UNIVERSITY OF ALBERTA

RISK AND RETURNS IN CATTLE FINISHING IN ALBERTA

BY

JAMES RYAN UNTERSCHULTZ

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science.

IN

AGRICULTURAL ECONOMICS

DEPARTMENT OF RURAL ECONOMY

EDMONTON, ALBERTA

FALL 1991

ISBN 0-315-70194-3

UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR: James Ryan Unterschultz

TITLE OF THESIS: Risk And Returns In Cattle Finishing In Alberta

DEGREE: Master of Science

YEAR THIS DEGREE GRANTED: Fall 1991

James Unterschultz

432 Huntington Hill N.W.

45 Ave 104 A St.

Edmonton, Alberta

T6H 5W6

DATE: Aug 1, 1991

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled RISK AND RETURNS IN CATTLE FINISHING IN ALBERTA submitted by JAMES RYAN UNTERSCHULTZ in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in AGRICULTURAL ECONOMICS.

F. S. Novak Supervisor

G. A. Mumey

G. W. Mathison

DATE: July 29/91

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 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.

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.

Table of Contents

List of Tables

Table of Figures

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.

---

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

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.

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 and optimal hedging. 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.

---

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.

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

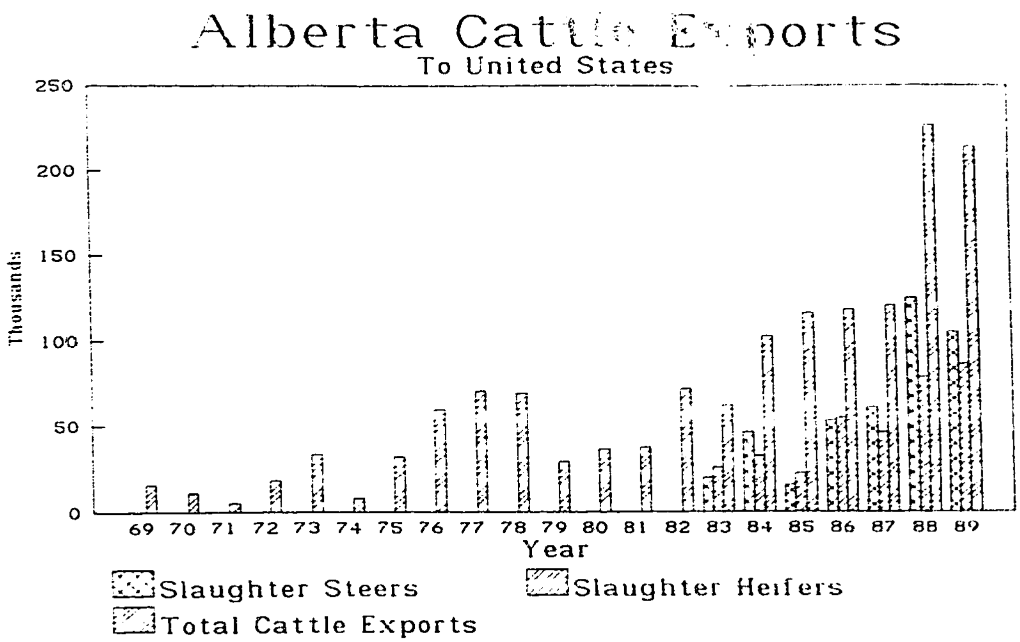
Alberta feedlots produce more slaughter beef cattle than are consumed in Alberta. Therefore, Alberta exports live slaughter cattle and beef to other provinces and other countries. The main importing country of Alberta slaughter cattle is the United States.

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 1980's. 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

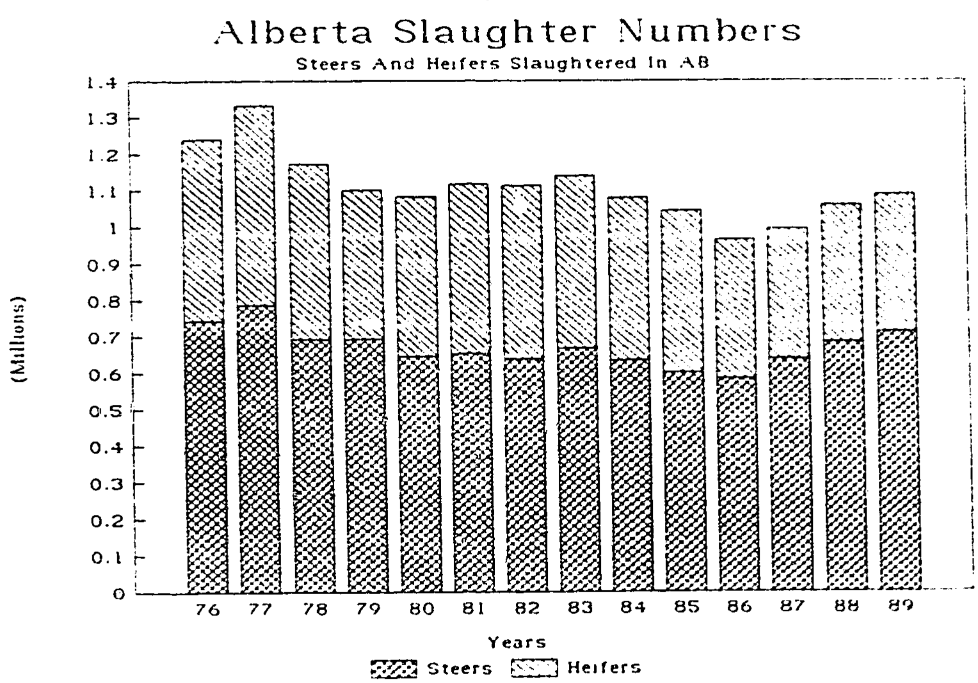


Figure 3

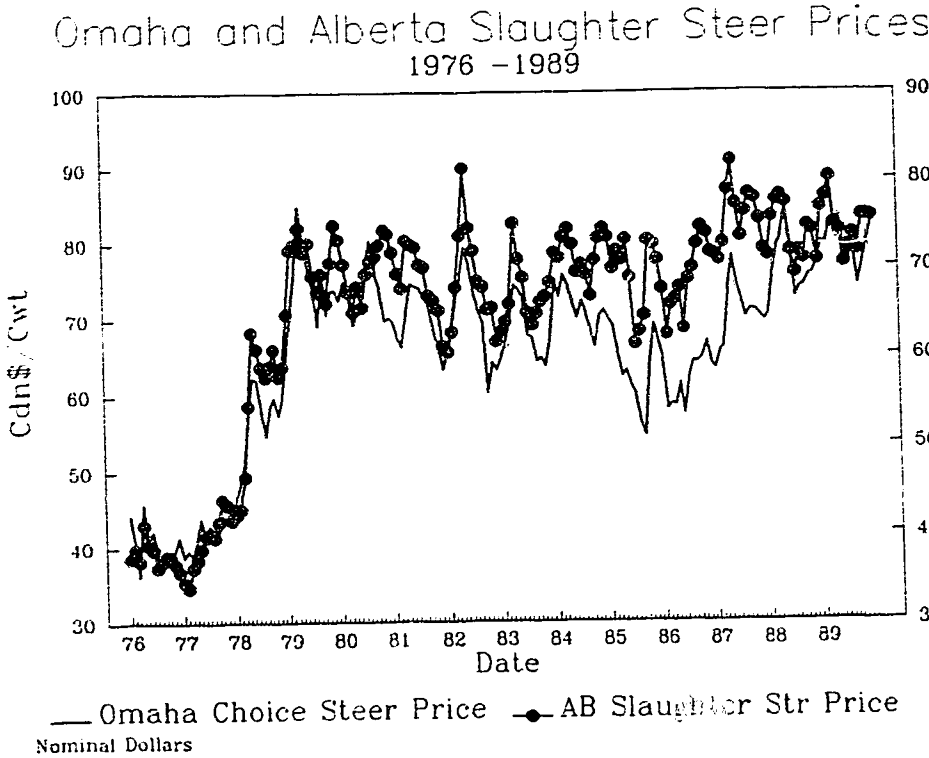


Table 1
Correlation Between Alberta And Omaha Slaughter Steer Prices
All Prices Are Nominal

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 1980's appear to show a closer linkage between the two markets than the early 1980's.

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 1980's may find the Chicago Mercantile Exchange (CME) futures market more useful for managing cattle feeding risk than during the 1970's or the early 1980's.

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 of 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):

> ...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.

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 1980's than in the early part of the 1980's or later 1970's. 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.

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.

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. The chapter concludes with a detailed discussion on optimal hedge ratios and estimating optimal hedge ratios. 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 (Barry and Robison (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.

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

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.

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 of 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 Brown (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.

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.

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 et al. (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 (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 et al. (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.

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, and participating in public programs. 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.

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, 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. A detailed discussion of optimal hedge theory and optimal hedge estimation concludes the chapter.

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 more distant futures (beyond 15 months) the cash market was a better predictor of the future 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 $Spot\ Price = \alpha + \beta(prior\ futures\ price) + residual$.

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) concluded using the CAPM 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.

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

---

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.

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 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

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..

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.

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. Brokers 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.

---

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.

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 forecast 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 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 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 Hartman (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

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.

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.

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, Cumby and Figlewski (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.

This author 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, Musser and Mason (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.

This author in reply to the review by Blank, suggests 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. $$R_{p.ce} = X_s E(\tilde{R}_s) + X_f E(\tilde{R}_f) - \frac{\lambda}{2}(X_s^2\sigma_s^2 + X_f^2\sigma_f^2 + 2X_sX_f\sigma_{sf})$$

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 the 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 $\lambda \to \infty$. 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 Moss 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.

---

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

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 describe by Bond et al. (1987) follows:

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

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 u and v are from OLS estimates of the linear models in equation 23. Meyers 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 differ-

14 ARCH stands for Autoregressive Conditional Heteroskedastic

ent 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 Meyers 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 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 investment and participation 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. Finally the definition of the optimal hedge and the calculation of the optimal hedge or minimum variance hedge was outlined. This information is used in the risk management strategies tested in this study.

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 was 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 .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 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 was collected from January 14, 1976 to December 13, 1989.

4.3 Live Cattle Prices

The data source for all cattle prices was Alberta Agriculture Economic Services. Prices were in dollars per hundred weight ($/cwt). Data was 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.

4.4 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.

4.5 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 was 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 was collected on the monthly totals for the U.S. 7 state cattle on feed survey. Data is the total number of head on feed divided by 1000.

4.6 Government Programs

The NTSP data source is 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.

4.7 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 MSE's 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 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, was 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[15]. 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.

The research uses the ex ante approach as much as possible in the development of the model. Only data that is 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

---

15 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.

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. This is beyond the scope of this study.

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:

28. $strprice_t = \alpha + feederprice_{t-3}a + baropen_{t-3}b + future_{j,Cdn\$,t-3}c + \mu$

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[16]. 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 28 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:

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

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

30. $\hat{\mu} = \hat{\mu}_{-1}\rho + \upsilon$

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.

---

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

31. $Pstr\hat{price}_{t+3} = x'_t \hat{\theta}_t + \hat{\rho}_t \hat{\mu}_t$

The last term in equation 31 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.[17] 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.

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

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.

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 time period 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:

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

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 32 are converted to June 1981 dollars using the CPI. Equation 32 forecasts slaughter steer prices in June 1981 dollars. The exchange rate forecast was discussed in chapter 3. The spot exchange rate at time t is used as the predicted exchange rate in time period 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[18]. 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.[19]

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

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[20]. 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

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

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

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

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.

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.[21]

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.

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.

21 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 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.[22] 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.

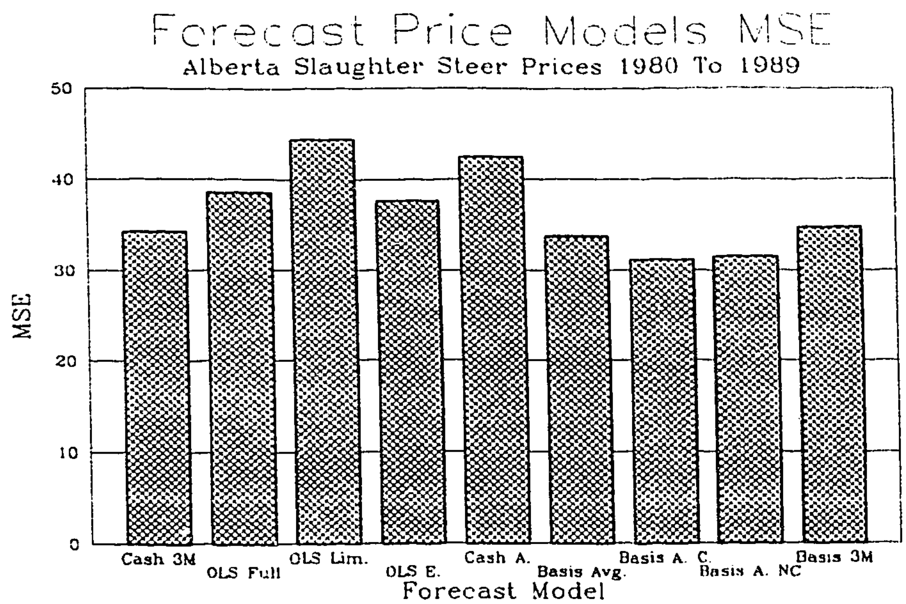
5.3.3 Choice of Alberta Slaughter Steer Price Forecasting Model

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.

22 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

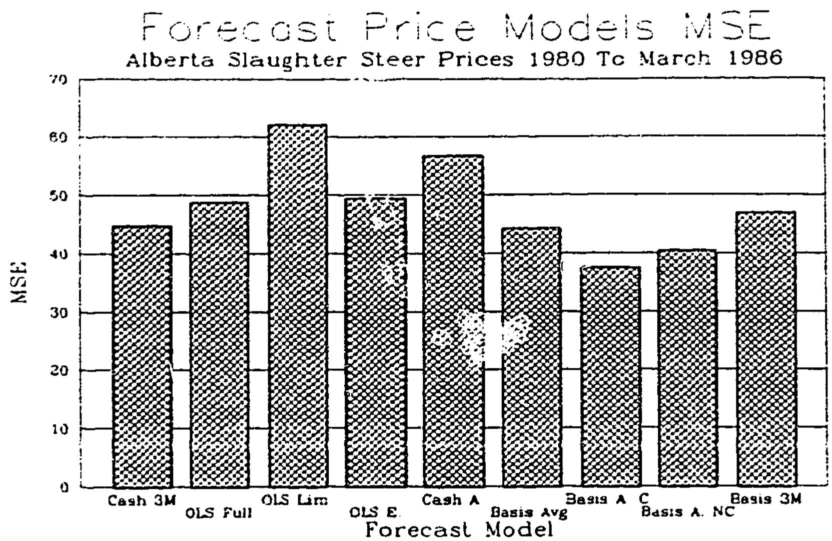
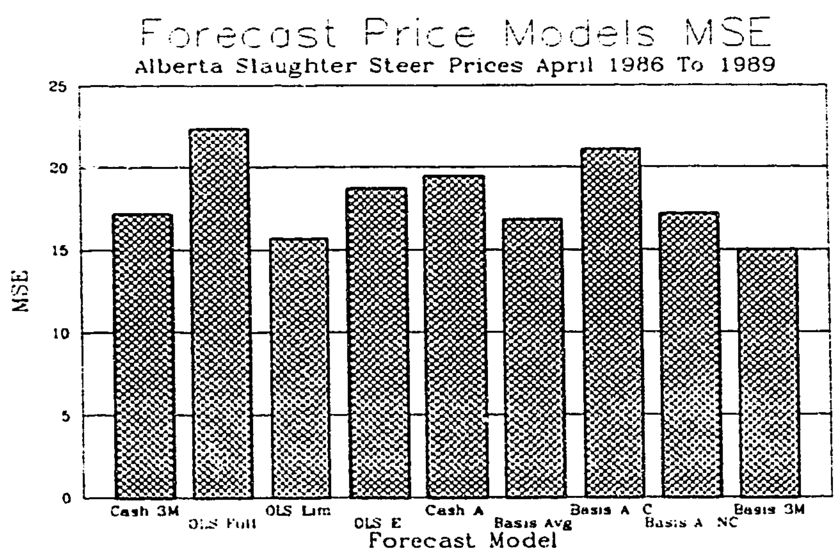


Figure 6



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:

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

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 33 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

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.

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.[23] 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.

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).

23 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.

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 (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:

$$34.\quad Feedcost_{t-3} = ration \times baropen_{t-3} - bamount \times crowben_{t-3} + bamount \times bartran_{t-3} + feedproc_{t-3}$$

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:

$$35.\quad Feeduse_{t-3} = (1 - deathlos) \times lotsize \times feedcon \times feeddays_{t-3} \times .001 + deathlos \times lotsize \times feedcon \times feeddays_{t-3} \times .25 \times .001$$

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 34 and 35 to get:

$$36.\quad Tfeedcost_{t-3} = feedcost_{t-3} \times feeduse_{t-3}$$

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

37. $Feedercost_{t-3} = feeder\,price_{t-3} \times feederwt_{t-3} \times lotsize \times .01 \times 2.2046 +$

$$\frac{truck_{t-3} \times distance}{truckcap} \times lotsize + buyer_{t-3} \times lotsize$$

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:

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

$$deathlos \times .25) + treat_{t-3} \times lotsize + process_{t-3} \times lotsize$$

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 36, 37 and 38:

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

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:

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

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 40 with the nominal Alberta steer price:

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

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:

42. $$ntsphead_t = ntsphead_{t-3} \times \frac{CPI_t}{CPI_{t-3}}$$

and for January, 1989 to December, 1989 as:

43. $$ntsphead_t = ntsphead_{t-2} \times \frac{CPI_t}{CPI_{t-2}}$$

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 41 with either equation 42 or 43:

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

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 39 with 41 or 44 and adjusts equation 39 for 3 months of inflation on input costs to get:

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

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 45 and 39 to get:

46.

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

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.[24] The net returns in Table 8 for the period April 1986 to December 1989 with participation in the NTSP is 2.37%.

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.

24 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

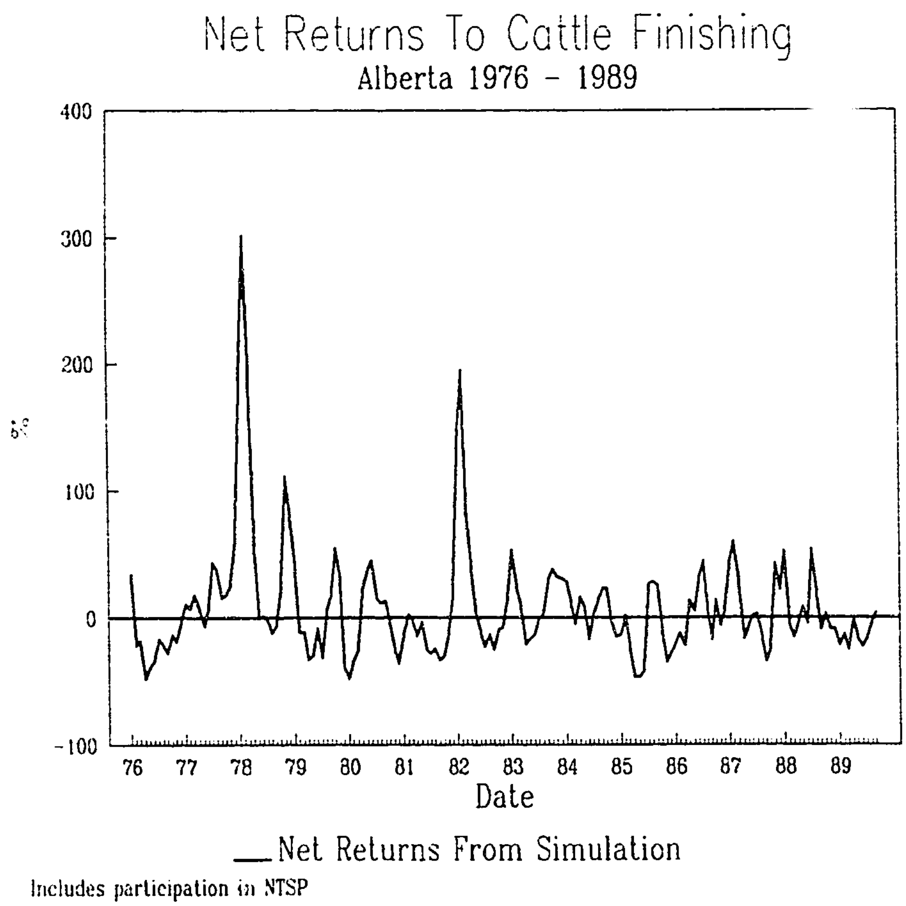
Year	Net Revenue Mean Per Lot Dec. 1989 $	Net Revenue Std. Dev.[1]	Net Returns Mean Real % Annual	Net Returns Std. Dev.[1]
76-89	621.86	10124.06	8.01[2]a	45.16
76-79	2807.13	13672.95	19.69abcd	65.95
80-89	-197.62	8345.57	3.63c	33.64
80-Mar86	-330.14	9703.49	4.39b	38.55
Apr86-89	23.26	5471.00	2.37d	23.64

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).

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 41 is replaced by the forecast price from equation 33. 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



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

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

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 40 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 39 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 46. 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 46 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[25]. 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.

25 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 49 and 50. 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. 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 brokers 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. Brokers 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:

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

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.

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

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

51. $$Hedgelot_{can\$,t} = Hedge_{can\$,t} \times finalwt_t \times \frac{2.2046}{100}$$

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 39 and 41. Brokers 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 45 and equation 46.

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

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

where:
Tfeedcost, equation 36, is total feed cost per lot,
feedercost, equation 37, is feeder purchase and marketing costs,
feedlot, equation 38, are total feedlot charges,
broker is the brokers 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)[26]. 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.[27] The net 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[28].

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.[29] The break down of different time periods in the tables gives a different picture. The period 1980 to March 1986 shows that 100% hedg-

---

26 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.

27 The compounding calculation of a rate of return per lot to an annual rate in equation 42 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 42 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. This gives some possible explanation for different results where studies measure risk using monthly or yearly cash flows such as Gillis et al. (1989).

28 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.

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

ing 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.

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.

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 47 with costs adjusted for brokerage fees as in equation 52. 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.

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.[30] 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[31]. Therefore the

30 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.

31 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.

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[32]. The following model shows one set of data points in the estimated model.

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

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 Decemner 1989. This method of updating should capture any possible changes in the 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.[33] 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

---

32 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.

33 A simplified Meyers and Thompson model (from equation 27)
$Strprice_t = \alpha + (Future_{Can\$,t} - Future_{Can\$,t-3})\gamma + strprice_{t-3}a + future_{t-3}b + \mu$ 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 Meyers and Thompson model are reported.

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.[34] 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.

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.

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.

34 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.

55. $Hedgelot_{cdns,t} = \left(Hedge_{cdns,t} \times finalwt_t \times \frac{2.2046}{100} \right) \times Y_{t-3}$

Brokers costs are similarly adjusted using the optimal hedge ratio.

56. $Totalcost_{t-3,h} = Tfeedcost_{t-3} + feedercost_{t-3} + feedlot_{t-3} +$

$$\left(broker_{t-3} \times finalwt_{t-3} \times \frac{2.2046}{40000} \right) \times Y_{t-3}$$

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.

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 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.

The revenue forecasts with optimal hedging use the same format as the 100% hedge and hold strategy. The total revenue forecast is equation 47 with costs adjusted for brokerage fees as in equation 56. 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 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.

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.

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.

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 returns 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 48.

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 33, 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:

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

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

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 brokers fees if hedging occurs. No inflation adjustment on brokers 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:

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

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 33
Forecast Selective Investment Strategy And MSE
Feeder Cattle Or T-Bills
Without Hedging And Without NTSP

Year	Net Revenue Mean Per Lot Dec. 1989 $	Net Returns Mean % Annual	MSE Net Returns
1980-89[1]	3362.61	9.20	743.8
1980-Mar86	3979.37	11.40	1192.8
Apr1986-89	2334.68	5.53	5.5

1. The MSE for the cattle investment which occurs 44 times is 2058.3 with an actual real rate of return of 11.2%. Other selective investment strategies have very similar patterns and numbers of cattle investment.

Table 34
Forecast Selective Investment Strategy And MSE
Feeder Cattle Or T-Bills
Without Hedging And With NTSP

Year	Net Revenue Mean Per Lot Dec. 1989 $	Net Returns Mean Per Lot % Annual	MSE Net Returns
1980-89	3405.75	9.44	770.1
1980-Mar86	3979.37	11.40	1192.8
Apr1986-89	2449.71	6.16	76.8

Table 35
Forecast Selective Investment Strategy And MSE
Feeder Cattle Or T-Bills
With Hedging And Without NTSP

Year	Net Revenue Mean Per Lot Dec. 1989 $	Net Returns Mean Real % Annual	MSE Net Returns
1980-89	2396.20	8.89	165.5
1980-Mar86	3048.38	10.95	239.9
Apr1986-89	1309.22	5.46	44.2

Table 36
Forecast Selective Investment Strategy And MSE
Feeder Cattle Or T-Bills
With Hedging And With NTSP

Year	Net Revenue Mean Per Lot Dec. 1989 $	Net Returns Mean Real % Annual	MSE Net Returns
1980-89	2448.52	9.11	179.2
1980-Mar86	3048.38	10.95	239.9
Apr1986-89	1448.76	6.05	81.1

The net returns for the selective investment in feeder cattle or T-Bills are greater than for any other strategy. The standard deviation of these net returns are lower than for the other comparable investment strategies. The selective strategies in general increase mean income over the base simulation with 100% hedging and with NTSP.

The number of times the investor feeds cattle or purchases T-Bills in selective investment strategy is in Appendix E. The majority of the investment in feeder cattle occurs in the period 1980 to 1986. Several years may pass with very little investment in feeder cattle. This is a drawback to the selective investment strategy. The cattle investor may not be able to selectively invest in cattle in one period and then not invest in cattle for several consecutive periods. The custom feedlot may prefer more regular investment in cattle to maintain the feedlot at minimum cattle numbers.

The selective hedging strategies and the selective investment strategy increase net returns. The selective investment in feeder cattle or T-Bills has the highest returns when compared to other strategies. More discussion on these strategies and the MSE is deferred until the next section on risk measurement. This completes the description of the different investment strategies in this research.

5.8 Analysis of Net Returns and Risk Measures

The MSE and the CAPM are the main risk measures described in Chapter 3. The MSE risk measure was reported in the previous section but very few comments were made on it. The MSE is analyzed in this section. The net returns of the different investment strategies are compared. The fourteen strategies are compared using the mean-variance efficiency criteria. The CAPM beta risk measure is calculated using the net returns and the TSE 300 and reported.

The square root MSE on cattle returns are reported in Table 37. The square root MSE is the comparable measure to the standard deviation. The root MSE of feeding cattle with no NTSP and no hedging are compared to participation in NTSP and 100% hedging for 1980 to 1989. The cattle feeding risk for the investor is reduced slightly by joining the NTSP. Root MSE drops by about 2% when the investor participates in NTSP. The 2% is calculated using the numbers (36.55-35.66)/36.55 from the top line of Table 37. The root MSE of no NTSP, no hedging is reduced 48% by 100% hedging. The selective hedge strategies and the optimal hedge strategy also reduce risk. The optimal hedge reduces the root MSE of no NTSP, no hedging by 44%. Selective hedging using the T-Bill rule reduces the root MSE of no NTSP, no hedging by 29%. The selective investment in cattle or T-Bill reduces the risk the most. The root MSE for no NTSP, no hedging drops by 27% with selective investment with no NTSP, no hedging. This root MSE changes by 63% with the selective investment with NTSP and hedging versus no hedging and no NTSP.

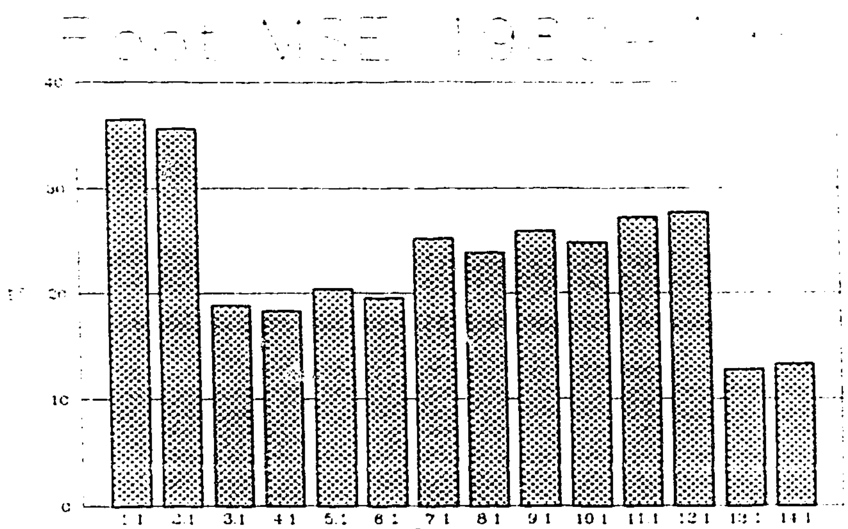
The square root MSE risk comparisons are shown in Figures 8, 9 and 10. The selective investment strategies in feeder cattle or T-Bills combined with hedging, strategies 13 and 14 in Figure 8, have the smallest risk over the period 1980 to 1989. These same strategies in Figure 10 have smaller root MSEs since the majority of the investments for April 1986 to 1989 are in T-Bills.

Table 37
Root Mean Square Error Of Cattle Investment Strategies

Time Period & Strategies	No Hedging No NTSP	No Hedging With NTSP	Hedging No NTSP	Hedging With NTSP
100% Hedge				
1980-89	36.55	35.66	18.88	18.41
80-Mar86	39.53	39.53	18.59	18.59
Apr86-89	31.37	28.47	19.56	18.32
Optimal Hedge				
1980-89			20.44	19.60
80-Mar86			20.58	20.58
Apr86-89			20.44	18.07
Selective Hedge 5%				
1980-89			25.33	24.00
80-Mar86			23.20	23.20
Apr86-89			28.80	25.53
Selective HedgeT-Bill				
1980-89			26.00	24.90
80-Mar86			24.56	24.56
Apr86-89			28.51	25.73
Selective Investment				
1980-89[1]	27.27	27.75	12.86	13.39
80-Mar86	34.54	34.54	15.49	15.49
Apr86-89	2.35	8.76	6.65	9.01

1. The root MSE for the cattle investment only, (44 feeding periods) with no NTSP and no hedging is 45.4. Other scenarios in this selective investment strategy have very similar cattle feeding investments.

Figure 8



Strategy Legend
1. Base Model - No Hedging, No NTSP.
2. Base Model - No Hedging, With NTSP.
3. 100% Hedging, No NTSP.
4. 100% Hedging, With NTSP.
5. Optimal Hedging, NO NTSP.
6. Optimal Hedging, With NTSP.
7. 5% Selective Hedge, No NTSP.
8. 5% Selective Hedge, With NTSP.
9. T-Bill Selective Hedge, No NTSP.
10. T-Bill Selective Hedge, With NTSP.
11. Selective Investment - Steers or T-Bills, No NTSP.
12. Selective Investment - Steers or T-Bills, With NTSP.
13. Selective Investment - Steers or T-Bills, With Hedging, No NTSP.
14. Selective Investment - Steers or T-Bills, With Hedging, With NTSP.

The decimals represent time period.
.1 = 1980 to 1989.
.2 = 1980 to March 1986 (NO NTSP).
.3 = April 1986 to 1989 (NTSP Available).

Figure 9

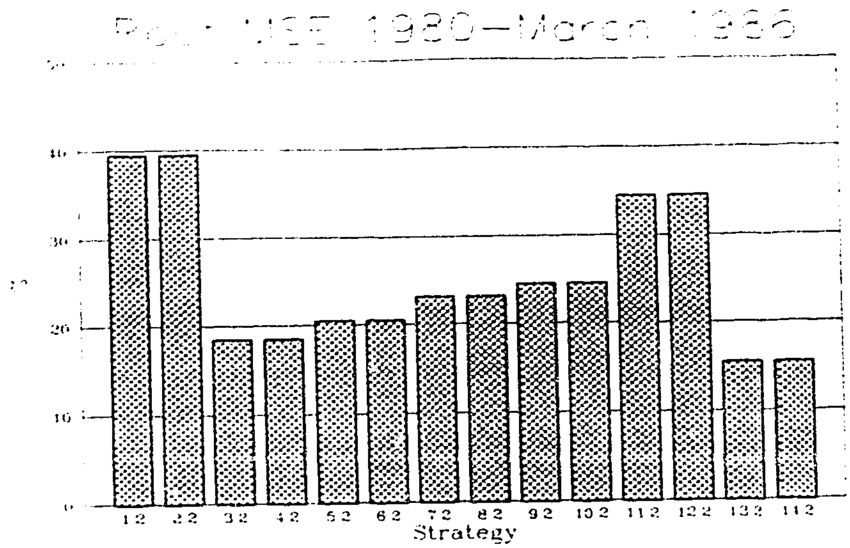
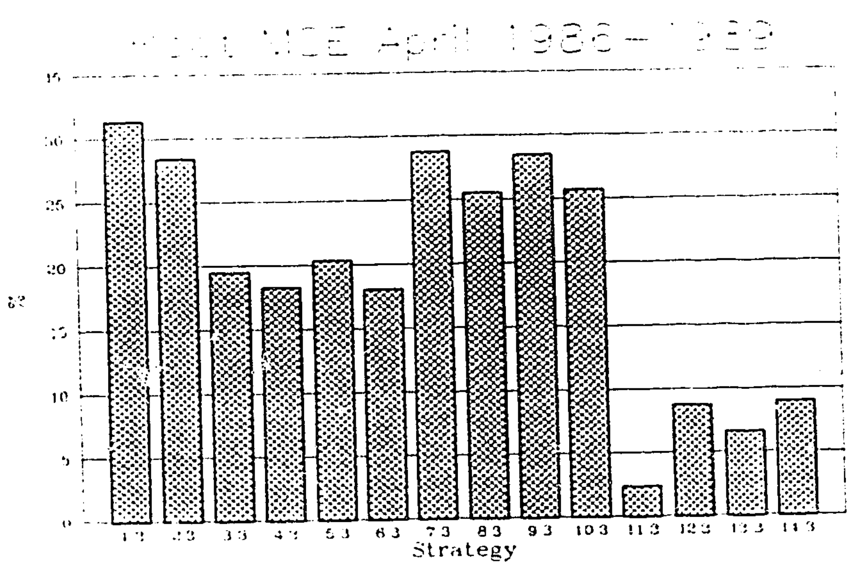


Figure 10



The no hedging with NTSP, strategy 2, for April 1986 to 1989 in Figure 10 reduces risk slightly over the base model of no hedging and no NTSP, strategy 1. The optimal hedge strategies 5 and 6 in Figure 8 reduce risk almost as much as the 100% hedge strategies 3 and 4. The selective hedging strategies 7, 8, 9 and 10 in Figure 9 reduce risk for the period 1980 to March 1986 compared to the base strategies 1 and 2. The selective hedge strategies are less effective in reducing risk for April 1986 to 1989 when relatively fewer hedges are placed. Participation in the NTSP does not appear to reduce the effectiveness of hedging as a risk management strategy.

Selected MSEs on net returns are tested for significant differences using the test of Ashley et al. (1980) to help determine the superior risk strategies. The alternative MSEs in Tables 9 and 10 using the forecast from the mean of net returns are not tested. The test description and detailed test results are in Appendix F. Some general conclusions on these tests follow.

The MSE error of participating in the NTSP is not significantly different from no NTSP.

The 100% hedge strategy MSE is significantly smaller than no hedging.

The selective hedge and selective investment strategies MSEs are significantly smaller than the no hedging strategies.

The 100% hedge strategy MSE is smaller than the selective hedge strategy.

The optimal hedge strategy MSE is smaller than the selective hedge strategy.

The selective investment strategy MSE is smaller than the optimal hedge or selective hedge strategies.

These tests of significance confirm what the graphs on root MSE show. The exception to this is the optimal hedge versus the 100% hedge. This test suggests that the optimal hedge MSE is smaller despite the fact that the MSE for the 100% hedge in absolute terms is smaller.[35]

This leads the discussion back to several hypotheses stated in Chapter 3. The NTSP has slightly reduced cattle feeding risk in Alberta however this reduction in risk is not significant. Therefore this may lead to the rejection of the hypothesis in section 3.2 that the NTSP has reduced cattle feeding risk. The hypothesis in section 3.3.3 that the 100% hedge strategy reduces risk over the no hedging strategy is not rejected. The hypothesis in section 3.3.5 that the optimal hedge strategy reduces risk over the no hedging strategy is not rejected.

The Alberta cattle feeder investor can reduce risk slightly by participating in a public program, the NTSP, although this risk reduction may not be significant. A different net returns forecast such as the mean of historical net returns MSE shown in Tables 9 and 10 may lead to a different conclusion. The Alberta cattle investor can significantly reduce risk by hedging. The optimal hedge results suggest that 100% hedging of heavy feeders is not required to get most of the benefits of risk reduction by hedging. Hedging about 60% of the feeder cattle gives similar reductions in risk. Selective hedging strategies lead to variable results in risk reduction depending on the time period and whether the strategy gives any hedge signals. The selective investment strategy in feeder cattle or T-Bills reduces risk however it may not be a viable option since it appears to favour one investment or the other investment for several years at a time. Cattle are fed only about 38% of the time with selective invest-

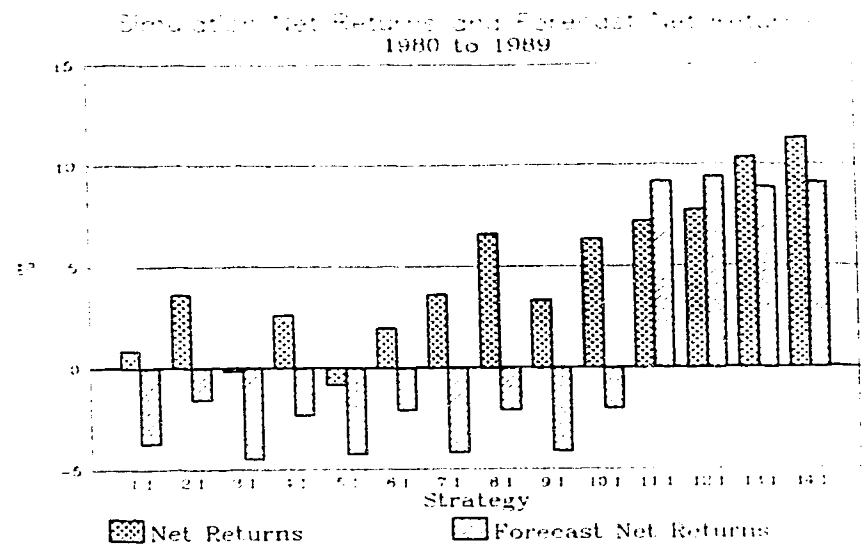
---

35 See Appendix F for a complete explanation on this result. The likely reason for this apparent contradiction is the way the MSE test is set up combined with the correction for autocorrelation.

ment strategies and most of the cattle feeding occurred in 1980 to 1986. Another problem with the selective investment strategy is the difficulty in forecasting NTSP pay outs. The forecast often indicates not to feed but the final result with NTSP is that the cattle investor should have fed cattle.

The net returns and the forecast net returns for the fourteen different strategies are compared in Figures 11, 12 and 13. The highest net returns in Figure 11 occur with the selective hedging and selective investment strategies over the period 1980 to 1989. Forecast net returns tend to underestimate the actual returns for the period 1980 to 1989 for most of the investment strategies. The forecasts are more accurate during 1980 to March 1986. The NTSP forecasts are not accurate and the period April 1986 to 1989 has relatively inaccurate net returns forecasts. All strategies have positive net returns for the period 1980 to March 1986. Only the selective investment strategies and some of the strategies with NTSP have positive net returns for the period April 1986 to 1989.

Figure 11



Strategy Legend
1. Base Model - No Hedging, No NTSP.
2. Base Model - No Hedging, With NTSP.
3. 100% Hedging, No NTSP.
4. 100% Hedging, With NTSP.
5. Optimal Hedging, NO NTSP.
6. Optimal Hedging, With NTSP.
7. 5% Selective Hedge, No NTSP.
8. 5% Selective Hedge, With NTSP.
9. T-Bill Selective Hedge, No NTSP.
10. T-Bill Selective Hedge, With NTSP.
11. Selective Investment - Steers or T-Bills, No NTSP.
12. Selective Investment - Steers or T-Bills, With NTSP.
13. Selective Investment - Steers or T-Bills, With Hedging, No NTSP.
14. Selective Investment - Steers or T-Bills, With Hedging, With NTSP.

The decimals represent time period.
.1 = 1980 to 1989.
.2 = 1980 to March 1986 (NO NTSP).
.3 = April 1986 to 1989 (NTSP Available).

Figure 12

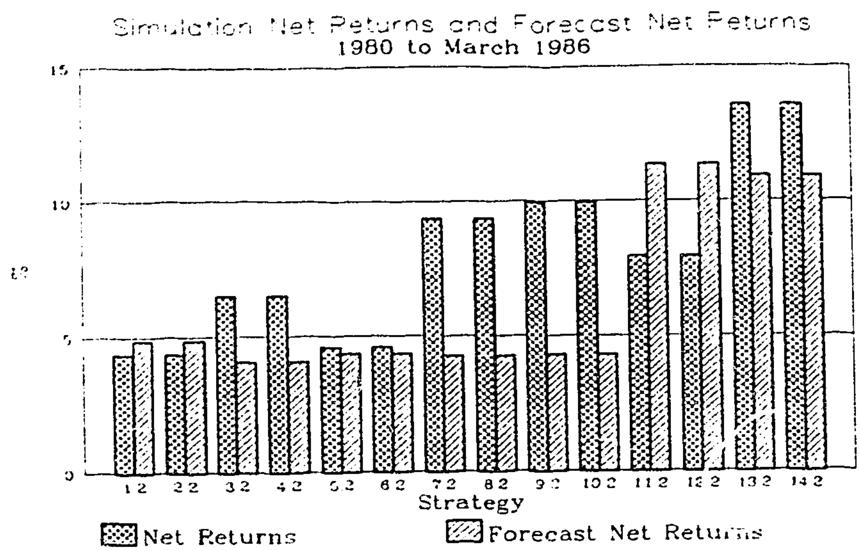
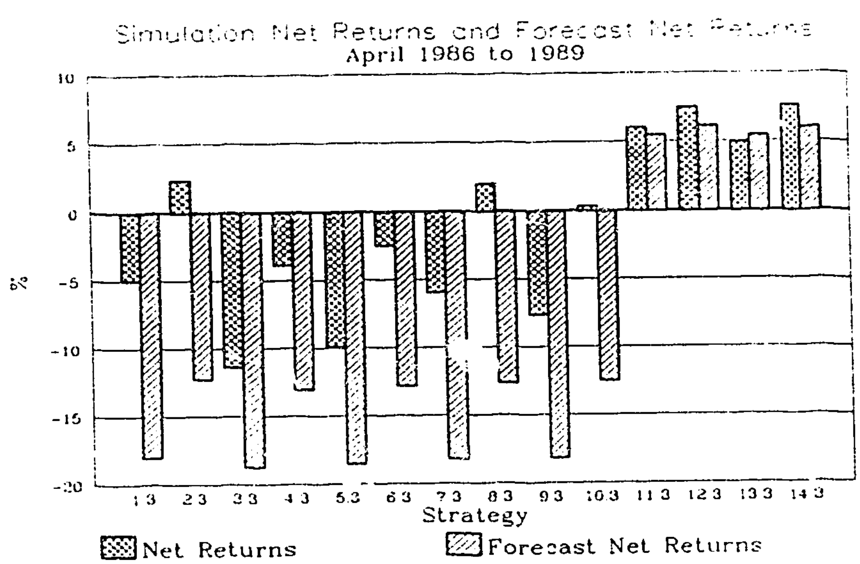
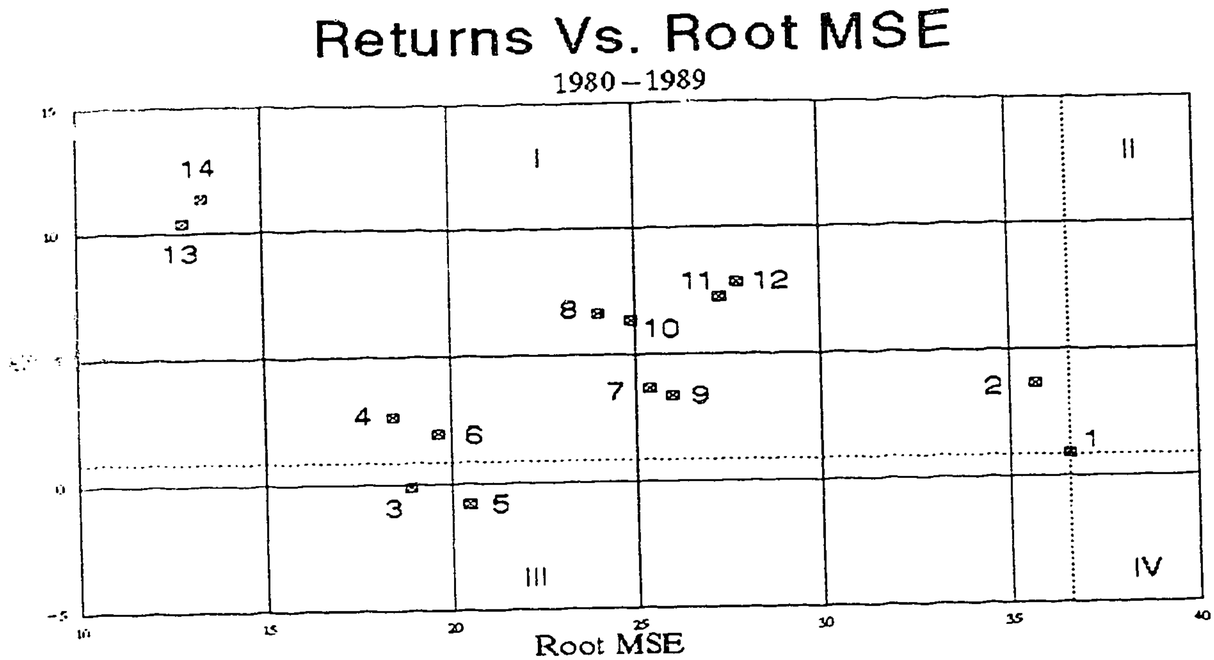


Figure 13



The discussion on the root MSE of net returns only evaluated the risk of different strategies. The returns of the strategies must also be considered by the investor. Risk and net returns are combined to evaluate the investment strategies. The following comparisons in Figures 14, 15 and 16 use the mean-variance risk efficiency criterion (with the variance replaced by the root MSE) explained in Chapter 3.1.1. This ranks the different strategies using both net returns and risk. The dotted lines intersecting at the point marked by 1 are the lines on the base strategy of no NTSP, no hedging. The dotted lines divide the graph into 4 quadrants. Strategies in quadrant I dominate the base simulation. Strategies in IV are dominated by the base strategy. Strategies in quadrants II and III do not dominate the base strategy and are not dominated by the base strategy. The choice of any particular strategy in quadrants II and III over the base strategy depends on an individual's level of risk aversion and their utility function.

Figure 14



Strategy Legend for Net Returns and Root MSE
1. Base Model - No Hedging, No NTSP.
2. Base Model - No Hedging, With NTSP.
3. 100% Hedging, No NTSP.
4. 100% Hedging, With NTSP.
5. Optimal Hedging, NO NTSP.
6. Optimal Hedging, With NTSP.
7. 5% Selective Hedge, No NTSP.
8. 5% Selective Hedge, With NTSP.
9. T-Bill Selective Hedge, No NTSP.
10. T-Bill Selective Hedge, With NTSP.
11. Selective Investment - Steers or T-Bills, No NTSP.
12. Selective Investment - Steers or T-Bills, With NTSP.
13. Selective Investment - Steers or T-Bills, With Hedging, No NTSP.
14. Selective Investment - Steers or T-Bills, With Hedging, With NTSP.

The decimals represent time period.
.1 = 1980 to 1989.
.2 = 1980 to March 1986 (NO NTSP).
.3 = April 1986 to 1989 (NTSP Available).

Figure 15

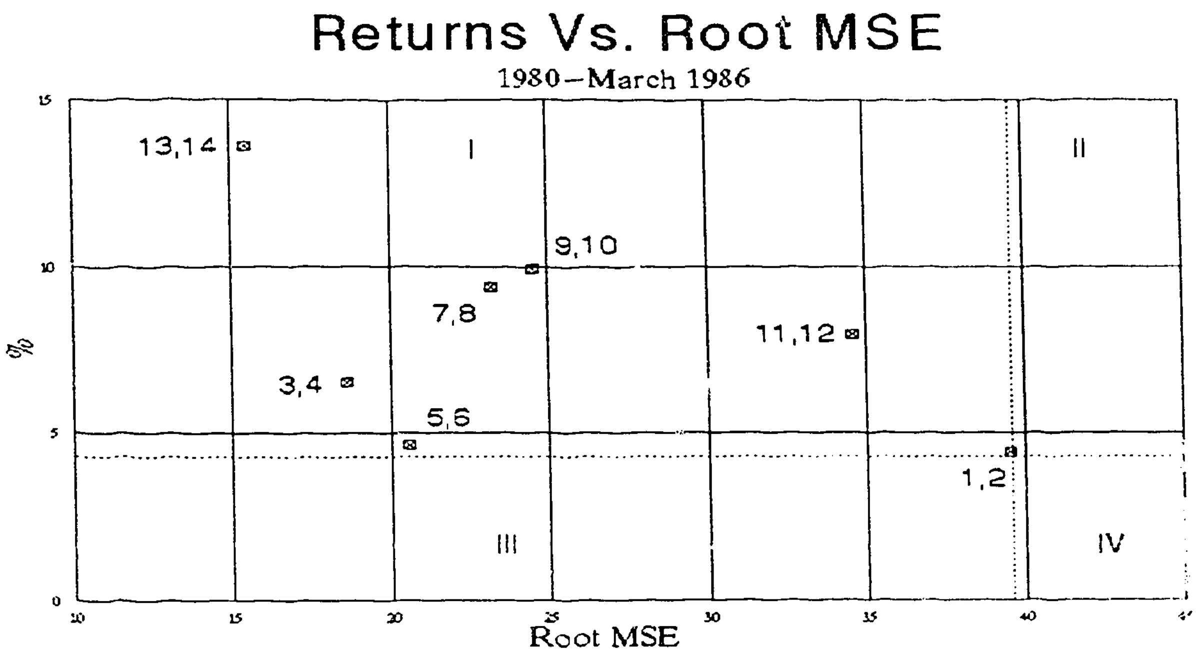
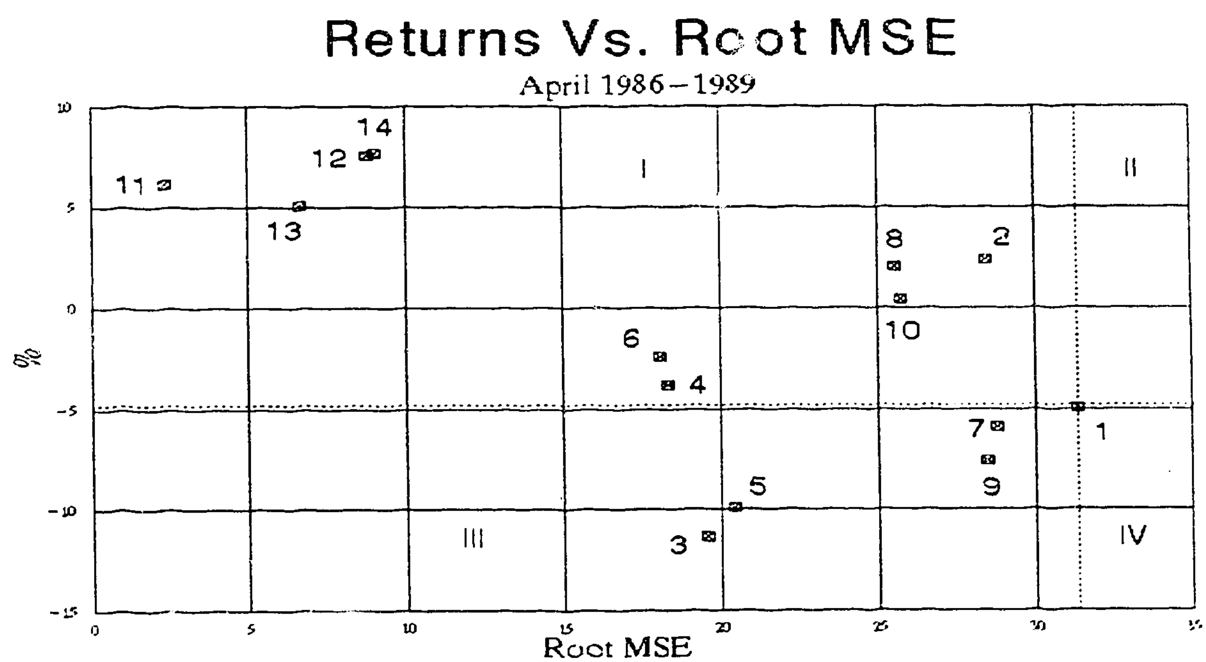


Figure 16



All strategy combinations in Figure 14 for the period 1980 to 1989 dominate the base model of no hedging and no NTSP (strategy 1) except for 100% hedging with no NTSP strategy 3 and optimal hedging with no NTSP strategy 5. Strategies 3 and 5 are in quadrant III. These two strategies have lower risk than strategy 1 but they also have lower returns. A risk averse individual may or may not prefer strategies 3 or 5 in quadrant III over strategy 1.

Figures 14, 15 and 16 compare the different strategies to each other. For example, the selective investment strategies 13 and 14 in Figure 14 dominate all the other strategies[36]. Any strategies that are to the left and above another strategy dominates that strategy. The strategies with NTSP usually dominate the strategies with no NTSP in Figure 16 for the period April 1986 to 1989. The hedging strategies reduce risk over the base model of no hedging in all strategies. The hedging strategies do not always dominate the no hedge strategy.

This brings up the question, is it worth while to use the 100% or the optimal hedge strategies? Figure 3 in Chapter 2 shows there was a major upward trend in nominal slaughter prices over the period 1977 to 1979. All hedging research that used this period (Caldwell (1982), Carter and Loyns (1985), Gaston and Martin (1984), Gillis et al. (1989)) reported that the hedge and hold strategies for slaughter cattle performed poorly. Most hedges (selling contracts) placed during this time period will lose money on the futures market and some of these hedges could lose very large amounts of money[37]. The cost of 100% hedging over 10 years, 1980 to 1989, drops the net returns on cattle feeding by about 1% which is not a high cost. The years 1986 to 1989 in Figure 3 show a another possible rising trend in nominal slaughter prices. This period also shows larger losses from futures hedging transactions[38]. The successful 100% hedge strategy requires financial resources and a long term commitment that will span both the up trends and the down trends in price. Over an extended time period the cost of the strategy is not high. Shorter time periods of three to four years may show high costs or high returns to this strategy. Some cattle investors may not be willing to endure several years of losses on the futures market following a 100% hedge strategy. The selective hedging strategies are an alternative which increase income but do not reduce risk as much as the 100% hedge strategy.

The CAPM beta's for each of the investment strategies are calculated and reported in Tables 38 to 43. The CAPM compares the cattle feeding investment to the market portfolio. The TSE 300 is used as the market portfolio for reasons explained in Chapter 3. Appendix G explains the calculation of the real TSE 300 returns to match the cattle returns calculation used in the research. The beta calculation uses equation 6 in chapter 3. The CAPM investment beta's for most of the cattle feeding period 1980 to 1989 are under 0.20[39]. This is different from Coles (1989) beta of 0.64 for cattle feeding in Alberta for the period 1973 to 1985. Brown (1989) reported a beta of -0.182 for cattle feeding

---

36 The selective investment in cattle only (44 lots) is not included in the graphs. The selective investment in cattle with no hedging and no NTSP has net returns of 11.2% and root MSE of 45.4. This would put this strategy in quadrant II in Figure 14.

37 Hedge results for 1976 to 1979 are in Appendix C.

38 See Appendix C.

39 Beta is not tested for significance since there is autocorrelation in the estimating equation. It is the author's opinion that these Beta's are probably not much different from 0.

in Saskatchewan for the period 1971 to 1987 which may be closer to the betas calculated in this study. The period 1976 to 1979 has a Beta of 1.00. The results of Coles (1989), Brown (1989) and this study may indicate that the value of any beta from the CAPM is dependent on the time period used in the calculation.

The systematic and the non systematic portion of the MSE risk is calculated using equations 7 and 8 in Chapter 3 and results are reported in Tables 38 to 43. The majority of the risk in these strategies is non systematic because the correlations between the net returns on cattle feeding and the TSE 300 are close to 0.

Table 38
Net Returns, CAPM Betas, Root MSE, Systematic Risk and Non Systematic Risk
Base Models - No Hedging

Strat. & Date	Net Returns %	Beta	Corr[1]	Root MSE	Sys. Risk	Non Sys. Risk
No NTSP						
76-89	6.02	0.111	0.093	--	--	--
76-79	19.69	1.000	0.358	--	--	--
80-89	0.89	0.018	0.022	36.55	0.80	35.75
80-Mar86	4.39	-0.023	-0.029	39.53	-1.15	40.68
Apr86-89	-4.94	0.161	0.201	31.37	6.31	25.06
NTSP						
76-89	8.01	0.099	0.084	--	--	--
76-79	19.69	1.000	0.358	--	--	--
80-89	3.63	0.0037	0.005	35.66	0.18	35.48
80-Mar86	4.39	-0.023	-0.029	39.53	-1.15	40.68
Apr86-89	2.37	0.102	0.139	28.47	3.96	24.51

1. This is the correlation between the cattle net returns and the TSE 300 net returns.

Table 39
Net Returns, CAPM Betas, Root MSE, Systematic Risk and Non Systematic Risk
100% Hedging

Strat. & Date	Net Returns %	Beta	Corr	Root MSE	Sys. Risk	Non Sys. Risk
No NTSP						
80-89	-0.15	0.130	0.219	18.88	4.13	14.75
80-Mar86	6.54	0.123	0.228	18.59	4.24	14.35
Apr86-89	-11.30	0.133	0.214	19.56	4.19	15.38
NTSP						
80-89	2.66	0.117	0.202	18.41	3.72	14.69
80-Mar86	6.54	0.123	0.228	18.59	4.24	14.35
Apr86-89	-3.82	0.079	0.122	18.32	2.24	16.08

Table 40
Net Returns, CAPM Betas, Root MSE, Systematic Risk and Non Systematic Risk
Optimal Hedging

Strat. & Date	Net Returns %	Beta	Corr	Root MSE	Sys. Risk	Non Sys. Risk
No NTSP						
80-89	-0.82	0.096	0.173	20.44	3.54	16.90
80-Mar86	4.62	0.079	0.153	20.58	3.15	17.43
Apr86-89	-9.89	0.142	0.242	20.44	4.95	15.49
NTSP						
80-89	1.96	0.082	0.154	19.60	3.02	16.58
80-Mar86	4.62	0.079	0.153	20.58	3.15	17.43
Apr86-89	-2.46	0.086	0.151	18.07	2.73	15.34

Table 41
Net Returns, CAPM Betas, Root MSE, Systematic Risk and Non Systematic Risk
5% Selective Hedging[1]

Strat. & Date	Net Returns %	Beta	Corr	Root MSE	Sys. Risk	Non Sys. Risk
No NTSP						
80-89	3.66	0.149	0.240	25.33	6.08	19.25
80-Mar86	9.40	0.127	0.232	23.20	5.38	17.82
Apr86-89	-5.90	0.210	0.283	28.80	8.15	20.65
NTSP						
80-89	6.63	0.133	0.232	24.00	5.57	18.43
80-Mar86	9.40	0.127	0.232	23.20	5.38	17.82
Apr86-89	2.02	0.146	0.229	25.53	5.85	19.68

1. The selective hedge with NTSP had 13 one month hedges, 13 two month hedges and 50 three month hedges. 75% of the hedges (57 hedges) are placed from 1980 to March 1986. Other selective hedge strategies have similar hedging numbers.

Table 42
Net Returns, CAPM Betas, Root MSE, Systematic Risk and Non Systematic Risk
T-Bill Selective Hedging

Strat. & Date	Net Returns %	Beta	Corr	Root MSE	Sys. Risk	Non Sys. Risk
No NTSP						
80-89	3.38	0.127	0.202	26.00	5.25	20.75
80-Mar86	9.97	0.109	0.193	24.56	4.74	19.82
Apr86-89	-7.60	0.174	0.243	28.51	6.93	21.58
NTSP						
80-89	6.37	0.114	0.194	24.90	4.83	20.07
80-Mar86	9.97	0.107	0.193	24.56	4.74	19.82
Apr86-89	0.36	0.122	0.191	25.73	4.91	20.82

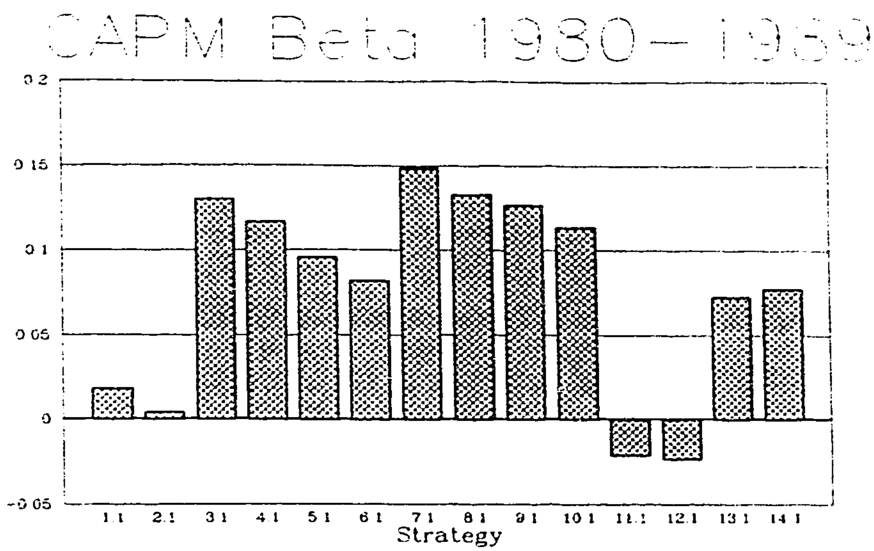
Table 43
Net Returns, CAPM Betas, Root MSE, Systematic Risk and Non Systematic Risk
Selective Investment in Feeder Cattle or T-Bills[1]

Strat. & Date	Net Returns %	Beta	Corr	Root MSE	Sys. Risk	Non Sys. Risk
No Hedge No NTSP						
80-89	7.26	-0.021	-0.033	27.27	-.90	28.17
80-Mar86	7.97	-0.031	-0.044	34.54	-1.52	36.06
Apr86-89	6.09	0.015	0.085	2.35	.20	2.15
No Hedge NTSP						
80-89	7.80	[illegible]	-0.035	27.75	-0.97	28.72
80-Mar86	7.97	[illegible]	-0.044	34.54	-1.52	36.06
Apr86-89	7.52	[illegible]	0.020	8.76	0.17	8.58
Hedge No NTSP						
80-89	10.40	0.074	0.194	12.86	2.49	10.37
80-Mar86	13.61	0.088	0.221	15.49	3.42	12.07
Apr86-89	5.04	0.011	0.047	6.65	0.31	6.34
Hedge NTSP						
80-89	11.37	0.078	0.200	13.39	2.68	10.71
80-Mar86	13.61	0.087	0.221	15.49	3.42	12.07
Apr86-89	7.65	0.035	0.101	9.01	0.91	8.10

1. Cattle are fed 45 times in the selective investment with hedging and NTSP. 89% of the cattle feeding (40 lots) is during 1980 to March 1986. The other strategies have similar results.

The CAPM Betas are compared in Figures 17, 18 and 19. These graphs show low Betas for the period 1980 to 1989. The CAPM betas and the non systematic risk measures show that cattle investors in heavy feeders can diversify most of their risk by investing in the TSE. The cattle investment is not closely linked to the parts of the economy that affect risk in the TSE 300. This would agree with results commented on by Hirshleifer (1988) that returns in stocks and commodities have low negative correlations.

Figure 17



Strategy Legend
1. Base Model - No Hedging, No NTSP.
2. Base Model - No Hedging, With NTSP.
3. 100% Hedging, No NTSP.
4. 100% Hedging, With NTSP.
5. Optimal Hedging, NO NTSP.
6. Optimal Hedging, With NTSP.
7. 5% Selective Hedge, No NTSP.
8. 5% Selective Hedge, With NTSP.
9. T-Bill Selective Hedge, No NTSP.
10. T-Bill Selective Hedge, With NTSP.
11. Selective Investment - Steers or T-Bills, No NTSP.
12. Selective Investment - Steers or T-Bills, With NTSP.
13. Selective Investment - Steers or T-Bills, With Hedging, No NTSP.
14. Selective Investment - Steers or T-Bills, With Hedging, With NTSP.

The decimals represent time period.
.1 = 1980 to 1989.
.2 = 1980 to March 1986 (NO NTSP).
.3 = April 1986 to 1989 (NTSP Available).

Figure 18

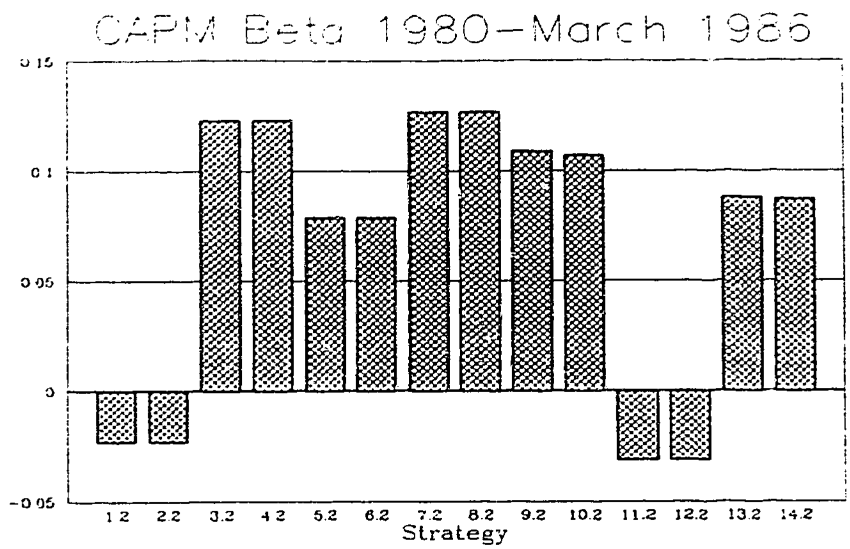
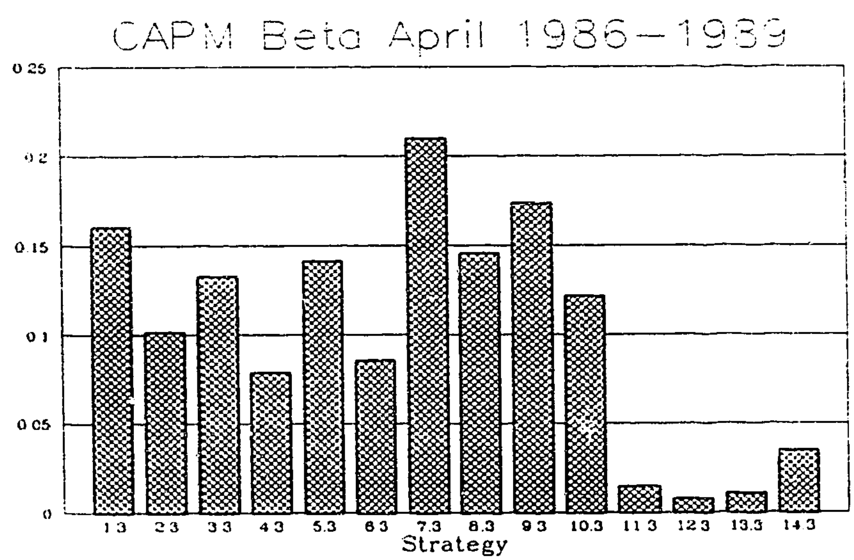


Figure 19



This section compared the risk and returns of the different Alberta cattle feeding investment strategies. The selective investment strategies and the hedging strategies reduce the risk of cattle feeding over no hedging and no participation in government programs. The hedging results in this study conflict with prior Canadian research and this is investigated further in the next section. The NTSP increases income and decreases risk slightly. Not all these strategies are preferred by a risk averse investor when the mean-variance efficiency criterion is used. The beta from the CAPM suggests that non agricultural investors can reduce systematic risk by investing in heavy feeder steers in Alberta. Alternatively investors in heavy feeder cattle can reduce most of their risk by investing in the TSE 300. Final comments on the use of these strategies by cattle investors are in Chapter 6.

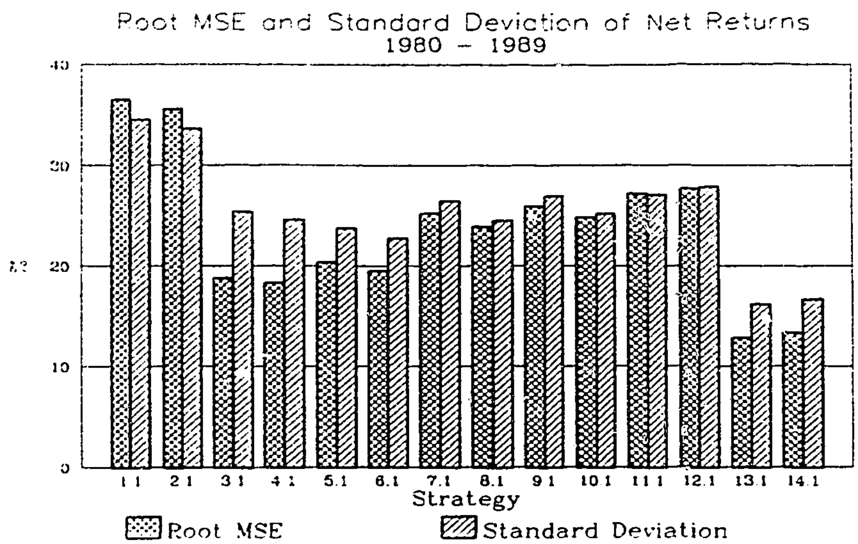
5.9 Issues in Risk Measures and Other Research Conclusions

Chapter 3 reported conflicting results in the literature on the use of different risk management strategies, especially the strategy using 100 % hedging. The MSE and the standard deviation from this study are briefly compared to determine if these lead to different conclusions. Canadian studies also concluded that basis is too variable to use hedging for managing risk. Currency exchange rate risks were cited as reasons for variable basis. The hedging results in this study may contradict the conclusions of these studies. Hedging is a risk reducing strategy that can be used by Alberta cattle feeder investors. One reason for this may be reduced basis risk. Exchange rate risk is a part of basis risk. This section further investigates hedging risk and compares the Alberta basis to the Omaha basis and tests basis variability during the past 10 years. A less variable basis implies less risk[40]. A comparison of exchange rate risk is also included.

The main risk measure used in this study is the MSE of net returns. The rational investor uses current as well as historical information to make investment decisions and measure risk. Standard deviation is an alternative risk measure used by other studies (Caldwell et al. (1982), Carter and Loyns (1985)). It was suggested earlier that the conflicting risk results reported in the literature may be from different risk measures. The MSE and the standard deviations risk measures are compared in Figures 20, 21 and 22.

40 Recall the results from the last section comparing the square root of MSE and standard deviations of net returns. The change in direction for standard deviations followed the same direction for MSE risk measures for different strategies.

Figure 20



Strategy Legend for Net Returns and Root MSE
1. Base Model - No Hedging, No NTSP.
2. Base Model - No Hedging, With NTSP.
3. 100% Hedging, No NTSP.
4. 100% Hedging, With NTSP.
5. Optimal Hedging, NO NTSP.
6. Optimal Hedging, With NTSP.
7. 5% Selective Hedge, No NTSP.
8. 5% Selective Hedge, With NTSP.
9. T-Bill Selective Hedge, No NTSP.
10. T-Bill Selective Hedge, With NTSP.
11. Selective Investment - Steers or T-Bills, No NTSP.
12. Selective Investment - Steers or T-Bills, With NTSP.
13. Selective Investment - Steers or T-Bills, With Hedging, No NTSP.
14. Selective Investment - Steers or T-Bills, With Hedging, With NTSP.

The decimals represent time period.
.1 = 1980 to 1989.
.2 = 1980 to March 1986 (NO NTSP).
.3 = April 1986 to 1989 (NTSP Available).

Figure 21

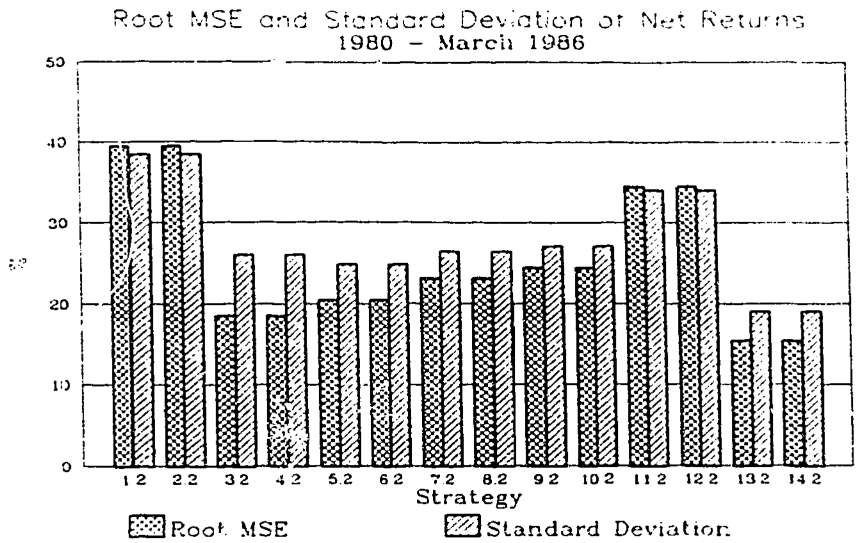
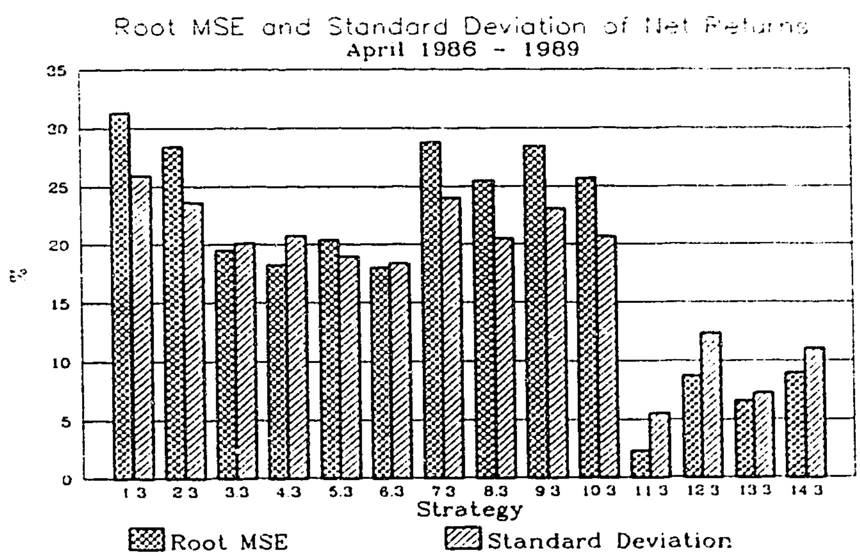


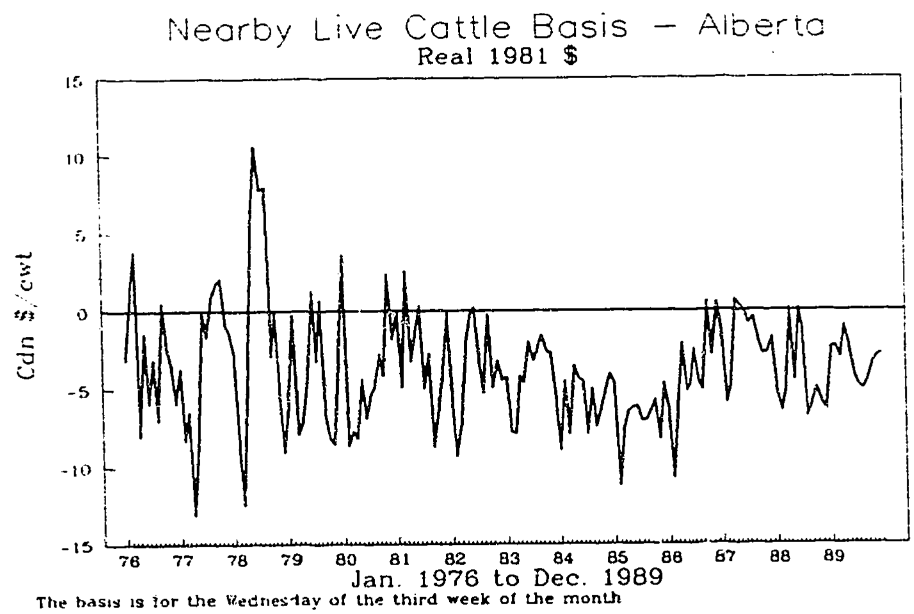
Figure 22



The MSE and standard deviation of net returns show similar changes in the direction of risk for the different investment strategies. The standard deviation would give similar rankings to the different strategies as the MSE risk measure when combined with net returns in a mean-variance efficiency criterion. The MSE is a better measure of risk for the reasons outlined in chapter 3. The standard deviation consistently underestimates the amount of the change in risk. Better price forecasts and NTSP pay out forecast would improve the MSE risk measure. The different results on the hedging reported by Caldwell et al. (1980) and by Carter and Loyns (1985) are probably caused by different time periods and different data. This study shows that different time periods give different answers about the best price forecasting models, best investment strategies or CAPM betas.

Alberta nearby basis is the difference between the Alberta slaughter cash price and the CME live cattle futures contract adjusted to Canadian dollars. Basis variability is tested here. Figure 23 is Alberta nearby basis in June 1981 dollars for the Wednesday of the third week of the months for 1976 to 1989. Figure 23 shows that Alberta basis is less variable in the period 1985 to 1989.

Figure 23



Sample means and sample standard deviations for basis for different time periods for Alberta and Omaha are in Tables 44, 45 and 46. The time periods 1976 to 1980 and 1985 to 1989 are used to compare two time periods of equal length. Thompson and Bond (1985) suggested that it is perceived basis variance that is important when comparing a United States hedger to an offshore hedger. The standard deviations for 1985 to 1989 for Alberta basis and Omaha basis (in Canadian dollars) are 2.72 and 3.51 respectively. Omaha basis is not less variable than Alberta basis for this time period.

Table 44
Alberta Nearby Basis in real Canadian June 1981 Dollars

Time Period	Mean	Std. Dev. Sample
1976-89	-3.73	3.64
1976-1979	-2.87	5.07
1976-1980	-3.11	4.85
1980-1989	-4.07	2.83
1980-Mar. 86	-4.68	3.01
1985-1989	-4.04	2.72
Apr. 86-89	-3.05	2.20

Table 45
Omaha Nearby Basis in real U.S. January 1982 Dollars

Time Period	Mean	Std. Dev. Sample
1976-89	-0.955	2.87
1976-1979	-1.35	3.47
1976-1980	-1.42	3.27
1980-1989	-0.79	2.58
1980-Mar. 86	-1.06	2.57
1985-1989	-0.96	2.70
Apr. 86-89	-0.345	2.58

Table 46
Omaha Nearby Basis in real 1982 Dollars Changed to Canadian Dollars

Time Period	Mean	Std. Dev. Sample
1976-89	-1.12	3.40
1976-1979	-1.41	3.72
1976-1980	-1.52	3.55
1980-1989	-1.01	3.28
1980-Mar. 86	-1.36	3.27
1985-1989	-1.26	3.51
Apr. 86-89	-.041	3.23

The hypothesis in Chapter 3, section 3.3.4 that Alberta basis is less variable in the period 1985 to 1989 than 1976 to 1980 is tested. The test uses a null hypothesis that the variance for 1976 to 1980 equals the variance for 1985 to 1989. The alternative hypothesis is that the variance for 1976 to 1980 is greater. The F statistic is 3.18 for the ratio of the variances. At the 5% level of significance the null hypothesis is rejected. Alberta basis is less variable for the period 1985 to 1989. The same test for Omaha (in U.S. dollars) has an F statistic of 1.48. At the 5% level of significance the null hypothesis is not rejected. These tests suggests the Alberta basis is less variable now than 10 years ago and the Omaha basis is not less variable now than 10 years ago[41]. The Alberta basis may be less variable because of increased cattle exports and because the exchange rate is less variable.

41 The Alberta and Omaha basis have autocorrelation. Correcting for the autocorrelation does not change the conclusions of the F test. This is explained in Appendix I.

The exchange rate is not formally tested, however the standard deviation of the exchange rate for the period 1976 to 1981 is 6.5 and for the period 1986 to 1989 it is 5.0. The exchange rate risk component in the MSE of net returns may not be that large. A simple test is to replace the forecast exchange rate in the slaughter price forecasts in equation 33 with the actual exchange rate that will occur. The investor has perfect knowledge of exchange rates. Compare the MSE with the forecast exchange rate to the MSE with the perfect knowledge exchange rate. This shows the change in total risk from exchange rates. The MSE on net returns with no hedging and no NTSP for 1980 to 1989 with perfect knowledge of exchange rates is 1292.7. The MSE on net returns for the same strategy in Table 9 using a forecast exchange rate is 1335.7. Risk drops marginally when exchange rate risk on the forecast price is removed. Exchange rate risk is this comparison is small.

Alberta basis variability is compared to Omaha basis variability to answer the question are Alberta cattle investors at a disadvantage in using the CME for risk management? It has been an implicit assumption of some Canadian studies that United States cattle investors are better able to use the futures market. The Alberta basis and the Omaha basis are not independent since they are both calculated from the same futures contract and the market for cattle is a North American market. A standard F test to compare the variances is not appropriate. It is the unpredictable portion of basis that is relevant to the cattle investor. Therefore, test the basis MSE between two similar forecast models for Alberta basis and Omaha basis using the test of Ashley et al. (1980) explained in Appendix F. Use this test as a proxy for comparing the variances.

The test proceeds as follows. The null hypothesis is that the unpredictable portion of Alberta basis and the Omaha basis are the same for 1980 to 1989. The Alberta basis (already in real 1981 $) is converted to U.S. dollars so the MSE have the same measure. It is the relative basis variability that is important. The forecast model used for both Alberta basis and Omaha basis is the historical average updated each month and used as the three month ahead basis forecast[42]. The alternate hypothesis is the Omaha basis has lower MSE than the Alberta basis. The null hypothesis is not rejected if the coefficients are both positive and not significantly different from 0 or neither coefficient is significantly positive. The results after adjusting for first order autocorrelation using ML are in Table 47. The last coefficient, auto, is the estimated autocorrelation coefficient.

Table 47
MSE Test Between Alberta Basis and Omaha Basis

Var	Coef	Std. Error	T-Ratio	P-Value
const.	0.21	0.60	0.36	0.72
X1	-0.63	0.15	-4.13	0.00
auto	0.37	0.08	4.38	0.00

OLS DW=1.24 Chi-Squared=17.2 P-Value Chi=0.00
Mean Prediction Errors AB Basis = -0.47(US $), Omaha Basis=0.19
(Alberta basis error vector multiplied by -1)

---

42 See Appendix I for further information on Omaha basis, and Omaha slaughter steer price forecasts. The basis average forecast model is chosen since it is calculated the same way in both locations, it is neither the worst nor the best basis forecast, and it is easy to calculate.

The test results are mixed. The constant is positive and not significant at the 5% level. The X1 coefficient is negative and significant. The asymptotic Chi-Squared test for the coefficients equal to zero cannot be used in the Ashley et al. (1980) test because of the opposite signs on the coefficients. The coefficients are not significantly positive so do not reject the hypothesis that the two MSE for the basis are the same. The conclusion is that the mean square error of the basis for Omaha is not smaller than the basis for Alberta. The 3 month basis forecast risk using the basis average forecast model during the period 1980 to 1989 was not greater for Alberta investors. This test indirectly rejects the hypothesis in Chapter 3, section 3.3.4, that Alberta live cattle basis is more variable than the Omaha live cattle basis. The Ashley et al. (1980) test is weak and should be interpreted with caution.

Alberta basis variability has decreased during the past 10 years and Alberta basis is not more unpredictable than the Omaha basis. Alberta basis contains an exchange rate component that Omaha basis does not have. The exchange rate may not be a major factor in basis movement and in slaughter price variability in Alberta for 1980 to 1989 although this conclusions needs much more research before placing high confidence in it.[43] The use of MSE and standard deviations as risk measures should lead to the same qualitative conclusions. This again suggests that the different risk findings of other studies are related to data and time periods studied.

5.10 Summary

This chapter reviewed the historical simulation and analysis of different cattle feeding management strategies. Different slaughter price forecasting models were compared as part of the gathering information risk management strategy. The CME live cattle futures contract and a basis forecast model were chosen for the simulation. Two efficiency tests did not reject the hypothesis that the CME live cattle futures contract is efficient. The futures market should be a good price forecast model and the variance minimizing hedge ratio is the optimal hedge ratio. Different investment strategies were compared. The selective hedging strategies and the selective investment strategies reduced the cattle feeding risk and increased returns. The 100% hedging strategies and the optimal hedging strategies lowered risk but they may have also lowered net returns. Participation in the government program, NTSP, increased income and reduced risk but the risk reduction was insignificant. The risk averse investor may choose different investment strategies for different time periods based on a mean-variance efficiency criterion. Alberta basis, a part of hedge risk and price forecast risk, is less variable now than ten years ago. Further comments regarding this study on cattle feeding risk in Alberta are in the next chapter.

---

43 Here is more supporting evidence on exchange rates and basis for 1980 to 1989. The correlation between the Alberta slaughter steer price (in Cdn $) and the CME nearby live cattle futures contract (in U.S..$) is 0.91. When the futures price is converted to Cdn. $ this correlation is 0.96. The Omaha slaughter steer price has a correlation of 0.94 with the nearby futures contract. The correlation of the Alberta nearby basis (in Cdn $) with the Omaha basis (in Cdn $) is 0.52. The correlation of the Alberta basis with the exchange rate is 0.14. The Omaha slaughter price (in U.S. $) correlation with the exchange rate, 0.69, is greater than the Alberta slaughter price (in Cdn $) correlation, 0.43. These data series are adjusted with the appropriate Canadian CPI or U.S. GNP.

Chapter 6 Conclusions

Chapter 1 listed nine objectives for this research. This concluding chapter reviews these objectives and the results presented in Chapters 2 through 5. This is followed with a discussion of the uses for these results, their limitations and possible further research.

The literature review identified some of the major sources of risk in investing in heavy feeder steers in Alberta. Slaughter steer price was identified as the major source of risk in finishing heavy feeder steers after the feeder purchase decision is made. Slaughter price risk was the main research focus.

Realized net returns from cattle feeding were measured and compared to forecast net returns. Several different strategies or combinations of strategies were measured. Selective investment strategies had the highest returns. The selective investment and the 100% hedging strategies had the lowest risk. This objective of measuring risk is tied quite closely to other objectives discussed later.

Beef cattle investments were compared to alternative investments using the CAPM. The cattle investment had low systematic risk for the period 1980 to 1989. There was a low correlation between the returns on finishing heavy feeders and the TSE 300. A large portion of risk in cattle feeding can be diversified by investment in the TSE 300. This conclusion may be time period dependent since other studies, such as Coles (1989), show the cattle investment with higher systematic risk.

Different slaughter steer price forecasting models were compared as part of the information gathering risk management strategy. This research did not reject the hypothesis that the CME live cattle futures contract adjusted for basis is an unbiased forecast of Alberta slaughter prices. Other models, such as econometric models, ARIMA cash price models and lagged cash prices did not forecast better than the futures price for the period 1980 to 1989. Over different time periods, different forecasting models perform better than other models.

The Alberta live cattle nearby basis is less variable now than it was ten years ago. This should improve risk reduction from hedging and price forecasting using the futures market. Increased cattle exports to the United States and lower exchange rate variability were proposed as possible reasons for less basis risk in 1986 to 1989. The Alberta basis is not more variable than the basis at Omaha and Alberta investors and Omaha investors have the same relative basis risk. Alberta basis is not too variable to use the CME live cattle futures contract in risk management strategies and this conclusion is different from the conclusions of other Canadian studies.

Other studies used different measures. The MSE and the standard deviation risk measures indicated different amounts of risk, but in general showed the same change in risk for different strategies. The conflicting results in other studies using standard deviations to measure risk may be more related to the time period and the data used.

The National Tripartite Stabilization Program was included in the investment strategies. The NTSP increased net returns over not participating in the program. Risk, as measured by MSE, was reduced slightly with NTSP. The forecasting of NTSP caused difficulties. Improved forecasts would increase the risk reduction of NTSP for the Alberta cattle investor. The risk averse and the risk neutral cattle investor benefited from participation in the NTSP.

Hedging using the CME live cattle futures market was included with several investment strategies. The 100% hedge and hold strategies significantly reduced risk and reduced annualized net returns slightly. It is not possible to state whether a risk averse person prefers this strategy to not hedging. Most of the risk reduction from hedging can be obtained by optimally hedging about 60% to 70% of the cattle on feed. The long term cost of hedging excluding brokers fees should be close to 0 since the CME live cattle futures market is unbiased. There may be periods of several years where hedge profits are positive or negative. Therefore over a short time period, the hedging strategy may appear to be increasing income or decreasing income and this may be unattractive to some cattle investors. The hedging conclusions from Freeze et al. (1990) and other researchers may not apply in different time periods or over longer time periods.

Selective investment strategies were compared. These included hedging if a target profit was forecast and investing in T-Bills if the forecast return on cattle feeding was less than the T-Bill rate of return. These strategies reduce risk. The net returns to these selective strategies are higher than the simple cattle investment. These strategies may give signals that for several years lead to little use of hedging or very little investment in feeder cattle. The forecasts tended to underestimate returns, especially with NTSP. It may not be possible to selectively invest in cattle for a time period and then not invest in cattle for a long time period. This makes these selective strategies less useful.

The Alberta investor in heavy feeder steers can use the research results in the following way. The three month price forecasting can be done using the CME futures market adjusted with an Alberta basis forecast. The basis forecast can be an ARIMA model but other basis estimates such as short term rolling averages may be suitable. Different models may be better price forecasters for different lengths of time and for different time periods. One price forecast should not be used exclusively for long periods of time and should be continually tested against competing models.

Participation in the NTSP, a public risk management program, from 1986 to 1989 benefited the risk neutral and risk averse cattle investor. Cattle investors could improve risk management with better forecasts of NTSP pay outs. The effect of the NTSP on feeder cattle prices or supply responses by cattle feeders were not studied.

Hedging, a private risk management strategy, reduces risk . Only a portion of the value of the cattle needs to be hedged to get most of the benefit of risk reduction. A hedge and hold strategy is expected to provide zero profits over the long run. Selective hedging when a forecast target profit can be locked in reduces risk and increases income. There may be several years where this strategy of selective hedging is used very little. Individual investors have to evaluate their level of risk aversion in choosing these strategies. The Alberta cattle investor does not appear to be at a disadvantage relative to an investor at Omaha in terms of using the CME futures market for risk management.

One limitation in this study is the production function which purchases heavy feeder steers each month and assumes zero production risk. This limits the flexibility a cattle investor has in choosing different types and sizes of cattle. The results may not apply to lighter feeder cattle where there may be more production risk or where a cattle investor feeds cattle only during certain times of the year. The econometric price forecasting models are weak and could be improved upon. The tests for significance on mean square error of Ashley et al. (1980) are weak and should be interpreted with caution. The level of net returns reported in this study should not be considered typical of any particular feedlot or cattle feeder. A change of only $0.01 to $0.02 per lb in costs or selling price would make a big difference in the actual level of net returns reported.

Future research directions could include the following:

1. Do similar research including different weights of cattle and types of cattle to extend the results to other cattle investors.

2. Alberta basis could be compared to several locations in the United States to confirm or reject the comparisons to Omaha done in this study. The factors that impact on basis risk could be measured and tested. The optimal hedge calculations for these different locations could be estimated and compared.

3. Alternative optimal hedge estimating models using ARCH or GARCH could be tested.

4. There is no information in the literature on the actual use of the futures market by cattle investors. This information would be very useful in determining future research directions. It could be used to test whether such factors as debt levels, length of feeding period and size of cattle investment impact on the use of hedging or other alternatives such as options or forward contracting. These results could indirectly support or reject the investor's perception regarding bias in the futures market.

5. Slaughter price forecasts and NTSP forecasts could be improved. The ARIMA models forecasting basis might be improved by adding other information such as cattle slaughter and cattle on feed numbers. Improved forecasting models and using different models in different periods may reduce risk and make the selective hedging and selective investment strategies more useful. The decision rules developed to change forecast models may help signal the price trend or level of price risk in the market.

6. Add live cattle options to the risk management strategies.

This research shows cattle investors in heavy feeders can reduce risk using different strategies. Some of these strategies may not decrease income. Further research could extend these results to different classes of cattle.

Bibliography

Alberta Agriculture. 1969-1989. *Agricultural Statistics Year Book*. Edmonton, Alberta.

Agriculture Canada. *National Tripartite Stabilization Program for Red Meats: Cattle Models.*

Alexander, V.J., Musser, W.N. and Mason, G. 1986. "Futures Markets and Firm Decisions Under Price, Production, and Financial Uncertainty." *Southern Journal of Agricultural Economics*. (Dec): 39-49.

Anderson, R.W. and Danthine, J.P. 1981. "Cross Hedging." *Journal of Political Economy*. 89: 1182-1196.

Ashley, R., Granger, C.W. and Schmalensee, R. 1980. "Advertising and Aggregate Consumption: An Analysis of Causality." *Econometrica*. Vol. 48: 1149-1167.

Baillie, R.T. and Myers, R.J. 1989. *Modeling Commodity Price Distributions and Estimating the Optimal Futures Hedge*. Working Paper Series CSFM #201, Michigan State University.

Bank of Canada. *Bank of Canada Review*. Ottawa.

Barry, P.J. 1980. "Capital Asset Pricing and Farm Real Estate." *American Journal of Agricultural Economics*. 62: 549-553.

Barry, P.J. and Baker, C.B. 1984. "Financial Responses To Risk In Agriculture." In *Risk Management in Agriculture*. P.J. Barry (editor). Iowa State University Press, Iowa.

Benninga, S., Eldor, R. and Zilcha, I. 1984. "The Optimal Hedge Ratio In Unbiased Futures Markets." *The Journal of Futures Markets*. 4: 155-159.

Berck, P. 1981. "Portfolio Theory and the Demand for Futures: The Case of California Cotton." *The American Journal of Agricultural Economics*. (Aug.): 466-474.

Blank, S.C. 1989. "Research on Futures Markers: Issues, Approaches, and Empirical Findings." *Western Journal of Agricultural Economics*. 14(1): 126 - 139.

Bond, E.B. and Thompson, S.R. 1985. "Risk Aversion and the Recommended Hedging Ratio." *American Journal of Agricultural Economics*. (Nov.): 870-872.

Bond, E.B. and Thompson, S.R. 1986. "Optimal Commodity Hedging within the Capital Asset Pricing Model." *The Journal of Futures Markets*. 6 (3): 421-432.

Bond, E.B., Thompson, S.R. and Lee, B.M.S. 1987. "Application of a Simplified Hedging Rule." *The Journal of Futures Markets*. 7(1): 65-72.

Boothe, P. and Longworth, D. 1986. "Foreign Exchange Market Efficiency Tests: Implications of Recent Empirical Findings." *Journal of International Money and Finance*. 5: 135-152.

Braga, F.S. March 1990. *On the Relation Between Adjusted Basis and Hedge Results*. Working Paper WP90/06, Department of Agricultural Economics and Business, University of Guelph, Ontario.

Brandt, J.A. 1985. "Forecasting and Hedging: An Illustration of Risk Reduction In the Hog Industry." *American Journal of Agricultural Economics*. (Feb): 24-31.

Brealey, R., Myers, S., Sick, G., and Whaley, R. 1986. *Principles of Corporate Finance*. McGraw-Hill Ryerson Ltd., Toronto.

Brown, W.J. 1989. *The Review of the Economies of Farm Enterprise Size and Implications for Farm Diversification*. Discussion Paper No. 360. Economic Council of Canada, Ottawa.

Brown, S.L. 1985. "A Reformulation of the Portfolio Model of Hedging." *American Journal of Agricultural Economics*. Aug.: 508-512.

Buccola S.T. 1989. "Pricing Efficiency in Agricultural Markets: Issues, Methods, and Results. *Western Journal of Agricultural Economics*. 14(1): 111-121.

Caldwell, J., Copeland, J., and Hawkins, M. 1982. "Alternative Hedging Strategies for an Alberta Feedlot Operator." *Canadian Journal of Agricultural Economics*. Vol.30: 257-72.

Carter, C.A. and Loyns, R.M.A. 1985. "Hedging Feedlot Cattle: A Canadian Perspective." *American Agricultural Economics Association*. (Feb.): 32-39.

Carter, C.A., Rausser, G.C. and Schmitz, A. 1983. "Efficient Asset Portfolios and the Theory of Normal Backwardation." *Journal of Political Economy.* 91(21): 319-331.

Cecchetti, S.G., Cumby, R.E. and Figlewski, S. 1988. "Estimation of the Optimal Futures Hedge." *Review of Economics and Statistics.* 623-630.

Chavas, J.P. and Pope, R. 1982. "Hedging and Production Decisions Under a Linear Mean-Variance Preference Function." *Western Journal of Agricultural Economics.* (July): 99-110.

Chicago Mercantile Exchange. 1976-1987. *Statistical Yearbook.* Chicago Mercantile Exchange, Chicago, Illinois.

Chrystal, K.A. and Thornton, D.L. "On The Informational Content of Spot and Forward Exchange Rates." *Journal of International Money and Finance.* 7: 321-330.

Coles, H. 1989. "Risk And Returns Analysis of Beef Feedlot Investments In Alberta." Masters of Science Thesis, Department of Rural Economy, University of Alberta, Edmonton, Alberta.

Collins, R.A. 1985. "Expected Utility, Debt-Equity Structure, and Risk Balancing." *American Journal of Agricultural Economics.* (Aug): 627-629.

Collins, R.A. and Barry, P.J. 1986. "Risk Analysis with Single-Index Portfolio Models: An Application to Farm Planning." *American Journal of Agricultural Economics.* 68: 152-161.

Danthine, J.P. 1977. Martingale, Market Efficiency and Commodity Prices. *European Economic Review.* 10: 1-17.

Featherstone, A.M., Moss, C.B., Baker, T.G. and Preckel, P.V. 1988. "The Theoretical Effects of Farm Policies on Optimal Leverage and the Probability of Equity Losses." *American Journal of Agricultural Economics.* (Aug): 572-579.

Feder, G., Just, R.E., and Schmitz, A. 1980. "Futures Markets and the Theory of the Firm Under Price Uncertainty." *The Quarterly Journal of Economics.* (March): 317-328.

Fishburn, P.C. 1977. "Mean-Risk Analysis With Risk Associated With Below-Target Return." *The American Economic Review.* 67. No.2: 116-126.

Freeze, B.S., Nelson A.B., Musser W.N. and Hironaka, R. 1990. "Feeding and Marketing Portfolio Effects of Cattle Feeding in Alberta." *Canadian Journal of Agricultural Economics.* Vol. 38: 233-252.

Gabriel, S.C. and Baker, C.B. 1980. "Concepts of Business and Financial Risk." *American Journal of Agricultural Economics.* Aug: 560-564.

Garcia, P., Leuthold, R.M., Fortenbery, R. and Sarassoro, G.F. 1988. "Pricing Efficiency in the Live Cattle Futures Market: Further Interpretation and Measurement." *American Journal of Agricultural Economics.* Feb.: 162-169.

Garcia, P., Leuthold, R.M. and Sarharn, M.E. 1984. "Basis Risk: Measurement and Analysis fo Basis Fluctuations for Selected Livestock Markets." *American Journal of Agricultural Economics.* Sept.: 499-504.

Gaston, C.W. and Martin, L. 1984. *Hedging Strategies to Protect The Financial Position Of Canadian Beef Feedlot Operators.* School of Agricultural Economics and Extension Education, University of Guelph, Guelph, Ontario.

Gillis, K.G., Jameson, K., and Kerr, W.A. 1989. *Hedging in International Markets: The Ramifications for Management of Beef Feedlots in Western Canada.* Discussion Paper 117, Department of Economics, University of Calgary.

Heifner, R.G. 1972. "Optimal Hedging Levels and Hedging Effectiveness in Cattle Feeding." *Agricultural Economics Research.* 24(2): 25-36.

Hill, J. and Schneeweis, T. 1982. " A Note on the Hedging Effectiveness of Foreign Currency Futures." *The Journal of Futures of Markets.* 1: 659-664.

Hirshleifer, D. 1988. "Residual Risk, Trading Costs, and Commodity Risk Premia." *The Review of Financial Studies.* 1(2): 173-193.

Holthausen, D.M. 1979. "Hedging and the Competitive Firm under Price Uncertainty." *The American Economic Review.* 69: 989-995.

Holthausen, D.M. 1981. "Risk Return Model with Risk and Return Measured as Deviations from a Target Return." *The American Economic Review*. 71: 182-188.

Johnson L.L. 1960. "The Theory of Hedging and Speculation in Commodity Futures." *Review of Economic Studies*. 27: 139-151. Reprinted in *Selected Writings on Futures Markets*, Vol 2. A.E. Peck (editor) Chicago Board of Trade. 209-222.

Judge, G.G., Griffiths,W.E., Hill R.C., Lutkepohl, H. and Lee, T. 1988. *Introduction To The Theory and Practice Of Econometrics. 2nd Edition*. John Wiley and Sons, Toronto.

Judge, G.G., Griffiths,W.E., Hill R.C., Lutkepohl, H. and Lee, T. 1985. *The Theory and Practice Of Econometrics. 2nd Edition*. John Wiley and Sons, Toronto.

Just, R.E. and Rausser, C.R. 1981. "Commodity Price Forecasting with Large Scale Econometric Models and the Futures Market." *American Journal of Economics*. (May): 97-208.

Kahl, K.H. 1983. "Determination of the Recommended Hedge Ratio." *American Journal of Agricultural Economics*. (Aug): 603-605.

Kahl, K.H. and Tomek W.G. 1986. "Forward Pricing Models For Futures Markets: Some Statistical and Interpretative Issues." *Food Research Institute Studies*. 20(1): 71-85.

Kamara, A. 1982. "Issues in Futures Markets: A Survey." *The Journal of Futures Markets*. 2: 261-294.

Kenyon, D. and Clay, John. 1987. "Analysis of Profit Margin Hedging Strategies for Hog Producers." *The Journal of Futures Markets*. 7(2): 183-202.

King, R.P. and Robison, L.J. 1984. "Risk Efficiency Models." In *Risk Management in Agriculture*. P.J. Barry (editor). Iowa State University Press, Iowa.

Kmenta, J. 1971. *Elements of Econometrics*. Macmillan Publishing Co. Inc., New York.

Leuthold, R.M.(1974). "The Price Performance on the Futures Market of a Nonstorable Commodity: Live Beef Cattle." *American Journal of Agricultural Economics*. Reprinted in *Selected Writings on Futures Markets*. 1977. Vol 2. A.E. Peck (editor) Chicago Board of Trade: 375-385.

Leuthold, R.M. (1979). "An Analysis of the Futures-Cash Price Basis For Live Beef Cattle." *North Central Journal of Agricultural Economics*. Vol 1. No.1: 47-52.

Leuthhold, R.M., Garcia, P., Adam, B.D., and Park, W.I. (1989). "An Examination Of The Necessary And Sufficient Conditions For Market Efficiency: The Case of Hogs." *Applied Economics*. 21: 193-204.

Leuthold, R.M. and Hartmann, P.A. 1981. "An Evaluation of the Forward-pricing Efficiency of Livestock Futures Markets." *North Central Journal of Agricultural Economics*. 3: 71-80.

Leuthold, R.M., Junkus, J.C., and Cordier, J.E. 1989. *Theory and Practice of Futures Markets*. Lexington Books, Toronto.

Leuthold, R.M. and Tomek, W.G. 1980. "Developments in the Livestock Futures Literature." In *Livestock Futures Research Symposium*, Leuthold, R.M. and Dixon, P. (editors). Chicago Mercantile Exchange.

Lindahl, M. 1989. "Measuring Hedging Effectiveness With R^2: A Note." *The Journal of Futures Markets*. 9(5): 469-475.

Lintner, J. 1965. "The Valuation of Risk Assets and Selection of Risky Investments in Stock Protfolios and Capital Budgets." *Review of Economics and Statistics*. 47: 13-37.

Longworth, D., Boothe, P. and Clinton, K. 1983. *A Study of the Efficiency of Foreign Exchange Markets*. Bank of Canada.

Marcus, A.J. 1984. "Efficient Asset Portfolios and the Theory of Normal Backwardation: A Comment." *Journal of Political Economy*. 92(1): 162-164.

Markowitz, H. 1952. "Portfolio Selection." *Journal of Finance*. 7: 77-91.

Martin, L. and Garcia, P. 1981. "The Price-Forecasting Performance of Futures Markets For Live Cattle and Hogs: A Disaggregated Analysis." *American Journal of Agricultural Economics*. (May): 209-215.

Myers, R.J. and Thompson, S.R. 1989. "Generalized Optimal Hedge Ratio Estimation." *American Journal of Agricultural Economics*. (Nov): 858-868.

Newbery, D.M.G. and Stiglitz, J.E. 1981. *The Theory of Commodity Price Stabilization A Study in the Economics of Risk.* Oxford University Press, New York.

Peck, A.E. 1975. "Hedging and Income Stability: Concepts, Implications, and an Example." *American Journal of Agricultural Economics.* (Aug): 419-410.

Peck, A.E. (editor) 1977. *Selected Writings on Futures Markets. Volume 2.* Chicago Board of Trade.

Peterson, P.E. and Leuthold, R.M. 1987. "A Portfolio Approach to Optimal Hedging for a Commercial Cattle Feedlot." *The Journal of Futures Market.* 7: 443-457.

Price, R.V., Morgan, T.H., Dayton, A.D. and McCoy, J.H. 1979. "Basis Variability of Live Cattle Futures At Selected Kansas Markets." *North Central Journal of Agricultural Economics.* 1: 133-139.

Robison, L.J. and Barry, P.J. 1987. *The Competitive Firm's Response to Risk.* Macmillan Publishing Company, New York.

Rolfo, J. 1980. "Optimal Hedging Under Price and Quantity Uncertainty: The Case of a Cocoa Producer." *Journal Of Political Economy.* 88: 100-116.

Ross, S.A. and Westerfield, R.W. 1988. *Corporate Finance.* Times Mirror/Mosby College Publishing, Toronto.

Selley, R. 1984. "Decision Rules in Risk Analysis." In *Risk Management in Agriculture.* P.J. Barry (editor). Iowa State University Press, Iowa.

Shapiro B.I. and Brorsen B.W. 1988. "Factors Affecting Farmers' Hedging Decisions." *North Central Journal of Agricultural Economics.* 10(2): 145-153.

Sharpe, W.F. 1964. "Capital Asset Prices: A Theory Of Market Equilibrium Under Conditions Of Risk." *Journal of Finance.* 19: 425-42.

Shonkwiler, J.S. 1986. "Are Livestock Futures Prices Rational Forecasts?" *Western Journal of Agricultural Economics.* 11(2); 123-128.

Statistics Canada. *CANSIM.*

Stein, J.L. 1961. "The Simultaneous Determination of Spot and Futures Prices." *The American Economic Review.* Vol LI. Reprinted in *Selected Writings on Futures Markets*, Vol 2. A.E. Peck (editor) Chicago Board of Trade. 223-235.

Thompson S.R. and Bond, G.E. 1985. "Basis and Exchange Rate Risk in Offshore Futures Trading." *American Journal of Agricultural Economics.* Dec.: 980-985.

Thompson S.R. and Bond, G.E. 1987. "Offshore Commodity Hedging Under Floating Exchange Rates." *American Journal of Agricultural Economics.* Feb.: 46-55.

Turvey, C.G. 1989. "The Relationship Between Hedging with Futures and the Financing Function of Farm Management." *Canadian Journal of Agricultural Economics.* 37: 629-638.

Turvey, C.G. and Baker, T.G. 1989. "Optimal Hedging under Alternative Capital Structures and Risk Aversion. *Canadian Journal of Agricultural Economics.* 37: 135-143.

Turvey, C.G. and Driver, H.C. 1987. "Systematic and Nonsystematic Risks in Agriculture." *Canadian Journal of Agricultural Economics.* 35: 386-401.

U.S. President. *Economic Report of the President.* Selected Issues.

Var Econometrics. *Regression Analysis of Time Series.* RATS Version 3.11.

Witt, H.J., Schroeder, T.C. and Hayenga, M.L. 1987. "Comparison of Analytical Approaches for Estimating Hedge Ratios for Agricultural Commodities." *The Journal of Futures Markets.* 7(2): 135-146.

Wolff, C.C.P. 1988. "Exchange Rates, Innovations and Forecasting." *Journal of International Money and Finance.* 7: 49-61.

Working, H. 1953a. "Futures Trading and Hedging." *American Economic Review.* June: 314-343. Reprinted in *Select Writings of Holbrook Working.* 1977. Board of Trade of the City of Chicago, Chicago.

Working, H. 1953b. "Hedging Reconsidered." *Journal of Farm Economics*. 35: 544-561. Reprinted in *Select Writings of Holbrook Working*. 1977. Board of Trade of the City of Chicago, Chicago.

Young, D.L. 1984. "Risk Concepts and Measures for Decision Analysis." In *Risk Management in Agriculture*. P.J. Barry (editor). Iowa State University Press, Iowa.

Appendix A Exact Parameters used in the Production Function

This appendix details the exact parameters used in the production function in the simulation and how these numbers are adjusted by different price indexes to provide costs in each month. The details of the production function especially in the area of the rates of gain and feed usage were checked with the Alberta Agriculture Beef Cattle Nutritionist[44]. There were no major adjustments required in the parameters used by Coles (1989). The major parameter values used in the production function follow.

Production Function Parameters

Parameters	Description
adg=1.48;	average daily gain in kg/head per day before shrink adjustment[45]
Bamount=.835;	barley in tonne of feeder ration based on Coles
bartran=6.5;	1988 barley transportation cost/ tonne
bedcost=.04;	bedding charge per head/day in 1987
bedding=.91;	kg straw used per day per head
Broker=75.0	Brokers fee for hedging one contract in Dec. 1989 $
Buyer=5;	buyers charge for feeders in 1988
deathlos=.004;	steer death loss rate from Coles
distance=285;	km distance feeders trucked to feedlot
dressing=.57;	dressing percentage for steers used from Coles
feedcon=7.46;	feed conversion ratio based on 7.102 x 1.05 where the 7.102 comes for Coles (1989) - increased this ratio to account for extra feed in winter
feedproc=11.05;	1984 feed processing cost per tonne
lotsize=100;	number of 363+ kg (800+ lb) feeder steers purchased each month
Process=2.75;	feedlot processing cost/head in June 1987
ration=1.082;	factor to use to price ration using barley price
shrink=.04;	selling shrink fob feedlot
treat=6.94;	treatment cost per head in July 1978
truck=1.25;	trucking of feeders $/km per loaded km in 1987
truckcap=46;	holding capacity of truck for heavy feeders
yardage=.15;	feedlot yardage charge per head per day in 1987

The adjustments to the parameters are explained. These adjusted production numbers are used with the price numbers to develop the simulation production function for each time period.

Barley transportation costs to the feed lot are adjusted using two indexes. The petroleum index times 0.33 and the motor vehicle maintenance index for Alberta times 0.67 adjust the barley transportation cost for each month.

The feedlot yardage charge is adjusted by the supply and service index for Western Canada.

The feed processing charge is adjusted by the supply and service index for Western Canada.

The bedding cost charge is adjusted by the legume and grass production index for Western Canada.

The treatment cost per animal in the feedlot is adjusted with the supply and services index for Western Canada.

The feedlot processing cost for incoming animals is adjusted using the supply and services index for Western Canada.

The buyer charge for purchasing feeder cattle is adjusted using the supply and services index for Western Canada.

---

44 Livestock Nutritionist. Barry Yaremcio.

45 Daily rate of gain after allowing for 4% sale shrink FOB the feedlot is 1.25 kg (2.76 lb).

The trucking of feeders to the feedlot is adjusted by two indexes. The indexes are the petroleum index times 0.33 and the moving vehicle maintenance index for Alberta times 0.67.

The brokers fee is adjusted by the CPI.

Appendix B Significance Tests On Net Returns

The statistical tests used to determine whether the means of net returns reported in Chapter 5 are significantly different from zero requires further clarification. This appendix explains the test of significance used on the means. The net returns are tested for a time trend.

The tests on the mean of net returns are done using the usual t test with the sample standard deviation and sample mean. There is evidence that the data is not independent. The sample means calculated in the net returns table can be viewed as coming from the linear model:

$$Net\ Returns = \alpha i + \mu$$

where:
α is the coefficient to be estimated and if OLS is used on the model this is the usual sample mean,
i is a vector of ones and
μ is the error term.

The variance calculated using this model under OLS is the same as the usual sample variance calculation. Putting the model in this form allows the testing of autocorrelation in the data[46]. The Durbin Watson statistic can be calculated and the autocorrelation coefficient can be estimated. One selected net returns series is tested using this method for autocorrelation. This series is the net returns for the period April 1976 to December 1989 with no hedging and no NTSP.

The OLS regression of this model yields the following results:

OLS Of Net Returns Regressed On A Constant
No Hedging And No NTSP For 1976-1989

Var	Coef	Std. Error	T-Ratio	P-Value
Const.	6.02	3.57	1.68	0.09

The Durbin Watson is 0.51. However there are no tables for Durbin Watson statistics for OLS regressions on a constant. An alternative test for the significance of the autocorrelation coefficient is an asymptotic Wald test. The autocorrelation coefficient is asymptotically normally distributed as:

$$\sqrt{T}(\hat{\rho} - \rho) \overset{a}{\sim} N(0,\ 1 - \hat{\rho}^2)$$

and the test statistic becomes

$$\frac{\hat{\rho}^2 T}{1 - \hat{\rho}^2} \overset{a}{\sim} \chi^2(1)$$

The T is the total number of observations. The estimate of the autocorrelation coefficient, $\hat{\rho}$, 0.74, uses an OLS regression of the residuals on the same residual lagged one period. This estimator

46 It should be remembered that in linear regression terms this may be a misspecified model with missing independent terms that contribute to possible bias. The test for autocorrelation may be picking up a misspecified model and not necessarily autocorrelation.

converges asymptotically to the Maximum Likelihood estimator of the autocorrelation coefficient. The Wald test statistic is 145 for the previous regression. This is significantly different from zero at the 5% level of significance.

The consequences of the autocorrelation (assuming the model is correct) is that the estimate of the mean is unbiased and the estimate of the sample variance is biased[47]. This reduces the confidence in any test of significance. This suggests two possible solutions to this problem. One solution is to determine the direction of the bias. A second solution is to estimate the same linear model (net returns regressed on a constant) using generalized least squares (GLS) that corrects for the autocorrelation. Time limitations prevent doing GLS for all the net returns numbers in the net returns tables. The GLS is done on the same selected return for the period 1976-1989 with no hedging and no NTSP in Table 7. This gives some idea of the direction of the bias. The actual estimation is an iterated Maximum Likelihood (ML) method equivalent to GLS. The results show:

Maximum Likelihood Estimation Of Mean Of Net Returns
No Hedging And No NTSP For 1976-1989
Adjusted For Autocorrelation

Var	Coef	Std. Error	T-Ratio	P-Value
Const.	6.48	8.90	0.73	0.47
auto	0.73	0.05	13.90	0.00

The estimate of the mean, 6.48, is weighted by the autoregressive structure of the estimated variance. The ML estimate of 6.48 is slightly greater than the OLS estimate of 6.02. The standard deviation estimate using ML is 8.90 versus the OLS estimate of 3.57. The OLS significantly underestimates the variance of the mean. The autocorrelation coefficient, 0.73, is significant and positive.

These results using ML adjusted for first order autocorrelation confirms the direction of bias reported by Judge et al. (1985, p. 281-282) for a model with first order autocorrelation and only one independent variable in the regression. The direction of bias of the OLS estimation of the variance in this special regression[48] is downward given the following conditions. The autocorrelation coefficient is positive. The independent variable also follows an independent first order autoregressive process and this autoregressive parameter is also positive.[49]

The autocorrelation coefficient is positive and the autocorrelation coefficient of the constant is assumed to be 1. The conclusion is that the sample standard deviation estimates for the means in the net returns tables underestimates the true standard deviations. The test to determine whether the mean is different from zero are biased towards rejection.

---

47 The observations are not independent. The assumption of independence is a crucial assumption in the usual test of significance of sample means using the sample variance.

48 The results on direction of bias are not generally applicable to other models.

49 The independent variable is constant in this case and can be considered to have an autoregressive parameter of 1. This particular case is not commented on by Judge et al. (1985).

The direction of the bias in tests for differences between means of net returns is not clear. The direction of bias in the standard deviation of the difference between two means is downward if the two means are independent. If the two means are not independent then the covariance term enters the estimation of the standard deviation[50]. The covariance term complicates the direction of the bias. One possible solution might be to regress the differences between each observation of the two series of numbers on a constant. OLS or more likely GLS can be used in this case. Again, this is not done in this study.

The conclusion is to interpret these test with caution. Higher confidence can be placed in tests that suggest that the mean of net returns is not different from 0 since the direction of bias is towards the rejection of this hypothesis. The likely direction of bias in the tests between two means is toward rejection of the null hypothesis if the covariance term is positive. Again this would lead to the rejection of the hypothesis the means are the same when in fact the means are not significantly different.

The selected results of the net returns regressed on a time trend are shown in the following part of this section. The two periods covered are the period April 1976 to December 1989 and January 1980 to December 1989. The two situations examined are the net returns with no hedging and no NTSP and net returns for no hedging and with NTSP. The net returns are regressed on a time trend. Not surprisingly the OLS estimates show significant first order autocorrelation. The regressions are estimated again using ML correcting for the autocorrelation.

None of the time trends are significant at the 5 % level using the reported P-value. This indicates there is no linear time trend in the net returns.[51] This completes the discussion on the testing of net returns for significant differences and for a time trend.

---

50 Recall that variance of the difference between two variables X1, X2 is Var(X1-X2) = Var(X1) + Var(X2) - 2xCovariance(X1,X2).

51 The use of a time trend vector $X' = 1, 2, ..., T$ in the regression may not lead to valid statistical inference. A time trend such as X is a non stationary regressor. This violates the assumptions of the OLS or GLS models that the probability limit of $X'X/T$ or $X'\Psi^{-1}X/T$ converges to a constant where psi is a positive definite weighting matrix of constants (Judge, (1985)). The estimates are still unbiased. The actual asymptotic distribution of the coefficients in the model are still normal but different from the estimates derived here. It seems that in practice (at least at this time) this problem is ignored. This same comment also applies to the tests for trends in the basis, and optimal hedge done elsewhere.

Net Returns Time Trend

1980-1989 No Hedging and With NTSP

Var	Coef	Std. Error	T-Ratio	P-Value
const.	15.41	20.45	0.75	0.45
Trend	-0.10	0.18	-0.57	0.57
auto	0.65	0.07	9.46	0.00

1976-1989 No Hedging and With NTSP

Var	Coef	Std. Error	T-Ratio	P-Value
const.	19.24	16.51	1.16	0.25
trend	-0.13	0.17	-0.77	0.44
auto	0.72	0.05	13.28	0.00

1976-1989 No Hedging and No NTSP

Var	Coef	Std. Error	T-Ratio	P-Value
const.	21.94	16.75	1.31	0.19
trend	-0.19	0.17	-1.07	0.28
auto	0.72	0.05	13.47	0.00

1980-1989 No Hedging and No NTSP

Var	Coef	Std. Error	T-Ratio	P-Value
const.	23.32	21.15	1.10	0.27
trend	-0.20	0.19	-1.07	0.29
auto	0.67	0.07	9.82	0.00

Appendix C Complete Hedge Results

This section reports the results of simulated hedging (selling) of live cattle futures contracts over different time periods. The 90 day hedge corresponds to the same period as the production function used in this research. The futures contracts are always closed one to two months prior to the contract expiration month.

Alberta hedge profits are in real 1981 Canadian dollars per cwt of slaughter cattle sold. The hedge involves selling live cattle futures contracts. No brokers fees or margin costs are included. Brokers fees in 1981 Canadian dollars are approximately $0.12 per cwt. The approximate length of time of each hedge is from the Wednesday of the third week of the month to the Wednesday of the third week of the month when the contract is purchased back. All hedges are closed by December 1989. The dates used for counting a hedge in a time period are the dates the hedge position are opened.

Some time periods may have hedge profits significantly different from zero. The t value at the 5% level of significance for 44 and 119 degrees of freedom are about 2.02 and 1.98 respectively. However the hedge profits also exhibit possible autocorrelation. The same autocorrelation analysis and model used in Appendix B is used here. The hedge profits for the 90 day hedge length for 1976 to 1989 are regressed on a constant using OLS. The coefficient on the constant is -0.114. The estimated autocorrelation coefficient is 0.63. The Wald test statistic is 109. This indicates that the autocorrelation coefficient is significant at the 5% level.

The estimates of sample mean standard deviations are biased. Since the autocorrelation coefficient is positive and following the argument used in Appendix B, the sample mean standard deviation is underestimated. The confidence in any test on whether the means are different from zero is over stated.

The means for two selected numbers from the Alberta hedge returns are estimated adjusting for the first order autocorrelation. The 90 day hedge for the period April 1986 to 1989 and the 180 day hedge for the period 1980 to March 1986 are estimated using the ML method. The weighted mean calculation, the coefficient on the constant, is not significantly different from zero.

Alberta Hedge Profits or Losses

Period Jan. 1976-1989[1]

Hedge Length	Mean S/cwt	Std. Dev. Sample	Std. Dev. Mean	t Statistic[2]
30 day	-0.08	4.03	0.31	-0.24
60 day	-0.16	5.26	0.41	-0.40
90 day	-0.11	6.23	0.49	-0.23
120 day	0.11	6.83	0.53	0.25
150 day	0.24	7.22	0.57	0.43
180 day	0.42	7.57	0.59	0.70

Period Jan. 1980-1989

30 day	0.01	3.31	0.30	0.04
60 day	0.10	4.57	0.42	0.24
90 day	0.33	5.29	0.49	0.67
120 day	0.62	5.71	0.53	1.16
150 day	0.78	5.77	0.54	1.45
180 day	1.04	5.71	0.54	1.94

Period Jan. 1976-1979

30 day	-0.29	5.47	0.79	-0.37
60 day	-0.82	6.67	0.96	-0.85
90 day	-1.19	8.05	1.16	-1.02
120 day	-1.03	8.95	1.29	-0.79
150 day	-1.05	9.82	1.42	-0.74
180 day	-1.06	10.70	1.54	-0.69

Period Jan. 1980-March 1986

30 day	0.37	3.69	0.43	0.88
60 day	0.70	5.13	0.59	1.18
90 day	1.12	5.98	0.69	1.63
120 day	1.55	6.42	0.74	2.09
150 day	1.76	6.45	0.74	2.36
180 day	2.04	6.43	0.74	2.75

Period April 1986-1989

30 day	-0.61	2.44	0.37	-1.64
60 day	-0.95	3.17	0.48	-1.96
90 day	-1.09	3.37	0.52	-2.10
120 day	-1.10	3.57	0.56	-1.97
150 day	-1.06	3.60	0.57	-1.86
180 day	-0.90	3.26	0.52	-1.72

1. The time periods include the date of opening the hedge position by selling contracts. The number of hedges in a time period decreases as the length of the hedge increases. All hedges are closed by December 1989. Dollars are in June 1981 S.
2. T statistic is the test for the difference of the mean from 0.

90 Day Alberta Hedge Mean Calculation
March 1986 to September 1989 Adjusted For Autocorrelation

Var	Coef	Std. Error	T-Ratio	P-Value
const.	-1.13	0.79	-1.43	0.16
auto	0.42	0.14	3.00	0.005

180 Day Alberta Hedge January 1980 to March 1986 Adjusted For Autocorrelation

Var	Coef	Std. Error	T-Ratio	P-Value
Const.	2.02	1.57	1.28	0.20
Auto	0.65	0.09	7.44	0.00

The estimates using OLS, of sample mean variances in the hedging table are biased downward. The conclusion is that the Alberta hedge profits for 1, 2, 3, 4, 5 and 6 months over the periods 1976 to 1989 are not significantly different from zero.

Omaha hedge profits are in real 1982 United States dollars per cwt. of slaughter cattle sold. The hedge in this case is selling live cattle futures contracts. No brokers fees or margin costs are included. The approximate length of time of each hedge is from the Wednesday of the third week of the month to the Wednesday of the third week of the month when the contract is purchased back. All hedges are closed by December 1989. The Omaha hedge profits are checked for autocorrelation. The hedge profits are based on the same data as the Alberta data. Therefore the data has the same autocorrelation and this overstates the confidence in the t tests on the means of Omaha hedge profits. The conclusion is that the CME live cattle contract is unbiased.

Omaha Hedge Profits or Losses
Jan. 1982 U.S. Dollars

Period Jan. 1976-1989

Hedge Length	mean	Std. Dev. Sample	Std. Dev. Mean	t Statistic[1]
30 day	-0.08	3.54	0.27	-0.27
60 day	-0.16	4.52	0.35	-0.46
90 day	-0.12	5.36	0.42	-0.28
120 day	0.11	5.83	0.46	0.25
150 day	0.21	6.15	0.48	0.44
180 day	0.38	6.39	0.50	0.76

Period Jan. 1980 to 1989

30 day	-0.09	2.84	0.26	-0.33
60 day	-0.10	3.95	0.36	-0.27
90 day	0.01	4.54	0.42	0.02
120 day	0.17	4.84	0.45	0.37
150 day	0.22	4.86	0.45	0.49
180 day	0.37	4.84	0.45	0.83

Period Jan. 1976-1979

30 day	-0.05	4.91	0.71	-0.07
60 day	-0.32	5.72	0.83	-0.38
90 day	-0.42	7.03	1.01	-0.41
120 day	-0.02	7.79	1.12	-0.02
150 day	0.20	8.55	1.23	0.16
180 day	0.39	9.14	1.32	0.30

Period Jan. 1980-March 1986

30 day	0.32	3.11	0.36	0.88
60 day	0.60	4.32	0.50	1.20
90 day	0.96	4.93	0.57	1.69
120 day	1.32	5.19	0.60	2.20
150 day	1.50	5.14	0.59	2.53
180 day	1.78	5.07	0.59	3.05

Period April 1986-1989

30 day	-0.77	2.17	0.33	-2.36
60 day	-1.31	2.87	0.44	-3.00
90 day	-1.70	3.10	0.48	-3.54
120 day	-1.94	3.22	0.50	-3.86
150 day	-2.18	3.13	0.50	-4.41
180 day	-2.34	2.88	0.46	-5.06

1. T statistic is the test for the difference of the mean from 0.

Appendix D Forecasting NTSP Pay outs

The objective of this appendix is to predict NTSP pay outs under the second prediction method mentioned in chapter 5, using the data collected for the simulation. The forecast is based on the program description in chapter 2. This forecast is compared to the forecast using 3 times the producer premium.[52] This appendix shows why the 3 times the producer premium is chosen as the NTSP forecast.

The proposed estimation method is to predict national cost and national price. With these predictions and the historical information on the 5 year average of costs and prices for the month or quarter, support levels are predicted. Then possible pay outs are predicted. Refer to chapter 2 for the description of the program.

The initial estimates look at the entire period and the linear relationship between national costs and lagged values of calf prices (East and West), bank rate, feeder prices, barley prices and the supply and services index. A simple OLS is done and the results viewed for quarterly data and monthly data. There is a strong relationship between the national cost (as estimated by the NTSP) and these variables. There is also autocorrelation and multicolinearity in the model. These are not corrected for in this part of the research[53].

There is a high degree of correlation between the national costs and the variables included in the model. The model is calculated for each month starting in the month January 1986. Complications in the calculations include the change over to monthly data from quarterly data in 1989. The model is updated each month. The general model includes the following variables.

Y = National Cost (dependent variable).
constant,
x1 = Toronto str. calf price 8 month prior to sale,
x2 = Edmonton str. calf price 7 months prior to sale,
x3 = 800+ lb Edmonton feeder str. 3 months prior (90 days) to sale,
x4 = open market barley price monthly average for Calgary 3 months prior to sale.
X5 = bank price loan rate 7 months prior,
x6 = supply and services index lagged 3 months.

Using information available at the time of the purchase of the feeder steers the national cost is estimated from this OLS regression. Linear OLS regressions are estimated to provide forecasts of national cost. Historical national costs are available from the program. Where quarterly data is used the lags are 2 quarters for 7 and 8 months and 1 quarter for 3 month lags indicated above. Quarterly data is developed from the monthly data.

The first estimates are required for cattle to be sold in April 1986. The period 1986 to December 1988 uses quarterly data in calculating support levels and 0.85 of gross margins. The period January 1989 to December 1989, uses monthly data to calculate support levels and 0.90 of gross margins. Quarterly costs are estimated using OLS and the variables listed above (plus a constant). The NTSP

---

52 A fourth alternative was also explored. The investor in this cattle feeding simulation is predicting profits. The fourth alternative assumed that the NTSP would make pay outs equal to the simulations predicted losses. This method did not compare favorably with the other two alternatives explored.

53 Work on OLS NTSP pay out model was discontinued after seeing the difference in MSE between this model and the 3 x Premium model.

gives these quarterly costs. The relationship is used to estimate the coefficients for prediction. The quarterly data is estimated to get a set of coefficients for December 1985 (using the data from January 1976 to December 1985 adjusted for lags). The coefficients are used with the data available in January 1986 (adjusted for lags if required) to estimate quarterly support levels in the 2nd quarter in 1986. The regression is estimated again each month adding one new data point and dropping off the oldest data point. Within the quarter the estimate for each quarter is updated each month and for the second and third month the input variables are unweighted averages of the months in the quarter. (For example: The first month in a quarter uses only that months prices to predict. The second month uses the average of the two months. The third month will use the average of the three months.)

Monthly coefficients are estimated starting in October 1985 to provide an estimate for January 1986. The estimate uses the information from January 1976 to October 1988. The regression is estimated again each month adding one set of new data points and dropping the oldest month of data.

These estimates of national cost at the time of sale of the animals are made at the time of purchase. The five year monthly average national cost and national prices are available from the NTSP program (and these were used to calculate the quarterly national cost and national price). The national support level is then calculated for quarterly time periods:

Support=.85(National Price - National Cost) + Estimated National Cost

The estimate for monthly time period is:

Support=.90(National Price - National Cost) + Estimated National Cost

Then the estimated NTSP pay out is the Estimated National Price - Support. If this is negative then there is a pay out. The explanation of the price prediction used is covered in chapter 5. The forecast price chosen in chapter 5 is used here.

All these prices are given in S/cwt of live animal. The national cost is available from the NTSP since this a historical 5 year average. The MSEs of the two methods of predicting the NTSP pay outs per head are calculated. The MSE are shown in the following table.

Table
NTSP Prediction Mean Square Error

	OLS Estimate	3 x Premium
Root MSE	34.3	22.4
MSE	1178.8	499.3

The table indicates that the 3 x Premium gives the lower MSE. Various ad hoc methods to adjust the OLS estimate (adjusting the predicted price to reflect the National Price) reduced the MSE to 762. Statistically testing the difference of the MSE in the table presents difficulties. The MSEs are not independent. This prevents the use of tests that directly compare MSE similar to the direct F test of two independent variances.

The Ashley et al. (1980) test explained in Appendix F is used to compare the MSE of out of sample forecasts from competing models. The MSE of the NTSP prediction errors are compared using this method. The null hypothesis is that the MSE errors from the two models are not different. This is tested by checking if the coefficients are non negative and significantly different from zero. The interpretation of the test and the set up of the model changes depending on the sign of the means of the forecast errors. The model is set up with the 3 x premium as model two as shown in the Appendix F to determine if the 3 x premium model has the smaller forecast error. The means of the forecast error for 3 x premium and for the OLS estimate are 3.25 and -16.10 respectively. The negative mean is adjusted accordingly by multiplying it by negative 1 to make it positive for this test.

The usual OLS regression of this model shows significant first order autocorrelation as shown by the significant Durbin Watson coefficient of 0.31 with 45 observations. The model is estimated using ML adjusted for first order autocorrelation.

Table
Mean Square Error Test On NTSP Prediction Models

Var	Coef	Std. Error	T-Ratio	P-Value
const	16.81	18.81	0.89	0.38
X1	0.83	0.16	5.32	0.00
auto	0.83	0.08	10.09	0.00

OLS DW=0.31 Chi-Squared= 28.9 P-Value Chi=0.00
Means of Errors: 3xPrem=3.25 NTSP OLS=-16.10
(For regression NTSP OLS error vector multiplied by negative 1.)

Following Ashley et al. (1980) the coefficients of the model are both positive and one of them is significantly positive at the 5% significance level. The small sample F test for the significance of the regression is replaced with an asymptotic Chi-squared test. The Chi-squared with 2 degrees of freedom is 28.9 and this is significant at the 5% level. The coefficients are greater than 0. This rejects the null hypothesis. The 3 x premium is the better forecasting model.

NTSP model building using the data collected for the main simulation was not successful. Forecasting problems make this a difficult method to use. It does not provide superior forecasts to the 3 times premium model.

Appendix E Selective Investment Strategies - Number of Hedges or Selective Investments

The number of times hedges are placed for each selective hedging strategy and the number of times investors purchase T-Bills in the selective investment strategy are reported here. The total time period covered is 120 months.

Number of Times the Investor Hedges in Hedge Strategies

	Length of Hedge		
Strategy	1 Month	2 Month	3 Month
100% Hedge			
No NTSP			120.0
NTSP			120.0
Optimal Hedge			
No NTSP			120.0
NTSP			120.0
Selective Hedge 5%			
No NTSP	8.0	9.0	50.0
NTSP	13.0	13.0	50.0
Selective Hedge T-Bill			
No NTSP	9.0	6.0	43.0
NTSP	12.0	7.0	43.0
Selective Investment			
No NTSP			43.0
NTSP			45.0

Selective Investment-Number of Times Invest in T-Bills Instead of Feeder Cattle

	No Hedge No NTSP	No Hedge NTSP	Hedge No NTSP	Hedge NTSP
Number	76	74	77	75

Appendix F Mean Square Error Tests Of Significance

The MSE statistical test of Ashley et. al. (1980) is explained. This test is not described in the econometric texts. The test results for the price forecasting models and net returns strategies from chapter 5 are reported.

The MSE's of different models are not independent. This precludes the use of the usual small sample F test to compare variances or even the use of asymptotic tests to do the same thing. The following is one possible method proposed to compare MSE in a statistical manner. This test is used by Brandt (1985), Garcia et al. (1988) and Leuthhold, Garcia, Adam and Park (1989).

Ashley et al. (1980) proposed the following test to compare MSE between competing models forecasting the same out of sample values. Let $\hat{\mu}_1$ and $\hat{\mu}_2$ be the out of sample vectors of forecast errors from two competing models. These models predict the same price. Hypothesize that model 2 has lower forecast error than model 1. Ashley et al. (1980) use a regression equation defined as follows:

$$\hat{\mu}_{1,t} - \hat{\mu}_{2,t} = \alpha_1 + \alpha_2[(\hat{\mu}_{1,t} + \hat{\mu}_{2,t}) - mean(\hat{\mu}_{1,t} + \hat{\mu}_{2,t})] + e_t$$

where:
the mean(.) is the mean of the two forecast errors added together and
the e is an independent error term with zero mean.

Now assume that the means of the two forecast errors are positive. Testing $\alpha_1 = \alpha_2 = 0$ against the alternative that both are non negative and at least one is positive is the test. A significant negative coefficient implies that model 2 is not better. If one coefficient is negative but not significant and the other coefficient is positive and significant then model 2 is better. If both coefficients are positive an F test can be used to test if the coefficients are jointly greater than 0. Ashley et al. (1980) point out that the F test as used here in this model has a significance level equal to one half that obtained from F value tables.

If both means of the forecast errors are negative then a different interpretation can be placed on the test. The test for model 2 superiority is that the intercept term be negative and the other coefficient be positive. If one error mean is positive and one error mean is negative then the results of the test are ambiguous. Then the intercept term of the regression is only negative or positive depending on which error mean is negative. However the nature of the test should allow the multiplying of the forecast error vector with the negative mean by negative one. This then gives the same test interpretation as when both error means are positive. The question of interest is whether the errors are smaller or larger and not whether one has a negative mean or a positive mean.

This test requires an explanation of the rationale behind the test. Ashley et al. (1980) start with difference between the two MSEs.

$$MSE(\hat{\mu}_1) - MSE(\hat{\mu}_2) = [s^2(\hat{\mu}_1) - s^2(\hat{\mu}_2)] + [mean(\hat{\mu}_1)^2 - mean(\hat{\mu}_2)^2$$

The s^2 is the sample variance of the errors. Using some algebra this expression is equivalent to:

$$MSE(\hat{\mu}_1) - MSE(\hat{\mu}_2) = Cov[(\hat{\mu}_1 - \hat{\mu}_2),(\hat{\mu}_1 + \hat{\mu}_2)] + [mean(\hat{\mu}_1)^2 - mean(\hat{\mu}_2)^2$$

The cov(.) denotes the covariance. The estimates of the coefficients of the regression are the following expressions.

$$\hat{\alpha}_1 = \sum_{t=1}^{n} \frac{(\hat{\mu}_{1,t} - \hat{\mu}_{2,t})}{n}$$

and

$$\hat{\alpha}_2 = \frac{Cov[(\hat{\mu}_1 - \hat{\mu}_2).(\hat{\mu}_1 + \hat{\mu}_2)]}{s^2(\hat{\mu}_1 + \hat{\mu}_2)}$$

The tests on the coefficients of the regression are tests to determine if the covariance of the sums and differences of the errors is 0 and whether the mean of the difference of the errors is 0.

Multiplying one error vector by negative 1 does not change the original MSE difference expressions since everything is squared. It does change the regression coefficients. However it is the difference in absolute terms that is of importance in this test. Again some algebra shows that the change in $\hat{\alpha}_2$ by multiplying one error term by negative one does not change the sign of the coefficient but it does change the magnitude of the coefficient. Only the variance term of the calculation changes. The intercept term changes. It can now be positive or negative depending on the relative size of the errors.

This concludes the discussion on the test of Ashley et al. (1980) on MSE.[54]

Tests of Price Forecast MSE

The following tables gives the results of the tests to compare MSE on slaughter steer price forecasters using the procedure of Ashley et al. (1980). The first model in the title is considered model 2. The test is to determine whether the model 2 has smaller mean square error. Unless otherwise stated the test is estimated using ML corrected for first order autocorrelation. The chi-squared statistic is the asymptotic test for the significance of the regression that the coefficients equal 0 (Judge et al. (1985)). The first series of tests are the direct cash forecasters that do not use the futures market. The second series of test are on the forecasts that use the futures for forecasters. The final series of tests are selected comparisons between the two groups of forecasters.

Comparison of Direct Cash Price Predictions

Cash 3 Months Prior Vs. OLS Full Information

Var	Coef	Std. Error	T-Ratio	P-Value
const	-2.12	1.50	-1.41	0.16
X1	-0.17	0.03	-6.06	0.00
auto	0.86	0.05	18.61	0.000

OLS DW=0.33 Chi-Squared=39.13 P-Value Chi=0.00
Means of Errors: Cash=-0.96, OLS=-3.23

Conclusion: Cash 3 Months Prior is not a better predictor than the OLS full information. The constant is negative but insignificant. The X1 is also negative and significant actually suggesting that the OLS full information may be a superior forecaster. (Remember that with both means negative the test for model 2 superiority is that the constant be negative and that the X1 be positive.)

54 This author used this test many times in this study. The test may have limited usefulness. The test results may lead to conflicting conclusions. Most of the tests in this study require correction for first order autocorrelation. After this correction, the test results may suggest that a forecast model with a smaller MSE than another model, has significantly larger MSE than the other model.

Cash 3 Months Prior Vs. OLS Limited Information

Var	Coef	Std. Error	T-Ratio	P-Value
const	-1.57	1.65	-.095	0.34
X1	-0.11	0.03	-3.60	0.00
auto	0.85	0.05	17.84	0.000

OLS DW=0.39 Chi-Squared=13.98 P-Value Chi=.001
Means of Errors: Cash=-0.96 OLS=2.45

Conclusion: Cash 3 months prior is not a superior price forecaster.

Cash 3 Months Prior Vs. OLS Error Correction (OLS Estimation)

Var	Coef	Std. Error	T-Ratio	P-Value
const	-20.99	0.86	-24.31	0.00
X1	0.46	0.07	6.59	0.00

OLS DW=0.421 (The estimated autocorrelation coefficient is over one and the estimate is nonstationary with ML estimation to correct for first order autocorrelation.)
Means of Errors: Cash=-0.96, OLS Correct=-21.95

Conclusion: No conclusions possible given the nature of the data. The coefficient signs are the ones that lead to suggesting Cash 3 months prior is superior.

Cash 3 Months Prior Vs. Cash ARIMA

Var	Coef	Std. Error	T-Ratio	P-Value
const	-1.02	0.15	-6.98	0.00
X1	0.05	0.01	6.17	0.000
auto	0.43	0.08	5.20	0.00

OLS DW=1.26 Chi-Squared=85.90 P-Value Chi=0.00
Means of Errors: Cash=--0.96 Cash ARIMA=-1.98

Conclusion: The Cash 3 months prior is superior to the Cash ARIMA. The constant is negative, the X1 is positive and the asymptotic test for the significance of the regression is significant.

OLS Full Information Vs. OLS Limited Information

Var	Coef	Std. Error	T-Ratio	P-Value
const	0.57	0.87	0.65	0.52
X1	0.05	0.01	3.18	0.002
auto	0.87	0.05	18.91	0.00

OLS Dw=0.27 Chi-Squared=10.59 P-Value Chi=0.01
Means of Errors: OLS Full=-3.23 OLS Limit=-2.45

Conclusion: The OLS full information may be superior to the OLS Limited Information. The constant is negative but insignificant. The X1 is positive and significant. The test for the significance of the regression cannot be used in this case since the signs of the coefficients are not in the right directions.

OLS Full Information Vs. OLS Error Correction (OLS Estimation)

Var	Coef	Std. Error	T-Ratio	P-Value
const	-18.72	0.55	-34.90	0.00
X1	0.38	0.04	9.71	0.00

OLS DW=0.36 (Autocorrelation non stationary)
Means of Errors: OLS Full=-3.22 OLS Error=-21.95

Conclusion: No test are applicable since the model has serious problems. The signs on coefficients support the superiority of the OLS Full Information.

OLS Full Information Vs. Cash ARIMA

Var	Coef	Std. Error	T-Ratio	P-Value
const	1.08	1.68	0.64	0.52
X1	0.24	0.30	7.94	0.00
auto	0.85	0.05	17.93	0.00

OLS DW=0.36 Chi-Squared=63.75 P-value Chi=0.00
Means of Errors:OLS Full=-3.23 Cash ARIMA=-1.98

Conclusion: The OLS Full Information may be superior to the Cash ARIMA predictions. The constant is positive but not significant. The X1 is positive and significant.

OLS Limited Information Vs. OLS Error Correction

Var	Coef	Std. Error	T-Ratio	P-Value
const	-19.50	0.68	-28.80	0.00
X1	0.31	0.05	6.67	0.00

OLS Dw=0.25 (Autocorrelation non stationary)
Means of Errors: OLS Limit=-2.45 OLS Error=-21.95

Conclusion: No tests are applicable to the regression. The signs of the coefficients are in the direction that suggest that the OLS limited information is the better predictor.

OLS Limited Information Vs. Cash ARIMA

Var	Coef	Std. Error	T-Ratio	P-Value
const	0.53	1.83	0.29	0.77
X1	0.19	0.04	5.43	0.00
auto	0.84	0.05	17.07	0.000

OLS DW=0.44 Chi-Squared=29.60 P-Value Chi=0.00
Means of Errors:OLS Limit=-2.45 Cash ARIMA=-1.98

Conclusion: The OLS limited Information may be better than the Cash ARIMA. The constant is positive but not significant. The X1 is positive and significant.

OLS Error Correction Vs. Cash ARIMA (OLS Estimation)

Var	Coef	Std. Error	T-Ratio	P-Value
const	19.96	0.95	20.87	0.00
X1	-0.44	0.08	-5.62	0.00

OLS DW=0.48 (Autocorrelation coefficient non stationary)
Means of Errors: OLS Error=-21.95 Cash ARIMA=-1.98

Conclusion: No tests are applicable. The signs of the coefficients suggest that the OLS error correction is not better than the Cash ARIMA for predicting slaughter cattle prices in Alberta.

There is no direct cash price predictor of Alberta slaughter steers that is clearly superior (or at least not inferior) when compared within the group of cash predictors.

Comparison of Predictions Using Futures Prices

Basis ARIMA (constant) Vs. Average Basis

Var	Coef	Std. Error	T-Ratio	P-Value
const	0.79	2.56	0.31	0.76
X1	0.63	1.05	0.60	0.55
auto	0.75	0.06	12.16	0.00

OLS DW=0.50 Chi-Squared=0.45 P-Value Chi=0.80
Means of Errors: Basis ARIMA (con)=0.08, Basis Avg.=-1.09
(Average Basis errors multiplied by negative 1 for regression)

Conclusion: The futures price predictor using the basis predictor with ARIMA with constant is not superior to average basis. The signs of the coefficients are both positive which is the direction required for the ARIMA Basis to be the better forecaster. The asymptotic test for the significance of the regression is not significant with a P-Value of 0.4. (The test for the significance of the regression if the signs of the coefficients are right is about 0.5 of the stated significance.) Alternatively if the test is reversed, the average basis forecast is not superior to the basis ARIMA with constant forecast.

Basis ARIMA (constant) Vs. Basis ARIMA (no constant)

Var	Coef	Std. Error	T-Ratio	P-Value
const	0.33	2.55	0.13	0.90
X1	0.19	4.35	0.04	0.96
auto	0.74	0.06	12.12	0.00

OLS DW= 0.51 Chi-Squared=0.02 P-Value Chi=0.99
Means of Errors: Basis Ar. Con.=0.08 Basis Ar. No Con.=-0.63
(Basis ARIMA No Constant errors multiplied by negative 1 for regression)

Conclusion: The basis ARIMA with constant is not a superior forecaster than the basis ARIMA with no constant.

Basis ARIMA (constant) Vs. Basis 3 Months Back

Var	Coef	Std. Error	T-Ratio	P-Value
const	0.11	2.56	0.04	0.97
X1	1.03	0.29	3.57	0.001
auto	0.74	0.06	12.15	0.00

OLS DW=0.515 Chi-Squared=12.77 P-Value Chi=0.002
Means of Errors: Basis Ar. Con.=0.08, Basis 3 months Pr.=-0.41
(Basis 3 Month Back Error multiplied by negative 1)

Conclusion: The basis ARIMA with constant is superior to the basis 3 months back prediction.

Average Basis Vs. Basis ARIMA (no constant)

Var	Coef	Std. Error	T-Ratio	P-Value
const	0.49	0.36	1.38	0.17
X1	-0.001	0.01	-0.49	0.62
auto	0.85	0.05	17.38	0.00

OLS DW=0.31 Chi-Squared=2.12 P-Value Chi=0.35
Means of Errors: Avg. Bas.=-1.09, Basis Ar. No Con.=-0.63

Conclusion: The constant is positive, the X1 is negative and neither coefficient is significant. The average basis is not a superior forecaster to the basis ARIMA with no constant.

Average Basis Vs. Basis 3 Months Prior

Var	Coef	Std. Error	T-Ratio	P-Value
const	0.71	0.42	1.71	0.09
X1	0.05	0.03	1.84	0.07
auto	0.43	0.08	5.14	0.00

OLS DW=1.21 Chi-Squared=6.35 P-Value Chi=0.04
Means of Errors: Basis Avg.=-1.09, Basis 3 Mon. Pr.=-0.41

Conclusion: The average basis is superior to the basis 3 months prior.

Basis ARIMA (no constant) Vs. Basis 3 Months Prior (Used OLS)

Var	Coef	Std. Error	T-Ratio	P-Value
const	0.24	0.27	0.89	0.38
X1	0.05	0.02	2.40	0.02
auto	0.32	0.09	3.73	0.00

OLS DW=1.41 Chi-Squared=6.56 P-Value Chi=0.04
Means of Errors: Basis Ar. (no con.)=-0.63, Basis 3 Mon Pr.=-0.41

Conclusion: The basis ARIMA with no constant is superior to the basis 3 months prior.

The basis ARIMA with constant has the smallest MSE of the price predictors using the futures markets. The tests between the predictors using the futures prices shows no other model that dominates the basis ARIMA with constant prediction. The price prediction using the basis ARIMA with constant is now compared to all the direct cash predictors since no dominant cash price predictor was found in the previous test.

Comparison Between futures predictor with basis ARIMA with constant compared to all direct cash predictors.

Basis ARIMA (constant) Vs. Cash 3 Months Prior

Var	Coef	Std. Error	T-Ratio	P-Value
const	0.65	2.56	0.26	0.80
X1	1.01	0.25	4.11	0.00
auto	0.74	0.06	12.16	0.00

OLS DW=0.62 Chi-Squared=16.94 P-Value Chi=0.17
Means of Errors: Basis Ar con.=0.08, Cash 3 mon. Pr.=-0.96
(Cash 3 month prior errors multiplied by negative 1)

Conclusion: The basis ARIMA with constant is superior to the cash 3 months prior at the 0.08 level of significance based of the test on the significance of the regression.

Basis ARIMA (constant) Vs. OLS Full Information

Var	Coef	Std. Error	T-Ratio	P-Value
const	2.75	2.17	1.27	0.21
X1	-0.45	0.33	-1.37	0.17
auto	0.72	0.06	11.26	0.00

OLS DW=0.59 Chi-Squared=3.54 P-Value Chi=0.17
Means of Errors: Basis Ar. Con.=0.08, OLS F.I.=-3.23
(OLS Full Information errors multiplied by negative 1)

Conclusion: The basis ARIMA with constant is not superior to the OLS full information prediction. The signs of the coefficients preclude the use of the test of the significance of the regression. The OLS full information does not dominate the ARIMA basis with constant. (The changing of the model definition changes the signs of the coefficients but no other changes occur in the regression. For example if the OLS full information is defined as model two then the regression coefficients become -2.75 and 0.45.)

Basis ARIMA (constant) Vs. OLS Limited Information

Var	Coef	Std. Error	T-Ratio	P-Value
const	2.11	2.32	0.91	0.37
X1	0.24	0.28	0.87	0.38
auto	0.72	0.06	11.50	0.00

OLS DW=0.54 Chi-Squared=1.57 P-Value Chi=0.46
Means of Errors: Basis Ar. Con.=0.08, OLS L.I.=-2.45
(OLS Limited Information errors multiplied by -1)

Conclusion: The basis ARIMA with constant is not superior to the OLS limited information prediction. The test for the significance of the regression is not significant at the 5% or 10% level.

Basis ARIMA (constant) Vs. OLS Error Correction (OLS Estimate)

Var	Coef	Std. Error	T-Ratio	P-Value
const	21.86	0.89	24.43	0.00
X1	0.54	0.08	6.96	0.00

OLS DW=0.54
Means of Errors: Basis Ar. Con.=0.08, OLS E.C.=-21.95
(OLS Error Correction errors multiplied by negative 1)

Conclusion: No test are applicable. The model did not properly estimate when corrected for first order autocorrelation.

Basis ARIMA (constant) Vs. Cash ARIMA

Var	Coef	Std. Error	T-Ratio	P-Value
const	1.73	2.74	0.63	0.53
X1	1.31	0.20	6.42	0.00
auto	0.76	0.06	12.90	0.00

OLS DW=0.60 Chi-Squared=41.49 P-Value Chi=0.00
Means of Errors: Basis Ar. Con.=0.08, Cash ARIMA=-1.98
(Cash ARIMA error multiplied by negative 1)

Conclusion: Basis ARIMA with constant is superior to the cash ARIMA based on the test for the significance of the regression.

No forecast model that directly forecasts the cash price is superior to the basis ARIMA(1,1,1) forecast model.

This concludes the MSE test on price forecast models. The general conclusions from these tests are in Chapter 5.

Tests of Net Returns MSE

The net returns MSE for the different investment strategies from the research are tested for differences using the test of Ashley et al. (1980). The first name in the title of each regression is considered as model 2. Unless otherwise stated the regressions are adjusted for first order autocorrelation using the ML procedure. The last line of each regression reports the autocorrelation coefficient. All tests are for the period of cattle sales January 1980 to December 1989 (120 months) unless stated otherwise. The first comparisons are between the base simulations of no NTSP-no hedging to NTSP-no hedging and no NTSP-100% hedging to NTSP-100% hedging for the period 1980 to 1989.

No NTSP, No Hedging Vs. NTSP, No Hedging

Var	Coef	Std. Error	T-Ratio	P-Value
const	0.17	2.36	0.07	0.94
X1	-0.002	0.01	-0.22	0.82
auto	0.85	0.05	17.83	0.00

OLS DW=0.30 Chi-Squared=0.06 P-Value Chi=0.97
Means of Errors: Model 1=5.16 Model 2=4.58

Conclusion: No difference in MSEs. Recall that the significance of the regression chi-squared asymptotic test is not used if the coefficients have different signs.

No NTSP, No Hedging Vs. No NTSP, 100% Hedging

Var	Coef	Std. Error	T-Ratio	P-Value
const	0.26	4.32	0.06	0.95
X1	-0.30	0.06	-4.88	0.00
auto	0.51	0.08	6.43	0.00

OLS DW=1.17 Chi-Squared=23.85 P-Value Chi=0.00
Means of Errors: Model 1=4.29 Model 2=4.58

Conclusion: The No NTSP, 100% hedging likely has the lower MSE based on the significant t statistic on X1.

No NTSP, No Hedging Vs. NTSP, 100% Hedging

Var	Coef	Std. Error	T-Ratio	P-Value
const	0.86	4.64	0.19	0.83
X1	-0.30	0.06	-4.70	0.00
auto	0.53	0.08	6.76	0.00

OLS DW=1.12 Chi-Squared=22.09 P-Value Chi=0.00
Means of Errors: Model 1=4.96 Model 2=4.58

Conclusion: NTSP, 100% Hedging may have the smaller forecast error based on the significant t statistic on the X1.

The time period April 1986 to 1989 with and without NTSP is compared.

No NTSP, No Hedging Vs. NTSP, No Hedging April 1986 to 1989

Var	Coef	Std. Error	T-Ratio	P-Value
const	0.03	5.51	0.01	0.99
X1	-0.01	0.03	-0.31	0.76
auto	0.84	0.08	10.45	0.00

OLS DW=0.40 Chi-Squared=0.10 P-Value Chi=0.95
Means of Errors: Model 1=14.61 Model 2=13.03

Conclusion: There is no difference in the MSEs.

The conclusions for this series of tests is that the NTSP does not significantly reduce the MSE versus no participation in NTSP. The 100% hedge strategy is likely significantly different (lower) than the base simulation with no hedging.

The next set of tests compares the base simulation of no NTSP-No hedging to the different strategies. It is assumed that the most likely program at this time by a cattle producer is to enroll in NTSP and not hedge. This is compared to strategies that involve selective hedging or selective investing.

No NTSP, No Hedging Vs. No NTSP, Optimal Hedge

Var	Coef	Std. Error	T-Ratio	P-Value
const	-0.95	2.11	-0.45	0.63
X1	-0.27	0.03	-8.78	0.00
auto	0.38	0.08	4.63	0.00

OLS DW=1.28 Chi-Squared=77.35 P-Value Chi=0.00
Means of Errors: Model 1=3.38 Model 2=4.58

Conclusion: The No NTSP, No Hedging is not superior to the No NTSP, Optimal Hedge. The reversal of the test indicates that the optimal hedge has significantly lower MSE based on both coefficients are negative and the significant chi-squared test on the significance of the regression.

NTSP, No Hedging Vs. NTSP, Optimal Hedging

Var	Coef	Std. Error	T-Ratio	P-Value
const	-0.94	2.09	-0.45	0.65
X1	-0.28	0.03	-8.78	0.00
auto	0.38	0.08	4.41	0.00

OLS DW=1.31 Chi-Squared=77.26 P-Value Chi=0.00
Means of Errors: Model 1=4.02 Model 2=5.16

Conclusion: The optimal hedge has significantly lower MSE based on the asymptotic chi-squared test for the significance of the regression. Recall that changing the order of the models (such as using the optimal hedge as model 2) changes the signs of the coefficients.

No NTSP, No Hedging Vs. No NTSP, Selective Hedging 5% Rule

Var	Coef	Std. Error	T-Ratio	P-Value
const	3.54	3.77	0.94	0.35
X1	-0.11	0.05	-2.41	0.02
auto	0.47	0.08	5.77	0.00

OLS DW=1.31 Chi-Squared=6.68 P-Value Chi=0.04
Means of Errors: Model 1=7.81 Model 2=4.58

Conclusion: The MSE of No NTSP, No Hedging is not lower. The evidence suggests that the selective hedge may have the lower MSE based on the t statistic of X1.

NTSP, No Hedging Vs. NTSP, Selective Hedging 5% Rule

Var	Coef	Std. Error	T-Ratio	P-Value
const	3.78	3.48	1.09	0.28
X1	-0.15	0.05	-3.06	0.003
auto	0.41	0.08	4.95	0.00

OLS DW=1.43 Chi-Squared=10.49 P-Value Chi=0.01
Means of Errors: Model 1=8.69 Model 2=5.16

Conclusion: The MSE of the selective hedge is likely the smaller MSE based on the t statistic on X1.

No NTSP, No Hedging Vs. No NTSP, Selective Hedging T-Bill Rule

Var	Coef	Std. Error	T-Ratio	P-Value
const	3.25	3.95	0.82	0.41
X1	-0.09	0.05	-2.00	0.05
auto	0.50	0.08	6.40	0.00

OLS DW=1.22 Chi-Squared=4.67 P-Value Chi=0.10
Means of Errors: Model 1=7.47 Model 2=4.58

Conclusion: The MSE of the selective hedge is likely smaller than the No NTSP, No Hedging based on the t statistic on X1.

NTSP, No Hedging Vs. NTSP, Selective Hedging T-Bill Rule

Var	Coef	Std. Error	T-Ratio	P-Value
const	3.47	3.77	0.92	0.36
X1	-0.11	0.05	-2.24	0.03
auto	0.47	0.08	5.87	0.00

OLS DW=1.32 Chi-Squared=5.85 P-Value Chi=0.05
Means of Errors: Model 1=8.33 Model 2=5.16

Conclusion: The MSE of the selective hedging strategy is likely smaller based on the t statistic on X1.

No NTSP, No Hedging Vs. Selective Investment, No NTSP, No Hedging

Var	Coef	Std. Error	T-Ratio	P-Value
const	-3.49	11.38	-0.31	0.76
X1	-0.46	0.19	-2.35	0.02
auto	0.68	0.07	10.09	0.00

OLS DW=0.75 Chi-Squared=5.65 P-Value Chi=0.06
Means of Errors: Model 1=-1.94 Model 2=4.58
(Errors of this Selective Investment multiplied by negative 1)

Conclusion: The MSE of the selective investment is the smaller MSE based on the significance of the test on the regression. Recall that a P-Value on the Chi-Squared overstates the significance by at least a factor of 2 times.

NTSP, No Hedge Vs. Selective Investment, NTSP, No Hedge

Var	Coef	Std. Error	T-Ratio	P-Value
const	-4.24	11.54	-0.37	0.71
X1	-0.35	0.20	-1.74	0.08
auto	0.67	0.07	9.97	0.00

OLS DW=0.75 Chi-Squared=3.15 P-Value Chi=0.21
Means of Errors: Model 1=-1.64 Model 2=5.16
(Errors of this Selective Investment multiplied by negative 1)

Conclusion: The selective investment likely has the smaller MSE based on the test on the significance of the regression. The significance of this test is at least .105. (This is the P-Value of the chi-squared divided by 2).

No NTSP, 100% Hedging Vs. Selective Investment, No NTSP, Hedging

Var	Coef	Std. Error	T-Ratio	P-Value
const	-2.71	1.58	-1.72	0.09
X1	-0.17	0.04	-4.53	0.00
auto	0.34	0.09	4.02	0.00

OLS DW=1.34 Chi-Squared=23.70 P-Value Chi=0.00
Means of Errors: Model 1=1.51 Model 2=4 29

Conclusion: The MSE of the selective investment is significantly lower based on the test on the significance of the regression.

NTSP, 100% Hedging Vs. Selective Investment, NTSP, Hedging

Var	Coef	Std. Error	T-Ratio	P-Value
const	-2.62	1.42	-1.84	0.07
X1	-0.14	0.04	-4.01	0.00
auto	0.31	0.09	3.61	0.00

OLS DW=1.39 Chi-Squared=19.60 P-Value Chi=0.00
Means of Errors: Model 1=2.26 Model 2=4.96

Conclusion: The selective investment has the lower MSE based on the significance of the regression.

The general conclusion of the previous sets of tests is that the selective hedge strategies and the selective investment strategies have lower MSEs than the No NTSP, No Hedging base simulation or the NTSP, No Hedging base simulation.

The next series of tests compares the NTSP-100% Hedging to the different hedge strategies.

NTSP, 100% Hedging Vs. NTSP, Optimal Hedging

Var	Coef	Std. Error	T-Ratio	P-Value
const	-1.08	2.44	-0.44	0.66
X1	-0.05	0.02	-2.38	0.02
auto	0.70	0.06	10.70	0.00

OLS DW=0.78 Chi-Squared=5.89 P-Value Chi=0.05
Means of Errors: Model 1=4.02 Model 2=4.96

Conclusion: The optimal hedging MSE is significantly smaller based on the signs of the coefficients and the test for the significance of the regression.[55]

NTSP, 100% Hedging Vs. NTSP, Selective Hedge 5% Rule

Var	Coef	Std. Error	T-Ratio	P-Value
const	3.67	1.95	1.89	0.06
X1	0.13	0.04	3.36	0.00
auto	0.29	0.09	3.31	0.00

OLS DW=1.41 Chi-Squared=14.98 P-Value Chi=0.00
Means of Errors: Model 1=8.69 Model 2=4.96

Conclusion: The 100% hedging has a significantly smaller MSE based on the test on the significance of the regression.

NTSP, 100% Hedging Vs. NTSP, Selective Hedging T-Bill Rule

Var	Coef	Std. Error	T-Ratio	P-Value
const	3.29	2.21	1.49	0.14
X1	0.16	0.04	3.62	0.00
auto	0.31	0.09	3.57	0.00

OLS DW=1.37 Chi-Squared=15.44 P-Value Chi=0.00
Means of Errors: Model 1=8.33 Model 2=4.96

Conclusion: The 100% hedge MSE is significantly smaller based on the test on the significance of the regression.

These previous tests lead to general conclusion that the 100 % hedge has a smaller MSE than the selective hedge strategies. The optimal hedge has a lower MSE than the 100% hedge strategy. It is interesting to note that the MSE for the NTSP-100% hedge is 339.0 and the MSE for the NTSP-Optimal Hedge is 384. The test for significance looks at other factors than the absolute level of the MSE.

The next series of test is between some of the different strategies. NTSP is included in the strategies.

---

55 This conclusion requires further clarification. The MSE for the NTSP-100% Hedge is 339. The MSE for the NTSP-Optimal Hedge is 384. Yet the test suggests that the optimal hedge strategy is significantly smaller than the 100% hedge MSE. The original OLS estimate of this test had a coefficient for X1 of 0.04 with a standard error of 0.02. The adjustment for autocorrelation changed the sign on the X1 coefficient. These results suggest caution be used when interpreting and making conclusions from this test.

NTSP, Optimal Hedging Vs. NTSP, Selective Hedge 5% Rule

Var	Coef	Std. Error	T-Ratio	P-Value
const	4.66	1.76	2.64	0.01
X1	0.13	0.03	3.81	0.00
auto	0.31	0.09	3.51	0.00

OLS DW=1.48 Chi-Squared=21.63 P-Value Chi=0.00
Means of Errors: Model 1=8.69 Model 2=4.02

Conclusion: The optimal hedge has significantly lower MSE based on the test for the significance of the regression.

NTSP, Optimal Hedging Vs. NTSP, Selective Hedging T-Bill Rule

Var	Coef	Std. Error	T-Ratio	P-Value
const	4.27	1.97	2.17	0.03
X1	0.16	0.04	4.36	0.00
auto	0.34	0.08	4.01	0.00

OLS DW=1.37 Chi-Squared=23.86 P-Value Chi=0.00
Means of Errors: Model 1=8.33 Model 2=4.02

Conclusion: The optimal hedge has significantly lower MSE based on the significance of the regression.

NTSP, Optimal Hedging Vs. Selective Investment, NTSP, Hedging

Var	Coef	Std. Error	T-Ratio	P-Value
const	-1.53	2.33	-0.66	0.51
X1	-0.10	0.04	-2.28	0.02
auto	0.05	0.08	6.35	0.00

OLS DW=1.20 Chi-Squared=5.69 P-Value Chi=0.06
Means of Errors: Model 1=2.27 Model 2=4.02

Conclusion: The selective investment has significantly lower MSE based on the significance of the regression at 3%.

NTSP, Selective Hedging 5% Rule Vs. NTSP, Selective Hedging T-Bill Rule

(OLS Regression)

Var	Coef	Std. Error	T-Ratio	P-Value
const	-0.36	0.72	-0.50	0.62
X1	0.02	0.02	1.55	0.12

OLS DW=2.03 F(2,118)=2.40 P-Value F=0.09
Means of Errors: Model 1=8.33 Model 2=8.69

Conclusion: The selective hedging 5% rule is not superior to the selective hedging T-Bill rule.

NTSP, Selective Hedge 5% Rule Vs. Selective Investment, NTSP, Hedging

Var	Coef	Std. Error	T-Ratio	P-Value
const	-6.27	2.01	-3.12	0.002
X1	-0.29	0.04	-6.49	0.00
auto	0.32	0.09	3.75	0.00

OLS DW=1.36 Chi-Squared=52.23 P-Value Chi=0.00
Means of Errors: Model 1=2.27 Model 2=8.69

Conclusion: The selective investment has a significantly lower MSE based on the significance of the regression.

NTSP, Selective Hedging T-Bill Rule Vs. Selective Investment, NTSP, Hedging

Var	Coef	Std. Error	T-Ratio	P-Value
const	-5.91	2.12	-2.79	0.012
X1	-0.33	0.05	-6.66	0.00
auto	0.29	0.09	3.35	0.00

OLS DW=1.42 Chi-Squared=52.45 P-Value Chi=0.00
Means of Errors: Model 1=2.27 Model 2=8.33

Conclusion: The selective investment has a significantly lower MSE based on the significance of the regression.

The general conclusion to this series of tests is that the optimal hedge has lower MSE than the selective hedge strategies. The selective investment has lower MSE than the optimal or selective hedge strategies.

This concludes the discussion on the tests for differences in MSE. The general conclusions on these tests are in chapter 5.

Appendix G T-Bill and TSE Calculations

This appendix explains how the real rates of return for T-Bills and the TSE 300 are calculated. This matches how the net returns in the cattle simulation are calculated. The means, standard deviations and MSE for the TSE are reported in this section. These are for comparison to other studies such as Coles (1989), if so desired. The MSE for the TSE 300 is calculated using the historical average as the predictor of future returns. This average is updated each month. The means, standard deviations and the MSE for the TSE are reported first.

Table
Real Returns for 91 Day T-Bills and the TSE 300

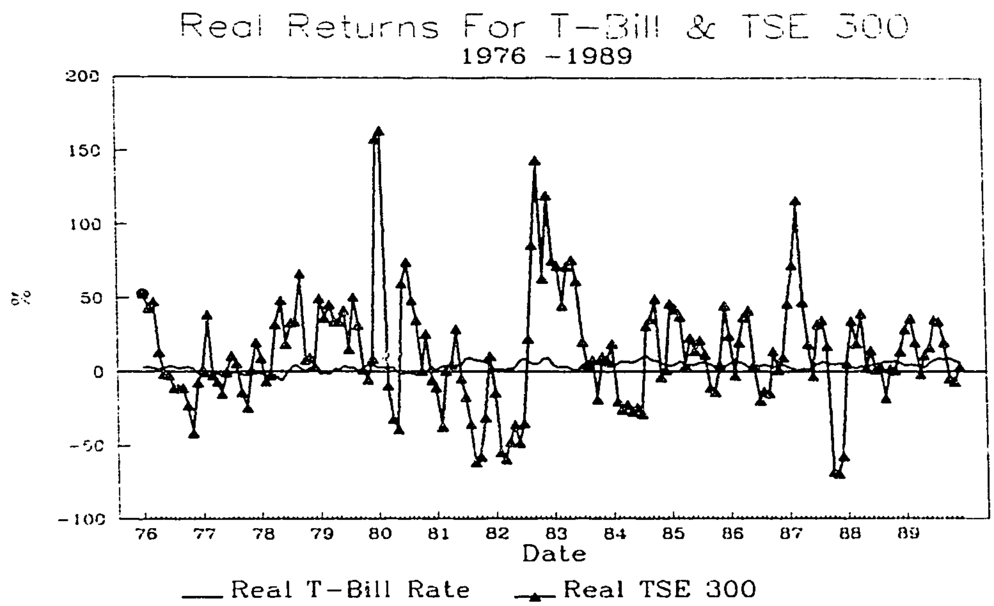
Time Period	T-Bill Returns % Annual Mean	TSE Returns % Annual Mean
1980-1989	4.74	14.04
1980-Mar86	4.67	14.85
Apr1986-89	4.87	12.68

Table
Standard Deviation And MSE For 91 Day T-Bills and the TSE 300

Time Period	T-Bill Std Dev Returns %	TSE Std Dev Returns %	TSE MSE	TSE Root MSE
1980-1989	2.60	42.83	1900.15	43.59
1980-Mar86	2.89	48.25	2891.63	53.77
Apr1986-89	2.05	32.28	1064.47	32.63

The Coles (1989) study reported a net return of 4.65% and a MSE of 1417 for the TSE 300 for the period 1973 to 1989. The T-Bill rate of return in his study was 1.41%. A graph of the calculated real returns for 91 day T-Bills and the TSE 300 on an annualized basis follows.

Figure



The T-Bill and TSE data collected for this study is converted to real rates of return that match the calculations in the simulation. The method for doing this is explained here. The starting data for The 91 day T-Bill and the TSE 300 are:

TB_{t-3} is the reported nominal 91 day T-Bill rate reported as an annual rate at the time of feeder purchase.

CPI_{t-3} is the all item consumer price index.

$TSEP_{t-3}$ is the TSE stock price index for each month at the time of the feeder purchase and

$TSED_{t-3}$ is the TSE 300 dividend of monthly returns reported as a annual rate for the month of the feeder purchase.

The quarterly returns reported on an annual basis for the T-Bill are calculated as shown. The nominal quarterly T-Bill rate is:

$$TBQ_{t-3} = \left[\left(1 + \frac{TB_{t-3}}{100} \right)^{.25} - 1 \right] \times 100$$

The real quarterly rate is:[56]

$$RTBQ_{t-3} = \left[\frac{1 + \frac{TBQ_{t-3}}{100}}{\frac{CPI_t}{CPI_{t-3}}} - 1 \right] \times 100$$

56 The inflation rate could also be calculated as CPI_{t-1}/CPI_{t-4} since the investments are made in the middle of the month.

The real T-Bill rate on an annual basis over the same time period as the feeding period ending in time period t is:

$$RTBA_{t-3} = \left[\left(\frac{RTBQ_{t-3}}{100} + 1\right)^4 - 1\right] \times 100$$

The TSE 300 real returns are calculated by first constructing a total returns index including the capital gains and the dividends. The monthly capital gains on the TSE in percent per month is:

$$MTSEP_{t-3} = \left(\frac{TSEP_{t-3}}{TSEP_{t-4}} - 1\right) \times 100$$

The monthly dividend return in percent per month is:

$$MTSED_{t-3} = \left[\left(1 + \frac{TSED_{t-3}}{100}\right)^{\frac{1}{12}} - 1\right] \times 100$$

The total monthly returns combines the capital gains and the dividends.

$$MTRTSE_{t-3} = MTSEP_{t-3} + MTSED_{t-3}$$

A monthly returns index is now constructed. Let time period 0 equal 1000. The rest of the index is calculated as follows.

$$Period_0 = 1000$$

$$Period_1 = Period_0 \times \left(\frac{MTRTSE_1}{100} + 1\right)$$

$$Period_2 = Period_1 \times \left(\frac{MTRTSE_2}{100} + 1\right)$$

etc.

The nominal quarterly returns over the feeding period ending at time t is calculated from the total returns index.

$$NTSEQ_t = \left(\frac{Period_t}{Period_{t-3}} - 1\right) \times 100$$

The real quarterly and real annual TSE rate of return are calculated.

$$RTSEQ_t = \left[\left(\frac{\frac{NTSEQ_t}{100} + 1}{\frac{CPI_t}{CPI_{t-3}}}\right) - 1\right] \times 100$$

$$RTSEA_t = \left[\left(1 + \frac{RTSEQ_t}{100}\right)^4 - 1\right] \times 100$$

This completes the calculations of the real rates of return for the 91 day T-Bill and the TSE 300.

Appendix H ARIMA Forecasting Models

Samples of the ARIMA models estimated in this study are presented here. ARIMA models are relatively easy to estimate with the statistical packages available. The ARIMA models used in this study have the following problems. Each ARIMA model is estimated 120 times. This suggests that the model should be identified and tested each time period. This is not done. The model estimation sometimes has difficulty converging in different time periods. This would suggest either a different numerical calculation method or a different model specification. This is not done here. This may be an area that could use more research.

The following are ARIMA models estimated in this study. These are models estimated for the period 1976 to September 1989. The data output is from the RATS statistical package (Var Econometrics).

ARIMA(1,1,1) With Constant For Alberta Basis in Nominal Cdn $[1]

NO.	LABEL	LAG	COEF	STAND. ERROR	T-STATISTIC
1	CONSTANT	0	-0.038	0.038	-1.01
2	AR	1	0.38	0.86	4.36
3	MA	1	-0.91	0.04	-24.12

1. AR is autoregressive and MA is moving average.
R Squared 0.27
DURBIN-WATSON 1.95
Q(36)= 43.47 SIGNIFICANCE LEVEL OF Q 0.183181

The Q statistic is a measure of autocorrelation in the model using in this test up to 36 lags.

ARIMA(1,1,1) No Constant For Alberta Basis Nominal Cdn $

NO.	LABEL	LAG	COEF	STAND. ERROR	T-STATISTIC
1	AR	1	0.36	0.09	4.07
2	MA	1	-0.90	0.04	-21.04

R Squared 0.27
DURBIN-WATSON 1.95
Q(36)= 44.12 SIGNIFICANCE LEVEL OF Q 0.17

ARIMA(1,0,1) with constant for Omaha Basis in US $ Nominal With Constant

NO.	LABEL	LAG	COEF	STAND. ERROR	T-STATISTIC
1	CONSTANT	0	-0.90	0.35	-2.56
2	AR	1	0.42	0.15	2.77
3	MA	1	0.060	0.17	0.36

R Squared 0.22
DURBIN-WATSON 1.98463315
Q(36)= 82.48 SIGNIFICANCE LEVEL of Q 0.17

ARIMA(1,1,1) with constant For Alberta Cash Steer Price in Nominal Cdn$

NO.	LABEL	LAG	COEF	STAND. ERROR	T-STATISTIC
1	CONSTANT	0	0.23	0.33	0.71
2	AR	1	0.017	0.49	0.035
3	MA	1	0.15	0.48	0.30

R Squared 0.94
DURBIN-WATSON 1.99
Q(36)= 107.58 SIGNIFICANCE LEVEL OF Q 0.47E-08

Appendix I Basis Testing

An analysis of the Omaha basis similar to that of the Alberta basis is presented in this appendix. This allows further comparisons between the basis faced by the Alberta investor and the Omaha investor. Further discussion on the autocorrelation in the Alberta basis variance test from Chapter 5 completes the Appendix.

Omaha basis is checked for trend and seasonality using the same form of model used to test the Alberta basis. The trend analysis is done using the ML estimator adjusted for first order autocorrelation since the OLS estimate of this model has a Durbin Watson statistic of 1.11 which is significant at the 5% level. The Omaha basis is first adjusted to January 1982 U.S. dollars using a GNP deflater. No significant trend is detected. There appears to be seasonality in 4 months at the 5% level of significance. This suggests that a different method of basis forecasting be tried.

Table

Omaha Nearby Trend and Monthly Seasonality Test Adjusted For First Order Autocorrelation

Var	Coef	Std. Error	T-Ratio	P-Value
constant	-1.10	0.87	-1.27	0.21
Trend	0.006	0.006	0.94	0.35
Jan.	0.31	0.72	0.43	0.67
Feb.	-1.88	0.85	-2.20	0.03
Mar.	-1.70	0.90	-1.88	0.06
April	-0.75	0.93	-0.81	0.42
May	0.40	0.93	0.43	0.67
June	2.38	0.94	2.55	0.01
July	1.30	0.93	1.39	0.17
Aug.	0.47	0.92	0.51	0.61
Sept.	-0.77	0.90	-0.86	0.39
Oct.	-2.12	0.85	-2.50	0.01
Nov.	-1.71	0.71	-2.43	0.02
auto	0.44	0.07	6.40	0.00

The mean of the basis for the past three years for the month is forecast by averaging the basis for that month in the three previous years. This forecast is based on the trend and seasonality results. For example, an average of the basis from February 1980, 1981, and 1982 is the forecast for February 1983. Omaha basis is also forecast by estimating a historical mean updated each month. Both these mean forecasts are done in January 1982 U.S. dollars. An ARIMA(1,0,1) with constant using nominal basis is identified using the autocorrelation plots, partial autocorrelation plots and the residual plots. The ARIMA forecasts are then converted to January 1982 U.S. dollars. It is interesting to note that the Omaha basis is considered stationary and no differencing is required in the model estimation. This contrasts with the Alberta basis ARIMA models that required first differencing. The reasons for this may be different inflation rates or some other unknown factor. The final forecast is basis in time period t to forecast basis in time period t+3 in January 1982 U.S. dollars.

The basis forecasts are used with the CME live cattle futures contract to forecast price. Another Omaha slaughter steer price forecast is to use the cash price at time t to forecast time period t+3. The results of one of the ARIMA models estimated for the Omaha basis are in Appendix H. The MSEs for five 3 month price predictors for Omaha are presented for information and comparison. All MSE are calculated in real 1982 U.S. dollars.

Table
MSE Of Price Forecasts
Omaha MSE On Price Prediction - 3 Month Forecasts (1982 US $)

	Cash 3 Mon. Prior	ARIMA Basis	Average Basis	Average Basis For Mon. From 3 Past years	Basis 3 Mon. Back
MSE 80-89	23.49	25.74	26.95	28.93	25.54
1980-Mar86	29.22	33.01	34.18	35.37	30.95
Apr86-89	14.39	14.11	15.40	18.74	17.01

The F tests in Chapter 5, section 5.9, comparing Alberta basis variance from 1976 to 1980 to basis variance from 1985 to 1989 may be unreliable because of autocorrelation. A test for autocorrelation on the sample basis is done following the discussion in Appendix B. The time period covered is 1976 to 1989. The autocorrelation estimate from the OLS model (Alberta basis regressed on a constant) is 0.46. The asymptotic Wald statistic on the autocorrelation is 45, which is chi-squared with one degree of freedom. This is significantly different from zero at the 5% level. The same results for the Omaha basis (in U.S. $) is an autocorrelation coefficient of 0.47 and an asymptotic Wald statistic of 47.

These results pose two possible problems for the tests between variances. The first problem is that the sample population of basis is not independent. This problem is solved by separating the two time periods in the test by four years. This minimizes any autocorrelation dependence between the two periods. The second possible problem is bias in estimating the sample variance. The test results do not change when the sample variances are estimated again using ML corrected for autocorrelation. The same F statistics for Alberta basis and Omaha basis are 3.19 and 1.49 if the sample standard deviations are estimated using ML adjusted for first order autocorrelation. There is no change in the conclusions from the tests. Alberta basis is less variable in the period 1985 to 1989. The Omaha basis variability is the same in 1985 to 1989.