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FARMING FOR THE FUTURE

Alberta AGRICULTURE

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Edmonton, Canada

An Economic Analysis of Risk Management Strategies for Alberta Beef Feeders[1]

Farming for the Future Project No. 90-0723

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Project Report No. 91-03

1. This research comes from the original master's thesis work of J. Unterschultz. See Unterschultz, J. 1991. "Risk and Returns In Cattle Finishing In Alberta." Master of Science Thesis, Department of Rural Economy, University of Alberta, Edmonton, Alberta.

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Abstract

This study investigates slaughter price risk and risk management in finishing heavy feeder steers in a custom feedlot in Alberta. The base model uses a simulation based on historical data of a cattle investor buying and feeding 100 heavy feeder steers each month from 1980 to 1989 in a custom feedlot in Alberta. Several investment strategies are studied using this base model including hedging using the Chicago Mercantile Exchange (CME) live cattle futures contract, put options and participating in the National Tripartite Stabilization Program (NTSP). Risk is measured using deviations from forecast net returns (Mean Square Error) and the investment beta from the Capital Asset Pricing Model. The CME live cattle futures contract adjusted for exchange rate and local basis is used to forecast Alberta slaughter steer prices.

Hedging 100% of expected production significantly reduces slaughter price risk. Over extended periods of time the cost of this strategy is not high. An Alberta cattle investor can get results similar to 100% hedging by selling CME live cattle contracts equal to about 60% of the expected cattle production. Basis risk, a part of hedging risk, is lower for the period 1985 to 1989 than for 1976 to 1980. Basis risk for the Alberta cattle investor does not prevent the effective use of the CME live cattle contract for managing risk. Put options can be used as insurance against price drops. However 100% hedging may be as effective.

Participation in the NTSP reduces risk slightly but not significantly, and increases net returns. The risk averse and risk neutral cattle investor benefits from participation in the NTSP.

The returns in cattle feeding in Alberta are not highly correlated to the TSE 300. A large portion of cattle feeding risk can be diversified away by investing in the TSE 300.

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Chapter 1 Introduction

The Alberta beef cattle industry is the single largest source of farm cash receipts in Alberta (Alberta Agriculture (1989)). Beef cattle receipts were 1.46 billion dollars in 1989 and were 32.4 percent of total farm receipts. The feeding and finishing of beef cattle in feedlots in Alberta is a big part of the beef cattle industry in Alberta.

Alberta feedlots feed their own cattle for slaughter markets or custom feed cattle for outside investors. Information on sources of risk and risk management in the cattle feeding industry will benefit Alberta investors in the beef industry. Selected comparisons to similar risks in the United States will help compare the Alberta risk to the risk of cattle feeding in the United States.

Previous research on the risks in the cattle finishing industry is limited and possibly outdated. Studies on the risks in cattle feeding in Canada by Caldwell et al. (1982), Gaston and Martin (1984), Carter and Loyns (1985) and Gillis et al. (1989) end by 1983. Coles's (1989) research ends in 1985. Recent developments not included in these studies are possible closer links between Alberta and the United States cattle market due to increased Alberta live cattle exports to the United States and the National Tripartite (Beef) Stabilization Program (NTSP), a government program that started in 1986. The research by Freeze et al. (1990) includes only the first year of the National Tripartite Stabilization Program. These recent developments may have changed the risk in cattle feeding in Alberta and the risk management strategies used by a cattle feeder investor.

These previous studies report conflicting results on risks in cattle feeding or the use of certain risk management strategies such as hedging. Part of this conflict may arise from the different definitions of risk used by these studies and the different time periods covered.

This study updates research on cattle feeding risk in Alberta to the end of 1989. The measurement of risk and the differences in risk management results from previous studies are discussed. Cattle feeding price risk in Alberta is compared to a selected location in the United States. Different cattle investment risk management strategies, including participation in the NTSP, are evaluated. This study will help cattle feeder investors assess risk, use risk management strategies, compare the risk in Alberta cattle feeding to United States cattle feeding and compare cattle feeding investments to alternative non farm investments. The next section states the research objectives and gives an outline to the rest of the research.

1.1 Study Objectives

This study evaluates the risks and returns from investing in heavy steers[1] in custom feedlots in Alberta. Specific objectives of this study include:

1. Identify the sources of risk for an investor in beef feeder cattle.
2. Measure realized net returns in cattle feeding and the variation in these returns from predicted.
3. Evaluate and compare beef feedlot investment opportunities to alternative investments.
4. Compare different methods of forecasting slaughter steer prices in Alberta.
5. Investigate the live cattle basis[2] and basis variability compared to the United States and prior time periods.
6. Investigate the conflicting results in the literature on risk and risk management in cattle feeding in Canada.
7. Include the National Tripartite Stabilization Program (NTSP) for slaughter beef cattle in the study, the effect of the NTSP on risk and returns and the effects on other risk management strategies.
8. Investigate risk management using the Chicago Mercantile Exchange futures market to hedge Alberta slaughter cattle.
9. Investigate and measure risk on different investment strategies for Alberta cattle investors.
10. Investigate the use of live cattle futures options for risk management.

---

1 Heavy feeder cattle as defined in this study are cattle weighing over 363 kilograms (800 pounds) and fed for the slaughter market.

2 Basis is the difference between the Alberta slaughter price and the relevant live cattle futures price. Live cattle basis and its importance to this study is defined later in the paper.

1.2 Study Plan

Chapter 2 discusses the Alberta cattle feeding industry and provides motivation for the research methods used. The relationship between the Alberta slaughter market and the United States slaughter market is discussed. The new government programs are described. These changed market conditions and programs may influence cattle feeding risk and risk management by Alberta cattle investors.

Chapter 3 explains the theory behind the analysis in this research. The theory deals specifically with the definition of risk, futures markets, price prediction, futures market efficiency, hedging, optimal hedging and options. The risk measures used in this study, Mean Square Error (MSE) and the investment beta from the Capital Asset Pricing Model (CAPM), are explained. Detailed references and comparisons to other research are made in this chapter.

Chapter 4 reviews the data used in the research. Limitations and problems in the data are explained.

Chapter 5 explains the research methods used and reports the results. A production function for cattle feeding is built. A historical simulation has an Alberta cattle investor purchase 100 heavy feeder steers each month and feed these cattle to slaughter in a custom feedlot. Actual historical data for the main time period 1980 to 1989 is used. Nine different methods of forecasting slaughter steer prices are estimated, compared and tested. One price forecast is chosen and used to measure risk in cattle feeding. Cost of production and net returns on each lot of feeder cattle fed are calculated. Net returns from cattle feeding are compared to different risk management strategies including hedging strategies, participation in the NTSP and selective feeder cattle investments. A cattle feeding investment is compared to non agricultural investments using the Capital Asset Pricing Model. The Canadian 91 day Treasury Bill (T-Bill) and the Toronto Stock Exchange (TSE) 300 index are used in the analysis of the different strategies and the comparison to non agricultural investments. Alberta basis and slaughter prices are compared to the Omaha basis and slaughter prices to measure the relative risk in cattle feeding between the two locations. The use of live cattle futures options to manage risk is simulated and measured.

Chapter 6 discusses applications of the results to cattle investment in Alberta. Limitations in the results are discussed. Future research directions are outlined.

The appendices contain background results used or derived by this study. These include the exact parameters used in the production function, the mean square error tests, and calculations of the real returns in T-Bills and the TSE 300 index.

Chapter 2 Cattle Feeding In Alberta

This chapter describes the institutional background for this study. Included here are reviews of the Alberta and United States cattle market, government programs and the Alberta custom feedlot industry. The first section describes the relationship between the Alberta and the United States cattle market and how this relates to risk in cattle feeding. Government programs and their possible impact on cattle feeding risk are then described. The chapter concludes with a brief description of the feedlot industry in Alberta and how this information is used to choose a cattle feeding model.

2.1 Alberta and United States Cattle Markets

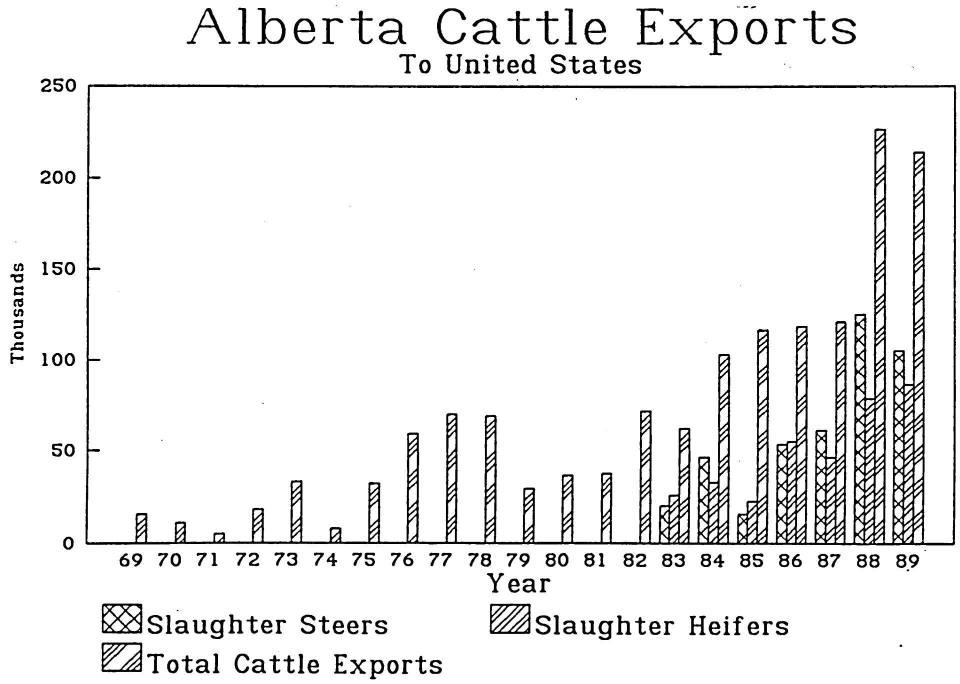
Alberta feedlots produce more slaughter beef cattle than are consumed in Alberta. Therefore, Alberta exports live slaughter cattle and beef to other provinces and other countries. The main importing country of Alberta slaughter cattle is the United States.

Figure 1 displays the number of live cattle exports to the United States for the years 1969 to 1989 (Alberta Agriculture). 98 to 99 per cent of Alberta's live cattle exports to foreign countries were to the United States. Exports of live cattle from Alberta to the United States increased during the 1980s. This is evidence of closer linkages between the Alberta and the United States cattle market.

The total numbers of steers and heifers slaughtered in Alberta have remained constant or dropped over the period 1976 to 1989. This is shown in Figure 2, a graph of total slaughter numbers of steers and heifers in Alberta (Alberta Agriculture). Figure 1 and Figure 2 show the increased importance of the United States market for Alberta cattle. Alberta slaughter prices should closely follow the prices in the United States if Canadian prices are based on the United States cattle market.

A graph of the nominal slaughter steer prices for Alberta and Omaha are in Figure 3. These monthly price series are described in Chapter 4. The graph shows a close relationship between the Alberta price and the Omaha price even though the Omaha price is in U.S. dollars. Alberta and the United States use different currencies and the Canada-United States exchange rate is required to directly compare slaughter prices between the two countries.

Figure 1[1]



1. No break down of steer and heifer slaughter exports was available prior to 1983.

Figure 2

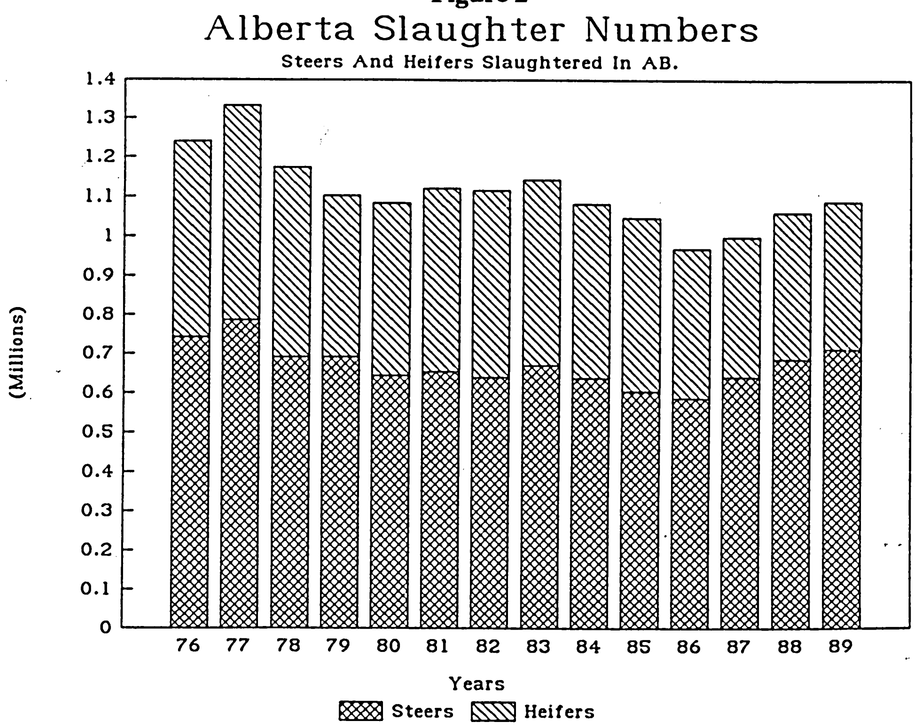


Figure 3

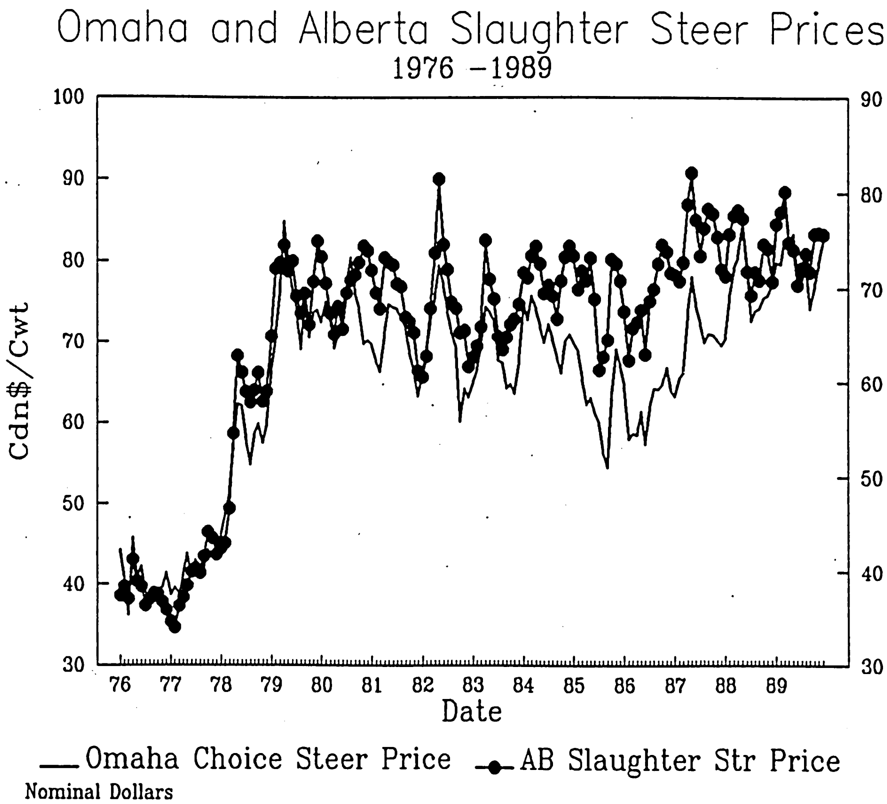


Table 1
Correlation Between Alberta And Omaha Slaughter Steer Prices
All Prices Are Nominal

Time Period	Correlation No Adjustment For Exchange Rate	Correlation Omaha Prices Adjusted to Canadian $
1976-1989	0.933	0.977
1976-1979	0.981	0.986
1980-1985	0.598	0.746
1980-1989	0.660	0.819
1986-1989	0.707	0.835

The correlations between nominal Alberta slaughter steer prices and nominal Omaha slaughter steer prices are in Table 1. The correlation between the two cash prices is higher in the period 1976 to 1979 than in the period 1986 to 1989. However the correlation for the period 1980 to 1985 is smaller than for the period 1986 to 1989. The evidence is not conclusive that the markets are now more closely linked. The later 1980s appear to show a closer linkage between the two markets than the early 1980s.

A close relationship between the Alberta and United States cattle markets suggests that the slaughter prices in both locations are linked together. Price movements in the United States cattle market should lead to similar price movements in the Alberta market. Alberta prices for slaughter steers should not fluctuate independently of United States prices. Alberta investors should be able to use the United States market, including the futures market for live cattle, in assessing price risk. Alberta investors in the late 1980s may find the Chicago Mercantile Exchange (CME) futures market more useful for managing cattle feeding risk than during the 1970s or the early 1980s.

2.2 Government Programs

Government policies and programs can significantly impact on the cattle feeding industry. Government programs may change the risk of the investment and it cannot be assumed that a government program reduces risk. The Crow Benefit Offset Program (CBOP) and the National Tripartite Stabilization Program for slaughter beef animals (NTSP) are the programs included in this research. The following sections describe these programs, relate their probable impact on cattle feeding risk and state how these programs are included in the research simulation.

2.2.1 CBOP

The CBOP is a feed cost reduction program paid by the Alberta provincial government to livestock producers. It compensates Alberta livestock producers for the positive impact on feed grain prices caused by the statutory grain rail freight rate subsidy. This freight rate subsidy is commonly referred to as the Crow freight rates. It is perceived that the federal government statutory grain freight subsidy for export grain increases the price of feed grain for Alberta livestock producers.

The CBOP started September 1, 1985. It pays a livestock feeder a fixed amount for each tonne of feed grains fed to livestock in the province of Alberta. There is usually no uncertainty in the amount of payment the cattle feeder qualifies for under the CBOP.

The subsidy was paid at the following rates:

September 1, 1985 to June 30, 1987	$21/tonne
July 1, 1987 to Aug. 31, 1989	$13/tonne
September 1, 1989 to end of this study	$10/tonne

The CBOP is included in the production function in this research. It reduces the cost of feed used in the production function. Nearly all livestock producers participate in this program in Alberta. The owner of feeder cattle in a custom feedlot qualifies for this program.

2.2.2 NTSP

The NTSP is a federal and provincial stabilization program for livestock producers. The program started in July 1986 with retroactive payments to April 1986. Cattle feeders are not required to join the program. Any cattle feeder who joins the program must register all cattle fed. The following describes the NTSP for the slaughter cattle option.

The NTSP uses a guaranteed margin approach to provide protection against increasing production costs and falling market returns. The guaranteed margin from January 1, 1986 to December 31, 1988 was 85% based on quarterly calculations. The margin changed to 90% starting January 1, 1989 when calculations switched to monthly results. Payments are triggered when the current calculated margin drops below the guaranteed margin.

The program describes the cash cost of production and the selling price as (Agriculture Canada and Alberta Agriculture (1989)):

> ...The cash costs of production are the estimated costs of purchasing a mixture of calves and short keeps and eventually producing cattle for slaughter purposes. The costs of these replacement calves and short keeps and the costs of feed, interest, trucking and selling are used by the slaughter option to determine support levels. These costs are weighted by inspected Western Canadian slaughter plus exports and by inspected Eastern Canadian slaughter minus imports of U.S. cattle...

The national average selling price of slaughter cattle is a weighted average of a blend of grades A, B and C slaughter cattle prices. It is calculated by using 96% of the A1 and A2 rail grade prices converted to live weight equivalent prices. In this conversion, it is assumed there is a 58.5 dressing percentage for steers and a 56.5 dressing percentage for heifers. The prices used are those for Alberta, Saskatchewan, Manitoba and Ontario as reported by Agriculture Canada in the Livestock and Meat Trade Report. The prices are weighted by the federally inspected slaughter volume...

The following equations show in general how support levels and pay outs are calculated:

1. $SL = CC + .85(FASP - FAC)$

$$Payment = NMP - SL$$

where:
SL is the support level for the month,
CC is the cash cost per head for the month,
.85 is the guaranteed margin percentage,
FASP is the five year average selling price for that month,
FAC is the five year average costs for that month,
NMP is the national average price per animal and
Payment is the per head pay out (if the calculation is < 0)

Premiums are shared equally by the producer, the provincial government and the federal government. The producer premium was:

January, 1986 to June, 1987	\$6.60 per head
July, 1987 to March, 1989	\$7.40 per head
April, 1989 to end of study	\$8.10 per head

The NTSP terminates December 31, 1995. Any deficit in the fund at that time will be shared by the federal and provincial government. Any surplus will be used for the general benefit of the producers.

There is uncertainty associated with pay outs from the NTSP. First, cattle investors may receive a price for their cattle that is different from the national average selling price. Secondly, the cattle investor may have different costs than the national average costs. Thirdly, the cattle investor may not be able to accurately predict the future pay outs of the NTSP program at the start of any feeding period.

All slaughter animals used in the historical simulation in this project meet the minimum requirements for the NTSP. Minimum requirements are that the animals be owned for over 60 days, that steers weigh over 476 kg (1050 lb) live weight (or provide proof of slaughter if a lighter weight) and grade A, B, or C.

The actual NTSP pay outs are added to the gross revenue of cattle owners participating in the program in the historical simulation. Scenarios of participating versus not participating in the NTSP are included in this research[3]. The measurement of risk defined later in this study requires the forecast of NTSP pay outs at the time feeder cattle are placed in the feedlot.

The expected effect of the NTSP program should be to increase net returns. The effect on risk, defined as MSE, is not clear. This research studies the effect on risk of participating in the NTSP.

2.3 Alberta Custom Feedlots

The cattle feeding industry provides opportunities for non feedlot owners to own and feed cattle. These custom feeding feedlots charge the investor for the cost of producing the animal. This provides the rational for the research method used in this study. The ownership of the feedlot is separate from the ownership of cattle. This simplifies the analysis. This research takes the viewpoint of an investor buying and placing steer feeder cattle in a custom feedlot.

3 Discussions with Alberta Agriculture, Central Program Support, indicated that most (if not all) major cattle feeders in Alberta are enrolled in the NTSP for slaughter beef cattle.

The custom feedlot looks after the feeder animals. The feedlot feeds the animals rations of grain, silage and other necessary supplements. The main ingredients in the feeder rations in Alberta are barley and silage. The feedlot charges the customer for the feed, the cost of bedding, the veterinary cost, and a daily yardage cost. All costs are paid by the owner of the feeder cattle.

Various types of cattle such as heifers or steers can be placed in the feedlot. The quality of the animals, which indirectly refers to the ability of the particular animal to gain weight quickly and complete the feeding period as a top grading slaughter animal, varies. Higher priced feeder animals in the same weight category are usually better quality animals. The weight of animals going into the feedlot can vary from 227 kg (500 lb) to 454 kg (1000 lb). Production risk, such as unexpected higher cattle death loss, or unexpected low rates of gain, decreases with heavier animals.

This research assumes the cattle investor purchases 100 heavy good quality feeder steers each month and places them on feed in a custom feedlot. The finished animals are sold in the Alberta market approximately 90 days later. More details on the production parameters are in chapter 5.

The institutional background reviewed in this chapter suggests that cattle feeding risk may be different in the latter part of the 1980s than in the early part of the 1980s or later 1970s. New government programs and closer linkages between the Alberta and United States cattle markets may change the risk and risk management conclusions reported by earlier studies. This study updates the research on the cattle feeding risk and includes these institutional factors. The separation of the ownership of the feedlot from the ownership of the cattle simplifies the research methods used.

Chapter 3 Theoretical Background

This chapter reviews the literature, describes risk and explains risk management strategies. Section 3.1 briefly reviews the expected utility model (EUM), the main risk model used in this study. Problems with risk measures used in previous studies on cattle risk in Canada are discussed. Next, the risk measures, MSE and the beta from the CAPM, are described. Possible risk management strategies available to the Alberta cattle investor are explained in section 3.2. A detailed look at the futures market and its role in risk management follows in section 3.3. Cattle basis is then defined and the role basis has on risk is analyzed. Next is a detailed discussion on optimal hedge ratios and estimating optimal hedge ratios. The use of live cattle futures options and some theory about options is described. These topics provide a background to the risk measures and to the risk management strategies used in the research.

3.1 Risk

The literature on risk in economics and business is extensive and contains several different measures and models of risk. Young (1984) reviewed risk concepts and measures used by economists. He placed them into three classes.

1. Decision rules requiring no probability information.
2. Safety first rules.
3. Expected utility maximization.

The expected utility model (EUM) from Von Neummann and Morgenstern is the most common risk concept in the literature. Mean-variance models, a special category of EUM, are used extensively and underlie much of the analysis in this research. The expected utility (EU) of a profit function can be rewritten in terms of the utility of its certainty equivalent expression. The model starts from a certain profit function such as (Robison and Barry (1987) or Selley (1984)):

2. $y = pq - C(q) - b$

where:
y is profit
p is output price
q is quantity
C(q) is variable cost and
b is fixed costs.

Assume profits are normally distributed and the investor has a negative exponential utility function[4]. The investor's expected utility with this profit model in equation 2 (EU(y)) when prices or quantity are stochastic is equivalent to the utility of the certainty equivalent profit ($U(y_{ce})$) of equation 3.

3. $$y_{ce} = E(y) - \frac{\lambda}{2} Var(y)$$

where:
y_{ce} is the certainty equivalent profit
E(y) is the expected profit,
λ is the Arrow - Pratt coefficient of Absolute Risk Aversion and
Var(y) is the variance of profit.

The EU(y) equals the $U(y_{ce})$. The second term on the right side in equation 3, $(\lambda/2)var(y)$, is the risk premium. This risk premium measures risk or the amount an individual is willing to pay to move from expected profit, E(y), to a certain level of profit, y_{ce}. Maximizing EU(y) is equivalent to maximizing $U(y_{ce})$. The certainty equivalent expression is easier to use in analyzing risk.

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4 The negative exponential utility function is $U(y) = -e^{-\lambda y}$.

This type of EUM underlies some portfolio selection theory (Markowitz (1952), Selley, (1984)) and the CAPM used in finance (Barry and Baker (1984), Sharpe (1964), Lintner (1965)). The EUM certainty equivalent expression is used in the analysis of the optimal hedge in section 3.3.5, a type of portfolio selection problem.

The EUM can be used to represent risk averse, risk neutral or risk seeking cattle investors. The risk averse investor ($\lambda > 0$) in the EUM minimizes risk for any given level of profit. The risk neutral investor ($\lambda = 0$) is only interested in maximizing profits and is indifferent to risk or measuring risk. The risk seeking investor ($\lambda < 0$) maximizes risk for a given level of profits. Neither the risk neutral nor the risk seeking cattle investor appears intuitively appealing in this study. The cattle investor in this study is assumed to be risk averse. The assumption of risk aversion is required for the risk efficiency criterion (explained below) and the CAPM.

Risk efficiency (King and Robison (1984)) maximizes individual utility by ordering choices between different cattle investment strategies or portfolios of investment. Alternative investment choices are ordered using the mean and variance of profits using the model in equations 2 and 3, and the assumption that the investor is risk averse. For example, two strategies, X and Y, are ranked based on profits or net returns. Choice X is preferred to (or dominates) choice Y if the Mean(X) $\geq$ Mean(Y) and the Variance(X) $\leq$ Variance(Y) and one of these two inequalities is strict. This says that more is better than less and that less variance for the same of amount income is better than more variance. Under the assumptions used here, the mean-variance risk efficiency criterion is equivalent to the efficiency criterion using second order stochastic dominance.[5] The mean-variance risk efficiency criterion may not always give clear choices between different strategies.

The risk efficiency criterion can be extended to groups of assets and different expected rates of return. Mean-variance risk efficient sets are combinations of risky assets with minimum variances for different expected returns (Barry and Baker (1984)). This concept is used in the CAPM. A variation of this risk efficiency criterion is used in chapter 5 to rank different cattle investment strategies. The variance of historical returns is replaced with MSE. The EUM is the theory behind the risk measures described next.

3.1.1 Measuring Risk

Risk is measured using two standards in this study. These two measures are mean square error (MSE) and the beta coefficient from the Capital Asset Pricing Model (CAPM). The risk measures used in previous Canadian studies are outlined first in this subsection. The reasons for choosing the two risk measures and only measuring slaughter price risk in this study are explained.

The literature on Canadian risk in cattle feeding uses different measures of risk. Caldwell et al. (1982), and Carter and Loyns (1985) used historical standard deviations of net revenue as measures of risk. Gillis et al. (1989) compared the monthly net cash flow for different strategies for a cattle feeder feeding cattle year round. Gaston and Martin (1984) compared the net cash flow of different strategies and quantified the probability of getting a positive cash flow based on historical information. Turvey and Driver (1987) and Brown (1989) used CAPM to measure cattle feeding risks relative to some specified market portfolio. Coles (1989) used the mean square error of deviations from forecast returns and CAPM as the measurements of risk. Freeze et al. (1990) used deviations below a target profit level as their definition of risk and forecasts were based on historical profits.

The historical standard deviations as a risk measure is a naive assumption that producers do not use currently available information in farm planning. The study by Freeze et al. (1990) ignores current market information that investors could use in making investment decisions and in determining risk in an investment. Gillis et al. (1989) and Gaston and Martin (1984) use net cash flow as a measure of risk. This also ignores the aspect of risk defined as deviations from a predicted value using all available information.

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5 Second order stochastic dominance, a way of ordering investments using the first and second moments of their distributions, is defined as X dominates Y if the distribution functions of X, F, and Y, G, have the following property where $\int_{-\infty}^{k} F(k)dk \leq \int_{-\infty}^{k} G(k)dk$ for all k and the inequality is strict for some value of k.

Canadian studies using the same risk measure have reported different results. The study by Caldwell et al. (1982) and Carter and Loyns (1985) used the historical standard deviation of net revenue as the measure of risk. Caldwell et al. (1982) reported that a 100% hedging strategy on slaughter cattle was risk increasing over not hedging. Carter and Loyns (1985) reported that a 100% hedging strategy was risk decreasing over a no hedging strategy for steers. Coles (1989) reported a beta of 0.64 on cattle feeding in Alberta for 1972 to 1985. Brown (1989) estimated a beta of -0.182 for Saskatchewan cattle feeders for 1971 to 1987. Both Coles and Brown used the same market portfolio in their CAPM.

Young (1984, p.40) discussed the estimation of the parameters in a mean-variance EUM model. He reviewed the various methods used for estimating the mean and the variance. Young concluded this section with "If the practical value of EV sets to decision makers rests on the normative information they provide about future outcomes of current decisions, then the vector μ should represent forecasted expected returns for the decision period. Similarly, σ is the variance-covariance matrix of these forecasts." Young (1984) was suggesting some type of mean square error (MSE) as the risk measure in mean-variance analysis and the use of estimation procedures such as ARIMA models, econometric models or other forecasting models. The statistical variance of this model supplies a measure of risk. Peck (1975),and Brandt (1985) also discussed the use of forecast error as the only portion of variance that is relevant to a decision maker in hedging.

Rational investors are assumed to use current as well as historical information in measuring risk and making investment decisions. This leads to the use of MSE rather than standard deviation as one risk measure. The MSE is useful in comparing the risk between different cattle investment strategies. MSE measures the dispersion of the predicted value around the observed value of the parameter (Kmenta (1971 p.156)). It is defined as:

4. $$MSE = \frac{1}{(n-1)}\sum_{i=1}^{n}(X_i - \hat{X}_i)^2$$

where:
$\hat{X}_i$ is the predicted value
X_i is the observed value.

The choice of the forecast in the MSE is discussed in chapter 5. High preference is given to price predictions with lower MSE. Several different slaughter price forecasters and NTSP pay out forecasters are evaluated later in this study. Coles (1989) used the Chicago Mercantile Exchange (CME) futures market for price forecasting. Following the suggestion of Young (1984), ARIMA, econometric and other slaughter price forecasters are also tested in this study.

The second risk measure used is the beta from the CAPM (Sharpe (1964), Lintner (1965)). This measure is useful when comparing the cattle feeder investment to non agricultural investments. The CAPM is based on the mean-variance EUM, equation 3, and assumes the investors are risk averse and hold diversified investment portfolios. Explanations on the CAPM are in business finance texts such Brealey et al. (1986) or Ross and Westerfield (1988). Applications of CAPM to agriculture are in Barry (1980), Turvey and Driver (1987), Coles (1989) and Brown (1989).

The beta coefficient from the CAPM is defined as:

5. $$\beta = \frac{Cov(X, M)}{\sigma_m^2}$$

where:
β is the beta coefficient for the investment X
Cov(X,M) is the covariance between the returns on investment X and the market portfolio return M and
σ_m^2 is the variance of returns on the market portfolio.

The beta in this study is calculated as a linear Ordinary Least Squares (OLS) regression of the returns of the asset on the returns of the market portfolio. The beta is calculated in this study using:

6. $$X = Constant + M\beta + \mu$$

The beta, a measure of systematic risk (Brealey et al. (1986), Ross and Westerfield (1988)), measures the variation in returns between the asset and the market portfolio. Systematic risk is affected by overall factors in the economy and is not eliminated by diversification. A beta of 1 indicates the asset has the same systematic risk as the market portfolio. A beta less than 1 indicates the asset has a lower systematic risk than the market portfolio. Non systematic risk is unique to the asset and can be eliminated by diversification. The market portfolio in CAPM can be a market index such as the TSE 300 (Coles (1989), Brown (1989)) or some farm market index (Turvey and Driver (1987), Collins and Barry (1986)). A diversified portfolio only has systematic risk.

The systematic and non systematic risk portions can be calculated (Turvey and Driver (1987, p. 389)). This measures the relative proportions of risk in the cattle feeding investment compared to some market portfolio. The non-systematic risk can be diversified away by investing in the market portfolio. The systematic portion of risk is:

7. $\rho_{x.m}\sigma_x$

The non systematic portion is defined as:

8. $(1-\rho_{x.m})\sigma_x$

where:

$\rho_{x.m}$ is the correlation between X and M and

σ_x is the standard deviation of the returns for X.

The σ_x is replaced by the square root of the MSE in this study when risks in equations 7 and 8 are calculated.

There are questions regarding the appropriate market index to include in the CAPM model. Turvey and Driver (1987) used a market portfolio composed of 28 farm products in the Ontario market. The risk free asset was the cash rent on land. Collins and Barry (1986) used a single index portfolio model to estimate the beta of 12 California crops and used this crop mix as the market portfolio. There is no evidence or conceptual rationale presented that the market indexes used by Turvey and Driver or Collins and Barry are actual portfolios used by farm investors. This may render the beta calculated in these studies irrelevant.

There is evidence that market indexes such as the Toronto Stock Exchange 300 (TSE 300) are more appropriate as a market index (Brealey et al. (1986, p.166)). For example, the use of diversified mutual funds as part of an individual portfolio would tend to follow the index used by Coles (1989) and Brown (1989). This study uses the TSE 300 as the market portfolio.

Government policy designed to reduce risk or increase mean income may lead a farm manager to increase risk (more debt) or change production and investment decisions (Gabriel and Baker (1980), Collins (1985), Featherstone et al. (1988)). There may be a certain level of risk and returns that the investor desires to maintain. The investor may therefore find ways to increase risk and potential returns if risk is reduced by a government program. These aspects of government programs are not explored in this research.

Coles (1989) evaluated the production risk and the price risks, in feeding 380 kg (838 lb) feeder steers to slaughter in Alberta. He concluded that almost all of the risk was due to slaughter price changes and not production related. Feder et al. (1980) developed a model of the firm with no production risk and suggested cattle finishing fits this particular model. The model in this research includes no production risk. The production risk is probably small in relation to the price errors and the production risk is likely uncorrelated with price or the market portfolio. Therefore production is expected to contribute very little to the total risk. The risk measured by the MSE and the beta from CAPM includes slaughter price risk and includes no production risk.

3.2 Risk Management Strategies

The risk management strategies used in this research are gathering information, hedging, diversifying, participating in public programs and using options. Robison and Barry (1987, p.59-70) list many more possible responses to risk. The following discussion describes the type of risk management tools and strategies used in this study.

The different models used to forecast Alberta slaughter steer prices and NTSP pay outs in the simulation represents the gathering of information. Improved price or revenue forecasts are better information. MSE is used to measure and compare these forecasts. Different investment strategies can be followed using the information.

The CME futures market has two possible roles in risk management. The first role is in information gathering. The slaughter steer price forecasting accuracy of the futures market is compared to other forecasts using Alberta cash prices, ARIMA models and econometric models. This price forecasting role involves issues such as live cattle futures contract pricing efficiency, forecasting Canada and United States currency exchange rates and forecasting basis to estimate an Alberta cash price. Different methods of basis forecasts are measured and compared. These futures market issues are discussed in detail later.

The second role for the futures market is hedging slaughter cattle. The definition of hedging and the different kinds of hedging are explained later in this chapter. The theoretical optimal hedge and its estimation are analyzed. The use of hedging and the optimal hedge are also related to the issue of futures market pricing efficiency and diversification. The optimal hedge under certain conditions is a special case of diversification in a two asset portfolio holding futures contracts and feeder cattle. The futures market also has a role in the use of options.

Diversification is measured in this study. The beta measurement from the CAPM and the measures of systematic MSE versus non systematic MSE measure the effectiveness of diversifying the cattle investment by investing in the TSE 300.

Joining public programs is another risk management alternative. The two programs included in the historical simulation are the CBOP and the NTSP. The CBOP is not expected to change risk (MSE) since there is very little uncertainty associated with this program. The CBOP is included to reduce the cost of production and increase net income.

The anticipated effect of the NTSP on risk is not certain. The NTSP is expected to increase mean income based on the premium contributions by the two levels of Canadian government. The risk is measured by MSE and the beta from CAPM. Therefore, forecasts of the NTSP pay outs are required. The details on the different forecasts compared are in chapter 5. It is the stated intention of the NTSP to reduce risk in cattle feeding. This gives the first hypothesis in this study.

Hypothesis: The NTSP has reduced the cattle feeding risk in Alberta.

Gathering information, hedging, using options, diversifying and joining public programs are the general risk management strategies analyzed in this research. The details on these strategies are explained in chapter 5. The next section covers topics related to the futures market and its role in risk management.

3.3 Futures Markets

The futures market used by Alberta cattle investors is the Chicago Mercantile Exchange (CME), in Chicago, Illinois, United States. The only contract used here is the live cattle contract for slaughter steers. The next sections review the role of the futures market and previous research on the futures markets in price forecasting and in risk management. The market efficiency issue is examined. Next, the best forecast for the Canada-United States exchange rate is reviewed. The exchange rate forecast is required to convert price forecasts from U.S. dollars to Canadian dollars. Hedging and live cattle basis and their role in risk management are then discussed. The use of options is explained in a later section. A detailed discussion of optimal hedge theory and optimal hedge estimation concludes the explanation on futures markets.

3.3.1 Pricing Efficiency In The Cattle Futures Market

Pricing efficiency is an important issue when using the futures market for price forecasting. Efficient markets should give superior price forecasts and better forecasts reduce risk. Three tests for market efficiency are commonly referred to in the literature. These tests are weak form, semi-strong form and strong form (Leuthold and Hartmann (1981, p. 71-72), Ross and Westerfield (1988, p.302-308), Blank (1989, p. 129-132)). The weak form tests whether all historical information is in the futures price. The semi-strong form tests whether historical and current public information is included in the price. The strong form tests whether all information, public and private, is included in the price.

Weak form market tests were reported by several researchers. Leuthold (1974) concluded using a weak form test on live cattle futures contracts that for price forecasts beyond 15 months the cash market was a better predictor of the spot price than the current futures price during the period 1965 to 1971. These were the start up years for the live cattle contract on the CME. The futures price was more accurate in predicting the future spot price for 3 months in the future or less. Shonkwiler (1986) using time series methods concluded that the live cattle futures market is not a rational price forecast for periods over 4 months. For two month periods the rationality of forecasts from the futures market would be accepted using conventional statistical tests. The four month forecast would be accepted as rational at the 10% significance level. Martin and Garcia (1981) studied the period from 1964 to 1977 and concluded that live cattle futures do not provide better forecasts than lagged cash price forecasts.

Kahl and Tomek (1986) discussed problems of estimating weak form market efficiency models using OLS and seemingly unrelated regression estimation procedures and the aggregation or disaggregation of data in the procedure. Their results questioned the results of weak form market efficiency tests using the traditional model $SpotPrice = \alpha + \beta(prior\ futures\ price) + residual$.

Semi-strong tests were reported by several researchers. Leuthold and Hartmann (1981) tested the cattle market by comparing an econometric model to the futures market. For the period 1971 to 1978 the futures market was not always efficient since the econometric model outperformed the futures market over several time periods. Carter et al. (1983) using the CAPM concluded that there was "Normal Backwardation"[6] in the livestock futures market and other commodities. However a comment by Marcus (1984) questioned the results of Carter et al. (1983) based on perceived biases in the market index chosen. Ehrhardt et al. (1987) tested market efficiency using Arbitrage Pricing Theory[7] and concluded that there was no normal backwardation in wheat, soybeans and corn futures as found by Carter et al. (1983). Just and Rausser (1981) compared the cattle futures to commercial econometric models for accuracy for the period 1976 to 1978. The live cattle futures had a smaller root mean square error than four of the five models tested for one quarter. The root mean square error for cattle futures tended to be greater than the econometric forecasts for longer horizons than one quarter. Econometric models were better forecasters than the futures market over longer time horizons. Garcia et al. (1988) tested the efficiency of the live cattle futures market using an econometric model, an ARIMA model and a composite model for the period up to 1985. The mean square error of the futures market tended to be larger than the other model forecasts, however under a simulation exercise the authors could not conclude that the futures market was inefficient.

Buccola (1989) questioned the research that concluded the livestock markets were inefficient based on perceived problems with these studies. The literature reviewed here used different price forecast models for comparison to the futures market price forecasts. These included lagged cash prices to forecast the subsequent cash price, ARIMA models and econometric models. These competing slaughter price forecast models are compared in this study.

The live cattle futures market efficiency is tested using the competing price forecast models developed in this study. The MSE of futures price forecasting models are compared to the MSE of competing models. This leads to the second hypothesis in this study.

Hypothesis. The CME live cattle futures market adjusted for basis and exchange rate is an unbiased price forecast for Alberta cattle feeders.

The literature reports mixed results on the efficiency of the live cattle futures contract as a price forecaster. One to three month time horizons prior to the contract expiry month are efficient. Periods over 4 months have other models or even current cash prices that provide superior price forecasts. This study will use forecasts of 1 to 5 months prior to the contract expiration month. Therefore the futures market will be in an area where the literature results suggest it may not be a good price forecaster.

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6 Normal backwardation is a term for futures prices to be consistently downward biased forecasts of the subsequent cash price. This is explained in more detail in the hedging section.

7 See Ross and Westerfield (1988) for a simplified explanation of Arbitrage Pricing Theory. p.181-194. A more detailed explanation is in Ross, S.A. 1976. "The Arbitrage Theory of Capital Asset Pricing." *Journal Of Economic Theory*. 13: 341-360.

3.3.2 Exchange Rate Forecast

The United States and Canada have different currencies. A forecast spot exchange rate between Canada and the United States is needed when using the CME live cattle futures contract for price forecasting. Coles (1989) used the 90 day spot futures exchange rate to convert forecast U.S. prices from the CME futures market to Canadian prices. This section reviews the literature on forecasting exchange rates and the choice of exchange rate forecast for this study.

Longworth et al. (1983) reviewed the literature on exchange rate efficiency and empirically tested the Canada and U.S. exchange rate. The spot exchange rate was a better forecaster of the future spot exchange rate than the current forward exchange rate. Their empirical tests further concluded that the futures exchange market for Canadian and U.S. dollars was not efficient and there was a time varying risk premium. Boothe and Longworth (1986, p.145) stated:

> The evidence ... indicates that the forward rate is not the best predictor of the future spot rate. At the minimum, forecasters would be advised to use the current spot rate, which Meese and Rogoff (1983) have shown outperforms the forward rate.

Wolff (1988) discussed more recent studies that did not show models with improvements over the naive random walk forecast. A further test of another model by Wolff (1988) did not generally out perform the random walk forecast. Chrystal and Thornton (1988) showed that the spot rate was in general a better predictor of the future spot rate than was the current forward rate of the same maturity.

There was no evidence in the reviewed literature that the futures market for exchange rates provides superior forecasts. This study uses the current spot exchange rate as the relevant forecast of the future spot exchange rate. This is a simple forecast and has not been consistently outperformed by more complicated models.

3.3.3 Hedging

The second risk management role for the futures market is hedging. Hedging is a private risk control management strategy. Hedging using futures contracts is defined in this section. The literature on hedging and how hedging is used to manage risk is reviewed and the hedging results from other Canadian studies are presented. These results allow comparisons to the results in this study.

Traditional theory viewed hedging strictly as the transfer of risk from the hedger to the speculator. Leuthold et al. (1989) attributed this early theory for hedging to John Maynard Keynes and John Hicks. The use of hedging to profit from basis changes is attributed to Holbrook Working by Leuthold et al. (1989). Working (1953b) gave several reasons for hedging and suggested that business risk reduction was not the primary reason for hedging and may just be a side benefit. Kamara (1982) reviewed the issues in futures marketing and listed 5 different categories of hedging. These categories were:

Carrying Charge Hedge (basis speculation)
Operational Hedging
Selective Hedging
Anticipatory Hedging
Pure Risk Avoidance Hedging.

Kamara (1982) stated that pure risk avoidance hedging was non existent in the markets. No evidence was provided to substantiate this statement by Kamara.

Empirical research into why farmers use or do not use the futures is limited. Shapiro and Brorsen (1988) tested farmer reasons for hedging on Indiana corn and soybean farms using a tobit regression model and found producers in the study did not hedge that much, and more highly leveraged producers were more likely to hedge. Forward contracting was used twice as much as hedging. The most important factor for using hedging was whether hedging was perceived to increase income stability.

Newbery and Stiglitz (1981) using a mean-variance portfolio model of hedging with no production risk, concluded that an unbiased futures market for non storable commodities provides superior income risk insurance as compared to perfect price stabilization. A futures market allows a farmer to choose the optimum hedge level whereas a price stabilization scheme essentially forces the farmer to completely hedge the crop. Various caveats on this conclusion were discussed by these authors. Feder et al. (1980) and Holthausen (1979) also modeled the hedging decision with a firm facing only price risk.

Chavas and Pope (1982) developed a model using mean-variance methods with stochastic production and prices. They concluded that an individual's hedging response to a change in expected price, price variance or risk aversion was ambiguous when production was stochastic. Where production was certain, hedging was inversely related to expected price. Hedging falls as the variance of production increases. Under certain production, increasing risk aversion increased the amount hedged.

The early literature on futures markets and hedging looked at the question of unbiased futures markets. Speculators were assumed to be selling insurance to hedgers. Most hedgers were considered net sellers of contracts and speculators were considered net buyers of contracts and this caused "normal backwardation" in the futures markets. The futures prices were considered downward biased estimates of the contract price in the future. With normal backwardation, speculators make profits from the risk premium (downward bias) created by buying contracts from hedgers.[8] The hedger sells futures contracts and pays a risk premium for the insurance. Researchers are still analyzing whether this risk premium exists.

The futures market is tested for bias in this study by determining whether the mean of profits from taking consistently short futures positions (selling contracts) is significantly different from zero. An efficient market should have zero hedge profits assuming no transactions costs and no bias. The relevant time period is the period over which an Alberta cattle investor would use the futures market for hedging. This eliminates the contract expiry month in this test. The data in this study allows different hedge holding periods of one through six months.

Researchers developed further reasons for hedging not totally related to risk reduction. Working (1953a) suggested that hedgers used the futures market to profit from expected basis change. A third reason for hedging uses portfolio theory and includes futures contracts and a cash commodity as part of a portfolio. Hedgers enter the futures market to get the highest return for a given risk level. Johnson (1960) used portfolio theory to develop various hedging and speculating positions. Other writers have used portfolio theory to work with hedging theory (Stein (1961), and Peck (1975)).

Canadian studies have used varied approaches to hedging. Caldwell et al. (1982) studied alternative hedging strategies for Alberta feedlot operators for the period September 1975 to January 1978. The study hedged slaughter cattle and feeder cattle on the Chicago Mercantile Exchange and hedged barley using U.S. corn futures. Eight different strategies were used. Mean returns per lot and standard deviations of net revenue were measured.

Caldwell et al. (1982) concluded that a producer could increase his income by hedging feeder cattle but the income variation as measured by standard deviations increased with hedging. Routine hedging of slaughter cattle reduced mean income and increased risk. These results are in contrast to U.S. studies done up until this time period. Leuthold and Tomek (1980) concluded in a review of livestock futures literature that routine hedging reduced risk considerably but also reduced mean returns to such a level as to make the strategy unattractive. None of the 100% hedging strategies in Caldwell et al. (1982) dominated a no hedge strategy based on a mean-variance risk efficiency criterion.

Gaston and Martin (1984) defined a set of hedging strategies that could be used by Canadian feedlot operators. They also compared the effects of alternative hedging strategies on the cash flow for a beef feedlot in Ontario and Alberta. The study simulated a feedlot during the period 1973 through 1981. The feedlot could hedge slaughter cattle, feeder cattle or corn futures. Moving averages and technical analysis were the main sources of different hedging strategies. Various profit margin/breakeven strategies and selective technical strategies were compared to a hedge and hold strategy. Basis was calculated using a three year historical average for that particular week.

Gaston and Martin concluded that routine hedge and hold strategies reduced income (as compared to no hedging) and risk was not reduced for the Ontario feedlot. Selective hedging strategies were far superior to the traditional hedging and hedging with a profit target. The hedge and hold strategy did not work because of the variability of basis.

Carter and Loyns (1985) compared alternative hedging strategies using actual data from over 100,000 head of custom cattle fed in Western Canada from 1972 to 1981. Four hedging strategies including hedge and hold, hedge if a target profit could be locked in, and do not feed unless a profit target is hedged were simulated. Only finished cattle prices were hedged. The impact of exchange rate on risk with hedging was also measured although their test ignored possible interactions between the Canadian and United States cattle markets.

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8 See *Selected Writings on Futures Markets. Volume 2.* 1977. Edited by Peck, A.E. for a series of writings on the debate of bias in the futures market by Cootner,P.H., Telser, L.G., Blau, G., Houthakker, H.S, Gray, R.W. and Rockwell, C.S.

Carter and Loyns concluded that a routine hedging strategy reduced average profit and increased price risk for heifers. This same strategy reduced average profit and reduced risk for steers. Exchange rate risk was also a significant source of risk when hedging. These results in their opinion raised doubts about the usefulness of the United States live cattle futures market for Canadian feeders.

Gillis et al. (1989) simulated a feedlot selling steers for the period 1976 to 1983 and hedged slaughter cattle, feeder cattle, feed grains, interest rates and exchange rates using various trading rules. Financial performance was measured using monthly net cash flow. Hedges were placed and lifted according to various criteria similar to Gaston and Martin (1984). Moving averages and technical analysis were major strategies.

Gillis et al. (1989) concluded that beef producers increased cash inflows the most from multiple technical hedging strategy. The hedge and hold strategies performed poorly. The authors also concluded that the Canadian dollar hedge positions were not useful in protecting exposure to exchange rate fluctuations. Nearly all the strategies ended the time period with negative cash flows.

Freeze et al. (1990) included the NTSP in their research on cattle feeding in Alberta. The model was a target MOTAD linear programming model. Risk was defined for average income falling below a target income of $50 per head in 1981 constant dollars for various feeding strategies and types of cattle. They concluded that participation in the NTSP and hedging in 1986-87 were risk reducing.

Canadian results on the use of hedging are mixed. The Canadian studies that use cash flow to measure risk appear to be looking at the returns from different strategies for investing in futures contracts. The ownership or investment in cattle is incidental to the whole problem addressed by these studies. The cash flow measures used by these studies do not address the issue of uncertainty of returns in the cattle investment. These studies are more portfolio diversification problems using specialized trading rules for the futures contracts. The issue of risk reduction in the cattle feeder investment is very loosely related to the futures investment strategies used in these studies. More formal models such as portfolio theory, CAPM, Arbitrage Pricing Theory or the optimal hedge ratio may be better models to work from when combining futures contract investments and cattle feeder investments.

This study uses the futures market to reduce risk by taking an equal and opposite position in the futures market. Live cattle futures contracts are sold equal to the amount of cattle owned by the investor. This is the 100 % hedge explained in chapter 5. Futures contracts are assumed to be infinitely divisible so that futures positions exactly match the expected cattle production. The cost of margin money[9] is assumed to be zero. The zero margin cost may not be implausible given an unbiased futures market and riskless borrowing and lending. Brokerage fees are included in the research model. The futures market is tested for bias in this study. The portfolio approach to hedging is simulated and the theory is explained in detail in section 3.3.5, optimal hedging. Alternative strategies which attempt to lock in a target profit level are investigated. The review of the hedging literature leads to a third hypothesis.

Hypothesis: Routine 100% hedge and hold strategies reduce risk when compared to no hedging.

This concludes the review of hedging literature. Hedging using futures markets can be useful private tools for managing risk. The theory suggests the level of hedging decreases with increasing production risk. Since production risk is not included in this study, any results on the level of hedging probably provide an upper bound on the amount of cattle to hedge in Alberta. The Canadian hedging studies report conflicting results on the use of hedging in risk reduction. This study checks the Canadian results on hedging as a risk management tool.

3.3.4 Live Cattle Basis

Alberta live cattle basis has two roles in this study. A basis adjustment is needed to localize cash price forecasts using the futures market. This requires a basis forecast. Secondly, basis variability impacts on the usefulness of hedging slaughter cattle. Several Canadian studies suggested Canadian live cattle basis is too variable to use the CME for hedging. Unpredictable basis may reduce the usefulness of hedging as a risk management strategy or the usefulness of the futures market for price forecasting. This section reviews previous research on basis and the estimation methods used to fore-

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9 Margin is the "good faith" money placed by the investor with the brokerage firm when buying and selling futures contracts. The amount of this margin money varies from 5% to 10% of the value of the contract for agricultural commodities.

cast basis. Reasons for comparing the Alberta basis to the Omaha basis are discussed. This section concludes with the types of basis forecasts that are compared and the basis hypotheses that are tested in this study.

Basis is defined by Leuthold, Junkus and Cordier (1989, p.45) as the difference between the quoted futures price for a particular delivery month and the local cash price. Basis can have time, space and quality components. This paper defines basis as:

9. $Basis = LocalCashPrice - FuturesPrice$

Leuthold, Junkus and Cordier (1989, p.144) discussed the following basis risk and its importance in forecasting price and in hedging.

> Managers using the futures market must manage basis risk. A hedger arbitrages between cash and futures prices, and since these prices do not move parallel to each other, there is a risk. Hedgers are basis speculators. For hedging to effectively reduce risk, the basis must have some predictable pattern to it...
> ...because of location and product quality differences, most agricultural firms do not experience the local basis closing to zero at contract maturity. These operators must adjust the futures price to an expected local cash market price after estimating the expected basis from historical information. This localized price is the target price...
> ...In fact once a manager has hedged, price risk actually becomes the deviation in price from the target price, or basis risk, because the hedger agrees to accept the target price.

Leuthold (1979) used an econometric model to study the live cattle basis in the U.S. He concluded that a high proportion of the live cattle variation in basis for 2 to 7 months prior to delivery could be explained by variables that explained and shifted the expected supply curve. The model included feed prices, slaughter prices, feeder prices, and cattle on feed numbers.

Price et al. (1979) concluded using an analysis of variance approach that basis in Kansas had significant variations by year, contract month and by location. This result suggests that simple historical means of basis may not be suitable forecasts.

Garcia et al. (1984) separated the systematic and non systematic variance of the basis. They used a variate difference approach which they described as similar to fitting a polynomial of given degree to a time series. These authors found little difference in basis risk at different U.S. locations or changes in basis risk as the contract approached maturity. There was no strong evidence of seasonality in cattle basis. This result suggests that a historical mean may be a suitable basis forecast and conflicts with the conclusion of Price et al. (1979).

Thompson and Bond (1985) reported there has been little empirical work in the area of offshore hedging risk. Thompson and Bond (1987) explored offshore commodity hedging with floating exchange rates using vector autoregression. They stated that the difference between a U.S. hedger and an offshore hedger will depend on the extent to which exchange rate interactions affect perceived basis variance.

The futures market applicable to Alberta is the Chicago Mercantile Exchange which trades the live cattle contract for slaughter cattle. This immediately indicates that Alberta faces the space component in basis. Alberta cattle feeders operate in a different currency than U.S. feeders. Secondly the grading systems for cattle in Canada and the United States differ. This implies quality components to the basis faced by Alberta cattle feeders that are not faced by U.S. cattle feeders. Cattle feeders in Alberta and the U.S. should face similar time components. These different factors between Alberta and the United States imply that basis is different between the two locations.

Studies on Canadian basis have concluded that the basis is too variable to use the CME for reducing risk. Gaston and Martin (1984) and Carter and Loyns (1985) suggested that Canadian basis for live cattle was too variable to successfully hedge Canadian slaughter cattle. These studies implied, although they did not explicitly state it, that United States cattle feeders face less variable basis than Canadian cattle investors and therefore U.S. investors can better use the CME for hedging. Caldwell et al. (1982) stated the basis for Calgary slaughter cattle was unpredictable. None of these studies investigated if there was a predictable component to the basis risk or if basis risk (or perceived basis risk) varied between Canada and the United States.

Coles (1989) checked Alberta basis for trend and seasonality. He found a trend in basis (where basis was adjusted using the Consumer Price Index (CPI) to a real value) and no monthly seasonality. This implies that a historical mean of basis is not a suitable basis forecast and any basis forecast does not need to be adjusted for seasonality. The possible existence of autocorrelation in the Coles model may reduce the confidence in his conclusions.

Braga (1990) defined adjusted basis between Canada and the U.S. as $Basis_{C\$} = Cash\ Price_{C\$} - (Futures\ Price_{US\$}/Exchange\ Rate)$. He further showed that this adjusted basis can be constant during the time of a hedge yet still not be a perfect hedge (if hedging Canadian commodities on U.S. markets). This situation may not be a major factor. Exchange rate movement during the typical period of a hedge or a short feeding period may be minor although other Canadian research (Carter and Loyns (1985)) has speculated otherwise. Gillis et al. (1989) concluded that it made little difference if the Canadian dollar was hedged in reducing risk due to exchange rate fluctuations. Exchange rate hedging is not included in this study, although a measure of exchange rate risk in price forecasting is presented in chapter 5.

Boundary conditions such as those hypothesized by Caldwell et al. (1982) would limit the independent price movement of Alberta live cattle basis relative to U.S. prices. These boundary conditions relate to the local supply conditions in Alberta and the distance to the United States markets. For example, an over supply of slaughter cattle in Alberta should lead to cattle exports to the U.S. Basis should approach its lower bound[10]. A shortage of slaughter cattle in Alberta should lead to imports of slaughter cattle from the U.S. Basis should approaching its upper bound. With higher exports of finished cattle to the U.S. from Alberta, basis should stay closer to the lower boundary condition. Figure 1 and Figure 2 in chapter 2 suggest that such a process has occurred in the Alberta market.

Reliable Alberta basis forecasts are required for hedging and for price forecasting using the CME futures market. Coles (1989) estimated Alberta basis using a mean basis adjusted for a time trend. Other studies used a three year historical mean basis estimate for the week[11] (Gaston and Martin (1984)) or the month (Brandt (1985), Kenyon and Clay (1987)). A historical mean estimate of basis was used by Leuthold and Hartmann (1981) for hogs. Leuthold (1979) used an econometric model to estimate cattle basis. Little justification is given in these studies for the choice of basis estimate (with the exception of Leuthold (1979)) and no comparisons were made to alternative basis forecasts.

The Alberta basis is tested for trend and seasonality in this study. This test determines the validity of using the historical mean as a basis estimate. Valid estimates of the mean require that the basis be converted to a common time period to remove the effect of inflation before the mean is calculated. The test for seasonality determines if a mean calculated from basis for the same month from three or more prior years is appropriate. Two other basis estimates that match the estimation methods for direct cash prices are an ARIMA estimate and lagged basis to estimate current basis. An econometric forecast of basis is not included due to data and time limitations. These different basis forecasts are combined with the futures price and are compared using the MSE criterion outlined earlier for the live cattle price forecasts.

Alberta basis variability is measured and compared for different time periods in this study. Less variable basis should lead to more reliable basis forecasts. This should improve price forecasts when using the CME. The different basis forecasts compared will give some indication on the predictability of basis. The underlying causes of Alberta basis variability are not researched.

A comparison of relative basis variability between Alberta and Omaha is done to follow up on the comments of Thompson and Bond (1987). This relative basis comparison may provide information on the different use of futures markets for hedging by Alberta cattle investors versus Omaha cattle investors[12]. Relative basis variability comparisons requires that basis be converted to a common currency. It is the variability in the purchasing power that is relevant and not the absolute variability of the basis in its own currency. This emphasis on relative variability suggests that the basis comparisons be adjusted for inflation to provide real comparisons in purchasing power.

Two hypotheses based on the discussion in this section are tested in this study.

Hypothesis: Alberta live cattle basis was less variable during the 1985-1989 period than the 1976-1980 period.

Hypothesis: Alberta live cattle basis is more variable than the Omaha live cattle basis.

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10 If cattle exports opportunities to the U.S. or elsewhere do not exist then the boundary conditions may not hold.

11 The basis estimate is the historical mean basis calculated from the same week or month in the past three years. For example, the basis for February in year 4 is calculated using the mean of the basis in February in years 1, 2, and 3.

12 There is no research reviewed in this study on the actual use of the CME by Canadian or United States cattle investors for hedging. This is one area of needed research.

Studies have concluded that Canadian basis is too variable to hedge live cattle. Different forecasts of basis have been used in previous studies. Different basis forecasts are compared and tested here. This study compares the recent period basis to earlier periods to determine if basis variability has changed. The Alberta basis is compared to Omaha to see if there is a difference between the two markets in relative basis variability. The basis research will help Alberta investors evaluate hedging and price forecasting in risk management.

3.3.5 Optimal Hedge or Risk Minimizing Hedge Ratios

The optimal hedge ratio is a risk management strategy used in this study. It is an alternative to the 100% hedge strategy. This section reviews the literature on optimal hedging and the results of some studies using optimal hedge ratios. The optimal hedge model using the mean-variance EUM is developed and compared to the minimum variance hedge ratio. The relationship between the optimal hedge, the minimum variance hedge and futures market efficiency is explained. Finally the section concludes with a review of the different ways to estimate these hedge ratios. The estimation method chosen for this study is explained.

There are two main formulations in the literature of the optimal hedge ratio. The first is derived by maximizing the certainty equivalent expression, equation 3 in section 3.1, using the two asset portfolio model with respect to cash and futures positions. The second model is a minimum variance ratio derived by minimizing the variance of returns of this two asset portfolio and it is not necessarily mean-variance efficient. The minimum risk ratio and the optimal hedge ratio are equivalent under certain conditions discussed later.

There are many references on the optimal hedge amount and the best formulation of this model (Rolfo (1980), Kahl(1983), Peck (1975), Stein (1961), Johnson (1960), Heifner (1972), Bond and Thompson (1985), Cecchetti et al. (1988), Anderson and Danthine (1981), Bond and Thompson (1986), Peterson and Leuthold (1987), Berck (1981), Kenyon and Clay (1987), Newbery and Stiglitz (1981), Robison and Barry (1987), Leuthold, Junkus and Cordier (1989)). Blank (1989) provided a review of some of the issues of optimal hedging found in the literature.

Heifner (1972) determined upper limits of optimal hedge ratios for cattle feeders in the U.S. that ranged from 0.56 to 0.88. Inclusion of hedging cost lowered the optimal hedge levels. Heifner concluded that about 1/3 to 1/2 of the price risk in his study area could be eliminated by optimal hedging. Carter and Loyns (1985) calculated optimal hedge ratios for the Canadian cattle feeder using OLS regressions of cash price changes and futures price changes. The results for steers were a hedge ratio of 0.62 with an R^2 or hedging effectiveness measure of 0.12.

Two studies considered optimal hedging and the use of futures in the context of a portfolio with more than two assets. Bond and Thompson (1986) discussed the optimal hedge in terms of the CAPM. They concluded that including more than the traditional 2 assets (cash product and futures) in the optimal hedge model may significantly reduce the optimal hedge level. The addition of an outside asset to the portfolio, in this case it was the Standard and Poor's Index of 500 stocks, dropped the hedge ratio from 0.79 to 0.13. Peterson and Leuthold (1987) treated the optimal hedge as a special case of the general portfolio model for cattle. Their model allowed the optimal hedging of feed costs, feeder prices and finished prices over three different parts of the feeding period. Their results showed various optimal hedge levels for two different levels of risk aversion. Routine use of fully hedged positions was not optimal for risk reduction when multiple cash commodities were included in the portfolio. They also concluded that the optimal hedge must be recalculated each time period because of changes in the variables over time. The results of Bond and Thompson (1986) and Peterson and Leuthold (1987) suggest that hedging and the use of futures be considered within the context of the individual's overall portfolio.

The authors would argue in response to the studies of Bond and Thompson (1986) and Peterson and Leuthold (1987) that the investment in the cash market and the futures market be viewed as one investment strategy for a single type of investment. Then this investment strategy can be compared to other investments through the use of the CAPM. Therefore this study does not include more than the cash product and the futures in the optimal hedge calculation. This is also done to simplify the study.

Alexander et al. (1986) added the costs of futures brokerage and margin requirements to a price and production risk model. Many other studies ignore this risk when determining the optimal hedge (such as Peterson and Leuthold (1987)). Their results suggested that the inclusion of this particular financial risk had a limited effect on the optimal hedge and therefore supported the assumption by many in the literature that hedging costs are zero. Blank (1989) stated in his review that other studies (in particular the study on hedging strategies for hog producers by Kenyon and Clay (1987)) found the costs of margins to be important in the calculation of the optimal hedge.

The authors in reply to the review by Blank, suggest that the role of margin is not important if the futures market is unbiased. The cost and returns on margin money should average out to zero over the long run with riskless borrowing and lending. The cost of margin money is not included in this study however brokerage charges are included.

This study does not have production risk. The optimal hedge ratio as given by Leuthold, Junkus and Cordier (1989, p.91-100) with no production risk is derived using the general model in section 3.1, equation 3. The expected return of the two asset portfolio is:

10. $E(\tilde{R}_p) = X_s E(\tilde{R}_s) + X_f E(\tilde{R}_f)$

where:

X_s is the amount of the cash position,

X_f is the amount of the futures position,

$E(\tilde{R}_s)$ is the expected return on the cash position and

$E(\tilde{R}_f)$ is the expected return on the futures position.

and where:

$E(\tilde{R}_s) = E(\tilde{S}_1) - S_0$

$E(\tilde{R}_f) = E(\tilde{F}_1) - F_0$,

S_1 is the spot price in the next time period,

S_0 is the current spot price,

F_1 is the futures price in the next time period and

F_0 is the current futures price.

This expected return assumes that the cash commodity is available for immediate sale. The situation where the hedge is for a future amount of product (such as finished beef) that is not currently available for sale gives a slightly different revenue function but does not change the following optimal hedge result.

Maximizing the expected utility from this two asset portfolio is equivalent to maximizing the certainty equivalent expression from section 3.1, equation 3 under the assumptions stated in the model. The certainty equivalent expression in this two asset frame work (with no production risk) is:

11. $$R_{p.ce} = X_s E(\tilde{R}_s) + X_f E(\tilde{R}_f) - \frac{\lambda}{2}(X_s^2 \sigma_s^2 + X_f^2 \sigma_f^2 + 2X_s X_f \sigma_{sf})$$

where:

$R_{p.ce}$ is the certainty equivalent portfolio return.

Taking the first derivative of the above expression with respect to X_f gives:

12. $$\frac{\partial R_{p.ce}}{\partial X_f} = E(\tilde{F}_1) - F_0 - \lambda X_f \sigma_f^2 - \lambda X_s \sigma_{sf} = 0$$

This can be rearranged as the optimal hedge ratio which maximizes expected utility:

13. $$\frac{X_f}{X_s} = \frac{E(\tilde{F}_1) - F_0}{\lambda \sigma_f^2 X_s} - \frac{\sigma_{sf}}{\sigma_f^2}$$

The second order condition with respect to X_f is $-\lambda\sigma_f^2$ which is negative if λ, the coefficient of absolute risk aversion, is greater than 0. This is the case when the investor is risk averse. Therefore this is a maximum.

The first component on the right hand side of the optimal hedge ratio in equation 13 is the speculative component and the second component is the hedge component (Leuthold, Junkus and Cordier (1989, p.92-95)). The hedge component is the same as the minimum variance of the two asset portfolio. The speculative component is the investor's anticipated gain when the expected futures price differs from the current futures price. This speculative component is also a function of the investors coefficient of absolute risk aversion. The speculative component and the hedge component make up the optimal hedge value that maximizes investor utility in this two asset portfolio.

The minimum variance hedge ratio is derived by minimizing the variance of this two asset portfolio:

14. $Var(\tilde{R}_p) = X_s^2\sigma_s^2 + X_f^2\sigma_f^2 + 2X_sX_f\sigma_{sf}$

where:

σ_s^2 is the variance of the cash returns,

σ_f^2 is the variance of the futures returns and

σ_{sf} is the covariance of the changes in the futures and cash prices.

Minimizing the above variance with respect to X_f gives:

15. $$\frac{\partial Var(\tilde{R}_p)}{\partial X_f} = 2X_f\sigma_f^2 + 2X_s\sigma_{sf} = 0$$

Solving for X_f gives the minimum variance hedge amount:

16. $$X_f = -X_s\frac{\sigma_{sf}}{\sigma_f^2}$$

The second order condition with respect to X_f is $2\sigma_f^2 > 0$. Therefore this is a minimum. Dividing by X_s gives the minimum variance ratio:

17. $$\frac{X_f}{X_s} = -\frac{\sigma_{sf}}{\sigma_f^2}$$

The measure of the effectiveness of the minimum variance hedge ratio can be shown to be the R^2, the coefficient of variation, of the estimating regression of equation 18 (Leuthold, Junkus and Cordier (1989, p.92-94).

18. $\Delta S_t = \alpha + \beta\Delta F_t$

where:

S are the spot prices,

F are the futures prices,

t denotes the time period

α & β are the parameters to be estimated and

Δ is the change (first difference) in prices.

The beta estimated by this regression is the minimum variance hedge ratio since $\beta = \sigma_{sf}/\sigma_f^2$, the minimum variance ratio for a given cash position. The measure of hedging effectiveness is $\sigma_{sf}^2/(\sigma_s^2\sigma_f^2)$ which is the same as the square of the correlation between cash and futures prices. The R^2 measures the variance in return of an unhedged position to a hedged position. Lindahl (1989) suggested that care must be exercised when comparing the R^2 between different estimating equations. R^2 is a measure of relative hedging effectiveness and does not measure the effectiveness in absolute terms. Valid comparisons of R^2 can be made when the same data set of cash prices is used. Other comparisons may be invalid.

The minimum variance hedge amount in equation 17 is equivalent to the optimum hedge amount in equation 13 if $E(\tilde{F}_1) - F_0 = 0$ or $\lambda \rightarrow \infty$. These imply that the current futures price is an unbiased estimate of the expected futures price or that the individual is infinitely risk averse. If these conditions are not met, then the minimum risk hedge is not mean-variance efficient. The condition, $E(\tilde{F}_1) - F_0 = 0$ is also another way of stating that the futures market is efficient (Leuthold, Junkus and Cordier, (1989)). Peck (1975) and other writers have estimated the minimum variance ratio and assumed the speculative component was zero. Cecchetti et al. (1988) considered it very important to look at the optimal hedge (and not the minimum risk hedge).

Turvey and Baker (1989) and Turvey (1989) added the capital structure (leverage ratio) to the optimal hedge calculation. Building on the work of Gabriel and Baker (1980), Collins (1985) and Featherstone et al. (1988), Turvey and Baker developed a utility model including the leverage ratio. Their solution of the optimal hedge amount included the leverage ratio of the individual. Turvey's (1989) model under certain assumptions suggested that more risk averse individuals hedge more and a farmer with a higher leverage ratio hedges more. A second result suggested that if hedging reduces business risk and increases returns on assets then the optimal leverage ratio would increase. Therefore optimal hedging was affected by the capital structure on the farm. Turvey and Baker also inferred the effects of government policy on hedging. They suggested that government policies that reduce business risk, reduce the need to hedge. The interaction of hedging versus participating in the NTSP is measured in this simulation in chapter 5.

This concludes the extensive review on the theory of the optimal hedge. If the futures market is efficient the speculative component of the optimal hedge ratio becomes zero. The optimal hedge ratio then equals the minimum variance hedge ratio for cash and futures. The Turvey and Baker (1989) and Turvey (1989) model with leverage reduces to the minimum variance hedge ratio if the futures market is efficient. The leverage of the investor does not impact on the optimal hedge ratio when the futures market is efficient.

This study calculates the minimum variance hedge ratio, equation 17. This is the optimal hedge ratio if the futures market is efficient. The tests on futures market bias determine whether this minimum variance hedge ratio can be considered the optimal hedge ratio. Estimating the speculative component of the optimal hedge ratio, if it is not 0, presents great difficulties. The estimation of the coefficient of absolute risk aversion is difficult and could be expected to vary between individuals. Also models based on individual utility functions may fail to recognize that there is a market for risk.

The optimal hedge ratio is now defined for this research. The problem remains of estimating the hedge ratio. The literature reports are mixed on the techniques to estimate the optimal hedge ratio or minimum variance hedge ratio. The rest of this section reviews the literature on estimating the optimal hedge ratio.

Witt et al. (1987) reviewed the literature stating that there were three ways of estimating the hedge ratio. These were:

Price level models.
Price difference models.
Percentage price change models[13].

Witt et al. (1987) concluded that the price level model was theoretically correct for highly risk averse hedgers and there was no basis for claiming one way of estimating was superior to another.

The price level estimating model described by Bond et al. (1987) and Benninga et al. (1984) follows:

19. $S_t = \alpha + \beta F_t + e_t$

This model estimates this hedge ratio.

20. $\frac{X_f}{X_s} = \frac{Cov(S,F)}{Var(F)}$

where:
X_f is the quantity of futures contracts sold,
X_s is the cash holdings,
S is the stochastic cash price and
F is the stochastic futures price.

Hill and Schneeweis (1982) suggested that the price difference method was superior to the price level estimates of optimal hedge levels. The price difference method was used by Benninga et al. (1984) and Carter and Loyns (1985). The price difference estimating model as described by Bond et al. (1987) follows:

13 See Brown (1985) for a paper using the percentage price change model to estimate optimal hedge ratios.

21. $S_{t+1} - S_1 = \alpha + \beta(F_{t+1} - F_1) + e_{t+1}$

This estimates the following hedge ratio.

22. $$\frac{X_f}{X_s} = \frac{Cov(F_{t+1} - F_t, S_{t+1} - S_t)}{Var(F_{t+1} - F_t)}$$

Bond et al. (1987) concluded a discussion on estimating the optimal hedge ratio by stating that the simple price difference estimate may not be appropriate. The data should be tested for the underlying price expectations mechanism.

Myers and Thompson (1989) took a more rigorous look at the whole question of estimating the minimum risk hedge ratio (under the assumption of unbiased futures markets $E f_t = f_{t-1}$.) and the underlying assumptions behind the different estimation models (equations 19 and 21). Myers and Thompson (1989) stated that simple regression estimates were inappropriate except in special circumstances. The previous models only looked at the unconditional covariances and unconditional variances, and Myers and Thompson (1989) claimed that conditional covariances and variances are required. They presented a generalized estimation procedure based on the linear equilibrium model:

23. $S_t = Q_{t-1}\alpha + u_t$

$f_t = Q_{t-1}\beta + v_t$

where:
S is the spot price,
f is the futures price,
Q_{t-1} is the vector of variables known at time t-1,
α, β are vectors of unknown parameters and
v_t and u_t are stochastic shocks with mean 0 and no serial correlation.

Myers and Thompson stated (with several assumptions) that the conditional estimator (conditional on Q_{t-1}) of the hedge ratio r is:

24. $$\hat{r} = \frac{\hat{v}'\hat{u}}{\hat{v}'\hat{v}}$$

The estimates of the vectors $\hat{u}$ and v are from OLS estimates of the linear models in equation 23. Myers and Thompson (1989) showed the special conditions required for the simple regressions on price level or price changes to be unbiased estimates of the hedge ratio. The OLS regression of price levels, equation 19, was equivalent to the general estimate in equation 24 when the conditional means of the spot and futures prices were constant. This implied that prices always come back to the same mean. They suggested that this was a very restrictive and unrealistic assumption.

Myers and Thompson (1989) showed that the OLS regressions of price level changes, equation 21, was equivalent to the general estimate in equation 24 when the spot and futures prices followed a random walk possibly with drift. The random walk was a more plausible model but Myers and Thompson (1989) stated there was no reason to always expect prices to follow a random walk. Myers and Thompson concluded that using returns would also be incorrect in estimating the hedge ratio using OLS. Myers and Thompson (1989) then showed single equation methods for estimating the hedge ratio. Starting with the model in equation 23 then the OLS estimate of the δ in the following regression was the generalized hedge ratio.

25. $S_t = \delta f_t + Q_{t-1}\alpha + \epsilon_t$

Equation 25, was not a structural equation but was a method to estimate the hedge ratio. If Q_{t-1} contained only a constant and q lags of spot and futures prices then the above equation became:

26. $$S_t = \alpha_0 + \delta f_t + \sum_{i=1}^{q} \alpha_i S_{t-i} + \sum_{j=1}^{q} \alpha_{q+j} f_{t-j} + \epsilon_t$$

Myers and Thompson (1989) added the restriction of unbiased futures markets (for a hedge ratio to be mean-variance efficient) to get a model and estimating equation 27:

27. $S_t = Q_{t-1}\alpha + u_t$

$f_t = f_{t-1} + v_t$

$S_t = \delta \Delta f_t + Q_{t-1}\alpha + \epsilon_t$

Cecchetti et al. (1988) departed from the traditional use of regression models and used an ARCH[14] model to estimate an optimal hedge for Treasury Bonds. This model allowed for the changing relationship between the cash and futures prices over time. Baillie and Myers (1989) continued on from the Cecchetti et al. (1988) and used a bivariate generalized ARCH (GARCH) model to estimate optimal hedge ratios for several commodities including beef. They concluded that in general the optimum hedge ratio was non-stationary implying the usual methods of estimation described earlier in this paper are inappropriate. However their results for beef did not show a wide variation between the GARCH estimation and the OLS price difference estimation model, equation 21. The optimal hedge ratio for beef calculated by Baillie and Myers (1989) did not greatly decrease the variance of returns over no hedging. Only the results of one contract, December 1986, were reported.

These results suggest the following procedure for estimating the optimal hedge ratio for live cattle. This research uses the simple price difference model, equation 21, with Ordinary Least Squares (OLS) estimation. The model is estimated again each month adding new data available each month. The updating each month should capture any changes in the parameters that may give different hedge ratios in different time periods. The optimal hedge is compared to the 100% hedge and no hedging using the historical variance of returns in the cattle feeding model. The Myers and Thompson (1989) model, equations 26 and 27, is also tested.

There are limitations in using OLS on a price difference model to estimate the optimal hedge. These limitations include the methods of estimation, the assumptions regarding market efficiency, and the inclusion of other assets in the portfolio model. However for simplicity and accuracy it is justified for use in this study. Using the optimal hedge in the simulation should reduce risk as defined in this study and it should reduce the variance of historical returns. This leads to two hypotheses.

Hypothesis: Using the optimal hedging ratio reduces risk where risk is measured as mean square error and the optimal hedge is compared to no hedging.

Hypothesis: Using the optimal hedging ratio reduces the historical variance of returns over using the 100 % hedging strategy.

This section reviewed the optimal hedge ratio and the minimum variance hedge ratio. With efficient futures markets the two ratios are equivalent. This study estimates the minimum variance hedge ratio. The estimation method that seems suitable for beef cattle is the simple OLS regression of the price difference model. This is the chosen estimation method for this study. These hedge ratios are used as a risk management strategy and to compare hedging between Alberta cattle investors and Omaha cattle investors. The simple comparison of the hedge ratios gives some relative idea of the usefulness of the CME for hedging in Alberta and Omaha.

3.4 Live Cattle Futures Options

Options are traded on the live cattle futures contract on the CME. The live cattle option is another tool available for risk management. Put and call options are defined in this section. The Black options model is explained. This information is useful in understanding the valuing of options and some of the uses for options. This will help the investor with the information gathering risk management strategy and other direct uses for options.

Explanations of put and call options are in Leuthold, Junkus and Cordier (1989), Cox and Rubinstein (1985), Ritchken (1987) and Hull (1989). Cox and Rubinstein (1985, p.1-3) gave the following definitions of puts and calls:

> A *call* option is a contract giving its owner the right to buy a fixed number of shares of a specified common stock at a fixed price at any time on or before a given date.

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14 ARCH stands for Autoregressive Conditional Heteroskedastic

A *put* option is a contract giving its owner the right to sell a fixed number of shares of a specified common stock at a fixed price at any time on or before a given date.

The words common stock in these definitions could be replaced with futures contracts and the definition then applies to the futures market. The reader is referred to the references for information on the investors who provide (write) call and put options.

Ritchken (1987, p.37) described four types of option positions.

1. Naked positions involve the sale or purchase of a single security.
2. Hedge positions consist of the underlying stock together with options that provide partial or full protection from unfavorable outcomes.
3. Spread options consist of a long position in one option and a short position in another option on the same underlying security.
4. Combinations consist of portfolios containing either long or short positions in call and put options on the same security.

The number of option strategies using the above positions are immense. The main strategy of interest to cattle feeders in reducing slaughter price risk is put options. Purchasing puts should in theory reduce the risk of a significant drop in finished cattle prices from forecast slaughter prices.

The cattle investor can purchase a put option when the feeder cattle are purchased. The option is based on the underlying live cattle futures contract month that is used for hedging this same lot of feeder cattle. The investor has the selection of different strike prices. The different strike prices are the value at which the put option purchaser has the right to sell the underlying futures contract. The value of the put option drops toward zero if the futures contract price goes up. The value of the put option increases if the futures contract price drops.

The slaughter cattle price follows the futures live cattle contract. If the futures price rises, then the cash slaughter steer price rises and the value of the put drops. If the futures price drops, then the cash slaughter price drops and the value of the put option increases. The put provides insurance against a slaughter price drop. The investor can sell the option if it has value, let the option expire valueless if the futures price remains above the strike price or exercise the option by using the right to sell a futures contract for the strike price.

An example may help clarify the above explanation. The cattle investor purchases heavy feeder cattle in January, 1986. The investor expects the cattle to be sold for slaughter in the middle of April, 1986. The nearest CME live cattle futures contract month that enters expiry month after this sale date is the June contract. Assume the price of the June futures contract is $72.65 per hundredweight (cwt) when the feeders are purchased. The put strike prices are every two dollars and on even numbers. So the different put strike prices on the June live cattle futures contract may be $68, $70, $72, $74, and $76 per cwt. The investor decides to purchase a put option just "out of the money"[15], at the $72 dollar strike price, by paying the option premium $1.00 per cwt. This gives the investor the right to sell a June live cattle futures contract at $72 per cwt at any time up until the option expires. In January, 1986 there is no incentive to exercise the option since the investor could sell the June future for $72 but could only buy back the June future for $72.65. This would be a net loss (excluding brokerage fees and option premium paid) of -0.65 per cwt. If the June futures contract drops in price, the value of the option (the option premium) increases. If the June futures price increases, the option premium decreases.

Assume in this example that the futures price drops to $70.25 per cwt by the time the cattle are sold for slaughter. The value, option premium, of a put option with a strike price of $72 is at least $1.75, (72-70.25). The investor can exercise the option by selling futures for $72 per cwt and buy back the contract for $70.25. The more likely alternative is to sell the put option for the current option market premium which should be at least $1.75 per cwt. Assuming that the cash slaughter prices moved in harmony with the futures price, the cattle investor protected the cattle investment from a

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15 A put option "just in the money" is the $74 per cwt strike price. This is the strike price just above the current value of the June futures contract. The option investor can pay the option premium, purchase the put with the $74 strike price and exercise the option by selling a June live cattle futures contract for $74 per cwt. The investor can immediately purchase this June futures contract back at $72.65. The investor gains (or is in the money) $1.35, (74-72.65), on the futures transaction since the purchased put was in the money. This does not mean the investor is a net winner since the option premium, and brokerage fees probably exceed $1.35 per cwt.

major fall in cattle prices. The investor paid $1.00 per cwt in option premium and protected the cattle investment from a major loss in value. The loss in value in this case is the $1.75 per cwt. This example ignored the problem of exchange rates faced by an Alberta investor.

This example does not give much information on valuing option premiums. The option premium has two main components, the time value and the intrinsic value. The time value is the length of time the option is from its expiry date. The farther the option is from the expiry date the more dollar value contained in the option premium for time. The intrinsic value refers to the underlying futures contract and the strike price. In the previous example the put option with a strike price of $74 has an intrinsic value of $1.35 (strike price 74 - futures price 72.65) in January 1986. The time premium paid for the put option is related to the underlying variability in price of the futures market. A futures commodity with more variable prices will have higher time value premiums.

The put premium reflects the market's underlying best estimate of the variability of the futures price. If the cattle investor expects less variability in prices, then the investor will likely not reduce risk from the use of put options if the investor's variance forecast is correct. However the investor can also use the put (or call option) to derive this market estimate of variability. This is useful information in assessing risk. For example, the live cattle contract is used to forecast Alberta slaughter steer prices. The option price can be used to get an estimate of the reliability of this forecast. The Black model can be used to value the option and estimate futures market variability. This is useful information and is part of an investor's information gathering risk management strategy. The Black model is not used directly in the simulation in this study, however knowledge of this model is helpful in understanding options and risk. The next part of this section describes the Black option pricing formula.

Black (1976) developed a theoretical model for the pricing of options on futures commodity contracts. This model applies to European options that can be only exercised at maturity. This call model is (Ritchken (1987 p. 255)):

28. $C(T) = e^{-rT}[F(T)N(d_1) - XN(d_2)]$

where:
$C(T)$ is the call option price with time T to maturity,
$F(T)$ is the current futures price,
$d_1 = [\ln(F(T)/X) + \sigma_F^2 T/2]/\sigma_F\sqrt{T}$
$d_2 = d_1 - \sigma_F\sqrt{T}$
σ_F is the standard deviation of the futures price (usually called the instantaneous standard deviation),
X is the strike (exercise) price of the option,
r is the continuously compounded interest rate and
N( ) is the cumulative standard normal density function.

The Black model for valuing European puts on the futures markets using the put - call parity relationship is (Ritchken 1987 p. 258-259):

29. $P^E = C^E + [X - F(T)]e^{-rT}$

where:
P is the put with exercise price E and
C is the call value using the Black model on the same futures contract with exercise price E.

An alternative formulation of the put model is:

30. $P^E = e^{-rT}[-F(T)N(-d_1) + XN(-d_2)]$

Notice that the variation in the prices of the futures contract is an important part of this Black formula. American options can be exercised prior to their expiration date. American options will not follow the Black formula exactly since options deep in the money will have a higher value if exercised (Ritchken (1987 p.256-257), Leuthold, Junkus and Cordier (1989 p.359-361)). American options (which includes the CME live cattle futures contract) will have a higher price than the European model. Both Ritchken (1987) and Cox and Rubinstein (1985) discussed binomial pricing models that provide numerical solutions to values for options that can be exercised prior to expiration.

Ritchken (1987) and Cox and Rubinstein (1985) discussed different estimation methods of the interest rate and the variance parameters in the Black option pricing model. Ritchken (1987) in particular discussed one method to estimate the variance in the Black model. This was an implicit estimate of the variance using the current price of the call or put. The current price of the option gives the market's best implicit estimate of the variance of the futures contract. Therefore take the observed prices as correct, place the prices in the Black model and do a numerical search to find the variance that gives this option price.

The cattle investors can use this variance estimate to compare their estimate of price variability to the market's variability estimate. Part of the option premium is a payment based on the variability of futures prices. The investor can determine if the option premium is justified based on the investors variance expectations or are the investor's variance expectations realistic given the markets expectations. This is part of the information gathering strategy. An investor with variance expectations greater than the markets variance estimate should gain from using options to reduce risk. An investor with variance expectations less that the market's estimate would not expect to gain from using options to reduce risk.

The literature reports mixed results on the use of the implied variance as a reliable estimate of the futures market variability. Wilson and Fung (1990) concluded that implied standard deviations using Black's model in selected grain futures markets performed poorly in estimating the actual futures volatility as compared to the options in the stock market. Fackler and King (1990) looked at the price probability distributions in live cattle futures implied by options premiums during the period 1985 to 1988. They found little evidence of any systematic option based probability assessment problems in live cattle.

Hauser and Neff (1985) suggested that Black's model is a good theoretical model however market premia often diverge from the model estimates. Wolf et al. (1987) suggested that their review of recent evidence justified the use of Black's model.

The Black model assumes constant variance. Various tests have been done on futures markets to test the change in variance. Hauser and Andersen (1987) reviewed some of the literature on this subject. Two sources of systematic change in variance have been tested. These were the time to maturity effect where volatility increased closer to maturity, and state variable effect where different states such as different seasons changed the variance. Hauser and Andersen (1987) reported 3 studies that supported a time to maturity effect on live cattle futures. They reported one study that rejected the state variable hypothesis for live cattle futures. These results indicate the variance of the live cattle futures contract increased as the contract neared maturity but did not vary over the year in a systematic manner.

The Alberta cattle investor can use the option premium to estimate the implied variance in the Black model. This gives some estimate of the price variability forecast by the market. No further details on this estimate are given here, however this use of options is available to the cattle investor. Other uses for options are in direct risk management similar to hedging using futures contracts.

Hauser and Andersen (1987) provided an analysis of hedging new crop soybeans using options. Hauser and Eales (1987) explored various option hedging strategies for soybeans using Fishburn's target deviation (Fishburn, (1977)) model. Some of their conclusions were that:

1. Regardless of strategy, as returns increases, risk increases.
2. Delta neutral positions do not minimize expected risk if the position is held over an extended period of time.
3. Marketing advice should emphasize the hedger's variance expectations relative to the implied volatility of the premium.
4. The use of puts is most likely when the hedger is risk averse over outcomes below the expected hedge price, risk seeking above the price, expects the volatility to be greater than the premium's implied volatility, and believes that the futures price is a biased forecast.

Option deltas and other jargon associated with the use of options, and option price movements are presented next. These measures are closely related to the Black option model. The use of deltas is covered to a limited extent in the simulation. Several measures of these movements are given and are described in Ritchken (1987), Wolf (1984), Cox and Rubinstein (1985) and Hull (1989).

Delta is a measure of how the option value changes with security prices. Leuthold et al. (1989) state that futures options well in the money have deltas close to 1. A delta of 1 indicates that a one dollar price change in the futures contract leads to a one dollar price change in the particular option. Options at or near the money usually have deltas of 0.5 and options well out of the money have deltas of 0. A fully hedged position using options requires that the investor be delta neutral. This means purchasing (1/delta) options for each underlying futures contract. Deltas change with the futures price. This change in delta affects the hedge and should be accounted for when using an option hedge, delta neutral strategy. At expiration of the option, the option delta should either be 0 or 1.

Delta can be estimated using the Black model where $\Delta = \partial P / \partial F(T)$[16]. The option gamma measures how the delta changes with the futures price. The gamma is estimated in the models by $\Gamma = \partial \Delta / \partial F(T)$. Theta measures how option values change with time. The theta is estimated in the models by $\theta = \partial P / \partial t$. A measure of changing volatility in the option is lambda. Lambda is estimated using $\lambda = \partial P / \partial \sigma$. Only the delta is used in this simulation.

This section reviewed some of the information on agricultural options. It explained briefly what options are and how they can be valued using the Black formula. Options and option values can be used for information gathering and for reducing risk by purchasing put options as a type of insurance. The use of options for hedging and insurance is simulated in this research.

3.5 Summary

The EUM was used to develop the risk measures, MSE and the beta for the CAPM. The general risk management strategies simulated in this study were outlined and several of these strategies were tied in with the CME futures market. These risk management strategies include improved price forecasting, 100% hedging, optimal hedging, selective investing, using options and participating in the NTSP. The relationship between the risk management role of the futures market and pricing efficiency was defined. The role of basis in risk was detailed. The definition of the optimal hedge and the calculation of the optimal hedge or minimum variance hedge was outlined. The live cattle option was described and the Black option pricing model was explained. This information is used in the risk management strategies tested in this study.

16 Wolf et al. (1987), Wolf (1984) and Hull (1989) present put delta formulas equivalent to $\Delta = -e^{-rT} N(-d_1)$ or $-e^{-rt}[1 - N(d_1)]$.

Chapter 4 Data Sources

Chapter 4 reviews the sources of data and the limitations of the data used in this study and in the models.

4.1 Futures Price - Live Cattle

The source of the futures prices were the Chicago Mercantile Exchange Yearbook for the years 1976 to 1987. The Wall Street Journal (various issues) provided the live cattle prices for 1988 and 1989. The data collected were the market closing price for the Wednesday in the third week of the month starting in January 1976 and ending in Dec. 1989. Any part week at the beginning of the month was counted as a week. For each contract month prices were collected on the contract starting 8 months before the contract month arrived. Closing month prices were not collected. Prices were in nominal U.S. dollars.

The live cattle contract specification is as follows. It is 40,000 lbs with a daily minimum price move of 0.025 cents/cwt ($10 per contract) and a maximum daily move of $1.50/cwt ($600 per contract). Trading terminates on the 20th business day of the delivery month or on the next business day if the 20th is not a business day. It is for yield grade 1, 2, 3 or 4 choice quality live steers with hot yield of 62% and various discounts apply. Live cattle contract months are traded for maturity in months February, April, June, August, October and December.

Other issues with the data were as follows. For 1976, 1977 and 1978 the CME yearbook reported a range of closing prices. These were averaged to arrive at a closing price (simple unweighted average). Starting in 1979 the yearbook changed to reporting a single settlement price. The U.S. cattle grading system changed in February 1976 and the CME changed the futures contract specifications to match the new system. Old contracts were traded for liquidation only after the announcement of this change of grading standards. As soon as possible for each contract, this study switched to new contract prices and did not use the old contract prices any more. Parts of the 1976 data are a blend of old and new contract prices. In 1977 or 1978 a January contract for live cattle was added. This January contract lasted only a few years and low trading volumes were observed throughout the life of this contract. No price data was collected on this January live cattle contract. A point of interest is that the first trading day for live cattle futures was November 30, 1964.

4.2 Live Cattle Futures Options

Data on put options for the CME live cattle futures contract were collected. The source was data provided by the Chicago Mercantile Exchange and the CME Yearbook for the years 1985 to 1987. The data was collected on put options starting with data six to seven months prior to the underlying futures contract expiration month. Options prices were collected on all strike prices for the same day of the month as for the CME live cattle futures prices. The CME's reported approximate delta for each option was also collected. No data was collected on the option value on the expiry date of the option.

The option contract has the following specification and rules. The first trading day for options on live cattle futures was October 3 1984. There is no limit on options price movement. The last trading day for options is the Friday which is at least 3 business days prior to the first business day of the underlying futures contract month. It has the same trading hours as the futures contract.

Very little trading activity in options in the early months of an option contract opening was observed. The CME quoted a settlement price but there were no trades (or only 1 or 2 trades). There were almost no trades of options well out of the money in the early part of the contract life. This has implications for using options as an insurance policy. It may be difficult to use options as disaster insurance by purchasing options that are well out of the money. Trading volumes on options appeared to be increasing over time with more trades for similar periods and months in later years such as 1989. In January 1989 a September live cattle option was added. No data was collected on this option data.

The cost of option trading is assumed to be $50 in December 1989 Canadian dollars per option contract purchased or sold. This cost is adjusted using the CPI to other months in the simulation.

4.3 Exchange Rate

Exchange rates were collected for the Wednesday of the third week of each month closing spot exchange rate. It was in nominal U.S. dollars to buy one Canadian dollar. The source was Alberta Agriculture Economic Services data base. Data were collected from January 14, 1976 to December 13, 1989.

4.4 Live Cattle Prices

The source of data for all cattle prices was Alberta Agriculture Economic Services. Prices were in dollars per hundred weight ($/cwt). Data were collected on the following types of animals for 1976 to 1989.

Prices were collected on 800+ lb good quality Edmonton feeder steers. These were the prices reported by auction markets. The price collected was the average price for the third week of each month. Daily prices were not available. These steers should exhibit good rates of gain of 2.7 lbs (1.22 kg) to 3.0 lbs. (1.36 kg). Different quality animals with lower rates of gain or higher rates of gain would change the rate of return calculations in chapter 5.

Prices were collected on the Alberta direct to packer live slaughter steer prices. This is an average weighted Alberta price on all A grades. The prices would be mostly weighted by A1 and A2. The prices used were the average for the third week of each month. (The source of the Alberta Agriculture prices for slaughter prices was CANFAX). Prices were in $/cwt. With more of the packing industry in Southern Alberta, this price would should tend to reflect the price around Calgary. Also, since it is a blend of prices for all A grades there is already an implicit discount for A3 and A4 cattle in the average price.

Prices were collected for Omaha slaughter steers for 1000 to 1100 lb choice steers in nominal U.S. dollars. These prices were the average for the third week of each month.

Calf prices were collected for heifers and steers for Toronto, Edmonton, Calgary, and Kansas City. Kansas City prices were reported in United States dollars. These were weekly averages from the third week of each month. Prices were in $/cwt.

4.5 Feed Prices

Alberta barley prices were collected from Alberta Agriculture Economic Services. One set of prices was the Calgary UGG elevator bid (net to farmer) for #1 feed barley. This Calgary UGG price was the average price for the third week of the month. A second monthly average barley price was collected. This was the Calgary open market barley price for feedmills and feedlots. Both price series were in nominal dollars per tonne for the period 1976 to 1989. The open market barley price is likely the price closer to the price paid by cattle feeders for barley over the period.

4.6 Cattle Numbers, Slaughter, and Import and Exports

There can be differences in the numbers on imports and exports depending on the source of data. The Agriculture Canada information is different than the Alberta brand inspection data. It is also difficult to break down the types of animals.

Monthly totals of Alberta imports of slaughter cattle, Alberta exports of slaughter Cattle to the U.S. and Alberta exports of feeder cattle to the U.S. for the period 1976 to 1989 were collected from Alberta Agriculture Economic Services. There is no breakdown as to type of cattle (such as heifers, steers, cows or weight ranges). This data were from Alberta Agriculture which originally comes from Agriculture Canada. Alberta Agriculture also had data on brand inspection of cattle exports to the United States.

Monthly totals of slaughter animals and cattle on feed for the period 1976 to 1989 were collected from Alberta Agriculture Economic Services. Data are available on Alberta totals, Canada totals and U.S. totals, for steers, heifers and cows. Canada does not have a cattle on feed survey. Data were collected on the monthly totals for the U.S. 7 state cattle on feed survey and are the total number of head on feed divided by 1000.

4.7 Government Programs

The NTSP information sources are Central Program Support of Alberta Agriculture and the various brochures on *The National Tripartite Stabilization Program For Red Meats: Cattle Models*, by Agriculture Canada and Alberta Agriculture. There have been several changes to the model and calculations over the time period 1986 to 1989. The source of data for the CBOP was the Crow Benefit program office with Alberta Agriculture.

4.8 Indexes

Various monthly or quarterly cost indexes from Cansim or the Bank of Canada Review were collected. These indexes are:

1. Building repair Ab - Cansim number D600052,
2. Machine and Motor Vehicle Operation Ab - D600305
3. Petroleum Inputs Ab - D600317
4. Machine and Motor Vehicle Maintenance Ab - D600350
5. Legume and Grass Production W. Canada - D600445
6. Animal Production Feed Use Cost W. Canada - D600650
7. Animal production feed preparation W.Canada - D600663
8. Animal production Grain Feed Ab. - D600759
9. Supplies and Services W. Canada - D600834
10. Hourly Labour Ab - D600911
11. Daily Labour Ab. - D600923
12. Monthly Labour Ab - D600935
13. Property Taxes Ab - D600948

Various monthly indexes of interest rates, exchange rates and Toronto Stock Exchange were collected from the Cansim data base from 1976 to 1989 (monthly data). These indexes are:

1. 91 Day T-Bill %/Annum monthly average rate of return - Cansim number B14001
2. Chartered Bank Prime Lending Rate for Business monthly average in % / annum - B14020,
3. TSE 300 stock price index monthly. 1975 = 1000. B4237.
4. TSE 300 stock dividend Yield in %/year (monthly data) - B4245.

A United States general price deflater (U.S. President) and the Canadian consumer price index (Bank of Canada) were collected. The consumer price index (CPI) is used to index for inflation. The consumer price index is used to compare costs and investments in different time periods since investment is an exchange of consumption over time. Therefore a consumption index is used.

Chapter 5 Methodology And Results

The first four chapters explained the research goals, background, theory and data employed in this study. A cattle feeding simulation model using historical data is described in this chapter. The simulation measures the net returns from feeding cattle in Alberta using different risk management strategies. The net returns and forecast net returns are required for the MSE and CAPM risk measures.

Section 5.1 explains the time period covered by this study. The data is monthly data from January 1976 to December 1989. Any models that require forecasts use the period January 1980 to December 1989. It also describes how the models are identified and how forecasts are updated each month with new information.

Section 5.2 explains the NTSP pay out forecast and the problems encountered in making this forecast. Section 5.3 details the nine different Alberta slaughter steer price forecasts developed and compared. This represents the risk management strategy of gathering information. There are two general types of price forecasts. These are forecasts that directly forecast the cash price and forecasts that use the futures market. The price forecast using the futures price requires a basis forecast. The price forecasts are tested and one forecast is chosen to use in the rest of the simulation.

Section 5.4 builds the production function for the cattle simulation and discusses the limitations of this model. The production function is required to estimate the net returns from investing in steer feeder cattle fed in a custom feedlot. This base investment model provides the comparison for the other risk management and investment strategies simulated. The production function with participation in the NTSP is the other base risk management strategy compared to other strategies.

Sections 5.5 and 5.6 present the 100 % hedge strategy and the optimal hedge strategy. A test on futures market efficiency and the calculation of the hedge ratio for the Alberta and Omaha cattle investor are done. The futures market efficiency test determines if there is bias in the market. The Omaha hedge ratio compares hedging risk management between Alberta and Omaha. Section 5.7 presents the results on the selective hedge strategies and the selective investment strategy.

Section 5.8 measures and compares the risk of the different investment management strategies. The MSEs of the management strategies are compared and statistical tests comparing the MSEs of the net returns are done. The CAPM beta risk measures are reported and discussed. The level of systematic risk is compared to non systematic risk.

Section 5.9 compares MSE to the standard deviation risk measure used by other studies, tests the variability of basis and compares the Alberta basis to the Omaha basis. Basis is identified in the literature as one reason that hedging may not reduce risk for Alberta cattle investors. Basis may also play an important role in information gathering (price forecasting).

Section 5.10 describes the use of put options for risk management. This options simulation is done separately from the rest of the study and is only selectively compared to the other risk management strategies. Section 5.11 summarizes the results from this chapter.

5.1 Time Period

The base historical simulation has a cattle investor purchase 100 heavy feeder steers each month and place them in a custom feedlot. This section explains the time periods covered and methods of model identification.

Monthly data, described in chapter 4, were collected for the time period January, 1976 to December, 1989. The first feeder steers in the main part of the simulation are purchased in October 1979 for sale in January 1980[17]. The last lot of feeders are purchased in September 1989 for sale in December 1989. All feeder purchases occur on the Wednesday of the third week of the month and all sales occur on the Wednesday of the third week of the month.

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17 Data on cattle feeding returns for cattle sales in the time period April 1976 to January 1979 (feeder purchases from January 1976 to October 1979) are calculated using this information set. This is useful information for comparing different time periods but this net return data for this time period does not enter the MSE risk calculations. Any calculations requiring forecasts (including MSE calculations) start with cattle sales in January 1980.

The research uses the ex ante approach as much as possible in the development of the model. Only information available at the time of the decision to feed cattle is used to make investment decisions and forecasts. For example, the decision to purchase feeder steers in January 1980 does not use any information from February 1980 or later. This ex ante approach is used to simulate as closely as possible the actual information set faced by a cattle investor at the time an investment decision is made.

The historical data from January 1976 to October 1979 are used to develop the first set of price and revenue forecasts. The predictions are updated each month. For example, a new forecast is developed each month using the most recent information available. The results are usually reported for the periods January 1980 to March 1986 and April 1986 to December 1989. This particular breakdown of the period is chosen since the NTSP started in April 1986.

Model identification uses the entire time period to identify the appropriate model. The results of this research will be applied to future time periods and this justifies the use of the entire time period to identify the model. After the model is identified (for example the ARIMA model on slaughter steer price forecast), the parameters of the model are recalculated each month updating with the new information that is available that month. The ex ante approach is used as much as possible in the cattle feeding simulation explained in the rest of the chapter.

5.2 NTSP Forecasts

The NTSP pay outs and the Alberta slaughter steer cash price must be forecast before MSE risk can be measured or strategies using price forecasts can be simulated. This section explains the NTSP pay out forecast model.

Three types of predictions models could be considered. The first prediction is to build the model using all the data described by the NTSP program. This first method is rejected based on the large amount of data required to build an exact model. A second prediction method is to use the variables already collected to build the production function and model the relationship between these variables and the NTSP pay outs. A third method is to predict pay outs based on the NTSP premiums paid by the cattle owner and matched by the provincial and federal government. This prediction is three times the NTSP premium paid on each steer sold.

The second and third prediction methods are compared. The second forecast method using the collected data to model NTSP is relatively complicated and has many technical problems that this study does not have time to correct. The explanation and results on this second method are in the Appendix D. The 3 times the producer premium forecast conclusively had a lower MSE than the second prediction method.

The NTSP pay outs in the simulation are forecast in the rest of the research using the 3 x premium model. This forecast is converted to June 1981 dollars using the CPI. The conclusion is that improved prediction of the NTSP requires the complete construction of the NTSP pay out model.

5.3 Slaughter Steer Price Forecasting

A three month forecast of Alberta slaughter steer prices is required for the selective hedging strategies, the selective investment strategy and for the MSE risk measure. A one month and two month price forecast is needed for the selective hedging strategies. The same forecast model chosen for the three month forecast is also used to do the one month and two month forecasts. This section explains and tests nine different price forecast models. The choice of price forecast models is part of the information gathering risk management strategy. The forecast model with the lowest MSE for the period 1980 to 1989 is used in the rest of the historical simulation.

5.3.1 Cash Price Prediction

Five different three month ahead direct slaughter steer price forecasts using econometric models, an ARIMA model and lagged cash prices are explained. These are similar to forecast models used in other research. The MSE of these price forecasts are calculated and compared. Explanations of forecasts using the CME futures market are deferred until later.

A linear model that directly estimates at time period t the predicted steer slaughter cash price for time period t+3 is developed. Forecasts from this model are estimated by three different methods. Several variables, including calf prices, Alberta hog prices and U.S. cattle on feed, were originally included in the model and tested before choosing the following linear model. Different functional forms were not tested. The model for estimating the parameters is:

31. $strprice_t = \alpha + feederprice_{t-3}a + baropen_{t-3}b + future_{j,Cdn\$,t-3}c + \mu$
where:
strprice is the slaughter steer price for Alberta at time t,
feederprice is the feeder steer price
baropen is the open market barley price,
future is the CME live cattle futures price in Canadian dollars,
futures contract month j matures after time t and
α, a, b and c are the coefficients to estimate.

The price data used in the econometric models are changed to real June 1981 dollars using the CPI before estimating the coefficients. The forecast slaughter steer prices are in real 1981 dollars.

This model is estimated by two methods using OLS. The first price forecast is needed for January 1980. The first OLS regression is estimated over the time period January 1976 to October 1979 to get the first set of coefficients for prediction. This follows the ex ante approach of only using information available at the time of the feeder purchase. The data available in October 1979 is used with the estimated coefficients to forecast the January 1980 slaughter price. Each month the model coefficients are estimated again adding the new information available that month to the data set. One model continues to add data and estimate the parameters each month. No data points are dropped. A second model drops the oldest data month when a new data month is added. This second method should forecast better if there are structural breaks in the prices.

A third method uses this OLS estimation method where no data points are dropped. The OLS regression Durbin Watson indicates there is significant first order autocorrelation in the model. This implies that the forecasts from methods one and two using OLS are biased (Judge et al. (1988)). The preferred solution to this is to estimate the model using some form of Generalized Least Squares (such as Prais-Winston) and use the disturbance term in the prediction of cash prices[18]. Computer and program limitations prevented the estimation of the model using Generalized Least Squares. The following solution to this problem is used. The OLS parameter estimates results with first order autocorrelation (with the rest of the usual model assumptions) are unbiased but inefficient. Since testing of parameters is not required, the efficiency is less critical for this prediction. Secondly the residuals for the OLS model are consistent and unbiased. This suggests that the prediction of cash prices can use the OLS parameter estimates and the residuals estimated from the OLS equation. The autocorrelation parameter is estimated by regressing the residuals on the lagged residuals. This estimate of the autocorrelation is biased but consistent. These estimates are updated each month as the new data is available. The mathematical description of the above procedure follows.

Estimate equation 31 using OLS. Calculate the residuals. Let $\hat{\theta}_t$ represent the vector of estimated coefficients calculated at time period t and x_{t-3} represent the independent variables used in time period t. Then the residual for time period t is:

32. $\hat{\mu}_t = strprice_t - x_{t-3}\hat{\theta}_t$

Let $\hat{\mu}$ be the vector of residuals. Then the coefficient of autocorrelation is calculated using OLS on the following model.

33. $\hat{\mu} = \hat{\mu}_{-1}\rho + v$
where:
$\hat{\mu}_{-1}$ is the vector of residuals lagged one month,
ρ is the autocorrelation and
v is white noise.

The out of sample estimate of the cash price is estimated using the adjustment for autocorrelation as outlined for the Generalized Least Squares in Judge et al. (1988). This forecast in any one month looks like the following.

34. $P\hat{strprice}_{t+3} = x_t\hat{\theta}_t + \hat{\rho}_t\hat{\mu}_t$

18 The other solution is to search for better models that may not have autocorrelation.

The last term in equation 34 adjusts the out of sample prediction for the effect of autocorrelation. This completes the description of the slaughter steer price forecasts using econometric models.

An ARIMA(1,1,1) model using only Alberta cash slaughter steer prices is used to forecast slaughter steer prices. The model is initially identified using the plots of residuals, partial autocorrelations and autocorrelations as found in the RATS statistical package (Var Econometrics). The identification uses the data from the entire period 1976 to 1989 to determine the level of differencing and the number of autocorrelations and moving averages to estimate. The ARIMA(1,1,1) is estimated using first order autocorrelation, one difference in prices and one moving average. No further tests on the model are carried out after the model is identified and estimated. The model is estimated using nominal Alberta slaughter steer prices.[19] After identification, the model is first estimated for the period January 1976 to October 1979. The model forecasts a nominal slaughter steer price for January 1980, 3 months into the future. The forecasts from the model are adjusted to June 1981 dollars using the CPI index at the time of the prediction (feeder purchase date) for comparison to other forecasts. The ARIMA model is estimated one hundred and twenty times, adding the new information available each month. One model estimated over the period 1976 to September 1989 is in Appendix H.

The final direct estimate of the cash price uses the cash slaughter steer price in month t to predict the price in month t+3. The cash price is adjusted to June 1981 dollars using the CPI before it is used for forecasting.

These Alberta slaughter price forecasters are all adjusted to forecast in 1981 dollars and are named the following:

1. OLS Full Information (no data dropped from the regression)
2. OLS Limited Information (data points dropped as new data added)
3. OLS Error Correction (estimates corrected for autocorrelation)
4. Cash ARIMA and
5. Cash 3 Months Prior.

The MSE of the three month price forecasts using these five models are calculated using equation 4, chapter 3, and are reported in Table 2. The MSE are calculated in June 1981 dollars.

Table 2
Mean Square Error
Three Month Alberta Slaughter Steer Price Forecast Models[1]

Time Period	Cash 3 Months Prior	OLS Full Informat.	OLS Limited Informat.	OLS Error Correct.	Cash ARIMA (1,1,1)
1980-89	34.27	38.65	44.49	37.73	42.56
1980-Mar86	44.88	48.82	62.21	49.55	56.86
Apr1986-89	17.20	22.42	15.69	18.71	19.49

1. Done in June 1981 dollars.

The smallest MSE, 34.27, for the period 1980 to 1989 is the price forecaster using the cash 3 months prior model. The MSE of the price predictions are tested for significant differences for the period 1980 to 1989 using the procedure of Ashley et al. (1980) explained in Appendix F. The test results are in Appendix F. The conclusions of these tests are that none of the five forecast models is significantly superior. Table 2 also shows that different models have the smallest MSE during different time periods. This is also shown in Figures 4, 5 and 6 in section 5.3.3 where all nine forecast model's MSEs are compared. The next section explains and analyzes the price forecasters using the futures market and the different Alberta basis forecasts.

19 Adamowicz W.L. Personal Communication. University of Alberta. Time series models may forecast more accurately if the numbers are not adjusted for inflation.

5.3.2 Futures Cash Price Prediction

Four Alberta slaughter steer price forecasters that use the CME live cattle futures contract and Alberta basis forecasts are outlined in this section. Forecasts using the futures market should be relatively accurate if the futures market is efficient. Basis forecasts are required to localize the CME price forecast to Alberta. Basis estimation models are described and compared.

The futures market forecast models require three predictions. The futures price at time t for the CME contract that expires just after period t+3 is used to predict the cash price for month t+3. The two other predictions required are the Canada-U.S. exchange rate and the nearby basis to adjust this price to Alberta. The Alberta slaughter steer price forecast using the CME live cattle contract is:

35. $Pstrprice_{t+3} = Future_{j,t} \times Pexchange_{t+3} + Pbasis_{t+3}$

where:
Pstrprice is the predicted Alberta slaughter steer price at sale time,
Futures is the CME live cattle contract for month j in U.S. dollars,
Pexchange is the predicted exchange rate at sale time and
Pbasis is the predicted Alberta basis at sale time.

All prices in equation 35 are converted to June 1981 dollars using the CPI. Equation 35 forecasts slaughter steer prices in June 1981 dollars. The exchange rate forecast was discussed in chapter 3. The spot exchange rate at month t is used as the predicted exchange rate in month t+3. The forecast exchange rate is used to convert the futures price to Canadian dollars.

The price forecasts using the CME are generated using different forecasts of Alberta nearby basis. Basis is defined as the local cash price minus the futures price converted to Canadian dollars. Further restrictions on the nearby basis definition are that the futures contract is the nearest contract month that is not yet into its expiry month. More analysis of the nearby basis is required before the different Alberta basis forecasts are chosen. The topics of basis, basis risk and basis forecasting are covered next.

Basis is checked for time trend and seasonality. This test determines the type of mean, if any, to use as one of the basis forecasts. The test uses Alberta nearby basis converted to June 1981 dollars with the CPI. Real basis numbers are used to remove the effect inflation may have on basis and in the calculation of the mean basis. For example, if basis is constant in real terms, nominal basis may still show a trend[20]. It is real changes in basis that are important to the cattle investor.

The Alberta nearby basis test for trend and seasonality for the period 1976 to 1989 uses the following model. The dependent variable is the Alberta basis. The independent variables are a constant, a time trend, and indicator variables for 11 months (January through November). OLS estimation of this model indicates there is first order autocorrelation. The Durbin Watson statistic is 1.102 and this is significant at the 5% level. The model is estimated again using a Maximum Likelihood (ML) procedure that adjusts for first order autocorrelation and the results are reported in Table 3. The autocorrelation coefficient is reported as the last variable in Table 3.[21]

There is no significant seasonality in Alberta basis. February is the only month showing some evidence of seasonality. Certain types of basis prediction are ruled out. For example, predictions using the average of the basis for March for the 3 previous years is not used with Alberta data[22]. The absence of a significant time trend suggests use the mean of nearby basis as one forecast. Coles (1989) reported a trend in real Alberta basis. The difference in the two results may be from the different time periods tested and from the possible autocorrelation in the Coles data. The first basis forecast model uses the mean of nearby basis calculated up to time t as the basis forecast for time t+3. The mean is calculated using basis converted to June 1981 dollars. The mean is recalculated each month adding the new information available that month.

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20 In fact Alberta nominal basis, in nominal dollars does show a significant trend at the 5% significance level.

21 The Alberta model is also estimated using quarterly data. There is no detectable seasonality in quarterly data.

22 This type of basis estimator is used in the literature reviewed in chapter 3.

Table 3
Alberta Nearby Basis Trend and Monthly Seasonality Test
Adjusted For First Order Autocorrelation

Variable	Coef	Std. Error	T-Ratio	P-Value
constant	-2.92	1.17	-2.48	0.01
Trend	-0.008	0.009	-0.91	0.36
Jan.	-0.08	0.98	-0.08	0.94
Feb.	-2.70	1.16	-2.32	0.02
Mar.	-1.98	1.23	-1.61	0.11
April	-0.80	1.26	-0.64	0.53
May	0.66	1.27	0.52	0.61
June	2.06	1.27	1.62	0.11
July	0.63	1.27	0.50	0.62
Aug.	0.63	1.26	0.50	0.61
Sept.	-0.06	1.23	-0.05	0.96
Oct.	0.14	1.15	0.12	0.90
Nov.	-0.19	0.96	-0.20	0.84
Auto	0.44	0.07	6.33	0.00

Two basis forecasts use ARIMA models. The basis is predicted using an ARIMA(1,1,1) model with and without a constant. The Alberta nearby basis is the only variable in the model. The identification of the ARIMA model uses the entire time period of 1976 to 1989. The model is identified using the plots for the residuals, autocorrelations and partial autocorrelations. The identification determines the level of differencing and the number of autocorrelations and moving averages to estimate. The ARIMA(1,1,1) has first order autocorrelation, one price difference and one moving average in the model. The model is estimated using nominal prices.[23]

After identification, the ARIMA model is first estimated for the period January 1976 to October 1979. The model forecasts a nominal Alberta basis for January 1980, 3 months into the future. The forecasts from the model are adjusted to 1981 real dollars using the CPI index at the time of the prediction (feeder purchase date). The basis ARIMA model is estimated one hundred and twenty times, updating the model with the new information available each month. One estimated basis ARIMA model is in Appendix H.

The ARIMA(1,1,1) model is estimated with a constant and without a constant. The constant is not significant in the model identification stage. However the final criteria in picking the slaughter price forecast is the lowest MSE. Therefore the ARIMA(1,1,1) is estimated with a constant and without a constant and MSE is used to choose between these and other price forecasts.

The fourth basis forecast is to use the Alberta basis at time t to forecast the basis at time t+3. This type of forecast model quickly shows if the basis variability is decreasing. Smaller basis variability should make this a superior forecaster. The Alberta basis is converted to June 1981 dollars before it is used in this forecast.

The names of the Alberta price forecast models using the futures market are:

1. Basis Average (mean of basis updated each month)
2. Basis ARIMA constant (models estimated with a constant)
3. Basis ARIMA no constant (models estimated with no constant)
4. Basis 3 months back (or prior).

The MSE of the three month price forecasts using these four models are calculated using equation 4 and are reported in Table 4. These MSEs are calculated in June 1981 dollars.

23 Adamowicz, W.L. Personal communication. University of Alberta.

Table 4
Mean Square Error
Three Month Alberta Slaughter Steer Price Forecasts[1]
Models Using CME Live Cattle Futures Contract

Time Period	Basis Average	Basis ARIMA(1,1,1) Constant	Basis ARIMA(1,1,1) No Constant	Basis 3 Mon. Back
1980-89	33.82	31.17	31.51	34.78
1980-Mar86	44.36	37.56	40.44	47.01
Apr1986-89	16.88	21.11	17.21	15.01

1. Done in June 1981 dollars.

The model using the basis ARIMA(1,1,1) with constant has the smallest MSE, 31.17, for the period 1980 to 1989 in Table 4. Table 4 shows that the basis ARIMA(1,1,1) with constant does not have the smallest MSE over the shorter time periods. The basis 3 months back has the lowest MSE, 15.01, for the period April 1986 to 1989. The MSE of these four price predictions are tested for differences over the period 1980 to 1989 using the procedure of Ashley et al. (1980) outlined in Appendix F. The test results are in Appendix F.

The conclusions of these tests are that no price forecaster using the futures market outperformed or had lower significant MSE than the price prediction using the futures contract with basis ARIMA(1,1,1) with constant. This is shown in Figures 4, 5 and 6 in section 5.3.3 where the MSE of the different price forecasting models are compared. Therefore the ARIMA(1,1,1) with constant is compared to the direct slaughter price forecasts.[24] The next section compares the basis ARIMA(1,1,1) with a constant to the direct slaughter cash price forecasts in section 5.3.1.

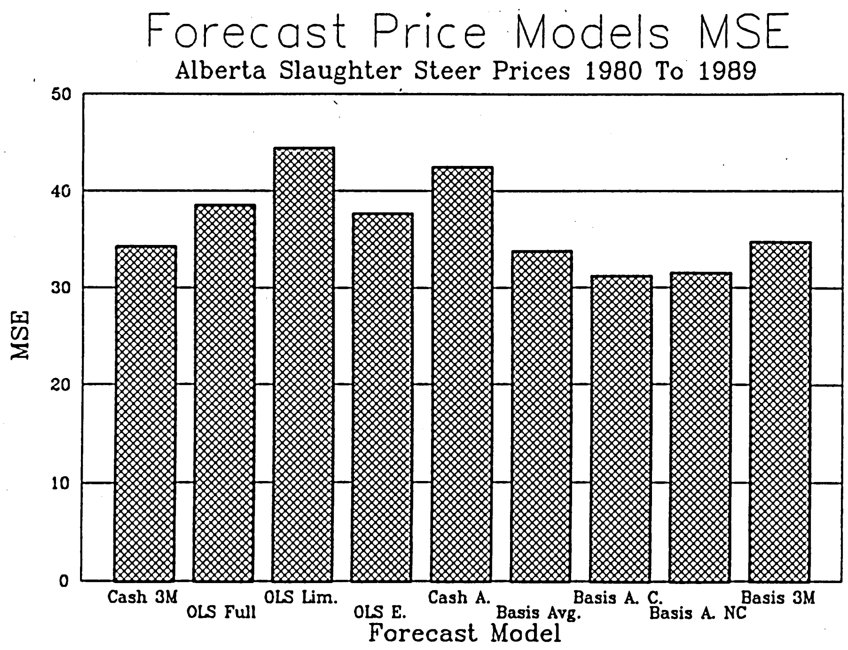
5.3.3 Choice of Alberta Slaughter Steer Price Forecasting Model

The direct Alberta slaughter steer price three month forecasting models in section 5.3.1 are compared to the basis ARIMA(1,1,1) with constant model. The forecasting model with the smallest MSE and significantly smallest MSE is chosen for use in the rest of the simulation and risk management strategies. This decision rule was chosen prior to the calculation of the price forecasts. This should be the best price forecast model. The section wraps up with a discussion of price forecasting models and the forecasting model used for the one month and the two month slaughter price forecasts.

The nine slaughter steer price forecasting models MSE are compared in Figures 4, 5, and 6. This ties together the forecast models explained in the previous two sections. The MSE for the basis ARIMA(1,1,1) with constant has the lowest MSE for the period 1980 to 1989.

24 The decision rule chosen prior to the calculation of the MSEs and tests for significance was to choose the price forecast with the lowest MSE for the period 1980 to 1989.

Figure 4



Price Forecast Model

Cash 3M. = Cash 3 Months Prior
OLS Full = OLS Full Information
OLS Lim = OLS Limited Information
OLS E. = OLS Error Correction
Cash A. = Cash ARIMA
Basis Avg. = Basis Average
Basis A. C. = Basis ARIMA constant
Basis A. NC = Basis ARIMA no constant
Basis 3M = Basis 3 months back

Figure 5

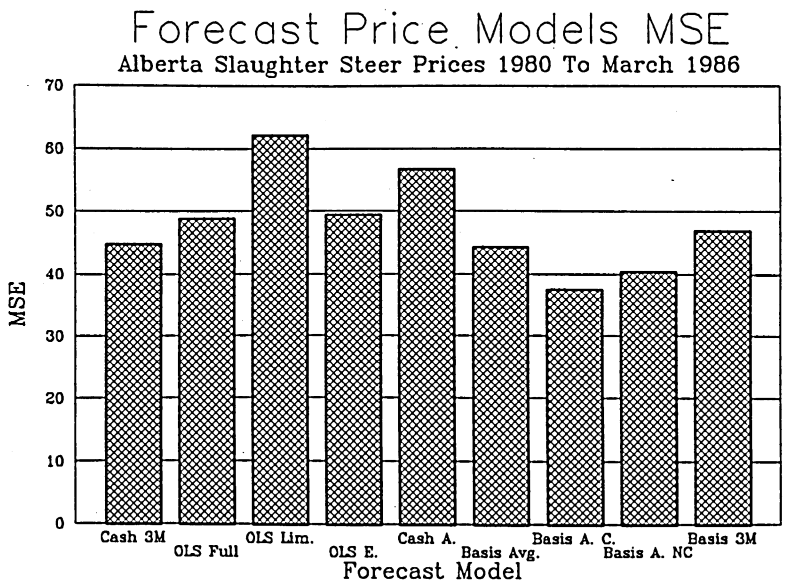
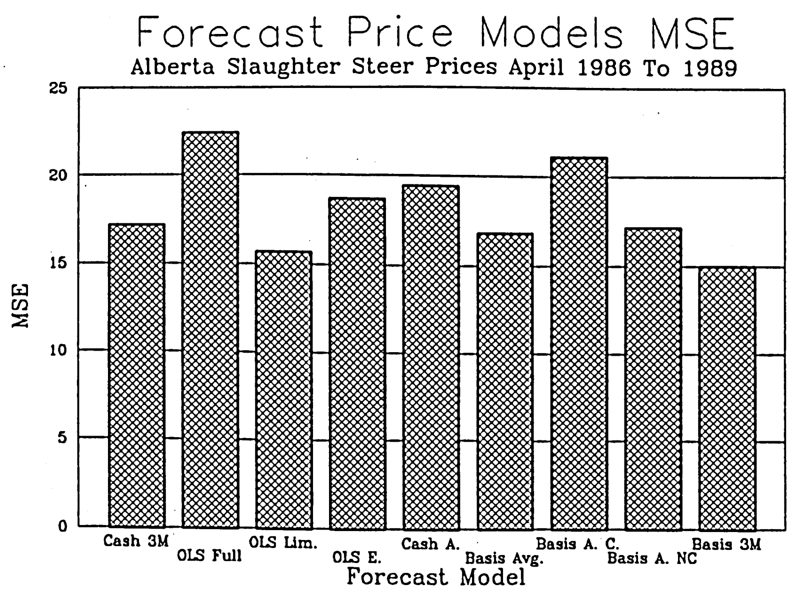


Figure 6



The five direct cash price predictors for the period 1980 to 1989, are compared to the CME futures model with the basis ARIMA(1,1,1) with constant using the test of Ashley et al. (1980) explained in Appendix F. The test results are in Appendix F. Based on the tests for MSE, there are no direct slaughter steer cash price forecasters superior to the futures predictor using the basis ARIMA with constant. The futures price forecaster using the basis ARIMA with constant has the lowest MSE, 31.17, of all nine forecast models. The basis ARIMA(1,1,1) with constant is the slaughter steer price forecast model chosen for use in the rest of the simulation based on the selection criteria to choose the model with the lowest MSE for 1980 to 1989.

These tests between the cash price forecasts and the basis ARIMA(1,1,1) with constant forecast are a test of the futures market pricing efficiency. This is a weak and semi-strong market efficiency test since the futures market is compared to historical information and models using historical information and current information. The tests do not reject the hypothesis in chapter 3, section 3.3.1, that the CME live cattle futures contract with a basis adjustment is an unbiased forecast of Alberta prices. These results strengthen the case for considering the minimum variance hedge ratios calculated in section 5.6 as the optimum hedge ratios.

Figures 4, 5 and 6 show the MSE from Tables 2 and 4 and that different models have lower MSE during different time periods. This suggests that different predictors be used during different periods. This research uses only one model to simplify the calculations. The three month ahead Alberta slaughter steer price forecast model is:

36. $$Pstrprice_{t+3} = \frac{Future_{j,t} \times Pexchange_{t+3} \times 100}{CPI_t} + Pbasis_{t+3}$$

where:
Pstrprice is the predicted Alberta slaughter steer price at sale time in June 1981 dollars,
Futures is the CME live cattle contract for month j in U.S. dollars,
Pexchange uses the spot exchange rate at time t,
CPI is the consumer price index,
100 adjusts the CPI and
Pbasis uses the basis ARIMA(1,1,1) with constant model forecast in June 1981 dollars.

This model is used to forecast the one month and two month slaughter prices for the selective hedging risk management strategies. This model is chosen since it greatly simplifies the building of the historical simulation. The reliability of the model for these shorter time period forecasts is shown by comparing the MSE of the one month and two month forecasts from the basis ARIMA model to three other forecast models described earlier. Lagged slaughter steer cash prices, average basis model and lagged basis are used in the comparison and the results are in Table 5 and Table 6. The basis ARIMA(1,1,1) with the constant model is not always the lowest MSE forecast for one month and two month ahead forecast. The lagged slaughter steer prices model or the lagged basis model give superior forecasts over different time periods.

Equation 36 forecasts Alberta slaughter steer prices in the rest of the simulation. Other simpler models such as the current cash price or lagged basis may be suitable price forecasts. Tables 2, 4, 5 and 6 indicate there is less variability in prices since 1985 and simpler models may give good forecasts at this time. The basis ARIMA model was chosen based on decision criteria determined before the models were calculated. Cattle investors may find it easier and as accurate to use other models that do not require the use of a time series package to forecast price. Cattle investors could use different price forecast models at different times as part of the information gathering risk management strategy.[25] This should reduce risk. Choosing the best forecast model in any particular time period is a problem not explored any further in this study. The cattle production function is explained in the next section.

25 Leuthold, Garcia, Adam and Park (1989) tested hog market futures efficiency using a strategy of choosing different hog price forecast models based on the model with the lowest MSE up to that time period.

Table 5
Mean Square Error[1]
Selected Models for One Month Ahead Alberta Slaughter Steer Price Forecast

Time Period	Cash 1 Month Prior	Basis ARIMA(1,1,1) Constant	Basis Average	Basis 1 Mon. Back
1980-89	9.56	10.27	14.42	10.70
80-Mar86	11.79	11.75	17.54	14.04
Apr86-89	6.03	8.02	9.49	5.33

1. Calculations are in June 1981 dollars.

Table 6
Mean Square Error[1]
Selected Models for Two Month Ahead Alberta Slaughter Steer Price Forecast

Time Period	Cash 2 Month Prior	Basis ARIMA(1,1,1) Constant	Basis Average	Basis 2 Mon. Back
1980-89	22.04	21.24	24.17	22.68
80-Mar86	27.81	25.42	31.52	30.16
Apr1986-89	12.84	14.69	12.34	10.63

1. Calculations are in June 1981 dollars.

5.4 Production Function

The base production function for feeding heavy feeder steers in a custom feedlot is explained in this section. First, the cost of production is calculated. Second, the total revenue is calculated. Net revenue and annual net returns per lot are calculated and participation in the NTSP is also simulated. The results of these base simulations and MSEs of net returns are reported. The forecast net returns are then explained and presented. Finally, some limitations on this production function are discussed.

The cattle investor purchases 100 good quality heavy feeder steers each month from Edmonton, Alberta and places them in the feedlot near Calgary, Alberta. All costs are assumed paid at the beginning of the feeding period. No production risk is included. The only risk is slaughter price risk. This research uses much of the production information reported by Coles (1989).

Three different beginning feeders weights are chosen based on the data collected to give similar finished selling weights of 525 kg (1157 lb). The 525 kg (1157 lb) is the unshrunk sale weight. The length between 3 month feeding periods (going from the Wednesday of month t to the Wednesday of month t+3) are 84, 91 or 98 day feeding periods. Most of the feeding periods are 91 days. 380 kg (838 lb) feeder weights are chosen when the feeding period is 98 days. 390 kg (860 lb) are chosen when the feeding period is 91 days. 400 kg (882 lb) are chosen when the feeding period is 84 days. No specific grade discounts on slaughter animals are used in this production function. The Alberta direct slaughter price is a weighted average of grade A prices for steers.

Various input costs are developed using Coles's (1989) study. Some of these costs are single data points and they are detailed in the Appendix A. Various cost indexes are used to adjust these single point numbers to provide costs for each month. The indexes adjust the dollar amounts to comparable dollars for each time period to account for the effect of inflation. A cattle feeder ration pricing factor based on the monthly barley price is used to determine the ration price in each feeding period. The Calgary open market monthly average barley price is used.

The following equations show how the cost of production in nominal dollars is calculated. A series of equations lead to the total cost equation to produce one lot of feeder cattle. Feed cost in dollars per tonne is:

37. $$Feedcost_{t-3} = ration \times baropen_{t-3} - bamount \times crowben_{t-3} + bamount \times bartran_{t-3} + feedproc_{t-3}$$

where:
t is the month the steers are sold for slaughter,
ration is the ration pricing factor using barley price,
baropen is the open market barley price in $/tonne,
bamount is the proportion of barley in the ration,
crowben is the CBOP payment per tonne of grain,
bartran is the barley per tonne transportation cost and
feedproc is the per tonne processing charge for feed.

Feedcost is reduced by the CBOP when applicable and the costs of barley transportation and feed processing are added to the cost. The open market barley price is used. Total feed use in tonnes per lot over the entire feeding period is:

38. $$Feeduse_{t-3} = (1 - deathlos) \times lotsize \times feedcon \times feeddays_{t-3} \times .001 + deathlos \times lotsize \times feedcon \times feeddays_{t-3} \times .25 \times .001$$

where:
deathlos is the proportion of feeders that die,
lotsize is the number of feeder steers purchased each month,
feedcon is the feed conversion ratio,
Feeddays is the number of days in the feeding period,
.001 factor converts kilograms to tonnes and
.25 factor assumes animals that die consume 25% of feed before death.

Total feed cost per lot combines equations 37 and 38 to get:

39. $$Tfeedcost_{t-3} = feedcost_{t-3} \times feeduse_{t-3}$$

Total feeder steer purchase, trucking and buyer costs per lot are:

40. $$Feedercost_{t-3} = feederprice_{t-3} \times feederwt_{t-3} \times lotsize \times .01 \times 2.2046 + \frac{truck_{t-3} \times distance}{truckcap} \times lotsize + buyer_{t-3} \times lotsize$$

where:
feederprice is the Edmonton 800+ feeder steer price in $/Cwt,
feederwt is the steer purchase weight in kgs of 380, 390 or 400,
.01 factor converts price series $/cwt to $/lb,
2.2046 converts kgs to lbs.
truck is hauling charge/km for feeder steers,
distance is trucking distance for feeder steers,
truckcap is the number of feeder cattle per truck load and
buyer is the buyer's fee per head purchased.

Total feedlot charges per lot (excluding feed) are:

41. $$Feedlot_{t-3} = (yardage_{t-3} + bedcost_{t-3}) \times feeddays_{t-3} \times lotsize \times (1 - deathlos + deathlos \times .25) + treat_{t-3} \times lotsize + process_{t-3} \times lotsize$$

where:
yardage is feedlot charge per head per day,
bedcost is bedding cost per head per day,
.25 factor assumes death loss occurs 1/4 of the way into the feeding period,
treat is total veterinary costs per head and
process is the feedlot processing charge for incoming feeders.

The nominal total production cost per lot paid at the time of the feeder purchase (t-3) combines equation 39, 40 and 41:

42. $Totalcost_{t-3} = Tfeedcost_{t-3} + feedercost_{t-3} + feedlot_{t-3}$

or

$$Totalcost_{t-3,ntsp} = Tfeedcost_{t-3} + feedercost_{t-3} + feedlot_{t-3} + ntspprem_{t-3} \times lotsize$$

where:
NTSPprem is the per head NTSP premium if enrolled in the program and
NTSP subscript indicates costs include NTSP premium.

This concludes the series of equations used to calculate the total cost of production per lot of feeder cattle. The factors used in the study are in Appendix A. The cattle investor pays this nominal cost at the time the feeder cattle are purchased. Costs are calculated each month for a different lot of feeder steers for the period January 1976 to September 1989.

The next series of equations calculate the nominal total revenue for each lot of finished cattle sold in Alberta. Feedlots often sell the finished cattle using the feedlot scale. Therefore there are no selling charges. The shrink adjusted final selling weight for the lot fob the feedlot is:

43. $Finalwt_t = (feederwt_{t-3} + feeddays_{t-3} \times adg) \times lotsize \times (1 - deathlos) \times (1 - shrink)$

where:
adg is the average daily feeder weight gain in kg, and
shrink is the proportion of selling weight deducted from the feedlot scale weight to account for the expected transportation shrinkage.

The total revenue for each lot before any NTSP pay out combines equation 43 with the nominal Alberta steer price:

44. $Totalrevenue_t = finalwt_t \times 2.2046 \times strprice_t \times .01$

where:
strprice is the nominal Alberta direct slaughter steer price for the third week of the month,
2.2046 factor converts kgs to lbs and
.01 factor converts $/cwt to $/lb.

Participation in the NTSP adds to revenue if there is a pay out. The NTSP paid out about 72 days after the end of the quarter (if a payment was made) from 1986 to the end of 1988. Starting in 1989 the payments were calculated monthly so the payments are assumed to come about 2 months after the sale. Therefore the NTSP payments are discounted to the total revenue time period using the general CPI. This discount is required to get numbers with similar purchasing power and the CPI is used since the investment is a shifting of consumption to different time periods. The NTSP pay out per head discounted back to the cattle sale date for April, 1986 to December, 1988 is calculated as:

45. $$ntsphead_t = ntsphead_{t+3} \times \frac{CPI_t}{CPI_{t+3}}$$

and for January, 1989 to December, 1989 as:

46. $$ntsphead_t = ntsphead_{t+2} \times \frac{CPI_t}{CPI_{t+2}}$$

where:
NTSPhead is the per head NTSP pay out,
t is time period in which cattle were sold on which NTSP was paid,
t+3 or t+2 is the time period when the NTSP was received on average and
CPI is the general consumer price index.

Then nominal total revenue with NTSP per lot in time t combines equation 44 with either equation 45 or 46:

47. $TotalRevenue_{t,ntsp} = Totalrevenue_t + ntsphead_t \times lotsize \times (1 - deathlos)$

This ends the calculations of the nominal total revenue per lot. The total revenue is calculated each month for the period April 1976 to December 1989.

The revenues and the costs for each lot of feeder cattle occur in different time periods. Costs are assumed paid at the beginning of the feeding period. Revenue is received at the end of the feeding period about three months after the cost are paid. These two nominal dollar figures are not the same valued dollars in terms of purchasing power because of inflation. The CPI is used to adjust dollars so that these dollar amounts are directly comparable. The CPI is used since the investment decision is a deferment of consumption to a different time period.

The net revenue equation uses equations 42 with 44 or 47 and adjusts equation 42 for 3 months of inflation on input costs to get:

48.
$$Netrevenue_t = Totalrevenue_t - \left(Totalcost_{t-3} \times \frac{CPI_t}{CPI_{t-3}} \right)$$

or

$$Netrevenue_{t,ntsp} = Totalrevenue_{t,ntsp} - \left(Totalcost_{t-3,ntsp} \times \frac{CPI_t}{CPI_{t-3}} \right)$$

The net revenues per lot are converted to net returns per lot and then converted to annual returns per lot. The annual net returns per lot allow for direct comparisons between each lot of cattle fed in the simulation and other investments such as the TSE 300 for the same time period. This is a real rate of return since the effect of inflation is removed. The annualized real net returns per lot in percent are calculated using equations 48 and 42 to get:

49.
$$Netreturns_{t,annual} = \left[\left(\frac{Netrevenue_t}{Totalcost_{t-3} \times \frac{CPI_t}{CPI_{t-3}}} + 1 \right)^{\left(\frac{365}{feeddays_{t-3}}\right)} - 1 \right] \times 100$$

or

$$Netreturns_{t,annual,ntsp} = \left[\left(\frac{Netrevenue_{t,ntsp}}{Totalcost_{t-3,ntsp} \times \frac{CPI_t}{CPI_{t-3}}} + 1 \right)^{\left(\frac{365}{feeddays_{t-3}}\right)} - 1 \right] \times 100$$

This gives the base model for calculating simulated costs and real net returns for the Alberta cattle investor in heavy feeder steers. The net revenue numbers for each lot of cattle are converted to real December 1989 Canadian dollars using the CPI. This puts the dollar figures in terms that are closer to current prices. The net revenue per lot and net returns per year are reported in Tables 7 and 8. The net returns are the main measurement used in this study for comparison. Net revenue were the measures used by Caldwell et al. (1980) and Carter and Loyns (1985). Net revenue is also related to the cash flow measures used by Gillis et al. (1989) and Gaston and Martin (1984). Comparisons using net returns versus using net revenue are commented on later in this chapter.

The net returns from Table 7 for the period January 1980 to December 1989 with no NTSP are 0.89%. The period January 1980 to March 1986 returns are 4.39%. The returns for the period April 1986 to December 1989 are -4.94 with no participation in the NTSP. The returns in Table 7 for the period April 1986 to December 1989 (no hedging and no NTSP) may be significantly different from the period January 1980 to March 1986.[26] The net returns in Table 8 for the period April 1986 to December 1989 with participation in the NTSP is 2.37%.

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26 Test of significance for differences in mean are shown in the tables. These tests results require caution in interpretation because of autocorrelation in the data.

Table 7
Net Returns
Base Model - No Hedging and No NTSP

Year	Net Revenue Mean Per Lot Dec. 1989 $	Net Revenue Std. Dev.[1]	Net Returns Mean Real % Annual	Net Returns Std. Dev.[1]
1976-89	69.65	10340.90	6.02	45.86
76-79	2807.13	13672.95	19.69[2]abc	65.95
80-89	-956.90[3]	8622.69	0.89c	34.54
80-Mar86	-330.14	9703.49	4.39b	38.55
Apr86-89	-2001.50	6398.70	-4.94b	25.93

Table 8
Net Returns
Base Model - No Hedging and With NTSP

Year	Net Revenue Mean Per Lot Dec. 1989 $	Net Revenue Std. Dev.[1]	Net Returns Mean Real % Annual	Net Returns Std. Dev.[1]
76-89	621.86	10124.06	8.01[2]a	45.16
76-79	2807.13	13672.95	19.69abcd	65.95
80-89	-197.62	8345.57	3.63c	33.64
80-Mar86	-330.14	9703.49	4.39b	38.55
Apr86-89	23.26	5471.00	2.37d	23.64

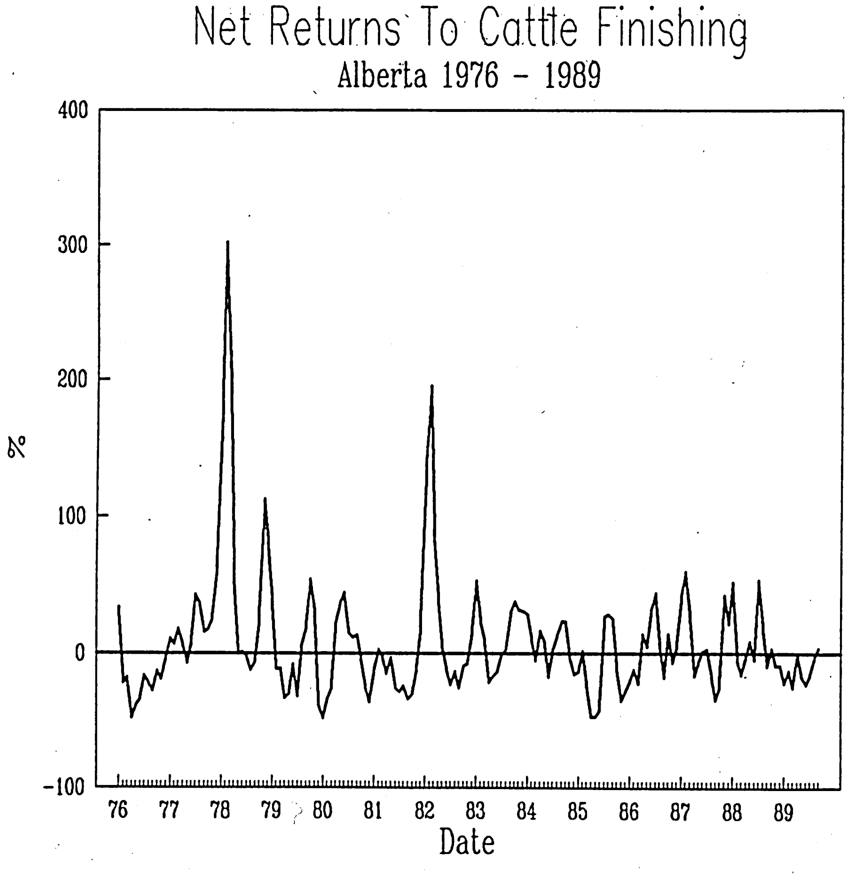
1. This is the standard deviation estimate of the population and not the standard deviation of the mean.
2. An a indicates the mean is significantly different from 0 using the assumption of normality and the t distribution at the 5% level of significance. Only the net returns are tested. A b, c or d indicates that the numbers with the b, c or d are statistically different from each other using assumptions of normality, independence between the populations, same variance and the t distribution at the 5% level of significance. These tests should be used with care since there appears to be autocorrelation in the net returns. See Appendix B for details on the autocorrelation and the direction of bias in the tests on net returns.
3. The net revenue is -956.90 and the net returns is 0.89. This apparent discrepancy is related to the compounding calculation used to get the annual rate of return and negative covariance between the net revenue and the reciprocal of the investment amount (cost).

Figure 7 is a graph of the net returns with participation in NTSP for finishing heavy feeders in Alberta. This shows the variability of returns over the time period of the simulation. Tests for a linear time trend in net returns (reported in Appendix B) do not show a significant increase or decrease in the net returns in the simulation. The net returns with NTSP for 1980 to 1989, 3.63%, is lower than the T-Bill rate of return, 4.74%, and the TSE rate of return, 14.04%. The standard deviation of net returns with NTSP for 1980 to 1989, 33.64, is higher than the T-Bill standard deviation, 2.60 and lower than the TSE standard deviation, 43.59. The net returns from cattle feeding are less variable than the TSE 300. Details on the T-Bill and TSE 300 calculations are in Appendix G.

The Alberta slaughter steer price forecast is used to forecast real net returns for each lot of cattle placed in the feedlot. This forecast is done at the time of the feeder cattle purchase. These forecasts are required for the MSE risk measure using net returns.

Total revenue prediction is straight forward. The revenue and net returns prediction use the same format as the actual returns in section 5.4. Actual slaughter steer price in equation 44 is replaced by the forecast price from equation 36. All costs are known at the time of the feeder cattle purchase. The revenue prediction is in June 1981 dollars. The forecast net revenue is:

Figure 7



Includes participation in NTSP

50. $PTotalrevenue_t = finalwt_t \times 2.2046 \times Pstrprice_t \times .01$

51. $$PNetrevenue_t = PTotalrevenue_t - Totalcost_{t-3} \times \frac{100}{CPI_{t-3}}$$

or

$$PNetrevenue_{t,ntsp} = PTotalrevenue_{t,ntsp} - Totalcost_{t-3,ntsp} \times \frac{100}{CPI_{t-3}}$$

where:
Ptotalrevenue is the predicted total revenue per lot in June 1981 dollars,
finalwt is equation 43 on shrink adjusted final sale weight,
Pstrprice is the forecast Alberta steer price in June 1981 dollars,
2.2046 and .01 are weight and price adjustment factors,

Pnetrevenue is predicted net revenue per lot,
Totalcost is equation 42 adjusted to June 1981 dollars using the CPI and,
ntsp subscript indicates that costs include NTSP premiums and the forecast NTSP pay outs.

The annual net returns calculations follows the same format as equation 49. The calculations are similar when NTSP is included. The forecast NTSP pay out, 3 x NTSP premium, replaces the actual NTSP pay out. The forecast net returns for the base production are in Tables 9 and 10. The MSE of net returns follows the format shown in chapter 3, equation 4 and uses the actual net returns and the forecast net returns from the price forecasts. An additional MSE is calculated for the base strategies only using the historical net rate of return from equation 49 as the forecast rate of return. The mean of net returns is calculated up to period t to forecast returns in period t+3. The mean is updated every month. This is very similar to the historical variance and this type of forecast has been suggested as an alternative[27]. The MSE for the net returns are also in Tables 9 and 10 but discussion on the MSE is deferred until all the strategy results are presented.

27 The historical mean for the entire feeding period of 1976 to 1989 is not used as the forecast in MSE (historical variance) in order to maintain the ex ante approach used in the price forecast for the net returns forecast. The use of the mean of net returns as a forecast of net returns may be a plausible forecast incorporating the varying relationships between costs and returns and the expected returns of the cattle feeders.

Table 9
Forecast Net Returns And MSE
Base Model - No Hedging and No NTSP[1]

Year	Net Revenue Mean	Net Returns % Mean	MSE Net Returns	MSE Net Returns Mean Forecast[2]
1980-89	-1095.65	-3.69	1335.7	1339.1
1980-Mar86	1274.83	4.89	1562.8	1642.1
Apr1986-89	-5046.45	-17.98	984.1	859.9

Table 10
Forecast Net Returns And MSE
Base Model - No Hedging and With NTSP[1]

Year	Net Revenue Mean	Net Returns % Mean	MSE Net Returns	MSE Net Returns Mean Forecast[2]
1980-89	-502.58	-1.53	1271.6	1248.0
1980-Mar86	1274.83	4.89	1562.8	1642.1
Apr1986-89	-3464.92	-12.23	810.8	613.7

1. Revenue reported in December 1989 dollars.
2. This is the MSE calculated using the mean of historical net returns at time period t to forecast returns at time period t+3. It does not dramatically improve the MSE. It does improve the forecast for the NTSP and this may indicate that the NTSP is reducing risk and helping to maintain a certain level of income for the cattle investor. With NTSP, this may be a better forecaster of net returns than using some other price and NTSP forecasters.

There are several limitations in this production function and the net returns reported in the base models in Table 7 and Table 8. One limitation is the assumption that the production is non stochastic. This problem is addressed earlier in this study and is justified based on the research by Coles (1989). Individual feedlots may have costs consistently lower or higher than the costs used in this study. This would change the comparison of net returns from cattle feeding to T-Bill or TSE 300 net returns over the same time period. Cattle feeding may be more or less profitable than shown in this simulation. The variability of cattle feeding net returns should be close to the same as in this study.

Another restriction is the assumption that the feedlot always buys heavy feeders. Heavy feeder steers may not be available year round in Alberta due to the biological processes in the production of beef cattle and the usual practice of late winter or spring calving. The main reason for using this restriction is that it simplifies the production model. Since a cattle investor is free to vary the quality and weight of cattle purchased and placed on feed, the production function used in this study should represent a lower bound on the profitability of feeding cattle. The production function should give a reasonable representation of the variation in returns in cattle finishing.

The other restriction is the lack of substitution in feed inputs. Alberta is limited in the type of feed grains grown in commercial quantities. Barley is the main feed grain used. Therefore little substitution of other feed grains for barley is expected. Silage, the other main ingredient in finishing rations in commercial feedlots, is usually not marketable except through cattle as a feed input. The bulkiness of silage makes alternative markets for silage limited due to high transportation costs. These factors imply little substitution with other feeds.

The base simulation reported net returns on investing in Alberta cattle with no NTSP and with NTSP. Participation in the NTSP may have increased the mean returns such that there is no significant difference in returns between 1980 to March 1986 and April 1986 to December 1989. The base production functions should be a lower bound on the profitability of feeding feeders in Alberta in a custom feedlot. The base production function is limited due to the restriction of always purchasing heavy feeders each month and heavy feeder steers may not be available year round. Further analysis of the base models results and the MSE calculations are deferred until the other investment strategies are presented. The next section builds the 100% hedge and hold risk management strategy using the base simulations from this section.

5.5 100% Hedge and Hold Strategy

The 100% hedge and hold risk management investment strategy is explained in this section. The live cattle futures contract is first checked for bias using a weak form efficiency test. This helps determine whether forecast hedge profits in the model should be non zero. The 100% hedge strategy builds upon the base model of cattle investing in Alberta with no NTSP and with NTSP. The equations, the actual results and the forecast results are reported.

The hedge profits or losses are important in the 100% hedge and hold strategy. An unbiased futures market would support the conclusion that over longer time periods 100% hedging is not an overly expensive strategy. As a check on futures market bias (a weak form market efficiency test), simulated hedges for the period 1976 to 1989 are done for 1, 2, 3, 4, 5 and 6 month holding periods. These hedges hold short (sell CME live cattle contracts) positions. A new hedge position is opened each month. Profits are calculated for the United States and the Canadian investor in $/cwt using the hedge profit equations 52 and 53. The mean of the hedge profits are tested to see if they significantly differ from zero using standard t tests. Different time periods over 1976 to 1989 are tested. The complete results are in Appendix C. Results for Alberta for 1980 to 1989 are in Table 11.

Table 11
Hedge Profit For Alberta Investor
January 1980 to December 1989[1]

Hedge Length	Mean $/cwt	Std. Dev. Sample	Std. Dev. Mean	t Statistic[2]
30 day	0.02	5.08	0.46	0.04
60 day	0.15	7.02	0.65	0.24
90 day	0.51	8.13	0.75	0.67
120 day	0.95	8.77	0.81	1.16
150 day	1.20	8.86	0.83	1.45
180 day	1.60	8.77	0.83	1.94

1. Means and standard deviations are reported in Dec. 1989 Canadian dollars. The approximate broker costs are $0.19/cwt in the same 1989 dollars and are not included in the numbers in the table. A factor of 1.536 can be used to divide the dollar figures to convert to June 1981 dollars.
2. T statistic is the test for the difference of the mean from 0. The t value at the 5% level of significance is approximately 1.98.

The simple tests on the mean for the period 1980 to 1989 in Table 11 indicate hedge profits are not significantly different from 0. This includes hedges for 1 month through to 6 months. Similar results hold for the other time periods for Alberta and Omaha. The reliability of these tests is weak due to possible autocorrelation in the sample. Further comments on this autocorrelation are in Appendix C. The likely direction of bias with autocorrelation is towards rejection of the hypothesis that the means are equal to zero. This strengthens the conclusion that hedge profits are not significantly different from 0. The rational investor would forecast zero hedge profits (excluding brokerage fees and margin money) when hedging cattle. This result further suggests that the minimum variance hedge ratios calculated in the next section are equivalent to the optimal hedge ratio.

Complete 100% hedge and hold strategies are simulated. The cattle investor sells CME live cattle futures contracts that exactly match the predicted output of cattle at sale time. The contracts are sold at the same time the feeder steers are purchased. The contracts are purchased back on the date the cattle are sold. The time period of each hedge is approximately 3 months and this matches the feeding period for each lot of cattle. Brokerage fees are included in the calculation but margin is not included. The futures contract used for hedging a lot of cattle always enters the contract expiry month after the sale of the cattle.

The profit (or loss) for a 3 month hedge in U.S. dollars per cwt is calculated as follows:

52.
$$Hedge_{us\$,t} = Future_{j,t-3} \times \frac{GNP_t}{GNP_{t-3}} - Future_{j,t}$$

where:
Hedge is the hedge profit in U.S. dollars at time t,
Future is the futures price at times t and t-3 for the same contract j,
j, the contract expiry month, occurs after time t and
GNP is a U.S. price deflater.

The Alberta hedge profit in $/cwt for the 3 month hedge is calculated by adjusting for exchange rates and three months of inflation.

53. $$Hedge_{Cdn\$,t} = Future_{j,t-3} \times Exchange_{t-3} \times \frac{CPI_t}{CPI_{t-3}} - Future_{j,t} \times Exchange_t$$

The hedge profit (or loss) for each lot of cattle fed is:

54. $$Hedgelot_{Cdn\$,t} = Hedge_{Cdn\$,t} \times finalwt_t \times \frac{2.2046}{100}$$

where:
Hedgelot is the hedge profit per lot in Canadian dollars and
finalwt is the total shrunk sale weight of the lot in kgs.

The following is an example of how costs and total revenue are updated using equations 42 and 44. Brokerage fees for the futures transactions are added to the total costs. Hedge profits are added to the total revenue. The rest of the calculations for net revenue and annual returns then follow the same format as shown in section 5.4, equation 48 and equation 49.

55. $$Totalcost_{t-3,h} = Tfeedcost_{t-3} + feedercost_{t-3} + feedlot_{t-3} + broker_{t-3} \times finalwt_{t-3} \times \frac{2.2046}{40000}$$

56. $$Totalrevenue_{t,h} = finalwt_t \times 2.2046 \times strprice_t \times .01 + hedgelot_{Cdn\$,t}$$

where:
Tfeedcost, equation 39, is total feed cost per lot,
feedercost, equation 40, is feeder purchase and marketing costs,
feedlot, equation 41, are total feedlot charges,
broker is the brokerage fee per 40000 lb futures contract,
finalwt is the shrink adjusted lot sale weight is kgs converted to lbs with 2.2046 and
strprice is the Alberta slaughter steer in $/cwt adjusted by .01.

The returns for cattle feeding with 100% hedging are reported in Tables 12 and 13. The annual net returns with 100% hedging gives mixed results over the no hedging results in Tables 7 and 8. Net returns of -0.15 with 100% hedging and no NTSP over the period 1980 to 1989 (Table 12) are lower than net returns of 0.89 with no hedging (Table 7)[28]. 100% hedging decreased net returns on the cattle investment by 1.04% (0.89-(-0.15)). The mean net revenue for the same time period, 1980 to 1989, for the 100% hedge and no NTSP is -$335 versus -$957 with no hedging. This apparent contradiction between the net revenue comparison and the net returns comparison is explained by the calculation which compounds the rate of return per lot to an annualized rate per annum.[29] The net

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28 The means and standard deviations are not tested for significant differences since these numbers are not independent in the statistical sense. The standard tests require independent populations.

29 The compounding calculation of a rate of return per lot to an annual rate in equation 45 tends to favour positive returns over negative returns in the final calculation of the arithmetic mean of annual rates of return. For example, assume costs are $100 and net revenues are $10 or -$10 in a three month period. The annualized rate of return for the $10 return using equation 45 is 46% and the rate of return for the -$10 is -34%. The average of annual net returns ((46% +(- 34%))/2) is 6% versus the average for the net revenues of 0. Also refer to Table 8, note 3, for the other reason for this sign change. This gives some possible explanation for different results where studies measure risk using monthly or yearly cash flows such as Gillis et al. (1989).

returns with 100% hedging over the period 1980 to March 1986, 6.54, is higher than the returns with no hedging, 4.39. 100% hedging increased net returns on the cattle investment by 2.15% (6.54-4.39). The net returns with 100% hedging over the period April 1986 to 1989 decreased returns by 6.36% (-4.94-(-11.30)) over no hedging.

The standard deviations of net returns with hedging in Tables 12 and 13 are all smaller than the comparable standard deviations with no hedging in Tables 7 and 8. This result contrasts with Caldwell et al. (1982) where standard deviations of income increased with 100% hedging. The standard deviation result here is similar to the result reported by Carter and Loyns (1985) for steers[30].

Leuthold and Tomek (1980) summarized results from several studies and concluded that 100% hedging reduced risk but it reduced returns to such a level that it was not profitable to feed cattle. This study does not fully support the conclusions of Leuthold and Tomek (1980). Net returns on the total cattle investment are reduced by about 1% with 100% hedging over the 10 year period 1980 to 1989. This is not an excessively high cost for a reduction in risk.[31] The break down of different time periods in the tables gives a different picture. The period 1980 to March 1986 shows that 100% hedging adds over 2% to the cattle feeding net returns and reduces risk. This contradicts Leuthold and Tomek's conclusions. The period April 1986 to 1989 shows that 100% hedging decreases cattle feeding net returns by over 6% and reduces risk. This supports Leuthold and Tomek's conclusions.

This study shows 100% hedging over longer time periods does not cost an excessive amount. The problem for the individual investor may be that over a period of 3 or 4 years the strategy may reduce cattle feeding returns substantially. The investor may not be able to sustain these losses or maintain confidence in the strategy. This may makes the 100% hedge and hold strategy a non viable risk management strategy for some cattle investors.

The revenue forecasts with 100% hedging use the same format as the actual revenue calculations in section 5.4. The total revenue forecast is equation 50 with costs adjusted for brokerage fees as in equation 55. No other changes are required in the revenue or net returns forecasts since the investor is expecting zero profits from the hedge. The total revenue forecasts are converted to December 1989 dollars. The MSE of net returns is calculated using the actual returns and the forecast returns as in equation 4, chapter 3. The net revenue forecasts, the net returns forecasts and the MSE for the 100% hedge and hold are in Tables 14 and 15. The means of the forecast are in general lower than the actual returns in the model and this is shown more clearly in a later section with graphs comparing the actual returns to the forecast returns for all strategies.

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30 Carter and Loyns (1985) reported a 14% decrease in the standard deviations of net revenue with 100% hedging. The net revenue standard deviations in Table 7 (8622) and Table 12 (7210) show a 16%, ((8622-7210)/8622)x100, reduction in the standard deviation with hedging.

31 The square root MSE on net returns are reported later in Table 37. 100% hedging reduces risk by 48% over not hedging.

Table 12
100 % Hedge and Hold Strategy
Without NTSP

Year	Net Revenue Mean Per Lot Dec. 1989 $	Net Revenue Std. Dev.[1]	Net Returns Mean Real % Annual	Net Returns Std. Dev.[1]
80-89	-335.12	7210.01	-0.15	25.49
80-Mar86	1517.20	7571.66	6.54[2]ab	26.12
Apr86-89	-3422.32	5345.96	-11.30ab	20.14

Table 13
100 % Hedge and Hold Strategy
With NTSP

Year	Net Revenue Mean Per Lot Dec. 1989 $	Net Revenue Std. Dev.[1]	Net Returns Mean % Annual	Net Returns Std. Dev.[1]
80-89	424.16	6863.51	2.66	24.69
80-Mar86	1517.20	7571.66	6.54[2]ab	26.12
Apr86-89	-1397.56	5055.30	-3.82b	20.80

1. This is the standard deviation estimate of the population and not the standard deviation of the mean.
2. An a indicates the mean is significantly different from 0 using the assumption of normality and the t distribution at the 5% level of significance. Only the net returns are tested. A b indicates that the numbers with the b are statistically different from each other using assumptions of normality, independence between the populations, same variance and the t distribution at the 5% level of significance. These tests should be used with care since there appears to be autocorrelation in the net returns. See Appendix B for details on the autocorrelation and direction of bias in the tests on net returns.

Table 14
Forecast 100 % Hedge and Hold Strategy And MSE
Without NTSP[1]

Year	Net Revenue Mean	Net Returns % Mean	MSE Net Returns
1980-89	-1312.26	-4.44	356.3
1980-Mar86	1058.22	4.10	345.6
Apr1986-89	-5263.05	-18.69	382.4

1. Revenue reported in December 1989 dollars.

Table 15
Forecast 100 % Hedge and Hold Strategy And MSE
With NTSP[1]

Year	Net Revenue Mean	Net Returns % Mean	MSE Net Returns
80-89	-719.18	-2.31	339.0
80-Mar86	1058.22	4.10	345.6
Apr86-89	-3681.52	-12.99	335.7

1. Revenue reported in December 1989 dollars.

The futures market was tested for bias in this section. Over extended time periods there does not appear to be bias in the futures market. This test on the efficiency of the live cattle futures market does not reject the hypothesis of live cattle market efficiency from chapter 3.[32] Further analysis of the 100% hedge and hold strategy and MSE calculations are deferred until all the investment strategy results are reported. The next section explains the optimal hedge risk management strategy.

5.6 Optimal Hedging

The optimal hedge risk management strategy is an alternative to the 100% hedge strategy. The futures market efficiency results in the previous section imply the minimum variance hedge ratios are also optimal hedge ratios. These minimum variance ratios are calculated for Alberta and Omaha investors to compare relative hedge effectiveness. The optimal hedge strategy net returns, forecasts and MSE of net returns are reported.

The price difference model, equation 21, is used to calculate hedge ratios. The prices used are the Alberta cash price differences and the CME futures market price differences[33]. Therefore the NTSP is not included in this optimal hedge calculation. The price difference method allows for some comparison between the Alberta and the Omaha cattle investor. All numbers used for Alberta are converted to real June 1981 Canadian dollars before calculating the hedge ratios[34]. The following model shows one set of data points in the estimated model.

57. $(Strprice_t - Strprice_{t-3})_t = \alpha + (Future_{j,Cdn\$,t} - Future_{j,Cdn\$,t-3})\gamma + \mu$

where:
Strprice is the Alberta steer price at time t and
Future is the j contract month price in Canadian dollars.

The γ is the optimal hedge ratio. The μ is assumed to have zero mean and homoskedastic variance with no serial correlation. The hedge ratio is estimated again each month adding the new set of information available for the month. For example, the first 3 month hedge ratio is calculated using the data available from January 1976 to October 1979. The next hedge ratio calculation adds the data for November 1979 to the data set. 120 hedge ratios are calculated for the period of cattle sales from January 1980 to December 1989. This method of updating should capture any possible changes in the

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32 Serial autocorrelation in returns has been used to test market efficiency where significant autocorrelation has been interpreted as market inefficiency. Danthine (1977) suggests that this may not be a valid interpretation of autocorrelation. Secondly, the autocorrelation picked up by the tests in the Appendix C may be model misspecification.

33 This model is a variance minimizing solution following the common estimation methods in the literature. An alternative solution to this model is to compare the differences between the (forecast price and the actual price) to the futures price difference or to compare the differences in (forecast revenue and actual revenue) to the futures price difference. These alternatives would be MSE minimizing hedge ratios. These alternative methods may be more consistent with the MSE definition of risk however this alternative was not used.

34 Real dollars are used since the hedge ratio measures variances and covariances of returns and their relationship. Variances and covariances of nominal returns are not directly comparable since each variance and covariance is in a different scale unless the numbers are converted to some base figure. This is done using the CPI or the U.S. GNP price deflater. Furthermore, returns with constant variance in real terms, an implicit assumption in this ratio calculation, will exhibit heterskedasdicity if nominal values are used. The use of real dollars should remove this trend. Finally, the two prices used in the price differencing, are not in the same valued currency unless they are adjusted for inflation to the same base period.

parameters over time. The R-Squared of equation 21 is the measure of hedging effectiveness. This model is calculated for 1, 2, 3, 4, 5 and 6 month price difference intervals.[35] This compares different hedge intervals used by other studies or used by cattle investors.

This model is also used to calculate the optimal hedges for cattle feeders at Omaha. The U.S. dollars are all converted to real January 1982 dollars using a GNP deflater before the optimal hedge is calculated.

Selected hedge ratio results are in Table 16. Selected hedge ratios for Alberta and Omaha show the first hedge ratio calculated and the last hedge ratio for cattle sales that occur from January 1980 to December 1989. The ratios do not change much from month to month. The hedge ratio for Alberta investors for the three month hedge varied between 0.64 and 0.71. This is similar to other studies such as Carter and Loyns (1985). The hedge effectiveness value, the regression R-squared, varied from .37 to .43. The similar period for Omaha investors shows hedge ratios varying from 0.69 to 0.75 with regression R-squared's of 0.45 to 0.56. There is not much difference between Alberta and Omaha in the level of optimal hedging.[36] Optimal hedging is likely as effective for Alberta investors as it is for Omaha investors in reducing the variance of historical net returns.

Alberta hedge ratios and the hedge effectiveness measures in Table 16 increase with longer hedge holding periods. Longer hedges may correct for short term differences in price movements in the Alberta cash market versus the CME. Different local supply conditions in Alberta may be the cause of the short term price differences. No investigation of these price differences or changes in hedge ratios is done.

The 3 month price difference optimal hedge for Alberta for the period of cattle purchases October 1979 to September 1989 is used instead of the 100% hedge and hold strategy. The 100% hedge is adjusted by the optimal hedge ratio γ_{t-3} calculated using the information available at time period t-3 when the feeders are purchased.

35 A simplified Myers and Thompson model (from equation 27)
$Strprice_t = \alpha + (Future_{Cdn\$,t} - Future_{Cdn\$,t-3})\gamma + strprice_{t-3}a + future_{t-3}b + \mu$ where the optimal hedge is calculated as a function of the futures prices difference and lagged variables of price was estimated for the 3 month holding period. This optimal hedge did not reduce the variance of returns as much as the simpler OLS price difference model used here. No further results from the Myers and Thompson model are reported.

36 Trend analysis of the hedging effectiveness and the optimal hedge ratio for Alberta investors indicates that the hedge ratio has increased over the past 10 years and that the hedge effectiveness has also increased.

Table 16
Selected Optimal Hedge Ratios
Alberta And Omaha

Hedge Length and Date Hedge Opened	Alberta Hedge Ratio	Hedging Effectiveness Alberta R-Squared	Omaha Hedge Ratio	Hedging Effectiveness Omaha R-Squared
1 Month				
19-Dec-79[1]	0.47	0.32	0.73	0.66
15-Nov-89	0.50	0.32	0.62	0.51
2 Months				
14-Nov-79	0.60	0.32	0.77	0.56
18-Oct-89	0.61	0.35	0.66	0.45
3 Months				
17-Oct-79	0.65	0.35	0.75	0.56
13-Sep-89	0.70	0.41	0.69	0.45
4 Months				
19-Sep-79	0.67	0.36	0.80	0.56
16-Aug-89	0.73	0.45	0.73	0.45
5 Months				
15-Aug-79	0.67	0.38	0.76	0.57
19-Jul-89	0.74	0.47	0.74	0.46
6 Months				
18-Jul-79	0.70	0.43	0.76	0.60
14-Jun-89	0.76	0.49	0.75	0.47

1. The first date after the length of hedge is the date the futures contract is sold (feeder purchase date) for a cattle sale that would occur in January 1980. The second date is the feeder purchase date for finished cattle sold in December 1989.

58. $$Hedgelot_{Cdn\$,t} = \left(Hedge_{Cdn\$,t} \times finalwt_t \times \frac{2.2046}{100}\right) \times \gamma_{t-3}$$

Brokerage costs are similarly adjusted using the optimal hedge ratio.

59. $$Totalcost_{t-3,h} = Tfeedcost_{t-3} + feedercost_{t-3} + feedlot_{t-3} + \left(broker_{t-3} \times finalwt_{t-3} \times \frac{2.2046}{40000}\right) \times \gamma_{t-3}$$

The calculations for net revenue and annual returns follow the same format as shown in section 5.4. The net returns with optimal hedging and the standard deviations of net returns are in Tables 17 and 18.

The standard deviation of the net returns using optimal hedge ratios (Tables 17 and 18) versus 100% hedges (Tables 12 and 13) decreases. The standard deviation for 1980 to 1989 of the 100% hedge with NTSP is 24.7 with mean net returns of 2.66%. The standard deviation with optimal hedge ratios and NTSP is 22.9 with mean net returns of 1.96%. This is the expected result. Optimal hedge ratios reduce the variance of returns over 100% hedging. These standard deviations are not independent and therefore cannot be directly tested for significant differences using the standard F test on variances. The hypothesis in section 3.3.5 that the optimal hedge ratio reduces the historical variance of net returns versus the 100% hedge strategy cannot be tested.

Table 17
Optimal Hedge Strategy
Without NTSP

Year & Strategy	Net Revenue Mean Per Lot Dec. 1989 $	Net Revenue Std. Dev.[1]	Net Returns Mean Real % Annual	Net Returns Std. Dev.[1]
80-89	-603.06	6441.37	-0.82	23.86
80-Mar86	833.08	6833.69	4.62[2]b	24.93
Apr86-89	-2996.62	4929.52	-9.89ab	18.98

Table 18
Optimal Hedge Strategy
With NTSP

Year & Strategy	Net Revenue Mean Per Lot Dec. 1989 $	Net Revenue Std. Dev.[1]	Net Returns Mean Real % Annual	Net Returns Std. Dev.[1]
80-89	156.23	6065.29	1.96	22.89
80-Mar86	833.08	6833.69	4.62[2]b	24.93
Apr86-89	-971.86	4344.17	-2.46b	18.43

1. This is the standard deviation estimate of the population and not the standard deviation of the mean.
2. An a indicates the mean is significantly different from 0 using the assumption of normality and the t distribution at the 5% level of significance. Only the net returns are tested. A b indicates that the numbers with the b are statistically different from each other using assumptions of normality, independence between the populations, same variance and the t distribution at the 5% level of significance. These tests should be used with care since there appears to be autocorrelation in the net returns. See Appendix B for details on the autocorrelation and direction of bias in the tests on net returns.

The revenue forecasts with optimal hedging use the same format as the 100% hedge and hold strategy. The total revenue forecast is equation 50 with costs adjusted for brokerage fees as in equation 59. No other changes are required in the revenue or net returns forecasts since the investor is expecting zero profits from the hedge. The total revenue forecasts are converted to December 1989 dollars. The MSE of net returns is calculated using equation 4, chapter 3. The net revenue forecasts, the net returns forecasts and the MSE of net returns for the optimal hedge are in Tables 19 and 20. The means of the forecast are in general lower than the actual returns in the model.

The optimal hedge ratio was estimated in this section. The optimal hedge ratio for Alberta cattle investors for a three month hedge in 1989 was 0.70. The optimal hedge reduces the variance of historical returns, hedge effectiveness, by about 0.41. This is an alternative to the 100% hedge strategy. Further analysis of the optimal hedge strategy and MSE calculation is deferred until the other investment strategies are reported.

Table 19
Forecast Optimal Hedge Strategy And MSE Without NTSP[1]

Year	Net Revenue Mean	Net Returns % Mean	MSE Net Returns
80-89	-1242.95	-4.20	417.7
80-Mar86	1130.22	4.36	423.4
Apr86-89	-5198.22	-18.48	417.7

Table 20
Forecast Optimal Hedge Strategy And MSE With NTSP[1]

Year	Net Revenue Mean	Net Returns % Mean	MSE Net Returns
80-89	-649.87	-2.06	384.0
80-Mar86	1130.22	4.36	423.4
Apr86-89	-3616.69	-12.77	326.4

1. Revenue reported in December 1989 dollars.

5.7 Selective Investment Strategies

The selective strategies attempt to lock in feeding returns greater than some target level. The selective strategies are simulated with and without participation in the NTSP and require net returns forecasts. The three strategies are called the 5% selective hedge strategy, the T-Bill selective hedge strategy and the selective investment in feeder cattle or T-Bills strategy. This section explains these three strategies and reports the forecast net returns and the actual net returns.

The first selective hedge strategy is to hedge using the CME live cattle futures contract if the forecast net return on feeding cattle is greater than 5%. This strategy requires net returns forecasts and attempts to lock in a cattle feeding profit with hedging. The 5% is picked in an ad hoc manner and is a real rate of return with the effect of inflation removed. The forecast net returns are tested at the time the cattle are purchased. If the forecast net returns are greater than 5%, a 100% hedge position is taken. If the forecast net returns are not greater than 5%, the hedge is not placed at the time the feeder cattle are purchased. The forecast net returns are then calculated from equation 51.

The hedge decision is tested again two months before the sale date, if no hedge is placed at the time the cattle are purchased. A 100% hedge is placed if the forecast net returns are greater than 5%. The hedge decision is tested again at one month before the sale date, if no hedge is placed at two months or three months. The same 5% rule is used.

The three, two and one month net returns forecasts for the same lot of cattle change. The rational cattle investor updates the slaughter price forecast using the most recent information. A variation on equation 36, the futures market and the basis ARIMA(1,1,1) with constant model, are used to forecast prices at two months and one month prior to the cattle sale date. The price forecasts, updated at two months and one month prior to sale, are:

60. $$Pstrprice_{t,2} = Future_{j,t-2} \times PExchange_{t,2} \times \frac{100}{CPI_{t-2}} + Pbasis_{t,2}$$

61. $$Pstrprice_{t,1} = Future_{j,t-1} \times PExchange_{t,1} \times \frac{100}{CPI_{t-1}} + Pbasis_{t,1}$$

where:

Pstrprice is the two month (subscript 2) or one month (subscript 1) forecast Alberta slaughter steer price for time t in June 1981 dollars,
Futures is the CME live cattle contract for contract month j in U.S. dollars,
Pexchange is the forecast exchange rate and uses the spot exchange rate at time t-2 or t-1,
CPI is the consumer price index,
100 adjusts the CPI and
Pbasis is the different 1 and 2 month basis forecast in June 1981 dollars.

The actual returns for the 5% selective hedge are adjusted for brokerage fees if hedging occurs. No inflation adjustment on brokerage fees are made if the hedge is placed two months or one month before sale date. This simplifies the calculation and the inflation error on this amount is negligible. If hedges are placed, the total revenue and the net returns are adjusted for the hedge profit or loss. The actual hedge profit or loss for the three month, two month or one month hedge are:

62.
$$Hedge_{Cdn\$,t} = Future_{j,t-k} \times Exchange_{t-k} \times \frac{CPI_t}{CPI_{t-k}} - Future_{j,t} \times Exchange_t$$

where:
Hedge is the hedge profit in Canadian dollars adjusted for inflation with CPI,
k is 1, 2, or 3 months prior to slaughter sale month

The net returns for this strategy are in Tables 21 and 22 and the forecast net returns and MSE are in Tables 23 and 24. The net returns with the 5% selective hedge strategy are greater than the comparable returns in the base strategies, 100% hedge strategy or the optimal hedge strategy. The standard deviations for this selective hedge strategy are smaller than the base strategies but usually greater than the 100% hedge or the optimal hedge strategies.

A second selective hedge strategy uses the 91 day T-Bill rate of return rather than the 5% rule. Selective hedges are placed if the forecast rate of return in feeding cattle is greater than the forecast T-Bill real rate of return over the feeding period. The rest of the T-Bill selective hedge strategy is the same as the 5% selective hedge strategy. T-Bills are assumed to be a riskless investment. The real returns for T-Bills over the cattle feeding period are known at the time the investor purchases the cattle. This assumptions makes the T-Bills riskless. The MSE of T-Bill returns is 0. The calculation of the real T-Bill rates are explained in Appendix G. The net returns for the T-Bill selective hedge strategy are in Tables 25 and 26. The net returns and standard deviations for the T-Bill strategy and the 5% strategy are similar. The forecast net returns and the MSE for the T-Bill selective hedge strategy are in Tables 27 and 28.

The majority of the hedges used in the selective hedge strategies are placed during the period 1980 to 1986. Relatively fewer hedges are placed in the period 1986 to 1989 because net returns forecasts are low. Most hedges are placed at three months when the cattle are purchased. The number of times three month, two month and one month hedges are placed is in Appendix E.

Table 21
5% Selective Hedge Strategy
Without NTSP

Year	Net Revenue Mean Per Lot Dec. 1989 $	Net Revenue Std. Dev.[1]	Net Returns Mean Real % Annual	Net Returns Std. Dev.[1]
1980-89	541.69	7538.96	3.66	26.58
1980-Mar86	2157.84	7891.04	9.40[2]ab	26.53
Apr1986-89	-2151.90	6092.49	-5.90b	24.04

Table 22
5% Selective Hedge Strategy
With NTSP

Year	Net Revenue Mean Per Lot Dec. 1989 $	Net Revenue Std. Dev.[1]	Net Returns Mean Real % Annual	Net Returns Std. Dev.[1]
Hedge, NTSP				
80-89	1375.38	6949.37	6.63[2]a	24.63
80-Mar86	2157.84	7891.04	9.40ab	26.53
Apr86-89	71.28	4806.78	2.02b	20.55

1. This is the sample standard deviation.
2. An a indicates the mean is significantly different from 0 using the assumption of normality and the t distribution at the 5% level of significance. Only the net returns are tested. A b indicates that the numbers with the b are statistically different from each other using assumptions of normality, independence between the populations, same variance and the t distribution at the 5% level of significance. These tests should be used with care since there appears to be autocorrelation in the net returns. See Appendix B for details on the autocorrelation and direction of bias in the tests.

Table 23
Forecast 5% Selective Hedge Strategy
Without NTSP

Year	Net Revenue Mean Per Lot Dec. 1989 $	Net Returns Mean % Annual	MSE Net Returns
1980-89	-1216.59	-4.15	641.5
1980-Mar86	1110.20	4.27	538.3
Apr1986-89	-5094.58	-18.16	829.7

Table 24
Forecast 5% Selective Hedge Strategy
With NTSP

Year	Net Revenue Mean Per Lot Dec. 1989 $	Net Returns Mean % Annual	Mse Net Returns
1980-89	-639.76	-2.05	575.8
1980-Mar86	1110.20	4.27	538.3
Apr1986-89	-3556.37	-12.58	651.9

Table 25
T-Bill Selective Hedge Strategy
Without NTSP

Year	Net Revenue Mean Per Lot Dec. 1989 $	Net Revenue Std. Dev.[1]	Net Returns Mean Real % Annual	Net Returns Std. Dev.[1]
1980-89	449.13	7642.26	3.38	27.04
1980-Mar86	2257.03	8034.78	9.97[2]ab	27.20
Apr1986-89	-2564.03	5875.84	-7.60ab	23.15

Table 26
T-Bill Selective Hedge Strategy
With NTSP

Year	Net Revenue Mean Per Lot Dec. 1989 $	Net Revenue Std. Dev.[1]	Net Returns Mean Real % Annual	Net Returns Std. Dev.[1]
1980-89	1279.75	7109.18	6.37[2]a	25.29
1980-Mar86	2257.03	8034.78	9.97ab	27.20
Apr1986-89	-349.05	4875.81	0.36b	20.66

1. This is the sample standard deviation.
2. An a indicates the mean is significantly different from 0 using the assumption of normality and the t distribution at the 5% level of significance. Only the net returns are tested. A b indicates that the numbers with the b are statistically different from each other using assumptions of normality, independence between the populations, same variance and the t distribution at the 5% level of significance. These tests should be used with care since there appears to be autocorrelation in the net returns. See Appendix B for details on the autocorrelation and direction of bias in the tests.

Table 27
Forecast T-Bill Selective Hedge Strategy and MSE
Without NTSP

Year	Net Revenue Mean Per Lot Dec. 1989 $	Net Returns Mean % Annual	MSE Net Returns
80-89	-1200.34	-4.09	675.8
80-Mar86	1127.54	4.32	603.4
Apr86-89	-5080.14	-18.10	813.0

Table 28
T-Bill Selective Hedge Strategy And MSE
With NTSP

Year	Net Revenue Mean Per Lot Dec. 1989 $	Net Returns Mean % Annual	MSE Net Returns
80-89	-614.49	-1.96	620.0
80-Mar86	1127.54	4.32	603.4
Apr86-89	-3517.87	-12.44	661.9

The final investment strategy simulated is selective investment in feeder cattle or T-Bills. The investment in cattle has risk. The T-Bill investment is riskless. The risk averse investor should prefer the cattle investment to have a greater rate of return than the T-Bill. The selective investment strategy is purchase feeder cattle if the forecast return is greater than the 91 day T-Bill rate over the same time period. If cattle are not fed then the same investment amount (the total costs of feeding cattle) is used to purchase T-Bills. The selective investment is simulated with the two base models, without NTSP and with NTSP, and with the 100 % hedge strategy, without NTSP and with NTSP.

Forecast net returns, if cattle are fed, are the same as detailed earlier. If cattle are not fed then the forecast net returns is the T-Bill real rate of return for the period. If cattle are fed then the actual net returns are the same as explained earlier in section 5.4 and 5.5. If the investment is in T-Bills then the actual returns are the T-Bill real rate of return over the period. The selective investment in feeder cattle or T-Bills net returns are reported in Tables 29 to 32. The forecast net returns and MSE for the selective investment strategy in feeder cattle or in T-Bills are in Tables 33 to 36.

Table 29
Selective Investment Strategy
Feeder Cattle Or T-Bills
Without Hedging And Without NTSP

Year	Net Revenue Mean Per Lot Dec. 1989 $	Net Revenue Std. Dev.[1]	Net Returns Mean Real % Annual	Net Returns Std. Dev.[1]
1980-89	2135.61	6478.25	7.26[2]a	27.16
1980-Mar86	1945.95	8178.77	7.97a	34.15
Apr1986-89	2451.70	916.23	6.09a	5.59

Table 30
Selective Investment Strategy
Feeder Cattle Or T-Bills
Without Hedging And With NTSP

Year	Net Revenue Mean Per Lot Dec. 1989 $	Net Revenue Std. Dev.[1]	Net Returns Mean Real % Annual	Net Returns Std. Dev.[1]
1980-89	2219.99	6628.15	7.80[2]a	27.97
1980-Mar86	1945.95	8178.77	7.97a	34.15
Apr1986-89	2676.73	2444.40	7.52a	12.42

Table 31
Selective Investment Strategy
Feeder Cattle Or T-Bills
With Hedging And Without NTSP

Year	Net Revenue Mean Per Lot Dec. 1989 $	Net Revenue Std. Dev.[1]	Net Returns Mean Real % Annual	Net Returns Std. Dev.[1]
1980-89	2748.94	4387.18	10.40a	16.24
1980-Mar86	3688.82	5203.47	13.61ab	19.08
Apr1986-89	1182.48	1582.06	5.04ab	7.34

Table 32
Selective Investment Strategy
Feeder Cattle Or T-Bills
With Hedging And With NTSP

Year	Net Revenue Mean Per Lot Dec. 1989 $	Net Revenue Std. Dev.[1]	Net Returns Mean Real % Annual	Net Returns Std. Dev.[1]
80-89	2968.93	4427.78	11.37a	16.74
80-Mar86	3688.82	5203.47	13.61ab	19.08
Apr86-89	1769.12	2265.11	7.65ab	11.12

1. This the sample standard deviation.
2. An a indicates the mean is significantly different from 0 using the assumption of normality and the t distribution at the 5% level of significance. Only the net returns are tested. A b indicates that the numbers with the b are statistically different from each other using assumptions of normality, independence between the populations, same variance and the t distribution at the 5% level of significance. These tests should be used with care since there appears to be autocorrelation in the net returns. See Appendix B for details on the autocorrelation and direction of bias in the tests.

TABLE. III-7: Farming Like Other Business		
Rank	FREQUENCY	VALID PERCENT
Strongly Agree	30	20.3%
Agree	46	31.1%
Neutral	7	4.7%
Disagree	44	29.7%
Strongly Disagree	21	14.2%

Note: Results of this frequency table relate to question 5 of the survey questionnaire in Appendix I.

TABLE. III-8: Take Risky Investment		
Rank	FREQUENCY	VALID PERCENT
Yes	78	52.7%
No	70	47.3%

Note: Results of this frequency table relate to question 6 of the survey questionnaire in Appendix I.

TABLE. III-9: Dryland Slough Area Scenario		
Land Use Option	FREQUENCY	VALID PERCENT
Subdivide and Sell	6	4.1%
Subdivide and Donate	4	2.7%
Lease	33	22.4%
Contract	75	51.0%
Drain	3	2.0%
No Change	26	17.1%

Note: Results of this frequency table relate to question 7 of the survey questionnaire in Appendix I.

TABLE. III-10: Rather Sell Dryland Slough To		
AGENCY	FREQUENCY	VALID PERCENT
Government	3	50.0%
Private	1	16.7%
No Preference	2	33.3%

Note: Results of this frequency table relate to question 7A1 of the survey questionnaire in Appendix I.

TABLE. III-11: Prefer To Receive Other Benefits		
BENEFIT	FREQUENCY	VALID PERCENT
No Other	1	16.7%
Project Signs	2	33.3%
Free Licenses	1	16.7%
Membership	2	33.3%

Note: Results of this frequency table relate to question 7A2 of the survey questionnaire in Appendix I.

TABLE. III-12: Additional Other Benefit #1		
BENEFIT	FREQUENCY	VALID PERCENT
More Compensation	1	50.0%
Access Control	1	50.0%

Note: Results of this frequency table relate to question 7A3 of the survey questionnaire in Appendix I.

TABLE. III-13: Rather Donate Dryland Slough To		
AGENCY	FREQUENCY	VALID PERCENT
Government	2	50.0%
Private	1	25.0%
No Preference	1	25.0%

Note: Results of this frequency table relate to question 7B1 of the survey questionnaire in Appendix I.

TABLE. III-14: Prefer To Receive Other Benefits		
Benefit	FREQUENCY	VALID PERCENT
No Other	2	50.0%
Project Signs	0	0.0%
Free Licenses	1	25.0%
Membership	1	25.0%

Note: Results of this frequency table relate to question 7B2 of the survey questionnaire in Appendix I.

TABLE. III-15: Additional Other Benefit #1		
BENEFIT	FREQUENCY	VALID PERCENT
Capital Improvements	1	100.0%

Note: Results of this frequency table relate to question 7B3 of the survey questionnaire in Appendix I.

TABLE. III-16: Rather Lease Dryland Slough To		
AGENCY	FREQUENCY	VALID PERCENT
Government	11	33.3%
Private	7	21.2%
No Preference	15	45.5%

Note: Results of this frequency table relate to question 7C1 of the survey questionnaire in Appendix I.

TABLE. III-17: Lease Term		
TERM	FREQUENCY	VALID PERCENT
10 Years	24	75.0%
20 Years	1	3.1%
In Perpetuity	7	21.9%

Note: Results of this frequency table relate to question 7C2 of the survey questionnaire in Appendix I.

TABLE. III-18: Prefer To Receive Other Benefits		
Benefit	FREQUENCY	VALID PERCENT
No Other	8	24.2%
Project Signs	13	29.4%
Free Licenses	8	24.2%
Membership	4	12.1%

Note: Results of this frequency table relate to question 7C3 of the survey questionnaire in Appendix I.

TABLE. III-19: Additional Other Benefit #1		
BENEFIT	FREQUENCY	VALID PERCENT
More Compensation	4	33.3%
Access Control	1	8.3%
Shorter Lease	1	8.3%
Allow Livestock Grazing	1	8.3%
Compensate Wildlife For Depredation	2	16.7%
Recognition	1	8.3%
Cancel After 10 Years	1	8.3%
Good Lessee Maintenance	1	8.3%

Note: Results of this frequency table relate to question 7C4 of the survey questionnaire in Appendix I.

TABLE. III-20: Rather Contract Dryland Slough To		
AGENCY	FREQUENCY	VALID PERCENT
Government	30	40.0%
Private	21	28.0%
No Preference	24	32.0%

Note: Results of this frequency table relate to question 7D1 of the survey questionnaire in Appendix I.

TABLE. III-21: Compensation Form		
FORM	FREQUENCY	VALID PERCENT
Annual Cash	60	80.0%
Annual Income Tax Rebate	3	4.0%
One Time Up Front	12	16.0%

Note: Results of this frequency table relate to question 7D2 of the survey questionnaire in Appendix I.

TABLE. III-22: Prefer To Receive Other Benefits		
Benefit	FREQUENCY	VALID PERCENT
No Other	15	20.3%
Project Signs	29	39.2%
Free Licenses	17	23.0%
Membership	13	17.6%

Note: Results of this frequency table relate to question 7D3 of the survey questionnaire in Appendix I.

TABLE. III-23: Additional Other Benefit #1		
BENEFIT	FREQUENCY	VALID PERCENT
More Compensation	4	19.0%
Access Control	3	14.3%
Capital Improvements	3	14.3%
Allow Livestock Grazing	1	4.8%
Keep Foreigners Out	1	4.8%
40+ Backflood Project	1	4.8%
Public Awareness	1	4.8%
Tax Compensation Payments Over 5 Years	1	4.8%
Longer Term	1	4.8%
Also Have Project Sign	1	4.8%
Waive Property Tax	2	9.5%
Flexible Owner Use	1	4.8%
Inform Owner of Success	1	4.8%

Note: Results of this frequency table relate to question 7D4 of the survey questionnaire in Appendix I.

TABLE. III-24: Reason #1 For Draining Dryland Slough		
REASON	FREQUENCY	VALID PERCENT
Adverse Financial Effect	1	33.3%
Use For Crops	1	33.3%
Too Much Set Aside Now	1	33.3%

Note: Results of this frequency table relate to question 7E of the survey questionnaire in Appendix I.

TABLE. III-25: Reason #2 For Draining Dryland Slough		
REASON	FREQUENCY	VALID PERCENT
Wildlife Depredation	1	100.0%

Note: Results of this frequency table relate to question 7E of the survey questionnaire in Appendix I.

TABLE. III-26: Would Increased Compensation Change Your Mind?		
RESPONSE	FREQUENCY	VALID PERCENT
Yes	2	66.7%
No	1	33.3

Note: Results of this frequency table relate to question 7E of the survey questionnaire in Appendix I.

TABLE. III-27 : Reason #1 For Continuing Without Any Changes

REASON	FREQUENCY	VALID PERCENT
Already Supports Wildlife	3	11.5%
Own Reserve and Management	2	7.7%
Use For Livestock Too	1	3.8%
Enjoy Wildlife	2	7.7%
Keep Future Options Open	1	3.8%
Easy - No Red Tape	2	7.7%
Retain Control	1	3.8%
Wildlife Depredation	2	7.7%
Leave For Pasture	1	3.8%
Retirement	1	3.8%
Compensation Too Low	1	3.8%
Fair To Continue	1	3.8%
Nature Takes Care	1	3.8%
Destroy Natural Environment	1	3.8%
Small Farms Need Cultivation	1	3.8%
Effect On Rest Of Farm	1	3.8%
Hunting Livestock Loss	1	3.8%
Water Is Valuable	1	3.8%
No Practical Options	1	3.8%
Maximize Profits	1	3.8%

Note: Results of this frequency table relate to question 7F of the survey questionnaire in Appendix I.

TABLE. III-28: Reason #2 For Continuing Without Any Changes		
REASON	FREQUENCY	VALID PERCENT
Already Supports Wildlife	1	11.1%
Own Reserve and Management	1	11.1%
Use For Livestock Too	2	22.2%
Doesn't Affect Me	1	11.1%
Retain Control	1	11.1%
Ban All Hunting	1	11.1%
Do Not Need More Habitat	1	11.1%
Project Access Problems	1	11.1%

Note: Results of this frequency table relate to question 7F of the survey questionnaire in Appendix I.

TABLE. III-29: Would Increased Compensation Change Your Mind?		
RESPONSE	FREQUENCY	VALID PERCENT
Yes	9	34.6%
No	17	65.4%

Note: Results of this frequency table relate to question 7F of the survey questionnaire in Appendix I.

TABLE. III-30: Irrigated Slough Area Scenario		
Land Use Option	FREQUENCY	VALID PERCENT
Subdivide and Sell	3	8.6%
Subdivide and Donate	2	5.7%
Lease	1	2.9%
Contract	12	34.3%
Drain	13	37.1%
No Change	4	11.4%

Note: Results of this frequency table relate to question 8 of the survey questionnaire in Appendix I.

TABLE. III-31: Rather Sell Irrigated Slough To		
AGENCY	FREQUENCY	VALID PERCENT
Government	1	33.3%
Private	1	33.3%
No Preference	1	33.3%

Note: Results of this frequency table relate to question 8A1 of the survey questionnaire in Appendix I.

TABLE. III-32: Prefer To Receive Other Benefits		
Benefit	FREQUENCY	VALID PERCENT
No Other	2	66.7%
Project Signs	0	0.0%
Free Licenses	1	33.3%
Membership	0	0.0%

Note: Results of this frequency table relate to question 8A2 of the survey questionnaire in Appendix I.

TABLE. III-33: Additional Other Benefit #1		
BENEFIT	FREQUENCY	VALID PERCENT
More Compensation	1	100.0%

Note: Results of this frequency table relate to question 8A3 of the survey questionnaire in Appendix I.

TABLE. III-34: Rather Donate Irrigated Slough To		
AGENCY	FREQUENCY	VALID PERCENT
Government	0	0.0%
Private	1	50.0%
No Preference	1	50.0%

Note: Results of this frequency table relate to question 8B1 of the survey questionnaire in Appendix I.

TABLE. III-35: Prefer To Receive Other Benefits		
Benefit	FREQUENCY	VALID PERCENT
No Other	2	100.0%
Project Signs	0	0.0%
Free Licenses	0	0.0%
Membership	0	0.0%

Note: Results of this frequency table relate to question 8B2 of the survey questionnaire in Appendix I.

TABLE. III-36: Additional Other Benefit #1		
BENEFIT	FREQUENCY	VALID PERCENT
None Indicated	2	

Note: Results of this frequency table relate to question 8B3 of the survey questionnaire in Appendix I.

TABLE. III-37: Rather Lease Irrigated Slough To		
AGENCY	FREQUENCY	VALID PERCENT
Government	0	0.0%
Private	1	100.0%
No Preference	0	0.0%

Note: Results of this frequency table relate to question 8C1 of the survey questionnaire in Appendix I.

TABLE. III-38: Lease Term		
TERM	FREQUENCY	VALID PERCENT
10 Years	0	0.0%
20 Years	1	100.0%
In Perpetuity	0	0.0%

Note: Results of this frequency table relate to question 8C2 of the survey questionnaire in Appendix I.

TABLE. III-39: Prefer To Receive Other Benefits		
Benefit	FREQUENCY	VALID PERCENT
No Other	0	0.0%
Project Signs	1	100.0%
Free Licenses	0	0.0%
Membership	0	0.0%

Note: Results of this frequency table relate to question 8C3 of the survey questionnaire in Appendix I.

TABLE. III-40: Additional Other Benefit #1		
BENEFIT	FREQUENCY	VALID PERCENT
None Indicated	1	

Note: Results of this frequency table relate to question 8C4 of the survey questionnaire in Appendix I.

TABLE. III-41: Rather Contract Irrigated Slough To		
AGENCY	FREQUENCY	VALID PERCENT
Government	2	16.7%
Private	6	50.0%
No Preference	4	33.3%

Note: Results of this frequency table relate to question 8D1 of the survey questionnaire in Appendix I.

TABLE. III-42: Compensation Form		
FORM	FREQUENCY	VALID PERCENT
Annual Cash	11	91.7%
Annual Income Tax Rebate	0	0.0%
One Time Up Front	1	8.3%

Note: Results of this frequency table relate to question 8D2 of the survey questionnaire in Appendix I.

TABLE. III-43: Prefer To Receive Other Benefits		
Benefit	FREQUENCY	VALID PERCENT
No Other	1	8.3%
Project Signs	6	50.0%
Free Licenses	2	16.7%
Membership	3	25.0%

Note: Results of this frequency table relate to question 8D3 of the survey questionnaire in Appendix I.

TABLE. III-44: Additional Other Benefit #1		
BENEFIT	FREQUENCY	VALID PERCENT
More Compensation	1	25.0%
Capital Improvements	2	50.0%
Own Hunting Rights	1	25.0%

Note: Results of this frequency table relate to question 8D4 of the survey questionnaire in Appendix I.

TABLE. III-45: Reason #1 For Draining Irrigated Slough		
REASON	FREQUENCY	VALID PERCENT
Adverse Financial Effect	1	7.7%
Irrigation Interference	4	30.8%
Use For Crops	5	38.5%
Recover Irrigation Fixed Costs	1	7.7%
High Land Value	1	7.7%
Farming Is Primary Business	1	7.7%

Note: Results of this frequency table relate to question 8E of the survey questionnaire in Appendix I.

TABLE. III-46: Reason #2 For Draining Irrigated Slough		
REASON	FREQUENCY	VALID PERCENT
Adverse Financial Effect	2	33.3%
Irrigation Interference	3	50.0%
Recover Irrigation Fixed Costs	1	16.7%

Note: Results of this frequency table relate to question 8E of the survey questionnaire in Appendix I.

TABLE. III-47: Would Increased Compensation Change Your Mind?		
RESPONSE	FREQUENCY	VALID PERCENT
Yes	7	63.6%
No	4	36.4

Note: Results of this frequency table relate to question 8E of the survey questionnaire in Appendix I.

TABLE. III-48 : Reason #1 For Continuing Without Any Changes		
REASON	FREQUENCY	VALID PERCENT
Own Reserve and Management	1	25.0%
Use For Livestock Too	1	25.0%
Retain Control	1	25.0%
Leave For Pasture	1	25.0%

Note: Results of this frequency table relate to question 8F of the survey questionnaire in Appendix I.

TABLE. III-49: Reason #2 For Continuing Without Any Changes		
REASON	FREQUENCY	VALID PERCENT
Doesn't Affect Me	1	100.0%

Note: Results of this frequency table relate to question 8F of the survey questionnaire in Appendix I.

TABLE. III-50: Would Increased Compensation Change Your Mind?		
RESPONSE	FREQUENCY	VALID PERCENT
Yes	1	25.0%
No	3	75.0%

Note: Results of this frequency table relate to question 8F of the survey questionnaire in Appendix I.

TABLE. III-51: Dryland Woodlot Area Scenario		
LAND USE OPTION	FREQUENCY	VALID PERCENT
Subdivide and Sell	10	6.8%
Subdivide and Donate	5	3.4%
Lease	78	53.1%
Drain	9	6.1%
No Change	45	30.6%

Note: Results of this frequency table relate to question 9 of the survey questionnaire in Appendix I.

TABLE. III-52: Rather Sell Dryland Woodlot To		
AGENCY	FREQUENCY	VALID PERCENT
Government	6	60.0%
Private	3	30.0%
No Preference	1	10.0%

Note: Results of this frequency table relate to question 9A1 of the survey questionnaire in Appendix I.

TABLE. III-53: Prefer To Receive Other Benefits		
Benefit	FREQUENCY	VALID PERCENT
No Other	4	40.0%
Project Signs	2	20.0%
Free Licenses	2	20.0%
Membership	2	20.0%

Note: Results of this frequency table relate to question 9A2 of the survey questionnaire in Appendix I.

TABLE. III-54: Additional Other Benefit #1		
BENEFIT	FREQUENCY	VALID PERCENT
More Compensation	1	50.0%
Capital Improvements	1	50.0%

Note: Results of this frequency table relate to question 9A3 of the survey questionnaire in Appendix I.

TABLE. III-55: Rather Donate Dryland Woodlot To		
AGENCY	FREQUENCY	VALID PERCENT
Government	1	20.0%
Private	3	60.0%
No Preference	1	20.0%

Note: Results of this frequency table relate to question 9B1 of the survey questionnaire in Appendix I.

TABLE. III-56: Prefer To Receive Other Benefits		
Benefit	FREQUENCY	VALID PERCENT
No Other	3	60.0%
Project Signs	1	20.0%
Free Licenses	0	0.0%
Membership	1	20.0%

Note: Results of this frequency table relate to question 9B2 of the survey questionnaire in Appendix I.

TABLE. III-57: Additional Other Benefit #1		
BENEFIT	FREQUENCY	VALID PERCENT
More Compensation	1	100.0%

Note: Results of this frequency table relate to question 9B3 of the survey questionnaire in Appendix I.

TABLE. III-58: Rather Lease Dryland Woodlot To		
AGENCY	FREQUENCY	VALID PERCENT
Government	40	51.3%
Private	12	15.4%
No Preference	26	33.3%

Note: Results of this frequency table relate to question 9C1 of the survey questionnaire in Appendix I.

TABLE. III-59: Lease Term		
TERM	FREQUENCY	VALID PERCENT
10 Years	50	71.4%
20 Years	13	18.6%
In Perpetuity	7	10.0%

Note: Results of this frequency table relate to question 9C2 of the survey questionnaire in Appendix I.

TABLE. III-60: Prefer To Receive Other Benefits		
Benefit	FREQUENCY	VALID PERCENT
No Other	16	20.8%
Project Signs	37	48.1%
Free Licenses	14	18.2%
Membership	10	13.0%

Note: Results of this frequency table relate to question 9C3 of the survey questionnaire in Appendix I.

TABLE. III-61: Additional Other Benefit #1		
BENEFIT	FREQUENCY	VALID PERCENT
More Compensation	8	19.0%
Access Control	3	7.1%
Capital Improvements	5	11.9%
Shorter Lease Term	11	26.2%
Maintain Property Taxes	2	4.8%
Allow Livestock Grazing	1	2.4%
Prefer Monetary Incentives	1	2.4%
Public Awareness	1	2.4%
Close Deer Hunting Season	1	2.4%
Good Lessee Maintenance	2	4.8$
Escape Clause	2	4.8%
Also Have Sign	1	2.4%
Waive Property Taxes	1	2.4%
Flexible Owner Use	1	2.4%
Owner Hunting Rights	1	2.4%
More Owner Consultation	1	2.4%

Note: Results of this frequency table relate to question 9C4 of the survey questionnaire in Appendix I.

TABLE. III-62: Reason #1 For Clearing Dryland Woodlot		
REASON	FREQUENCY	VALID PERCENT
Adverse Financial Effect	2	22.2%
Use For Crops	5	55.6%
Habitat On Marginal Land	1	11.1%
Make A Living	1	11.1%

Note: Results of this frequency table relate to question 9D of the survey questionnaire in Appendix I.

TABLE. III-63: Reason #2 For Clearing Dryland Woodlot		
REASON	FREQUENCY	VALID PERCENT
Use For Crops	1	33.3%
Maintain Land Management	1	33.3%
Doesn't Help Livestock	1	33.3%

Note: Results of this frequency table relate to question 9D of the survey questionnaire in Appendix I.

TABLE. III-64: Would Increased Compensation Change Your Mind?		
RESPONSE	FREQUENCY	VALID PERCENT
Yes	8	100.0%
No	0	0%

Note: Results of this frequency table relate to question 9D of the survey questionnaire in Appendix I.

TABLE. III-65 : Reason #1 For Continuing Without Any Changes		
REASON	FREQUENCY	VALID PERCENT
Already Supports Wildlife	4	9.3%
Own Reserve and Management	4	9.3%
Use For Livestock Too	11	25.6%
Enjoy Wildlife	1	2.3%
Keep Future Options Open	3	7.0%
Few People Subdivide	1	2.3%
Don't Want To Clear	2	4.7%
Retain Control	4	9.3%
Erosion control	1	2.3%
No Bother To Leave It	1	2.3%
Can Afford To Leave It	1	2.3%
To Much Habitat Interference	1	2.3%
Nature Take Own Course	1	2.3%
Land Is Poor	1	2.3%
Natural Appeal	2	4.7%
Project Access Problem	2	4.7%
Wildlife Benefits Farm	1	2.3%
Enough Game Now	1	2.3%
No Practical Options	1	2.3%

Note: Results of this frequency table relate to question 9E of the survey questionnaire in Appendix I.

TABLE. III-66: Reason #2 For Continuing Without Any Changes		
REASON	FREQUENCY	VALID PERCENT
Already Supports Wildlife	8	33.3
Own Reserve and Management	2	8.3
Use For Livestock Too	1	4.2
Doesn't Affect Me	1	4.2
Easy - No Red Tape	1	4.2
Retain Control	2	8.3
Erosion Control	2	8.3
No Development Needed	1	4.2
Compensation Too Low	1	4.2
Can Not Clear All Trees	1	4.2
Renters - Rock The Boat	1	4.2
Project Access Problems	1	4.2
Keep Without Payment	1	4.2
Enough Game Now	1	4.2

Note: Results of this frequency table relate to question 9E of the survey questionnaire in Appendix I.

TABLE. III-67: Would Increased Compensation Change Your Mind?		
RESPONSE	FREQUENCY	VALID PERCENT
Yes	12	29.3%
No	29	70.7%

Note: Results of this frequency table relate to question 9E of the survey questionnaire in Appendix I.

TABLE. III-68: Marginal Compensation With a Certificate of Recognition		
MARGINAL COMPENSATION	FREQUENCY	VALID PERCENT
More	13	8.8%
Less	4	2.7%
Same	131	88.5%

Note: Results of this frequency table relate to question 10A of the survey questionnaire in Appendix I.

TABLE. III-69: Marginal Compensation With Free Hunting/Fishing Licenses		
MARGINAL COMPENSATION	FREQUENCY	VALID PERCENT
More	4	2.7%
Less	17	11.5%
Same	127	85.8%

Note: Results of this frequency table relate to question 10B of the survey questionnaire in Appendix I.

TABLE. III-70: Marginal Compensation With Free Lifetime Membership		
MARGINAL COMPENSATION	FREQUENCY	VALID PERCENT
More	6	4.1%
Less	6	4.1%
Same	136	91.9%

Note: Results of this frequency table relate to question 10C of the survey questionnaire in Appendix I.

TABLE. III-71: Marginal Compensation With Publicly Posted Project Signs		
MARGINAL COMPENSATION	FREQUENCY	VALID PERCENT
More	12	8.1%
Less	7	4.7%
Same	129	87.2%

Note: Results of this frequency table relate to question 10D of the survey questionnaire in Appendix I.

TABLE. III-72: Farmers Responsible To All Those Now Living		
Rank	FREQUENCY	VALID PERCENT
Strongly Agree	44	29.7%
Agree	80	54.1%
Neutral	7	4.7%
Disagree	12	8.1%
Strongly Disagree	5	3.4%

Note: Results of this frequency table relate to question 11 of the survey questionnaire in Appendix I.

TABLE. III-73: Farmers Responsible To Future Generations		
Rank	FREQUENCY	VALID PERCENT
Strongly Agree	45	30.4%
Agree	85	57.4%
Neutral	6	4.1%
Disagree	9	6.1%
Strongly Disagree	3	2.0%

Note: Results of this frequency table relate to question 12 of the survey questionnaire in Appendix I.

TABLE. III-74: Government Responsible To Enforce Habitat Preservation		
Rank	FREQUENCY	VALID PERCENT
Strongly Agree	14	9.5%
Agree	43	29.1%
Neutral	17	11.5%
Disagree	38	25.7%
Strongly Disagree	36	24.3%

Note: Results of this frequency table relate to question 13 of the survey questionnaire in Appendix I.

TABLE. III-75: Government Responsible To Compensate Farmers		
Rank	FREQUENCY	VALID PERCENT
Strongly Agree	50	33.8%
Agree	74	50.0%
Neutral	13	8.8%
Disagree	8	5.4%
Strongly Disagree	3	2.0%

Note: Results of this frequency table relate to question 14 of the survey questionnaire in Appendix I.

TABLE. III-76: Farmers, In General, Value Wildlife Habitat On Their Farms		
Rank	FREQUENCY	VALID PERCENT
Strongly Agree	32	21.8%
Agree	68	46.3%
Neutral	17	11.6%
Disagree	27	18.4%
Strongly Disagree	3	2.0%

Note: Results of this frequency table relate to question 15 of the survey questionnaire in Appendix I.

TABLE. III-77: I Value Wildlife Habitat On My Farm		
Rank	FREQUENCY	VALID PERCENT
Strongly Agree	89	64.5%
Agree	54	36.7%
Neutral	3	2.0%
Disagree	0	0.0%
Strongly Disagree	1	0.7%

Note: Results of this frequency table relate to question 16 of the survey questionnaire in Appendix I.

TABLE. III-78: Increase Wildlife Populations Increases Farm Market Value		
Rank	FREQUENCY	VALID PERCENT
Strongly Agree	8	5.4%
Agree	30	20.3%
Neutral	42	28.4%
Disagree	55	37.2%
Strongly Disagree	13	8.8%

Note: Results of this frequency table relate to question 17 of the survey questionnaire in Appendix I.

TABLE. III-79: I Will Alter Less Habitat In The Future If I Am Compensated		
Rank	FREQUENCY	VALID PERCENT
Strongly Agree	35	23.8%
Agree	80	54.4%
Neutral	16	10.9%
Disagree	13	8.8%
Strongly Disagree	1	2.0%

Note: Results of this frequency table relate to question 18 of the survey questionnaire in Appendix I.

TABLE. III-80: My Neighbours Will Alter Less Habitat If They Are Compensated		
Rank	FREQUENCY	VALID PERCENT
Strongly Agree	19	14.0%
Agree	59	43.4%
Neutral	44	32.4%
Disagree	12	8.8%
Strongly Disagree	2	1.5%

Note: Results of this frequency table relate to question 19 of the survey questionnaire in Appendix I.

TABLE. III-81: Shelterbelt-Dryland Cultivation Interaction For Profit		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	60	40.5%
Compatible	60	40.5%
Neutral	11	7.4%
Competitive	15	10.1%
Strongly Competitive	2	1.4%

Note: Results of this frequency table relate to question 20 of the survey questionnaire in Appendix I.

TABLE. III-82: Ditch Cover-Dryland Cultivation Interaction For Profit		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	30	20.3%
Compatible	55	37.2%
Neutral	41	27.7%
Competitive	19	12.8%
Strongly Competitive	3	2.0%

Note: Results of this frequency table relate to question 20 of the survey questionnaire in Appendix I.

TABLE. III-83: Grass Waterways-Dryland Cultivation Interaction For Profit		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	45	30.6%
Compatible	53	36.1%
Neutral	32	21.8%
Competitive	16	10.9%
Strongly Competitive	1	0.7%

Note: Results of this frequency table relate to question 20 of the survey questionnaire in Appendix I.

TABLE. III-84: Sloughs-Dryland Cultivation Interaction For Profit		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	22	15.1%
Compatible	36	24.7%
Neutral	29	19.9%
Competitive	47	32.2%
Strongly Competitive	12	8.2%

Note: Results of this frequency table relate to question 20 of the survey questionnaire in Appendix I.

TABLE. III-85: Woodlots-Dryland Cultivation Interaction For Profit		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	21	14.2%
Compatible	40	27.0%
Neutral	37	25.0%
Competitive	42	28.4%
Strongly Competitive	8	5.4%

Note: Results of this frequency table relate to question 20 of the survey questionnaire in Appendix I.

TABLE. III-86: Shelterbelt-Irrigation Cultivation Interaction For Profit		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	25	19.4%
Compatible	58	45.0%
Neutral	25	19.4%
Competitive	18	14.0%
Strongly Competitive	3	2.3%

Note: Results of this frequency table relate to question 20 of the survey questionnaire in Appendix I.

TABLE. III-87: Ditch Cover-Irrigation Cultivation Interaction For Profit		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	22	16.3%
Compatible	53	39.3%
Neutral	37	27.4%
Competitive	19	14.1%
Strongly Competitive	4	3.0%

Note: Results of this frequency table relate to question 20 of the survey questionnaire in Appendix I.

TABLE. III-88: Grass Waterways-Irrigation Cultivation Interaction For Profit		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	29	21.6%
Compatible	53	39.6%
Neutral	28	20.9%
Competitive	17	12.7%
Strongly Competitive	7	5.2%

Note: Results of this frequency table relate to question 20 of the survey questionnaire in Appendix I.

TABLE. III-89: Sloughs-Irrigation Cultivation Interaction For Profit		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	14	10.1%
Compatible	37	26.6%
Neutral	23	16.5%
Competitive	44	31.7%
Strongly Competitive	21	15.1%

Note: Results of this frequency table relate to question 20 of the survey questionnaire in Appendix I.

TABLE. III-90: Woodlots-Irrigation Cultivation Interaction For Profit		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	13	9.6%
Compatible	29	21.3%
Neutral	33	24.3%
Competitive	36	26.5%
Strongly Competitive	25	18.4%

Note: Results of this frequency table relate to question 20 of the survey questionnaire in Appendix I.

TABLE. III-91: Shelterbelt-Dryland Pasture Interaction For Profit		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	57	38.5%
Compatible	72	48.6%
Neutral	17	11.5%
Competitive	2	1.4%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 20 of the survey questionnaire in Appendix I.

TABLE. III-92: Ditch Cover-Dryland Pasture Interaction For Profit		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	37	25.0%
Compatible	68	45.9%
Neutral	34	23.0%
Competitive	7	4.7%
Strongly Competitive	2	1.4%

Note: Results of this frequency table relate to question 20 of the survey questionnaire in Appendix I.

TABLE. III-93: Sloughs-Dryland Pasture Interaction For Profit		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	56	38.1%
Compatible	73	49.7%
Neutral	9	6.1%
Competitive	8	5.4%
Strongly Competitive	1	0.7%

Note: Results of this frequency table relate to question 20 of the survey questionnaire in Appendix I.

TABLE. III-94: Woodlots-Dryland Pasture Interaction For Profit		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	37	25.2%
Compatible	75	51.0%
Neutral	23	15.6%
Competitive	9	6.1%
Strongly Competitive	3	2.0%

Note: Results of this frequency table relate to question 20 of the survey questionnaire in Appendix I.

TABLE. III-95: Shelterbelt-Irrigated Pasture Interaction For Profit		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	38	27.1%
Compatible	66	47.1%
Neutral	23	16.4%
Competitive	11	7.9%
Strongly Competitive	2	1.4%

Note: Results of this frequency table relate to question 20 of the survey questionnaire in Appendix I.

TABLE. III-96: Ditch Cover-Irrigated Pasture Interaction For Profit		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	26	18.4%
Compatible	73	51.8%
Neutral	28	19.9%
Competitive	11	7.8%
Strongly Competitive	3	2.1%

Note: Results of this frequency table relate to question 20 of the survey questionnaire in Appendix I.

TABLE. III-97: Sloughs-Irrigated Pasture Interaction For Profit		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	28	20.0%
Compatible	61	43.6%
Neutral	22	15.7%
Competitive	27	19.3%
Strongly Competitive	2	1.4%

Note: Results of this frequency table relate to question 20 of the survey questionnaire in Appendix I.

TABLE. III-98: Woodlots-Irrigated Pasture Interaction For Profit		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	21	14.9%
Compatible	62	44.0%
Neutral	25	17.7%
Competitive	26	18.4%
Strongly Competitive	7	5.0%

Note: Results of this frequency table relate to question 20 of the survey questionnaire in Appendix I.

TABLE. III-99: Shelterbelt-Dryland Cultivation Interaction For Wildlife		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	70	47.3%
Compatible	74	50.0%
Neutral	4	2.7%
Competitive	0	0.0%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 21 of the survey questionnaire in Appendix I.

TABLE. III-100: Ditch Cover-Dryland Cultivation Interaction For Wildlife		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	61	41.2%
Compatible	80	54.1%
Neutral	7	4.7%
Competitive	0	0.0%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 21 of the survey questionnaire in Appendix I.

TABLE. III-101: Grass Waterways-Dryland Cultivation Interaction For Wildlife		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	58	39.5%
Compatible	78	53.1%
Neutral	11	7.5%
Competitive	0	0.0%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 21 of the survey questionnaire in Appendix I.

TABLE. III-102: Sloughs-Dryland Cultivation Interaction For Wildlife		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	88	59.5%
Compatible	56	37.8%
Neutral	3	2.0%
Competitive	0	0.0%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 21 of the survey questionnaire in Appendix I.

TABLE. III-103: Woodlots-Dryland Cultivation Interaction For Wildlife		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	92	62.2%
Compatible	52	35.1%
Neutral	3	2.0%
Competitive	0	0.0%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 21 of the survey questionnaire in Appendix I.

TABLE. III-104: Shelterbelt-Irrigation Cultivation Interaction For Wildlife		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	62	43.1%
Compatible	74	51.4%
Neutral	8	5.6%
Competitive	0	0.0%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 21 of the survey questionnaire in Appendix I.

TABLE. III-105: Ditch Cover-Irrigation Cultivation Interaction For Wildlife		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	64	44.8%
Compatible	73	51.0%
Neutral	6	4.2%
Competitive	0	0.0%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 21 of the survey questionnaire in Appendix I.

TABLE. III-106: Grass Waterways-Irrigation Cultivation Interaction For Wildlife		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	59	41.5%
Compatible	68	47.9%
Neutral	14	9.9%
Competitive	1	0.7%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 21 of the survey questionnaire in Appendix I.

TABLE. III-107: Sloughs-Irrigation Cultivation Interaction For Wildlife		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	77	53.5%
Compatible	60	41.7%
Neutral	6	4.2%
Competitive	1	0.7%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 21 of the survey questionnaire in Appendix I.

TABLE. III-108: Woodlots-Irrigation Cultivation Interaction For Wildlife		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	83	57.6%
Compatible	53	36.8%
Neutral	6	4.2%
Competitive	2	1.4%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 21 of the survey questionnaire in Appendix I.

TABLE. III-109: Shelterbelt-Dryland Pasture Interaction For Wildlife		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	74	50.0%
Compatible	68	45.9%
Neutral	6	4.1%
Competitive	0	0.0%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 21 of the survey questionnaire in Appendix I.

TABLE. III-110: Ditch Cover-Dryland Pasture Interaction For Wildlife		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	71	48.3%
Compatible	71	48.3%
Neutral	5	3.4%
Competitive	0	0.0%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 21 of the survey questionnaire in Appendix I.

TABLE. III-111: Sloughs-Dryland Pasture Interaction For Wildlife		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	90	61.2%
Compatible	53	36.1%
Neutral	3	2.0%
Competitive	1	0.7%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 21 of the survey questionnaire in Appendix I.

TABLE. III-112: Woodlots-Dryland Pasture Interaction For Wildlife		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	92	62.2%
Compatible	53	35.8%
Neutral	3	2.0%
Competitive	0	0.0%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 21 of the survey questionnaire in Appendix I.

TABLE. III-113: Shelterbelt-Irrigated Pasture Interaction For Wildlife		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	67	46.9%
Compatible	71	49.7%
Neutral	5	3.5%
Competitive	0	0.0%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 21 of the survey questionnaire in Appendix I.

TABLE. III-114: Ditch Cover-Irrigated Pasture Interaction For Wildlife		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	66	46.2%
Compatible	72	50.3%
Neutral	5	3.5%
Competitive	0	0.0%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 21 of the survey questionnaire in Appendix I.

TABLE. III-115: Sloughs-Irrigated Pasture Interaction For Wildlife		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	84	58.3%
Compatible	54	37.5%
Neutral	4	2.8%
Competitive	2	1.4%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 21 of the survey questionnaire in Appendix I.

TABLE. III-116: Woodlots-Irrigated Pasture Interaction For Wildlife

Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	82	56.9%
Compatible	57	39.6%
Neutral	4	2.8%
Competitive	1	0.7%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 21 of the survey questionnaire in Appendix I.

TABLE. III-117: Shelterbelt-Dryland Cultivation Interaction For Erosion Control

Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	102	68.9%
Compatible	44	29.7%
Neutral	2	1.4%
Competitive	0	0.0%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 22 of the survey questionnaire in Appendix I.

TABLE. III-118: Ditch Cover-Dryland Cultivation Interaction For Erosion Control

Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	67	45.3%
Compatible	67	45.3%
Neutral	13	8.8%
Competitive	1	0.7%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 22 of the survey questionnaire in Appendix I.

TABLE. III-119: Grass Waterways-Dryland Cultivation Interaction For Erosion Control		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	94	63.5%
Compatible	49	33.1%
Neutral	4	2.7%
Competitive	1	0.7%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 22 of the survey questionnaire in Appendix I.

TABLE. III-120: Sloughs-Dryland Cultivation Interaction For Erosion Control		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	52	35.1%
Compatible	62	41.9%
Neutral	30	20.3%
Competitive	3	2.0%
Strongly Competitive	1	0.7%

Note: Results of this frequency table relate to question 22 of the survey questionnaire in Appendix I.

TABLE. III-121: Woodlots-Dryland Cultivation Interaction For Erosion Control		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	71	48.0%
Compatible	68	45.9%
Neutral	9	6.1%
Competitive	0	0.0%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 22 of the survey questionnaire in Appendix I.

TABLE. III-122: Shelterbelt-Irrigation Cultivation Interaction For Erosion Control		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	81	57.0%
Compatible	56	39.4%
Neutral	5	3.5%
Competitive	0	0.0%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 22 of the survey questionnaire in Appendix I.

TABLE. III-123: Ditch Cover-Irrigation Cultivation Interaction For Erosion Control		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	59	41.8%
Compatible	67	47.5%
Neutral	15	10.6%
Competitive	0	0.0%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 22 of the survey questionnaire in Appendix I.

TABLE. III-124: Grass Waterways-Irrigation Cultivation Interaction For Erosion Control		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	79	55.2%
Compatible	54	37.8%
Neutral	8	5.6%
Competitive	2	1.4%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 22 of the survey questionnaire in Appendix I.

TABLE. III-125: Sloughs-Irrigation Cultivation Interaction For Erosion Control		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	46	32.4%
Compatible	64	45.1%
Neutral	27	19.0%
Competitive	5	3.5%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 22 of the survey questionnaire in Appendix I.

TABLE. III-126: Woodlots-Irrigation Cultivation Interaction For Erosion Control		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	60	42.0%
Compatible	72	50.3%
Neutral	10	7.0%
Competitive	1	0.7%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 22 of the survey questionnaire in Appendix I.

TABLE. III-127: Shelterbelt-Dryland Pasture Interaction For Erosion Control		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	73	49.3%
Compatible	49	33.1%
Neutral	25	16.9%
Competitive	1	0.7%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 22 of the survey questionnaire in Appendix I.

TABLE. III-128: Ditch Cover-Dryland Pasture Interaction For Erosion Control		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	58	39.2%
Compatible	60	40.5%
Neutral	30	20.3%
Competitive	0	0.0%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 22 of the survey questionnaire in Appendix I.

TABLE. III-129: Sloughs-Dryland Pasture Interaction For Erosion Control		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	54	36.5%
Compatible	56	37.8%
Neutral	36	24.3%
Competitive	2	1.4%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 22 of the survey questionnaire in Appendix I.

TABLE. III-130: Woodlots-Dryland Pasture Interaction For Erosion Control		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	68	45.9%
Compatible	55	37.2%
Neutral	25	16.9%
Competitive	0	0.0%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 22 of the survey questionnaire in Appendix I.

TABLE. III-131: Shelterbelt-Irrigated Pasture Interaction For Erosion Control		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	58	40.8%
Compatible	56	39.4%
Neutral	27	19.0%
Competitive	1	0.7%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 22 of the survey questionnaire in Appendix I.

TABLE. III-132: Ditch Cover-Irrigated Pasture Interaction For Erosion Control		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	54	37.8%
Compatible	60	42.0%
Neutral	29	20.3%
Competitive	0	0.0%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 22 of the survey questionnaire in Appendix I.

TABLE. III-133: Sloughs-Irrigated Pasture Interaction For Erosion Control		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	44	30.6%
Compatible	59	41.0%
Neutral	38	26.4%
Competitive	3	2.1%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 22 of the survey questionnaire in Appendix I.

TABLE. III-134: Woodlots-Irrigated Pasture Interaction For Erosion Control		
Rank	FREQUENCY	VALID PERCENT
Strongly Compatible	58	40.3%
Compatible	56	38.9%
Neutral	29	20.1%
Competitive	1	0.7%
Strongly Competitive	0	0.0%

Note: Results of this frequency table relate to question 22 of the survey questionnaire in Appendix I.

TABLE. III-135: Primary Operation		
ENTERPRISE	FREQUENCY	VALID PERCENT
Grain	70	47.3%
Cattle	54	36.5%
Hogs	5	3.4%
Dairy	3	2.0%
Forage	9	6.1%
Other	7	4.7%

Note: Results of this frequency table relate to question 23 of the survey questionnaire in Appendix I.

TABLE. III-136: Net Household Income		
INCOME COHORT	FREQUENCY	VALID PERCENT
< $10,000	20	14.4%
$10,000 - $19,999	21	15.1%
$20,000 - $29,999	18	12.9%
30,000 - $39,999	29	20.9%
$40,000 - $49,999	14	10.1%
$50,000 - $59,999	13	9.4%
$60,000 - $69,999	6	4.3%
$70,000 - $79,999	5	3.6%
$80,000 - $89,999	3	2.2%
$90,000 - $99,999	2	1.4%
$100,000 and over	8	5.8%

Note: Results of this frequency table relate to question 25 of the survey questionnaire in Appendix I.