-845.17
NRI	Mean	($)	-6753.98	-22124.57	243370.00	-90565.68
	Minimum	($)	-194336.31	-595082.31	93348.37	-645192.75
	Maximum	($)	227293.87	346804.06	415256.37	336032.68
	Coef. Var.	(%)	-1370.44	-1098.53	27.31	-237.41
Probability of:						
					(%)	
	Survival		40%	54%	100%	24%
	Econ. Success		40%	54%	100%	26%
Year in Operation			6.74/10	6.72/10	10.00/10	4.74/10

ENW = Present Value of Ending Net Worth
NRI = Average Annual Net Ranch Income

TABLE XI

THE IMPACT OF PRODUCTION DECISION AND MARKETING STRATEGIES ON FINANCIAL MEASURES WITH 65 PERCENT INITIAL D/A

Financial Measures			Marketing Strategies			
			Cash Sales	Simp. Hdg.	Stra. Hdg.	Mult. Hdg.
Yearly Decision:						
				($)		
ENW	Mean	($)	148958.37	23071.47	368992.68	46730.60
	Minimum	($)	-306507.62	-9306737.18	-662841.75	-1224562.00
	Maximum	($)	1244401.00	1437511.00	1510768.00	1928014.00
	Coef. Var.	(%)	272.1	2794.84	166.9	1786.07
NRI	Mean	($)	-2801.61	-55658.62	31973.72	-60691.10
	Minimum	($)	-146176.37	-476964.87	-335033.37	-632745.43
	Maximum	($)	218471.56	236897.68	262453.56	388201.00
	Coef. Var.	(%)	-3161.63	-332.96	470.02	-428.55
Probability of:						
				(%)		
	Survival		30%	28%	52%	32%
	Econ. Success		32%	36%	56%	34%
Year in Operation			4.94/10	4.70/10	6.20/10	4.64/10
Within Year with Feeding:						
				($)		
ENW	Mean	($)	44017.25	280286.50	1177236.00	-443287.00
	Minimum	($)	-492991.25	-1394457.00	-443185.43	-1971421.00
	Maximum	($)	1364080.00	1669683.00	2070454.00	992829.18
	Coef. Var.	(%)	922.53	288.99	57.08	-141.16
NRI	Mean	($)	-5812	33976.07	227323.18	-174801.12
	Minimum	($)	-181860.68	-659638.06	-155463.62	-965429.93
	Maximum	($)	264748.56	367496.50	412880.56	223372.00
	Coef. Var.	(%)	-1708.22	658.27	62.61	-143.68
Probability of:						
				(%)		
	Survival		24%	54%	86%	14%
	Econ. Success		36%	56%	86%	16%
Year in Operation			4.94/10	6.44/10	8.80/10	2.90/10

TABLE XI (Continued)

Financial Measures			Cash Sales	Simp. Hdg.	Stra. Hdg.	Mult. Hdg.
			Marketing Strategies			
Within Year with Stocking Adjustment:						
				($)		
ENW	Mean	($)	-125133.31	222097.25	945471.18	-432174.43
	Minimum	($)	-564220.56	-1344149.00	-541670.62	-1503249.00
	Maximum	($)	489402.43	1616277.00	1803619.00	1075565.00
	Coef. Var.	(%)	-173.36	334.67	65.61	-110.72
NRI	Mean	($)	-38535.78	22971.19	176092.25	-131024.18
	Minimum	($)	-219612.18	-632975.43	-207660.75	-717299.12
	Maximum	($)	106142,87	352753.37	349199.56	243427.56
	Coef. Var.	(%)	-183.88	910.59	74.15	-141.33
Problem of:						
				(%)		
	Survival		8%	52%	82%	8%
	Econ. Success		14%	60%	82%	10%
Year in Operation			3.66/10	6.44/10	8.68/10	2.76/10

ENW = Present Value of Ending Net Worth
NRI = Average Annual Net Ranch Income

Annual Production Decision

At a 35 percent beginning debt to asset ratio, the ranch with a yearly production decision and using strategic hedging has $64,899 average annual net ranch income (NRI) and $578,230 present value of ending net worth (ENW). These financial measures are the highest compared to those from other strategies. The lowest NRI and ENW resulted from simple hedge (-$109,038 and $31,672), followed by multiple hedge (-$51,981 and $58,861) and cash sales strategy ($8,842 and $218,560). The lowest coefficient of variation for the NRI and ENW is also achieved by the strategic hedge ($278.66 and $113.61) compared to cash sales ($1,247.98 and $192.91), multiple hedge (-$475.94 and $1,350.54), and simple hedge strategy (-$237.35 and $2,104.58) (Table X).

The strategic hedge also has a higher probability of survival and economic success (68 and 66 percent) than cash sales (48 and 46 percent), simple hedge (34 and 36 percent), and multiple hedge strategy (30 and 34 percent). The probability of survival is defined as the ratio between the number of solvent iterations and the total iterations divided by 100. The probability of economic success is defined as the probability of the ranch having a positive net present value and is determined using the cumulative distribution for ending net present value. Accordingly, the average length (years) the ranch remains in operation during the 10-year planning horizon is longer when the ranch uses a strategic hedge (7.62) than when using a cash sales (7.24), simple hedge (5.22), and multiple hedge strategy (5.20).

It is not surprising that the strategic hedging outperforms the rest of the available strategies since it operates in a way that the rancher can lock in the price or profit objective using a breakeven cost (BEC) criterion. The program allows the model to increase or decrease the BEC level by specifying a multiplier factor other than 1.0. Thus, the strategic hedge can be evaluated with alternative "breakeven" levels. The rancher will not place a hedge until the current month's futures price is greater than the BEC, hence, a hedge placed during the production period assumes a profit.

The cash sales strategy ranked second after the strategic hedge in both average annual net ranch income and present value of ending net worth. Unlike other marketing strategies, the cash sales depends only on the stochastic weight gain and cash prices in determining whether it is profitable or not. Since the price effect plays an important role in most cases and the animals are gaining weight during the six-month period, the net cash receipts at the end of the production period will likely be positive although some iterations during the stochastic process did generate a negative net cash ranch income.

A relatively higher variability in both NRI and ENW is found in simple hedge and cash sales. That result can be explained by the nature of the strategies. For example, the simple hedge always places a hedge at the beginning of the production period regardless of the price's level. Therefore, with a simple hedge strategy, the ranch may have a net loss from selling a futures contract with a low current month's futures price which allows for a situation where a loss is locked in early.

The multiple hedge strategy involves a more complicated action in determining whether the hedge must be placed or lifted. The position of a three month moving averages futures price relative to the current month's futures price, determines a hedge place or lift decision. A possible explanation for a high variability of income in this strategy may be attributed to the low accuracy of the price prediction from the three-month moving averages. This result is different from a study done by Brown and Purcell (1978) in which a five-day vs. a ten-day moving averages criterion was used in a multiple hedge strategy.

Their study shows that the multiple hedge generates the highest average returns compared to other strategies. The simulation model does not accomodate daily price data at present.

A similar ordering of the yearly decision strategies in this occurred for the 65 percent beginning debt to asset ratio. However, in this scenario the ranch is in an unfavorable initial financial position and all the financial measures being used are worse than those from the 35 percent initial D/A scenario.

Table XI shows that with a 65 percent initial D/A the strategic hedge generates only $31,973 NRI and $368,992 ENW. With this strategy the ranch has lower probability of surviving and economic success (52 and 56 percent and is often declared technically insolvent around the eighth year. Other strategies are declared technically insolvent at earlier (fifth) year of the 10-year planning horizon.

Within-Period Decisions With Supplement Feeding

In this scenario the ranch uses a 43 percent protein soybean meal as a feed supplement to produce a 36 percent higher gain during the last grazing period than without supplement (Lusby, Horn, and Dvorak, 1981).

Under a 35 percent initial D/A, the strategic hedge results in a much higher NRI ($298,913) and ENW ($1,667,153) with lower coefficient of variation (22.24 and 19.33, respectively) than those from a yearly decision with 35 percent initial financial situation. This strategy allows the ranch to survive for the entire 10 years of the planning horizon with a 100 percent probability of economic success (Table X).

Cash sales and the simple hedge strategies show a similar impact. These strategies have about 72 and 70 percent probability of surviving and economic success with an average length in operation of about 8.70 and 7.72 years, respectively. The cash sales strategy generates a lower income ($71,120 NRI and $493,665 ENW) than the simple hedge strategy ($77,283 and $678,480 ENW). However, the variability of these financial measures is lower in the cash sales (131.27 and 85.81) than the simple hedge strategy (229.14 and 115.89) for the respective measures.

The multiple hedge strategy ends up with a net loss in both financial measures. With this strategy the ranch has only a 34 percent chance to survive and a 34 percent chance of economic success and is declared technically insolvent in an average of the fifth year of the planning horizon. This strategy also shows the lowest NRI (-$123,159) and ENW (-$124,228) and the highest income variability (-$230.25 and -$708.35) among all strategies in the within-year decision with 35 percent initial debt to asset ratio.

As expected, with a 65 percent beginning debt to asset ratio the ranch's ability to survive financially reduces to only 24, 54, 86 and 14 percent for the cash sales, simple hedge, strategic hedge, and multiple hedge, respectively. The representative ranch remains in operation for an average of about five, six, nine, and three years for the above respective strategies. The strategic hedge is again ranked first in terms of financial measures used. Its average annual net ranch income (NRI) is $227,323, with a present value of ending net worth (ENW) of $1,177,236. The financial measures (NRI and ENW) for the rest of the strategies are $33,976 and $280,286 (simple hedge), -$5,812 and $44,017 (cash sales), and -$174,801 and -$443,287 (multiple hedge), respectively.

Within-Year With Stocking Adjustment Decision

Under a 35 percent initial debt to asset ratio, ranking of the marketing strategies is similar to the previous (feeding supplement) scenario with the same initial financial position.

The strategic hedge remains the superior strategy with 100 percent chance to survive and 100 percent chance of economic success over the 10 years planning horizon. In this scenario, the rest of the strategies have lower probability of surviving financially than in the feeding supplement scenario. For example, with a survival probability of 40 percent (cash sales) and 54 percent (simple hedge), the ranch will remain operational up to the seventh year. In addition, the multiple hedge with only 24 percent survival probability shortens the ranch operational year to the fifth year of the planning horizon.

In this scenario the average annual net ranch income (NRI) for the strategic hedge is $243,370 and the present value of ending net worth (ENW) is $1,395,810 with a coefficient of variation of 27.31 and 25.20, respectively. These figures indicate lower financial measures and higher variability than those from the feeding scenario. The rest of the marketing strategies experienced a net loss in both NRI and ENW. For example, -$55,753 and $164,389 (cash sales), -$22,124 and $302,106 (simple hedge), and -$90,565 and -$77,546 (multiple hedge) of NRI and ENW, respectively.

As the ranch's financial position worsens from a 35 percent to a 65 percent beginning debt to asset ratio, the survival probability (and approximate years the ranch remains in operation) for each strategy reduces to 8 percent (four years), 52 percent (six years), 82 percent (nine years), and 8 percent (three years) for cash sales, simple hedge, strategic hedge, and multiple hedge strategies, respectively.

Compared to the initial financial position, this scenario reduces the strategic hedge's average annual net ranch income to $176,092 and ending net worth to $945,471 with coefficient of variation of 74.15 and 65.61, respectively.

Stochastic Dominance Analysis

All marketing strategies and production decision alternatives under the 35 and 65 percent initial debt to asset ratio situations are ordered using the stochastic dominance with respect to a function (SDWRF) criterion. First degree stochastic dominance (FSD) and second degree stochastic dominance (SSD) are special cases, as described in Chapter II. Cumulative distribution functions (CDF) for the average annual net ranch income (NRI) and the present value of ending net worth (ENW) are used to describe the stochastic dominance analysis. Figures 39 through 42 present selected illustrations of the cdf's of the NRI and ENW from different marketing strategies and production decisions under 35 percent initial D/A ratio.

Since the SDWRF is an evaluative criterion that orders choices without restrictions of a particular utility function or specified characteristics of risk attitudes, it requires a specification of the lower and upper bound of the absolute risk aversion coefficient. The respective values used in this study are 0.001 and 0.01 to reflect a risk averse type of decision maker as described in Chapter II.

Tables XII and XIV present the results from the SDWRF analysis on each marketing strategy, under a 35 percent initial debt to asset ratio, for the yearly production decision, within-year decision with feeding supplement, and within-year decision with stocking rate adjustment, respectively. In addition, a similar

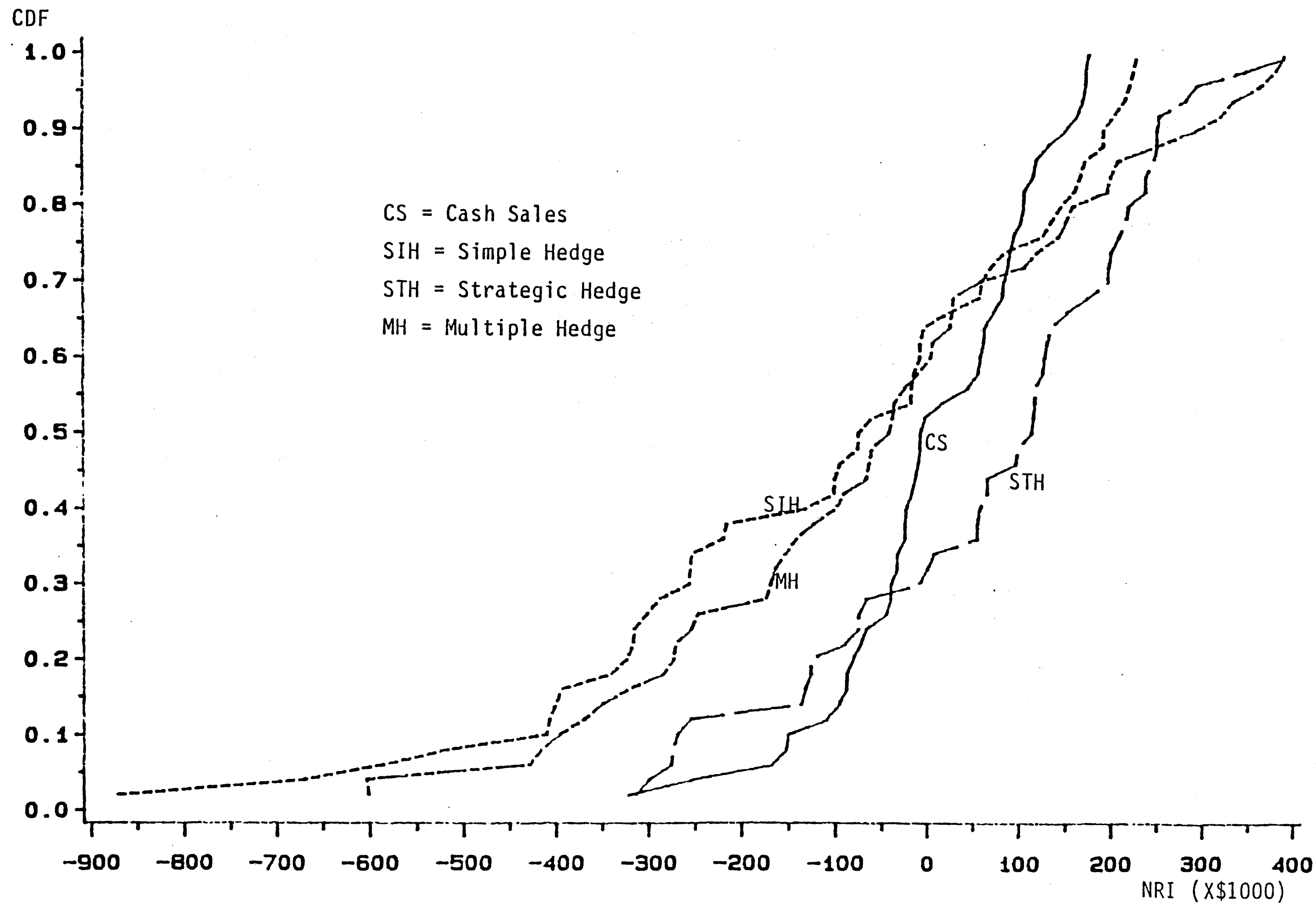


Figure 39. Cumulative Distribution Functions of Average Annual Net Ranch Income (NRI) Under the 35 Percent Initial Debt to Asset Ratio and a Yearly Decision Scenario

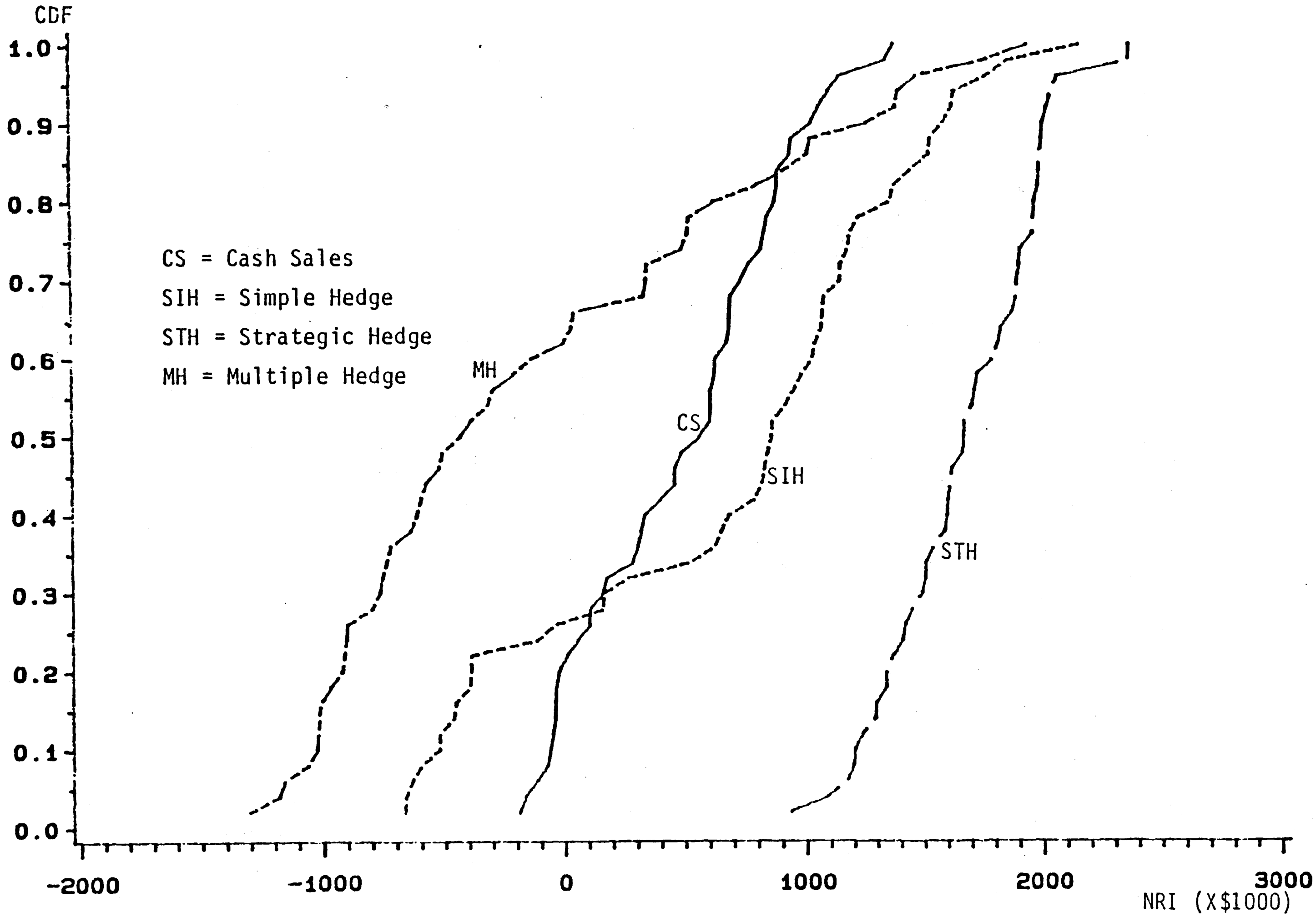


Figure 40. Cumulative Distribution Functions of Present Value of Ending Net Worth (ENW) Under the 35 Percent Initial D/A Ratio and Within-Year Decision with Feeding Supplement Scenario

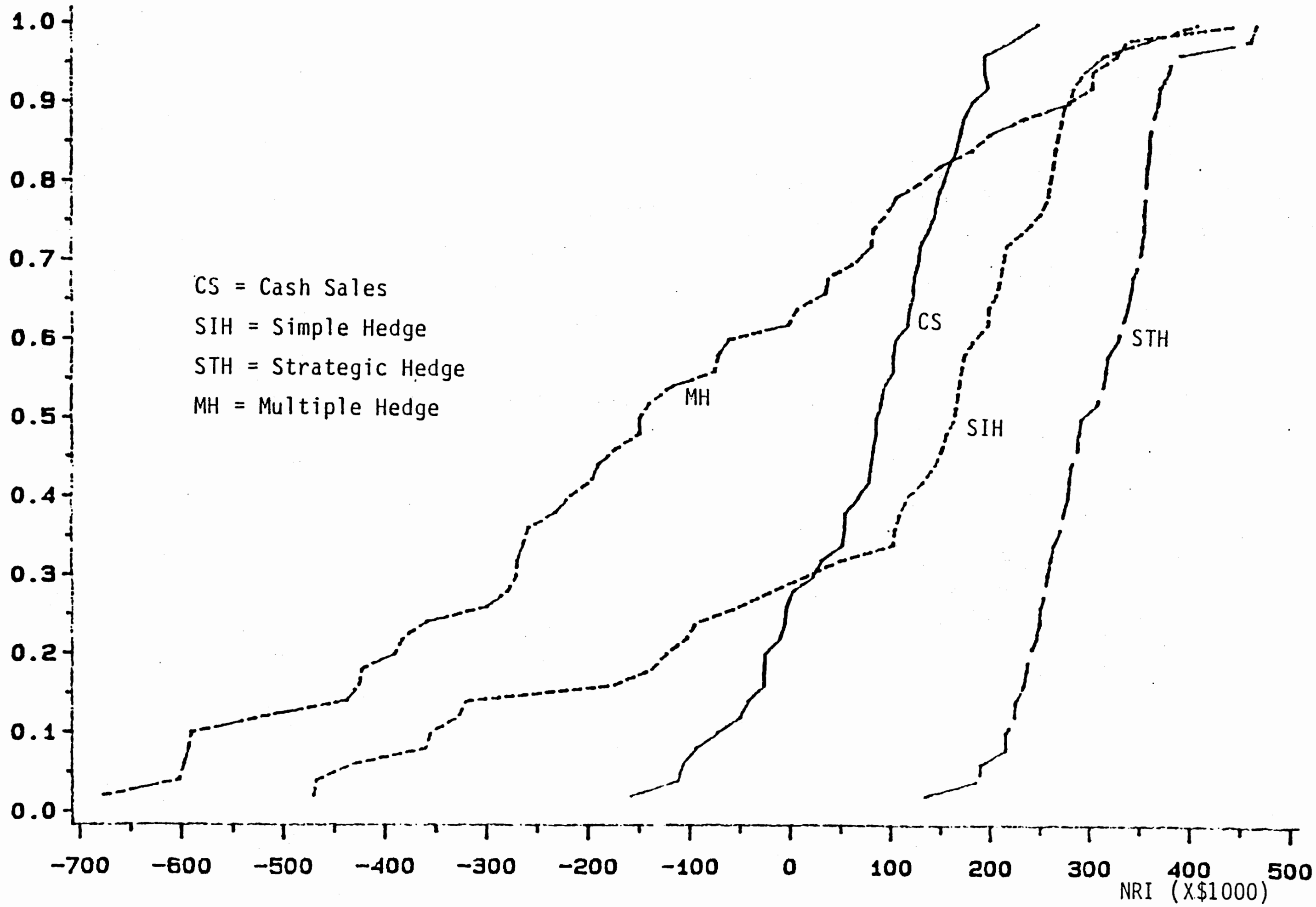


Figure 41. Cumulative Distribution Functions of Average Annual Net Ranch Income (NRI) Under the 35 Percent Initial Debt to Asset Ratio and Within-Year Decision with Feeding Supplement Scenario

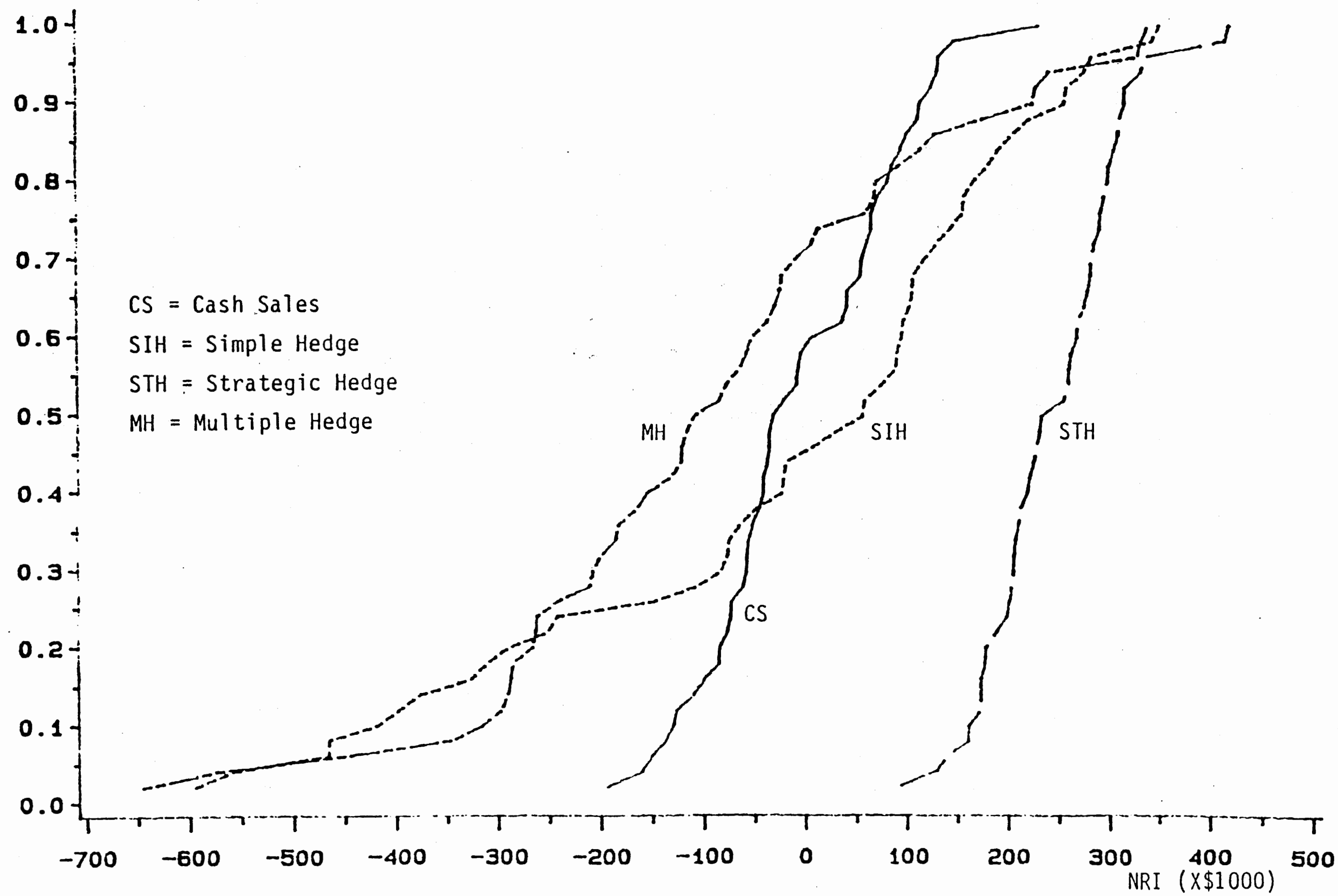


Figure 42. Cumulative Distribution Functions of Average Annual Net Ranch Income (NRI) Under the 35 Percent Initial Debt to Asset Ratio and Within-Year Decision with Stocking Rate Adjustment Scenario

TABLE XII

ORDERING MARKETING STRATEGIES FOR YEARLY PRODUCTION DECISION WITH 35 PERCENT INITIAL RANCH DEBT TO ASSET RATIO, AND MEDIUM INITIAL STOCKING RATE

Key Marketing Strategy	Versus Marketing Strategies	SDWRF Results Financial Measures NRI	ENW
Cash Sales	Simple Hedge	X	D
	Strategic Hedge	X	d
	Multiple Hedge	X	D
Simple Hedge	Cash Sales	X	d
	Strategic Hedge	d	d
	Multiple Hedge	d	X
Strategic Hedge	Cash Sales	X	D
	Simple Hedge	D	D
	Multiple Hedge	D	D
Multiple Hedge	Cash Sales	X	d
	Simple Hedge	D	X
	Strategic Hedge	d	d

D = key strategy is dominating

d = key strategy is dominated

X = strategies cannot be ordered using SDWRF

TABLE XIII

ORDERING MARKETING STRATEGIES FOR THE WITHIN-YEAR DECISION WITH FEEDING SUPPLEMENT AND 35 PERCENT INITIAL RANCH DEBT TO ASSET RATIO, AND MEDIUM INITIAL STOCKING RATE

Key Marketing Strategy	Versus Marketing Strategies	SDWRF Results Financial Measures NRI	ENW
Cash Sales	Simple Hedge	X	X
	Strategic Hedge	d	d
	Multiple Hedge	D	D
Simple Hedge	Cash Sales	X	X
	Strategic Hedge	d	d
	Multiple Hedge	D	D
Strategic Hedge	Cash Sales	D	D
	Simple Hedge	D	D
	Multiple Hedge	D	D
Multiple Hedge	Cash Sales	d	d
	Simple Hedge	d	d
	Strategic Hedge	d	d

D = key strategy is dominating

d = key strategy is dominated

X = strategies cannot be ordered using SDWRF

TABLE XIV

ORDERING MARKETING STRATEGIES FOR THE WITHIN-YEAR DECISION WITH STOCKING RATE ADJUSTMENT AND 35 PERCENT INITIAL RANCH DEBT TO ASSET RATIO, AND MEDIUM INITIAL STOCKING RATE

Key Marketing Strategy	Versus Marketing Strategies	SDWRF Results Financial Measures NRI	ENW
Cash Sales	Simple Hedge	X	X
	Strategic Hedge	d	d
	Multiple Hedge	X	D
Simple Hedge	Cash Sales	X	X
	Strategic Hedge	d	d
	Multiple Hedge	D	D
Strategic Hedge	Cash Sales	D	D
	Simple Hedge	D	D
	Multiple Hedge	D	D
Multiple Hedge	Cash Sales	X	d
	Simple Hedge	d	d
	Strategic Hedge	d	d

D = key strategy is dominating

d = key strategy is dominated

X = strategies cannot be ordered using SDWRF

SDWRF analysis with a 65 percent initial debt to asset ratio is presented in Tables XV through XVII.

Table XII indicates that, under a yearly production decision with 35 percent initial D/A ratio, the cash sales strategy cannot be ordered with other strategies using net ranch income (NRI). The strategic hedge is preferred to both simple hedge and multiple hedge, and the multiple hedge is preferred to simple hedge. On the other hand, using the ending net worth measure (ENW), the strategic hedge is preferred to the rest of the strategies. Cash sales is preferred to both simple hedge and multiple hedge strategies, while the simple hedge and multiple hedge cannot be ordered with SDWRF.

Identical ordering is obtained by using both the NRI and the ENW, when the ranch under the 35 percent initial D/A uses a within-year decision with feed supplement (Table XIII). The strategic hedge is preferred to the rest of the strategies, while the multiple hedge strategy is always dominated by other strategies. The simple hedge and the cash sales strategies cannot be ordered with SDWRF.

Table XIV suggests that the ranch with a 35 percent initial D/A ratio and using within-year stocking rate adjustments has identical SDWRF ordering using NRI and ENW except in the case of multiple hedge versus cash sales. Using NRI, the cash sales versus multiple hedge cannot be ordered with SDWRF but it is preferred to multiple hedge using ENW. Cash sales versus simple hedge and multiple hedge cannot be ordered with SDWRF using NRI. The strategic hedge always dominates all other strategies using both NRI and ENW.

TABLE XV

ORDERING MARKETING STRATEGIES FOR YEARLY PRODUCTION DECISION WITH 65 PERCENT INITIAL RANCH DEBT TO ASSET RATIO, AND MEDIUM INITIAL STOCKING RATE

Key Marketing Strategy	Versus Marketing Strategies	SDWRF Results Financial Measures NRI	ENW
Cash Sales	Simple Hedge	X	D
	Strategic Hedge	X	X
	Multiple Hedge	X	D
Simple Hedge	Cash Sales	X	d
	Strategic Hedge	d	d
	Multiple Hedge	X	X
Strategic Hedge	Cash Sales	X	X
	Simple Hedge	D	D
	Multiple Hedge	D	D
Multiple Hedge	Cash Sales	X	d
	Simple Hedge	X	X
	Strategic Hedge	d	d

D = key strategy is dominating

d = key strategy is dominated

X = strategies cannot be ordered using SDWRF

TABLE XVI

ORDERING MARKETING STRATEGIES FOR THE WITHIN-YEAR DECISION WITH FEEDING SUPPLEMENT AND 65 PERCENT INITIAL RANCH DEBT TO ASSET RATIO, AND MEDIUM INITIAL STOCKING RATE

Key Marketing Strategy	Versus Marketing Strategies	SDWRF Results Financial Measures NRI	ENW
Cash Sales	Simple Hedge	X	X
	Strategic Hedge	d	d
	Multiple Hedge	D	D
Simple Hedge	Cash Sales	X	X
	Strategic Hedge	d	d
	Multiple Hedge	D	D
Strategic Hedge	Cash Sales	D	D
	Simple Hedge	D	D
	Multiple Hedge	D	D
Multiple Hedge	Cash Sales	d	d
	Simple Hedge	d	d
	Strategic Hedge	d	d

D = key strategy is dominating

d = key strategy is dominated

X = strategies cannot be ordered using SDWRF

TABLE XVII

ORDERING MARKETING STRATEGIES FOR THE WITHIN-YEAR DECISION WITH STOCKING RATE ADJUSTMENT AND 65 PERCENT INITIAL RANCH DEBT TO ASSET RATIO, AND MEDIUM INITIAL STOCKING RATE

Key Marketing Strategy	Versus Marketing Strategies	SDWRF Results Financial Measures NRI	ENW
Cash Sales	Simple Hedge	X	X
	Strategic Hedge	d	d
	Multiple Hedge	X	D
Simple Hedge	Cash Sales	X	X
	Strategic Hedge	d	d
	Multiple Hedge	D	D
Strategic Hedge	Cash Sales	D	D
	Simple Hedge	D	D
	Multiple Hedge	D	D
Multiple Hedge	Cash Sales	X	d
	Simple Hedge	d	d
	Strategic Hedge	d	d

D = key strategy is dominating

d = key strategy is dominated

X = strategies cannot be ordered using SDWRF

When ordering is made for a yearly decision with a 65 percent debt to asset ratio as the initial financial position (Table XI), the cash sales versus all other strategies cannot be ordered with SDWRF using NRI. The strategic hedge only dominates the simple hedge and the multiple hedge under NRI and ENW, the cash sales dominates the simple hedge and the multiple hedge.

Ordering of marketing strategies for the within-year decision with supplement presented in Table XIII for the 35 percent and in Table XVI for the 65 percent initial debt to asset ratio is similar for both NRI and ENW. The strategic hedge is the most dominating and preferred strategy to the rest of the strategies.

Table XVII also suggests that the strategic hedge is preferred to all other strategies for the within-year decision with stocking rate adjustment and a 65 percent initial debt to asset ratio. SDWRF analysis cannot order cash sales and simple hedge strategies using both NRI and ENW, as well as cash sales and multiple hedge using NRI.

Analysis and Results for the High Initial Stocking Rate

Another alternative strategy for the rancher is to increase stocking rate at the beginning of the production period. Table XVIII presents the results for the ranch with 35 percent beginning debt to asset ratio and high initial stocking rate.

Annual Production Decision

Under the annual production decision, the representative ranch using strategic hedge with 35 percent beginning debt to asset ratio has the highest NRI ($112,958) and ENW ($670,283) compared to other strategies. The cash

TABLE XVIII

THE IMPACT OF PRODUCTION DECISION AND MARKETING STRATEGIES ON FINANCIAL MEASURES WITH 35 PERCENT INITIAL D/A AND HIGH INITIAL STOCKING RATE

Financial Measures			Cash Sales	Simp. Hdg.	Stra. Hdg.	Mult. Hdg.
			Marketing Strategies			
Yearly Decision:						
				($)		
ENW	Mean	($)	420754.31	100492.81	670283.37	-229524.37
	Minimum	($)	-259024.50	-1296783.00	-344992.81	-1511214.00
	Maximum	($)	1327934.00	2229574.00	2074113.00	1257828.00
	Coef. Var.	(%)	125.16	887.21	106.77	-265.92
NRI	Mean	($)	53765.99	-85643.75	112958.37	-196704.06
	Minimum	($)	-245141.06	-801449.18	-274460.25	-915098.68
	Maximum	($)	259833.75	479875.25	447520.37	259397.00
	Coef. Var.	(%)	250.78	-364.57	157.86	-132.07
Probability of:						
				(%)		
	Survival		56%	40%	68%	18%
	Econ. Success		56%	42%	68%	18%
Year in Operation			7.60/10	5.52/10	7.98/10	3.68/10
Within-Year with Feeding:						
				($)		
ENW	Mean	($)	461217.75	727609.18	1852260.00	-86845.68
	Minimum	($)	-326772.12	-1078500.00	1082382.00	-1914419.00
	Maximum	($)	1515523.00	2547775.00	2558931.00	2607895.00
	Coef. Var.	(%)	111.99	123.94	18.55	-965.54
NRI	Mean	($)	65194.73	73746.62	347280.68	-76063.93
	Minimum	($)	-226651.43	-685758.75	157447.50	-825696.25
	Maximum	($)	262473.37	505115.18	513420.56	584419.06
	Coef. Var.	(%)	178.91	373.45	21.58	-344.93
Probability of:						
				(%)		
	Survival		66%	72%	100%	28%
	Econ. Success		64%	72%	100%	34%

TABLE XVIII (CONTINUED)

Financial Measures			Marketing Strategies			
			Cash Sales	Simp. Hdg.	Stra. Hdg.	Mult. Hdg.
Year in Operation			8.26/10	7.76/10	10.00/10	5.44/10
Within-Year with Stocking Adjustment:						
				($)		
ENW	Mean	($)	133269.25	224691.75	1549006.00	-284875.75
	Minimum	($)	-398875.93	-1046793.87	676402.31	-1589878.00
	Maximum	($)	1392503.00	2110286.00	2330537.00	2003979.00
	Coef. Var.	(%)	284.20	365.60	23.85	-258.55
NRI	Mean	($)	-9830.96	-46906.45	283100.06	-168811.87
	Minimum	($)	-258019.75	-668954.68	101045.81	-839945.62
	Maximum	($)	239476.25	390757.18	450308.87	430127.75
	Coef. Var.	(%)	-1045.10	-575.25	26.63	-170.14
Probability of:						
				(%)		
	Survival		40%	46%	100%	20%
	Econ. Success		36%	46%	100%	26%
Year in Operation			6.76/10	6.46/10	10.00/10	4.42/10

ENW = Present Value of Ending Net Worth
NRI = Average Annual Net Ranch Income

sales is the next profitable strategy with $53,765 NRI and $420,754 ENW followed by simple hedge (-$85,643 NRI and $100,492 ENW), and multiple hedge (-$196,704 NRI and -$229,524 ENW).

The probabilities of survival and economic success are also higher with the strategic hedge (68 and 68 percent) than the cash sales (56 and 56 percent), the simple hedge (40 and 42 pecent), and the multiple hedge (18 and 18 percent). At the same time, the average length the ranch remains in operation during the 10 years planning horizon is longer with the strategic hedge (7.98 years) than with cash sales (0.60 years), the simple hedge (5.52 years), and the multiple hedge strategy (3.69 years).

The strategic hedge outperforms all other strategies with similar reason as in the medium initial stocking rate scenario. It operates in such a way that the rancher locks in the profit except, in this scenario, the strategy generates higher NRI (#112,958 vs. $64,899) and ENW ($670,283 vs. $578,230) than the medium initial stocking rate.

In general, the high initial stocking rate scenario improves both financial measures (NRI and ENW) in all strategies with 35 percent beginning debt-to-asset ratio. However, the probability of survival and economic success improve only for the cash sales and the simple hedge strategies. The survival probability of the strategic hedge remains the same with slightly better chance of economic success, while in the multiple hedge strategy these probabilities are worse and the length of operation is also shortened from 5.20 to 3.68 years. As explained earlier, a high variability of income in the multiple hedge strategy may be attributed to the low accuracy of the price prediction from the three-month moving averages. Therefore, using multiple hedge strategy putting more steers at the beginning of the production period creates more income variability for the ranch.

Within-Year With Supplement Feeding Decision

In this scenario, the strategic hedge with a 35 percent initial debt-to-asset ratio results in a much higher NRI ($347,280) and ENW ($1,852,260) with lower coefficient of variation (21.58 and 18.55, respectively) than those from the annual decision with medium initial stocking rate scenario.

Consequently, the strategy allows the representative ranch to survive for the entire 10 years of the planning horizon with 100 percent chance of economic success.

The simple hedge strategy ranked second after the strategic hedge in both NRI and ENW. With $73,746 NRI and $727,609 ENW, the simple hedge has better probability of survival (72 percent) economic success (72 percent) and remains in operation for 7.76 years, than those found in the annual production decision scenario. However, the coefficient of variation is higher than those found in the medium initial stocking rate with the same scenario (373.45 vs. 229.14 for the NRI and 123.94 vs. 115.89 for the ENW).

The cash sales strategy with $65,`94 NRI and $461,217 ENW has 66 percent probability of survival and 64 percent probability of economic success. With this strategy the ranch remains in operation for 8.26 years. Both financial measures are higher, with lower coefficient of variation than those found in the annual production decision scenario but are lower than those found in the medium initial stocking rate scenario with higher coefficient of variations as well.

The multiple hedge strategy maintains a low probability of survival and economic success (28 and 34 percent, respectively). With this strategy the ranch has negative values in both NRI and ENW.

Within-Year With Stocking Adjustment Decision

As in the medium initial stocking rate scenario, the strategic hedge remains the preferred strategy with less income variability in terms of NRI and ENW. The strategy results in an average annual net ranch income (NRI) of $283,100 and a present value of ending net worth (ENW) of $1,549,006 with 26.63 and 23.85, respectively, coefficient of variation. The strategy also allows the ranch to survive for the entire 10 years of the planning horizon and to have a 100 percent chance of economic success. In this scenario, all other strategies have lower probability to survive financially than the within-year with feeding scenario (Table XVIII.)

The simple hedge and the cash sales strategies remain in operation for 6.46 and 6.76 years, respectively. These strategies have positive ENWs ($2244,691 and $133,269) but negative NRIs (-$46,906 and -$9,830). The multiple hedge strategy has negative values in both NRI (-$168,811) and ENW (-$284,875) and remains in operation for only 4.42 years.

Stochastic Dominance Analysis

Under the high initial stocking rate scenario, only the 35 percent beginning debt to asset ratio is analyzed. Therefore, all marketing strategies and production decision alternatives are ordered by SDWRF only for the 35 percent debt-to-asset ratio.

Table XIX presents the results from ordering marketing strategies for the annual production decision scenario and shows that the strategic hedge dominates all other strategies using NRI and ENW except that it can not be ordered by SDWRF, using ENW, with the cash sales strategy. On the other hand, the multiple hedge always is dominated by all other strategies using

TABLE XIX

ORDERING MARKETING STRATEGIES FOR THE YEARLY DECISION WITH 35 PERCENT INITIAL D/A AND HIGH INITIAL STOCKING RATE

Key Marketing Strategy	Versus Marketing Strategies	SDWRF Results Financial Measures NRI	ENW
Cash Sales	Simple Hedge	D	D
	Strategic Hedge	d	X
	Multiple Hedge	D	D
Simple Hedge	Cash Sales	d	d
	Strategic Hedge	d	d
	Multiple Hedge	D	D
Strategic Hedge	Cash Sales	D	X
	Simple Hedge	D	D
	Multiple Hedge	D	D
Multiple Hedge	Cash Sales	d	d
	Simple Hedge	d	d
	Strategic Hedge	d	d

D = key strategy is dominating

d = key strategy is dominated

X = strategies cannot be ordered using SDWRF

both NRI and ENW financial measures. The cash sales strategy dominates the simple hedge and the multiple hedge strategies using NRI and ENW. However, it cannot be ordered by SDWRF using ENW with the strategic hedge.

Results from ordering marketing strategies for the within-year with feeding supplement decision scenario are presented in Table XX. In this scenario the strategic hedge dominates all other strategies using both NRI and ENW. The multiple hedge strategy is not completely dominated by all other strategies since SDWRF cannot order this strategy with the cash sales strategy. The cash sales strategy dominates the multiple hedge strategy only when using ENW, while the simple hedge strategy dominates the multiple hedge strategy using both NRI and ENW. Moreover, SDWRF cannot order the simple hedge and the cash sales strategies.

Table XXI presents the results from the within-year with stocking adjustment decision scenario. The table indicates the same ordering of the strategies as for the within-year with feeding supplement scenario except that in this scenario, the multiple hedge strategy is completely dominated by all other strategies using both NRI and ENW.

TABLE XX

ORDERING MARKETING STRATEGIES FOR THE WITHIN-YEAR DECISION WITH FEED SUPPLEMENT, 35 PERCENT INITIAL D/A AND HIGH INITIAL STOCKING RATE

Key Marketing Strategy	Versus Marketing Strategies	SDWRF Results Financial Measures NRI	ENW
Cash Sales	Simple Hedge	X	X
	Strategic Hedge	d	d
	Multiple Hedge	X	D
Simple Hedge	Cash Sales	X	X
	Strategic Hedge	d	d
	Multiple Hedge	D	D
Strategic Hedge	Cash Sales	D	D
	Simple Hedge	D	D
	Multiple Hedge	D	D
Multiple Hedge	Cash Sales	X	d
	Simple Hedge	d	d
	Strategic Hedge	d	d

D = key strategy is dominating

d = key strategy is dominated

X = strategies cannot be ordered using SDWRF

TABLE XXI

ORDERING MARKETING STRATEGIES FOR THE WITHIN-YEAR DECISION WITH STOCKING ADJUSTMENT, 35 PERCENT INITIAL D/A AND HIGH INITIAL STOCKING RATE

Key Marketing Strategy	Versus Marketing Strategies	SDWRF Results Financial Measures NRI	ENW
Cash Sales	Simple Hedge	X	X
	Strategic Hedge	d	d
	Multiple Hedge	D	D
Simple Hedge	Cash Sales	X	X
	Strategic Hedge	d	d
	Multiple Hedge	D	D
Strategic Hedge	Cash Sales	D	D
	Simple Hedge	D	D
	Multiple Hedge	D	D
Multiple Hedge	Cash Sales	d	d
	Simple Hedge	d	d
	Strategic Hedge	d	d

D = key strategy is dominating

d = key strategy is dominated

X = strategies cannot be ordered using SDWRF

CHAPTER VI

SUMMARY AND CONCLUSIONS

A steadily rising cost of production, lower product prices received, and declining asset values have created persistent economic pressure and financial difficulties for Southern Plains ranchers. Economic vitality of a ranch, however, depends not necessarily only on producing more beef per acre but also on the rancher's ability to produce that beef while receiving an acceptable return to resources and financial difficulties.

In this regard, new technology and marketing opportunities create challenges and opportunities to the rancher for achieving greater profit. Inflation rates, weather conditions, insect infestation, diseases, institutional changes, and unpredictable price fluctuations create much uncertainty in evaluating whole-ranch decisions. As a result, ranchers have to make difficult decisions on what production level, technologies, and production and marketing practices will provide the best opportunity to compete, gain profit, and survive in the business.

Those apparent economic problems faced by the Southern Plains' ranchers encourage the researcher to undertake business analyses as close to the real decision environment as possible. In the case of livestock enterprise, weight gain and selling price distributions are important components that influence the ranch cash receipts. Furthermore, distributions of input factor costs are also important in determining the net cash ranch income. Therefore, close attention to these components in analysis is expected to improve the distribution of ranch income.

The major purpose of this study is to provide tools for analyzing profitability, solvency, and survivability of a representative ranch in an uncertain business environment. The available computerized firm simulator (FLIPSIM V) was modified, by expanding the livestock section, to simulate a representative ranch which is subject to stochastic production and prices. The modified model is for use in evaluating and providing alternative strategies for the ranch with different initial financial positions and production decision alternatives.

Production Data and Strategies

A distribution of steer weight gain, conditional upon the level of stocking rate, is developed using Taylor's Hyperbolic Tangent function. Input data used for developing the conditional distribution were taken from a study done by Rodriguez (1987) in Baca County, southeastern Colorado. In addition, the distribution of steer cash and futures prices as well as the basis were developed using an autoregressive integrated moving average (ARIMA) model introduced by Box and Jenkins (1976). Cash price and the basis are assumed to be correlated, hence the ARIMA model generates the mean price and the factored correlation matrix provides a multivariate distribution about the means. This study assumes that steer weight gain and steer cash and basis prices are multivariate empirically distributed.

Two different initial financial positions, representing 35 percent and 65 percent beginning debt to asset ratios, are selected as financial scenarios. Three production decision alternatives including a yearly decision, a within-year decision with feeding supplement, and a within-year decision with stocking rate adjustment are used with each marketing strategy (cash sales, simple hedge, strategic hedge, and multiple hedge).

The yearly decision assumes that the representative ranch uses a steer weight gain expectation for the end of the production period, hence, the ending steer weight is the sum of initial purchased steer calf weight and the weight gain achieved during the entire six-month production period. On the other hand, the within-year decision assumes that the ranch evaluates the steer weight gain at the end of the first three-month production period and makes a decision for the last three months. The stocking rate can be adjusted or supplemental feed can be used when the animals experience a low gain during the first period. A low gain is defined as a current period's stochastic weight gain that is less than the expected weight gain across the stocking rates.

Under the supplement use, a 43 percent protein is fed and the supplement cost added to the ranch cash expenses. However, the animals will have a higher second period's weight gain due to feeding. This study uses a multiplier factor of 1.36. Under this scenario, the original stocking rate level is maintained over the first and second grazing periods.

The stocking rate option assumes that the rancher adjusts the current stocking rate level to the next lower specified level when a low gain is obtained in the first three months. Unlike the preceding (feeding) scenario, a decision with stocking rate adjustment does not add a cost. However, the current stocking rate is reduced and fewer animals are raised in the last grazing period. The number of animals sold due to this adjustment is equal to the difference between the initial and the current adjusted stocking rate level. About 157 out of 1,500 head are sold at the end of the first period to move from medium stocking rate (4.66 acres/head) to the low stocking rate (5.21 acres/head).

Marketing Data and Strategies

Four marketing strategies: cash sales, simple hedge, strategic hedge, and multiple hedge, and two levels (35 and 65 percent) of ranch initial debt to asset ratios are evaluated for their impacts on the financial measures used, the net ranch income (NRI), and the ranch's present value of ending net worth (ENW).

The cash sales strategy uses the stochastic cash price for the weight class achieved by the stochastic ending weight at the end of the production period. The product of this price level and the total number of animals, taking death losses into account with their individual stochastic ending weight, determines the ranch's cash receipts.

The simple hedge strategy always places a hedge by selling futures when the animals are put on pasture at the beginning of the production period (May). A hedge is placed using the current (May) month's stochastic November futures price, held for the entire period, and lifted in late October. The animals are sold in the cash market using the current (November) month's cash price. The profit (or loss) from this hedging is the difference between selling and liquidating the contract. Finally, the net ranch cash receipts is the sum of net receipts from cash sales in November and the profit (or loss) from hedging.

Another variation of simple hedging is called strategic hedging. In this strategy, instead of placing a hedge at every beginning of the production period, the rancher observes the current month's futures price and compares it with a specified breakeven cost (BEC) per pound. If the BEC is higher than the futures price no hedge is placed, otherwise a hedge is placed and held for the entire production period. The rest of the procedure follows the simple hedge strategy.

The multiple hedge strategy compares the current month's stochastic futures price with the three-month moving averages of monthly stochastic futures price every month during the production period. A hedge is maintained whenever the three-month moving averages are above the current month's futures price. A hedge is lifted when the opposite condition prevails, indicating an upturn in prices. The cattle remains unhedged as long as the futures price for the month lies above the three month moving averages. If the futures price for the month crosses the three-month moving averages from above, the hedge is again placed. The hedge is held until an upward trend is designated by the moving averages.

Yearly Decision Results

Results from the medium initial stocking rate show that both scenarios for the initial financial positions, 35 and 65 percent initial ranch's debt to asset (D/A) ratios, present similar ordering for the marketing strategies. The strategic hedge ranks first, in terms of average annual net ranch income (NRI), and present value of ending net worth (ENW), as well as their coefficient of variations for both measures. The strategic hedge is followed in rank by cash sales, multiple hedge, and simple hedge strategies.

In the 35 percent initial D/A, the strategic hedge resulted in $64,889 NRI and $578,230 ENW with coefficients of variation of 278.66 and 113.61, respectively. The ranch has a 66 percent probability of economic success and survives up to 7.62 operational years in the 10-year planning horizon or a 68 percent probability of survival. The ranch survives longer under the simple hedge strategy than the multiple hedge and thus has a chance to lose more as indicated by its NRI and ENW (-$109,038 and $31,672) compared to multiple hedge (-$51,981 and $58,861).

The high initial stocking rate scenario with a 35 percent beginning debt-to-asset ratio shows that the strategic hedge has the highest NRI ($112,958) and ENW ($670,283) compared to other strategies. This strategy provides a 68 percent chance of survival and economic success with 7.78 years to remain in operation. The next strategies, such as the cash sales, the simple hedge, and the multiple hedge has $53,765, -$85,643, and -$196,704 of NRIs and $420,754, $100,492, and -$229,524 of ENWs, respectively.

As the beginning financial position worsens, from 35 percent to a 65 percent initial D/A, the values of financial measures and survival probability are reduced while income variability increases. The financial measures with their coefficient of variations for the strategic hedge are $31,973 (470.02) NRI and nearly $368,992 (166.90) of ENW, respectively, and the ranch is declared technically insolvent at the sixth year of the planning horizon.

Within-Year Decision Results

As in the yearly decision scenario, ranking of the marketing strategies under the within-year decision scenario does not change when initial financial position changes from 35 percent D/A to 65 percent D/A. As expected, the changes occurred on the magnitude of both financial measures and the length of operational year indicated by the survival probability.

The strategic hedge ranks first followed by simple hedge, cash sales, and multiple hedge. This strategy allows the ranch to survive for the entire 10-year planning horizon for both the feeding supplement and the stocking rate adjustment scenarios under 35 percent initial D/A ratio.

Feeding Supplement Scenario

Under a 35 percent initial D/A and medium initial stocking rate scenario the ranch using the strategic hedge, has 100 percent probability of survival, a nearly $298,913 NRI and over $1,667,153 ENW with 22.24, and 19.33 coefficient of variation, respectively. The cash sale and simple hedge strategies remain in operation for about eight years while the multiple hedge up to only 5 years of the planning horizon.

Under the high initial stocking rate scenario with a 35 percent beginning debt-to-asset ratio, the ranch using the strategic hedge also has a 100 percent probability of survival and economic success. It has higher NRI ($347,280) and ENW ($1,852,260) with lower coefficient of variations (21.58 and 18.55, respectively) compared to the medium initial stocking rate scenario. The cash sales, simple hedge, and multiple hedge strategies have only $65,194, $73,746, and -$76,063 NRIs with $461,217, $727,609, and -$86,845 ENWs, respectively.

For the 65 percent initial D/A ratio, all NRI, and ENW values, as well as the ranch's survival probability are reduced. The strategic hedge generates only $227,323 NRI and $1,177,236 of ENW with 86 percent survival probability. The cash sales and simple hedge strategies survive only 24 percent and 54 percent of the time. The multiple hedge has only a 14 percent survival probability.

Stocking Rate Adjustment Scenario

Using a stocking rate adjustment with medium initial stocking rate scenario and a 35 percent initial D/A ratio, the strategic hedge has a 100 percent chance to survive the entire 10 years of the planning horizon. However, under this scenario the rest of the strategies have a lower survival probability. For example, simple hedge, cash sales, and multiple hedge strategies had only 54, 40, and 24 percent chance to survive, respectively. Strategic hedge has $243,370 of NRI and $1,395,810 of ENW. These financial measures are lower than those from the supplement feeding scenario.

The strategic hedge remains superior to the rest of the strategies under the high initial stocking rate scenario. The strategy has $283,100 NRI and $1,549,006 ENW with a 100 percent chance of economic success. The ranch using this strategy survives for the entire planning horizon. The rest of the strategies have lower NRI and ENW with shorter length of operation. For example, the simple hedge, cash sales, and multiple hedge have only -$46,906, -$9,830, and -$168,811 of NRIs and $224,691, $133,269, and -$284,875 of ENWs. These strategies can survive the representative ranch for only 6.46, 6.76, and 4.42 years, respectively.

For the higher initial (65 percent) debt to asset ratio, all the financial and survivability figures are reduced. Strategic hedge survivability is only 82 percent followed by simple hedge (52 percent), and both cash sales and multiple hedge reached only 8 percent. With a $176,092 NRI and $945,471 ENW, the strategic hedge remains in the first rank.

Conclusions

The results from this study obviously support the importance of using marketing strategies other than cash sales. The strategic hedge was the most attractive marketing alternative for all production decisions and initial financial positions as indicated by the NRI and ENW financial measures. The highest average annual net ranch income (NRI) $ and present value of the ending net worth (ENW) under the 35 percent initial debt to asset ratio ($298,913 and $1,667,153) was achieved by the strategic hedge under the feeding supplement scenario. The strategy also had the lowest coefficient of variations for NRI and ENW. The superiority of this strategy is also true for the 65 percent initial debt to asset ratios.

The simple hedge and cash sales strategies rank either second or third under the different scenarios. In most cases, under both the 35 and 65 percent initial D/A ratio, the multiple hedge strategy having the lowest rank, is not an attractive marketing alternative in terms of the financial measures being used.

Under a yearly production decision, the cash sales strategy performs better than the simple hedge, but not under the within-year decision with both the feed supplement and the stocking rate adjustment scenarios. However, as the initial financial position worsens (with a 65 percent D/A), the simple hedge performs better than the cash sales strategy.

Limitation of the Results

Different specifications of weight gains and price distributions may result in different findings and conclusions. Also since this study is designed particularly for a summer stocker operation as indicated in the modification procedures within the FLIPSIM V model, application to other livestock enterprises in a ranch business will require further model adjustments and modifications as the relationship between livestock enterprises becomes important.

Needs for Future Studies

Future studies involving all livestock enterprises, such as cow-calf and feedlot operations, within a ranch business would benefit and help the ranchers to improve. Different assumptions and specifications of the livestock weight gains and price distributions and variations in the marketing strategies would also be of interest.

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