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Department of Rural Economy
Faculty of Agriculture and Forestry
University of Alberta
Edmonton, Canada

An Analysis of Risk and Return in Hog Finishing

Frank Novak, Leonard Bauer,
Sally Dailly and Richard Melvin

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The authors are, respectively, Assistant Professor, Professor, and Graduate Research Assistants, Department of Rural Economy, University of Alberta.

Abstract

The objectives of this study were to measure returns and the variation in returns for hog finishers in Alberta. From this base, different strategies were assessed as to their ability to reduce the level of price risk faced by producers. The National Tripartite Stabilization Program was reviewed along with hedging strategies using the Chicago Mercantile Exchange Live Hogs futures.

Risk was measured using the Mean Square Error (MSE) and the Capital Asset Pricing Model (CAPM) beta. A twelve month rolling average of nearby basis was used to predict hog prices.

All of the strategies studied, the NTSP, a selective investment model, a 100% hedge and an optimal hedge, reduced risk compared to the base model. The 100% hedge reduced risk to the greatest extent. The NTSP alone reduced risk and increased returns. When using the Capital Market Line as a means of measuring the risk return tradeoff, all the strategies provided a viable alternative for risk reduction compared to the base model. The CAPM betas for the various strategies were very low. Hog finishing could provide a diversification opportunity for holders of a market portfolio.

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CHAPTER 1 INTRODUCTION

Hog finishing operations in Alberta are subject to a great deal of risk. Production risk arises from uncertainties due to management practises, while price risk results from variable prices in the market. Little information is available on the sources of price risk and its measurement. It is extremely important that producers be able to understand and use the available private risk management alternatives. The changing nature of markets and price risk affecting Alberta hog finishers provides the incentive to identify sources of risk and develop strategies to reduce this risk.

Producers have several risk management alternatives available to them. These include participation in government programs such as the National Tripartite Stabilization Plan (NTSP) and private risk management plans such as participation in the futures market. Management of agricultural risk has historically required a substantial commitment of resources from the farmer, agricultural lender, agribusiness and the public sector. With markets becoming more global in nature and increasing urbanization, programs which rely heavily on the public sector to manage risk may be in their final years. To date, the potential usefulness of the private risk management alternatives has not been assessed for the Canadian hog finisher.

This study aims to measure the level of price risks faced by Alberta hog finishers. Different risk management strategies such as hedging in the futures market and participation in the NTSP are also evaluated for their effect on price risk.

1.1 STUDY OBJECTIVES

This study evaluates the risks and returns from feeding hogs from the weaner stage to market weight (101 kg). More specifically, the objectives are:

1. Measure realized net returns in hog finishing and the variation in these returns.
2. Compare the effectiveness of the National Tripartite Stabilization Program (NTSP) for hogs with various private risk management strategies such as hedging in the futures market.
3. Evaluate and compare hog finishing investment opportunities to alternative investments.

1.2 STUDY PLAN

This report contains 5 chapters. A brief background of hog feeding in Alberta and the relationships between the Alberta and US markets and prices are reviewed in chapter two.

Chapter 3 provides the conceptual and methodological background for the study. Risk is defined along with the concepts necessary to evaluate the risk management strategies (price prediction, futures markets, hedging and optimal hedging).

The study methods, data sources and results are presented together in chapter 4.

Finally, a summary of results and conclusions as well as ideas for future research are presented in chapter 5.

CHAPTER 2 HOG PRODUCTION IN ALBERTA

This chapter briefly reviews Alberta hog production and markets. The relative size of the United States market stresses the importance of defining possible strategies to reduce price risk for Alberta hog producers. The type of production unit being modelled in this study is described in this chapter providing background for the strategies presented in chapter 4.

2.1 ALBERTA HOG PRODUCTION

There are three types of production units in Alberta: farrow to finish, farrow to weaner, and feeder operations. Hog production is highly specialized and generally takes place in total confinement facilities. Due to the type of production methods employed, hog production and feeding are very capital intensive. Approximately 30 % of pigs marketed in Alberta are those being sold to feeder operations (Alberta Agriculture, 1983). For the purposes of this study, the operation and cost structure is assumed to be a feeder type production unit.

Typically piglets will be purchased at the weaner stage, at a weight of between 16 and 20 kilograms and fed through until reaching a market live weight of between 93 and 109 kilograms. In this study it is assumed that pigs are purchased at 20 kg and fed through to 101 kg.

Feeder hogs are generally fed two or three rations. Initially, they may receive a high protein starter ration to counter the effects of shipping and settling into a new facility (10 days on feed). A grower ration with a slightly lower protein content is fed until the pigs reach approximately 45 kgs (31 days on feed) with the finisher ration being fed until market weight is reached (67 days on feed).

Canadian hogs are graded based on the percentage of backfat present, quality and texture of the meat. An index system is used with 100 being the base and source of the price quote. For example if the average index for hogs marketed is 102.9 and the price for index 100 is 85.00, the price received would be:

$85.00/cwt. * 102.9/100 = $87.47/cwt

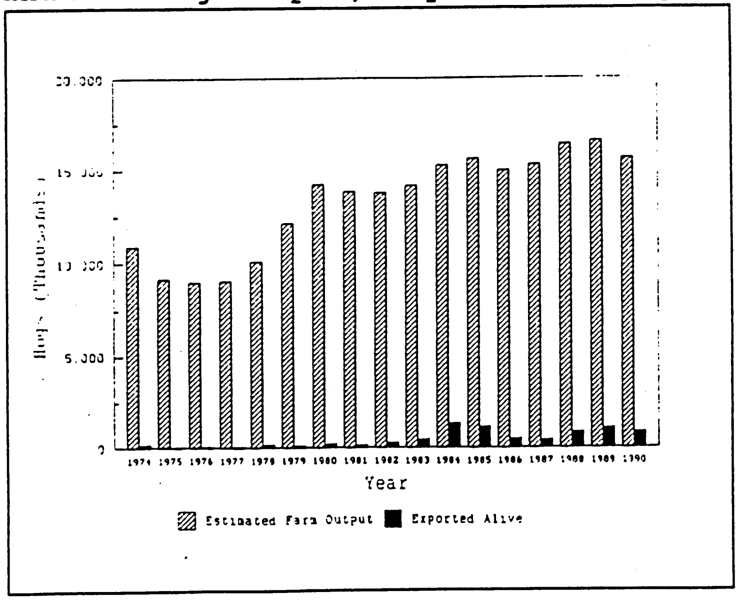
In Alberta in 1991 the top finisher producing between 1000 and 3000 hogs per year had an average index of 109.08 (Alberta Pork Producer's Development Corporation). The average index for hogs marketed in this study is 104.

2.2 ALBERTA AND UNITED STATES MARKETS

Canada produces between 12 - 14 % of the North American hog supply. Alberta contributes in the order of 3 % to this market and is the third largest hog producer in Canada behind Quebec and Ontario. Canada has generally been a net exporter of pork with the

United States. Approximately 28 % of Canadian hog production is exported to the United States (Alberta Agriculture, 1987). Figure 1 illustrates exports relative to Canadian farm output. Most of the exports are destined to the United States. Canada's relatively small contribution to the total North American hog supply suggests that Alberta producers will be price takers in a market based on the U.S. market. Given the portion of the market determined by Alberta production, it is not surprising that Alberta and Canadian producers are price takers based on the U.S. market for hogs. This along with the fact that there is no futures contract for hogs in Canada, leaves Canadian hog finishers with little control over the price of hogs.

Figure 1
Canadian Hog Output, Exports and Imports



Hog production follows cycles of low and high production and prices that generally span three years. The time required to complete one production period is quite short. Gestation is approximately 3 months and 3 weeks resulting in multiple births, while growing these pigs to market weight takes between 5 and 6 months. With this relatively short production period, hog producers can respond quickly to changes in feed and hog prices.

A high supply elasticity in conjunction with a relatively low elasticity of demand, leads to a highly volatile market. This price volatility leaves the hog finishers faced with a high degree of uncertainty or risk.

In response to the fluctuations in hog prices, the Canadian government introduced the NTSP in 1986. Producers and the provincial and federal governments contribute into this plan which pays out when prices are below a certain level. As an alternative to, or in conjunction with the public program, producers may pursue private means of reducing this price risk. This includes using the futures market as an information source or hedging. The NTSP and private risk strategies reviewed in this study are outlined in chapter 4.

This chapter has provided a brief overview of hog production in Alberta. The introduction of the NTSP in 1986 has conceivably changed the risk involved with hog production. The next chapter reviews the literature relevant to and provides background for the risk management strategies proposed in this study.

CHAPTER 3 THEORETICAL BACKGROUND

This study aims to measure risk and look at risk management strategies which could feasibly reduce price risk for Alberta hog finishers. In this chapter the concepts of risk and its measurement are reviewed. We will make use of two risk measures, the mean square error (MSE) and the Capital Asset Pricing Model (CAPM) beta, which are developed below. Potential risk management strategies are also described in this chapter. The futures market is introduced as an information source and as a risk management alternative.

3.1 RISK

Risk can be defined as the probability of failure or as risk associated with the variability of returns. For the purposes of this report, risk is defined as the variability of returns. Young (1984) reviewed risk concepts and categorized them in the following way:

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

The third category, Von Neumman and Morgenstern's expected utility model (EUM) is the most commonly used risk concept. In this study, a special category of the EUM, the mean variance model, is the basis for much of the analysis.

Standard deviation and mean square error are measures commonly used to determine the variability of an investment's return. The Capital Asset Pricing Model beta is also often used to measure an investment's risk. This measure indicates whether the investment returns correlate with the movement of a market portfolio. Measurement of risk in this study is discussed in further detail in section 3.2.

For the purposes of this study, only the risk averse investor will be considered since the only reason to look at risk management strategies would be if the investor felt some degree of risk aversion. Risk aversion is a necessary assumption for the CAPM and the risk efficiency criterion.

The risk efficiency criterion (King and Robison, 1984) refers to the idea of maximizing utility through the ordering of choices. In the mean-variance framework, this constitutes choices where the return of one option(A) is greater than the other(B) and the variance of the returns of A is less than or equal to the variance of returns for B. With this type of ordering it will not always be possible to illustrate a clear choice. For example, it will be difficult to choose when given an option with higher returns and a higher variance than another. It is possible to reduce the set of outcomes to those which are risk efficient. This reduced set can then be presented to decision makers. This type of ordering is used to assess the risk management strategies in chapter 4.

Before the background for the strategies is reviewed, the issue of risk measurement must be addressed.

3.2 RISK MEASUREMENT

The measurement of risk has been approached differently by different researchers. In this study we concentrate on two risk measures. The mean square error (MSE) is a measure of variability much like traditional measures such as the standard deviation. The CAPM beta (β) is a measure which is based on the relative contribution of one asset to the total variability of a diversified portfolio. The standard deviation measure of risk is also used to report risk in the initial base model in this study. These measures are developed further in this section.

This study emphasizes short run risk; the risk which occurs between the time of the production decision and marketing. This short run risk can be measured using the MSE which measures deviations from forecasts (equation 1).

$$MSE=\frac{1}{(n-1)}\sum (X_i-\hat{X}_i)^2 \quad (1)$$

$\hat{X}_i$ = *predicted value*
X_i = *observed value*

In the case of price risk, the MSE measures the difference between forecasted and realized prices (Holt, Brandt and Hurt (19), Leuthold and Hartmann (1979), Harris and Leuthold (1985)). The root MSE measures the unexplained or unpredicted part of the price movement.

The MSE (or RMSE) has been used quite commonly in studies using different forecasting techniques (Unterschutz, 1991). When assessing the price prediction models in this study, the MSE is determined and the method with the lowest MSE in the sample data is picked as the superior solution.

Peck (1975) addresses the issue of risk measurement and suggests that the MSE is the measure suitable to assess short term risk, while the standard deviation better determines risk over the long term. The MSE is used to measure risk in all strategies in this study, with the standard deviation being reported only for the base model.

Unterschultz (1991) noted that studies using the same measure have reported conflicting results. Using standard deviation of net returns on feeder cattle to measure risk, Carter and Loynes (1985) found a 100% hedge strategy to be risk reducing while Caldwell et al (1982) found the reverse to be true.

The other method used to assess risk in this study is the Capital Asset Pricing Model (CAPM). The Capital Asset Pricing Model (Sharpe (1964), Lintner (1965)) is based on the mean-variance EUM and assumes investors are risk averse and hold diversified investment portfolios. The beta from the CAPM is the second form of risk measurement used in this study. The sensitivity of returns of a particular investment to market movements is represented by the beta coefficient. The CAPM beta for a particular investment X, is defined as:

$$\beta = \frac{Cov(X,M)}{\sigma^2_m} \quad (2)$$

where:
β = beta coefficient for investment X
Cov (X,M) = covariance between the returns on investment X and the market portfolio M
σ^2_m = variance of returns on the market portfolio

A large diversified portfolio such as the TSE 300 is considered to be free of any diversifiable risk. The term systematic risk is used to describe the risk which cannot be offset or diversified away by combining the stock with other stocks in a portfolio. The beta coefficient for investment X is used as a relative measure of X's systematic risk. When markets are in equilibrium, the expected return on X is directly related to the systematic risk of X. This can be illustrated by the Security Market Line:

$$E(R_x) = R_x + \beta_x (R_m - R_f) \quad (3)$$

where:
R_f = risk free return
R_m = mean return on portfolio M

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

$$X = Constant + M\,\beta + \mu \quad (4)$$

where:
X = return on asset
M = return on market portfolio
β = beta
μ = error term

Systematic risk is affected by the economy and cannot be removed through diversification. An asset with a beta of 1 moves in perfect correlation with the market. This asset has the same systematic risk as the market portfolio. A beta of less than 1 would indicate a lower systematic risk than that of the market portfolio. Systematic risk (Equation 5) is the product of the market-asset correlation and the standard deviation of the asset.

$$\sigma^s = \rho_{x,m}\sigma_x \tag{5}$$

where:
σ^s = systematic risk
$\rho_{x,m}$ = correlation between X and M
σ_x = standard deviation of returns on X

Using the CAPM β as a risk measure and the same market portfolio, Coles (1989) determined a β of 0.64 for Alberta cattle feeding between 1972 and 1985 while Brown (1989) estimated a β of --0.0182 for Saskatchewan cattle feeders between 1971 and 1987. Coles' results indicate that the investment in feeder cattle during the period of his study shows some positive correlation with the market portfolio. Sixty four percent of the price risk is systematic risk with some benefit possible from diversification. Brown's results however indicate virtually no correlation with the market portfolio, very low systematic risk, and that diversification would reduce risk faced by the cattle feeders.

The non-systematic portion of risk can be eliminated through diversification. Non-systematic risk is defined as:

$$\sigma^{ns} = (1-\rho_{x,m})\,\sigma_x \tag{6}$$

where:
σ^{ns} = non-systematic risk

For most of this study, root MSE replaces the standard deviation, σ_x, in the calculation of risks.

Turvey and Driver (1987) estimated a beta of 0.08 for swine finishing using a farm sector portfolio in place of the market portfolio. Other portfolios have been used as a model of a market portfolio (Collins and Barry, 1986). A diversified portfolio has only systematic risk. In this study the diversified portfolio is represented by the TSE 300 (Coles, (1989), Brown (1989).

The CAPM beta and measurements of systematic and non systematic risk are used to measure the effectiveness of diversification in the TSE 300 as a means to reduce risk.

3.3 RISK MANAGEMENT STRATEGIES

In the previous section we reviewed the concept of risk and its measurement. The definition of risk selected for this study is variability of returns which can be measured in isolation as MSE. The contribution of one risky investment to a portfolio is measured using the CAPM beta. The beta and MSE risk measures will be used in this study. In this section the proposed risk management alternatives of hedging, diversification and the use of a public insurance program (the NTSP) are reviewed.

The Chicago Mercantile Exchange (CME) futures market can be used in two ways as a risk management strategy. First it can be used to gather information. Secondly, the futures market can be used to hedge local price risk.

The use of the National Tripartite Stabilization program (NTSP) as a risk management strategy is reviewed on its own and in conjunction with the proposed strategies.

3.4 THE NTSP

A 1985 amendment to the Agriculture Stabilization Act led to the development of national plans to support the red meats industry. The National Tripartite Stabilization Plan for hogs was signed in 1986. The program is designed to reduce losses to producers resulting from market risks by stabilizing prices. Costs are shared equally by producers, provincial and federal governments. Average producer premiums per hog for the period studied were:

1986	$2.90
1987	$3.40
1988	$2.78
1989	$3.26

Support payments are based on a guaranteed margin approach. The support price per quarter is equal to the national average cash costs per quarter plus the percentage of difference or margin between the national average price and the national average cash cost for the same quarter over the last 5 years. If the market price is less than the calculated support price, then a payment amounting to the difference is issued to producers. The following equations show the general method of calculating the support level and payments.

$$S = CC + .93(FASP - FAC) \quad (7)$$

$$P = NMP - S \quad (8)$$

where:
S = support level for the quarter
CC = cash cost per head per quarter
.93 = guaranteed margin percentage
FASP = five year moving average of price for that quarter
FAC = five year moving average of cost for that quarter
P = payment (if NMP - S < 0)
NMP = national weighted average market price

Costs are calculated based on regions, with a standard list of costs being assessed.

It is planned that the NTSP will be terminated on December 31, 1995. Any deficit in the fund will be split by the federal and provincial governments while any surplus will be used to benefit producers.

Any uncertainty associated with this program may be associated with an individuals' cost structure which differs from that of the national weighted average. Also, producers may receive a price for their hogs which differs from that of the national weighted average market price.

Hogs in this study are assumed to have an average index of 104 and are fed over a period of approximately 108 days. This meets the requirement for participation in the NTSP, which states that hogs must have a minimum index of 80 and be held by the enrolling producer for at least 60 days (Tan, 1988).

The NTSP is reviewed with the expectation that it increases mean income since it protects against increasing input costs and drops in market price. The stated purpose of the NTSP is to reduce risk to hog producers. This study will assess whether risk is reduced through participation in the NTSP alone and in conjunction with other management strategies.

3.5 FUTURES MARKETS

Live hogs are traded on the Chicago Mercantile Exchange (CME) (located in Chicago, Illinois, United States) in lots of 30,000 pounds. Canadian finishers can use the futures market as an information source or to hedge lots of hogs produced.

The following sections review hedging and relevant issues, such as pricing efficiency, exchange rate risk and basis, for using the futures market.

3.5.1 HEDGING

The futures market provides a hedging mechanism which can be used to eliminate or decrease the risk of cash price fluctuations. It can also act as an information source aiding producers with production and marketing decisions.

Feeding animals is particularly risky because the producer faces not only variable prices, but also variable input costs. Another factor in the risk associated with feeding is that there is a very limited window for varying marketing time of animals fed. When purchasing the animals, the producer needs to determine the final breakeven or target price necessary to cover costs. To reduce the risk associated with feeding a producer may hedge the production by selling contracts in the futures market for the month closest to, or immediately following the time the animals will be ready to market.

A simple production hedge involves a producer going short, or selling, in the futures market. For example, when the production decision to feed hogs is made in January, a short position is taken in the futures market for live hogs. The nearest contract which does not expire at or prior to marketing is the June contract. At the time of marketing the local cash price is received and the futures contract is closed out through buying June futures. In Table 1 the cash price received is $51.50, which along with the net effect of the futures contract, is increased to $57.47 per hundredweight dressed.

Table 1
Hedge Example

Date	Cash Transaction	/cwt dressed	Futures Transaction	/cwt dressed
Jan. 2	Breakeven price	$50.00	Sell June futures	$75.51
April 20	Sell cash hogs	$51.50	Buy June futures	$69.54
		+$1.50		+$5.97

Final price received: $57.47/cwt dressed

In this case the futures market increased the net return (excluding hedging costs). However, if the price increases as the contract matures, the production hedge may decrease returns. Assuming an efficient market zero hedge profits will be attained, but price variability will be decreased.

Beauchamp and Toensmeyer (1979) reviewed feeder hog marketing strategies between June 1969 and February 1977. During this period a 100 % hedge strategy did not substantially reduce price risk compared to the unhedged position.

Using a target MOTAD linear programming model Freeze et al. (1990) reported that cattle investors could increase income and reduce risk by hedging the Canadian dollar and live cattle in the 1986-1987 feeding year. The NTSP was included in this project and was found to be risk reducing.

In this study, one approach to using the futures market is to take an equal and opposite position in the market to the amount of hogs available to market (100% hedge and hold). Futures contracts are assumed to be infinitely divisible to match quantities marketed and simplify calculations. The cost of the money necessary to maintain a margin is assumed to be zero, however brokerage fees are included in the analysis. The period evaluated is the hedge period prior to the contract expiry month.

The futures contract price is essentially a current forecast of the market's expectation of price in the contract expiration month. In order for the market to accurately predict prices, based on current information, it must exhibit some degree of market efficiency. The concept of market efficiency is reviewed in the following section.

The difference between the current futures price and the cash price is the basis. The movement of the basis or the futures price relative to the cash price determines the effect of the hedge. Generally basis variability is less than cash price variability (Leuthold et al., 1989). Hedging in the futures market allows producers to exchange cash price risk for basis risk. Apart from basis risk, Canadian hedgers are subject to exchange rate fluctuations. Basis and exchange rate risk are discussed further following a review of pricing efficiency.

3.5.2 PRICING EFFICIENCY

In order for markets to provide accurate price forecasts, some degree of market efficiency must be present. An efficient market is one in which prices fully reflect available information (Leuthold et al., 1989). Three levels of testing market efficiency are generally referred to:

1. Weak form: the information of past prices is reflected in current prices.
2. Semistrong form: All public information is reflected in current prices.
3. Strong form: All information, public and private, is reflected in current prices.

Weak form efficiency is of concern in this study. In a market with weak form efficiency, historical information cannot be used to predict hedge profits. Generally, an OLS regression is used to evaluate weak form market efficiency (Blank, 1989). The standard equation form is:

$$S_t=\alpha+\beta F_{t-1}+e_t \qquad (7)$$

where:
S_t = spot price
α = intercept
β = regression coefficient relating the two prices[1]
F_{t-1} = previous period's price for the same contract
e_t = error at time t

or:

$$F_t=\alpha+\beta F_{t-1}+e_t \qquad (8)$$

where:
F_t = futures price at time t of contract expiring at some time t+i

The hypotheses implied in the weak form model are tested by computing the t - statistics for:

$H_o = \alpha = 0$ and $\beta = 1$

Leuthold and Hartmann (1979) were inconclusive as to the efficiency of the hog market over the period from 1971 - 1978. An econometric model was found to be able to out predict the futures market for spot prices. This may be attributed to the fact that the 1970's was an extremely volatile period for prices in the hog market. In another study, a seasonal pattern was found to exists

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[1]Beta, in this context is not the same as the CAPM beta (equation 2)

in hog markets which was reflected in the futures market (Martin and Garcia, 1981). Hog futures were found to be a good predictor except during unstable economic periods.

Empirical tests of the futures markets response to information have attempted to identify any bias in the pricing mechanism. Buccola (1989) suggests that implied inefficiency of livestock futures does not imply that they are valueless. Cash price efficiency in cattle and hogs has increased since the introduction of futures markets. Buccola summarizes much of the recent literature of pricing efficiency in agricultural markets and questions many of the results which have stated inefficiency based on the notion that many of the transaction or agents' costs are totally ignored.

The CAPM can be used to test for 'normal backwardation' in the market. Normal backwardation refers to the idea that futures prices exhibit a consistent downward biased forecast of the subsequent cash price. Dusak (1973), found no evidence of systematic risk in grain futures. Elam and Vaught (1988) found insignificant systematic risk and zero risk premiums in livestock (cattle and hog) futures markets. Using the CAPM, the performance of the asset is compared to the markets as a whole to estimate the degree of risk in the asset and whether a market determined risk premium exists. With betas close to zero, the CAPM framework of analysis has shown no systematic risk in the futures market (Blank, 1989).

Weak form efficiency is tested in this study to ensure that the futures market is an unbiased price forecast for Alberta hog producers. To determine this, hedge profits are tested to see if they are significantly different from zero, since in an efficient market hedge profits are zero.

3.5.3 HOG BASIS

The futures contract prices are used to determine predictions of the hog cash prices. The CME live hogs contract is also used to take a short hedge position in the market. In order to effectively hedge or use the futures price as a predictor, some understanding of basis is necessary.

Basis, as defined by Leuthold et al., (1989) is the difference between the futures price for a particular delivery month and cash price.

$$\textit{Basis} = \textit{Futures Price} - \textit{Cash Price} \tag{11}$$

Risk arising from using the futures contract price is present in two forms. The first is the risk associated with the futures market. The second, basis risk, refers to the risk inherent in the movement of the basis.

For storable commodities such as grain, the current spot price is related to, but independent of the futures price. Working's theory of price storage (1953) states that basis is equal to the net carrying cost (storage, insurance, opportunity cost and convenience yield) which is determined by the supply of storage (Naik and Leuthold, 1988). For nonstorable commodities such as hogs, the supply and demand characteristics prevent direct application of Working's theory of price storage.

Livestock producers must understand the intramarket (cash-futures) price relationships in order to hedge successfully. It was believed that no relationship existed between the two intertemporal prices of a nonstorable commodity since stocks cannot be carried over (Leuthold, 1979). However more recent empirical studies of intramarket intertemporal price relationships in livestock markets have indicated that the cash and the nearby futures price are related (Leuthold, 1979 and Tomek, 1980). Cash and far futures price are not necessarily related (Tomek, 1980). Naik and Leuthold (1988) looked at the basis relationship for cattle and hogs in an expected utility maximization framework. Their results suggest that a small change in price may not be well coordinated in cash and futures movement. Also a seasonality component was detected in the hog basis with respect to risk premium, speculative component and the maturity basis. It is suggested that the variation between the cash and futures prices makes participation in the livestock futures market less attractive to hedgers.

Garcia et al. (1984) looked at the systematic and non-systematic components of basis risk in live cattle. The possible reasons given for variability in basis as new information became available were:

1. The arrival of new information is uncertain and unpredictable
2. Similar information may have different effects depending on when it is received
3. As maturity approaches cash and futures prices are more closely tied and forecasts may also be more accurate
4. The market location may affect the level of risk.

The CME is the market of concern to Alberta hog feeders which brings in the elements of distance to market, exchange rate risk and grading standards.

Exchange rate fluctuations can affect the basis variability. Canadian hedgers must be careful to convert prices to current Canadian dollars. Braga (1990) adjusted basis for Canadian hedgers in the U.S. market in the following manner.

$$\text{Basis}_{C\$} = \text{Cash Price}_{C\$} - (\text{Futures Price}_{US\$} / \text{Exchange Rate}) \quad \textbf{(12)}$$

Some studies suggest that basis risk is too large to make hedging Canadian cattle feeders profitable (Carter and Loyns, 1985, Gaston and Martin, 1984). This may be due to exchange rate variability or possibly the different market locations. Thompson and Bond (1987) studied offshore hedging with a floating exchange and concluded that the extent to which exchange rate affects perceived basis variance will determine the different positions taken by a U.S. hedger as opposed to an offshore hedger. Unterschultz (1991) found exchange rate risk to be insignificant in the short term for Canadian cattle feeder hedging. Gillis et al. (1989) studied hedging of Canadian beef feeders and concluded that it made little difference to risk reduction if the Canadian dollar was hedged due to exchange rate fluctuations. Hedging in this study occurs over the short run, thus exchange rate risk is not considered.

Alberta basis forecasts are required for hedging and price forecasting using the CME. Coles (1989) used a mean basis adjusted for time trend to forecast Alberta cattle basis. Unterschultz (1991) found an ARIMA (1,1,1) model to best forecast Alberta basis for cattle. Other studies used a three year historical mean basis estimate for the week (Gaston and Martin, 1984) or the month (Brandt, 1985; Kenyon and Clay, 1987). Leuthold and Martin (1979) used an historical mean estimate of basis for hogs. Little information is given as to the reasons for choosing the various basis models and no comparisons between models is employed (with the exception of Unterschultz, 1991). Unterschultz compared a historical mean basis, an ARIMA estimate and lagged basis to estimate current basis. When combined with the futures prices, comparisons were made between these models using the MSE criterion to determine forecasting ability. A similar procedure is followed in this study.

The variability of the Omaha and Alberta basis are compared to note differences between domestic and offshore hedgers and is briefly reviewed in Appendix E. This comparison may provide insight into the usefulness of the CME for Canadian as opposed to American producers. In order to compare the different locations, basis must be converted to a common currency (Canadian $). Due to market location it is proposed that the Alberta basis will be more variable than the Omaha basis. Basis variability affects the usefulness of hedging as a risk management strategy for Canadian producers.

3.5.4 EXCHANGE RATE RISK

More than 80 % of the volume of international futures trading takes place on exchanges in the United States. Agricultural producers in Canada can trade on the Winnipeg Exchange for some commodities, but for hogs the only available contracts are those listed at the Chicago Mercantile Exchange (CME). This makes Canadian producers wishing to hedge, offshore hedgers.

The decision environment of the offshore hedger is similar in many regards to that of the domestic hedger. Both are concerned with levels of commodity stocks and sales and the timing of borrowing and lending commitments. However offshore hedgers are subject to fluctuating exchange rates and the possibility that not all grades or classes of commodities are deliverable against the specified futures contracts. Therefore, strategies for offshore hedgers may differ from those of domestic hedgers.

Movement in the exchange rate affects both the level and variability of returns. Thompson and Bond (1985, 1987) note that there is a significant interaction between the U.S. dollar commodity prices (both spot and futures) and the exchange rate. Influence of the exchange rate risk on offshore hedging decisions emerges partly as a result of movement between spot and futures prices and partly as a result of exchange rate. Given a high degree of interaction between prices and exchange rate, the offshore trader will view price risk differently than the domestic trader. If the commodity is a major export, the impact of changing world commodity prices on the exchange rate of a small open economy may be quite significant. Developments in the financial sector of the producers economy such as monetary shocks will in turn influence exchange rates. Alternate means to counteract this may include forward cover transactions and offshore borrowing.

In a study of Canadian feedlot cattle hedged on the CME both basis and exchange rate risk were found to be lower in the late 1980's than in the late 1970's for Canadian producers (Unterschultz, 1991). Overall, for the period being studied and the futures contracts chosen, exchange rate risk between Canada and the U.S. was not an important risk factor. Since this study spans the same time period as the Unterschultz study, exchange rate risk is not measured.

3.5.5 EXCHANGE RATE FORECAST

When using the CME hog futures to forecast prices, a forecast spot exchange rate between Canada and the United States is needed.

Coles (1989) used the 90 day spot futures exchange rate to convert forecast U.S. prices from the CME to Canadian prices. Unterschultz (1991) used the current spot exchange rate as the forecast of the future spot exchange rate.

Longworth et al. (1983) determined that the spot exchange rate was a better forecaster of the future spot exchange rate than the current forward exchange rate. They concluded that the futures exchange market for Canadian and U.S, dollars was not efficient and there was a time varying risk premium.

The current spot exchange rate is used in this study to forecast the futures spot exchange rate. Again, this relies on the background provided by Unterschultz (1991).

3.5.6 OPTIMAL HEDGE

The full or 100% hedge is one risk management strategy available to producers. With efficient markets and no transaction costs, the net hedge profit should be zero. Many studies suggest that while risk is decreased with such a strategy, returns are also significantly decreased. An alternative strategy is the use of the optimal hedge ratio.

Standard portfolio theory determines the hedger's optimal behaviour by maximizing the expected utility in a mean-variance framework (Chee, 1990). Optimal hedging is that level of the futures position relative to the cash position resulting in the greatest utility relative to returns and risk for a particular individual (Leuthold et al., 1989). Portfolio theory can be used to determine the optimal hedge ratio. The optimal hedge ratio (with no production risk as in this study) as given in Leuthold et al., is derived from determining the maximum expected utility as shown below. The expected return of the two asset portfolio is:

$$E(R_p) = X_s E(R_s) + X_f E(R_f) \tag{13}$$

where:
X_s = the amount of the cash position
X_f = the amount of the futures position
$E(R_s)$ = the expected return on the cash position
$E(R_f)$ = the expected return on the futures position

and the risk of holding these units can be expressed by the variance of the returns:

$$Var(R_p) = X_s^2 \sigma^{2s} + X_f^2 \sigma_f^2 + 2 X_s X_f \sigma_{sf} \tag{14}$$

where:
σ^2 = the variance of the cash returns
$\sigma^{2s}{}_f$ = the variance of the futures returns
σ_{sf} = the covariance of the changes in futures and cash prices

The optimal hedge ratio which maximizes expected utility can be derived from the two asset portfolio[2].

$$\frac{X_f}{X_s} = \frac{E(F_1) - F_0}{\lambda \sigma_f^2 X_s} - \frac{\sigma_{sf}}{\sigma^{2f}} \tag{15}$$

where:
$E(F_1)$ = the expected futures price in the next time period
F_0 = the current futures price

The first component on the right hand side of equation 15 is the speculative portion, while the second component is the pure hedging or hedge ratio component (Leuthold et al., 1989). The speculative component reflects the expected futures price difference from the current price which results in the investor anticipating some sort of gain. The speculative component also includes the investors degree of risk aversion. Should the risk aversion approach infinity or if the expected futures price does no differ from the current price, the optimal hedge ratio becomes the minimum variance position given by the hedge ratio component.

The minimum variance hedge ratio is derived from minimizing the variance of the two asset portfolio (equation 14). Minimizing with respect to X_f and solving for X_f defines the minimum variance

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[2]A more detailed derivation of the optimal hedge ratio and the minimum variance hegde ratio can be found in Unterschultz, 1991.

hedge amount:

$$X_f = -X_s \frac{\sigma_{sf}}{\sigma_f^2} \qquad (16)$$

This in turn can be simplified to determine the minimum variance hedge ratio:

$$\frac{X_f}{X_s} = -\frac{\sigma_{sf}}{\sigma_f^2} \qquad (17)$$

The use of the optimal hedging strategy should reduce the variability of returns over both a no hedging strategy and a 100% hedge strategy. In a cattle feeding study, Novak et al (1991) found that optimally hedging 60% to 70% of the cattle on feed could obtain most of the risk reductio of a 100% hedge. There is however some question in the literature as to whether an optimal hedge ratio can in fact be calculated when both price and quantity uncertainty are present (Grant, 1985). This violates the basic assumption of a known cash position and thus the calculation of an optimal hedge strategy. In the extreme, if investors are very confident about expected price movements, an optimal hedge ratio of greater than one may be indicated. Generally this is considered irrelevant in agricultural literature since it introduces more risk (Blank, 1989). The use of futures markets in agriculture is considered to be that of risk reduction not speculation. For the purposes of this study, it is assumed that production risk is not present, thus the cash position is known.

The minimum variance hedge ratio (optimal hedge) is estimated with a price difference model using Ordinary Least Squares (Bond et al., 1987). The beta estimated by the regression is the minimum variance hedge ratio.

$$\Delta S_t = \alpha + \beta \Delta F_t \qquad (18)$$

where:
S = spot prices
F = futures prices
t = time period
α & β = parameters to be estimated
Δ = the change in prices

Since the derived optimal hedge ratio is a minimum variance hedge ratio, the variance of returns will be reduced compared to a zero or a 100 % hedge position. This does not necessarily mean that the risk, measured in this study by the root MSE will be decreased. The root MSE does not measure the variance of returns, but instead measures deviations from forecasted returns. The effectiveness of the hedging strategies as risk management tools will be assessed using the root MSE as a measure.

3.6 SUMMARY

In this chapter risk and its measurement were reviewed. The CAPM beta and MSE will be used in chapter 4 to assess the various risk management strategies. The material in this chapter provides the background for the development and review of the proposed risk management strategies using the futures market. It was proposed that the NTSP will also reduce the price risk present in Alberta hog production. The effect of the NTSP alone and with the other strategies will be measured and discussed in chapter 4.

Chapter 4 METHODOLOGY AND RESULTS

The previous chapters reviewed risk and risk measures. This study focuses on MSE as a risk measure. The level and variability of returns are measured using an historical simulation model which is developed in the following stages. First a model of finished hog production is described. This model is used to produce forecasted and actual returns. The various models used to produce price forecasts and the choice of the best price forecast model are described next. The predictive model with the lowest MSE is chosen as the predictive model for the evaluation of the various risk management strategies.

This best forecast model is used in the simulation model to produce a base measure of return and risk. The model is run with and without participation in the NTSP. The base model provides a starting point from which the risk management strategies can be developed.

The simulation model is used to evaluate 3 different strategies. The management strategies to be reviewed by this study include: a selective investment strategy without hedging, a 100% hedge and hold strategy, and an optimal hedge strategy. Each of these strategies is tested with and without participation in the NTSP. Net returns and the root MSE for each strategy are compared over the whole period.

The evaluation of different risk management strategies is the main goal of this study. The second risk measure used in this study, the CAPM beta, evaluates the strategies movement with the market portfolio (TSE 300). This measure provides an indication as to the nature of price risk. Systematic and non systematic risk figures are calculated and reported for each strategy.

4.1 PRODUCTION MODEL

To determine returns of the base model and proposed management strategies, a production model must be derived for the hog feeding operation. This section develops the production model for the base case of no hedging. Production risk will vary between farms and over time. The strategies assessed in this study address only price risk. For this reason it is assumed that no production risk affects this operation. The only risk arises from hog sales in the form of price risk.

Returns, or net profits, are calculated on each lot of hogs using the general format shown in equation 19.

$$NP_{t+3} = (HP_{t+3} * Q_{t+3} - TC_1) \qquad (19)$$

where:

NP_{t+3} = net profits per lot sold in month t+3

HP_{t+3} = Alberta hog price

Q_{t+3} = quantity of hogs sold

TC_t = total production cost paid in month t

Specifically what is included in equation 17 shall be presented in greater detail. Cost functions are first reviewed followed by a brief description of revenues.

Feeder hogs (weaners) are purchased at a 20 kg weight at the beginning of each month. The purchase price of the weaners is calculated using a formula from the Alberta Pork Production Handbook.

$$Feederprice = \frac{HP_t}{2} + 1.25 * (feeder\ weight - 15) * 3 \qquad (20)$$

where:
HP_t = Alberta current hog price

Feed rations are calculated based on the Alberta Pork Manual and from guidelines given by Co-op Feeds (Federated Co-operative Ltd.). Percentages of feed ingredients and tonnes fed per growing period are listed in Appendix A. Based on the ration guidelines, a time series is created for each feed (grower, starter, finisher and supplement) to provide prices over the period being studied.

Starter and grower rations are purchased at the beginning of the feeding period, while finisher is assumed to be purchased in the second month. All costs are discounted, using the prime rate, back to the date of feeder purchase. Death losses are assumed to be 3%. These losses occur at the end of the starter feeding period, with all hogs initially purchased (113 weaners) consuming all starter ration. Feed costs for starter and grower follow the same format in equation 21. Finisher costs are adjusted to the beginning of the feeding period (equation 22).

$$starter\ cost = starter_t * tonnesstarter \qquad (21)$$

$$Fincost_t = fin\ cost_{t+1} * tonfin * (1+r_{t+1})^{-1} \qquad (22)$$

where:
$fincost_{t+1}$ = finisher cost in 2nd month of feeding period
$starter_t$ = starter cost per tonne at time t

Trucking and pelleting add to the feed cost.

$$Feed\ trucking_t = \$5.50/tonne_{Dec\ 1989} \frac{CPI_t}{CPI_{Dec\ 1989}} \qquad (23)$$

$$Pelleting_t = \$38.80/tonne_{Dec\ 1989} * \frac{CPI_t}{CPI_{Dec\ 1989}} \qquad (24)$$

A time series for trucking and pelleting is created by using a known 1989 price and CPI. The CPI at time t deflates the cost to reflect cost at time t.

Total feed expenses are derived by summing feed, trucking and pelleting costs. Other expenses include the NTSP premium (when participating in the program), APPDC, Phif, fixed costs[3] and various maintenance costs (Appendix B). These are added to feed costs to derive total expenses.

$$T\ expenses_t = feedcost_t + feeders_t + paid\ labour_t + hog\ trucking_t + NTSP\ premium_t + APPDC_t + Phif_t + RMcost_t + vetcost_t + fuel_t + licences_t + fixed\ costs_t \quad (25)$$

where:

$feeders_t$ = feeder purchase price
$APPDC_t$ = Alberta Pork Producers Development Corporation
$Phif_t$ = Producers Hog Indemnity Fund
$RMcost_t$ = repair and maintenance costs
$Vetcost_t$ = veterinary/animal health costs
$fuel_t$ = fuel costs
$licences_t$ = licence costs
$fixed\ costs_t$ = fixed costs

Total expenses are converted to December 1989 dollars using the current CPI and the December 1989 CPI. The correction to 1989 dollars makes the values more comparable to today's dollar.

$$TR\ expenses = T\ expenses_t * \frac{CPI_{Dec89}}{CPI_t} \quad (26)$$

Revenues are calculated based on the hog price in the marketing period, the hog index and the NTSP payout (when participating in the program).

$$Sales_t = HP_{t+3} * \frac{index}{100} * cwtdr * hogs \quad (27)$$

where:

HP_{t+3} = hog price when marketed
index = 104
cwtdr = hundred weight dressed = 101.83 kg * 78.5% * 2.2 lb/kg
hogs = number of hogs per marketing (110)

Real revenue is calculated correcting to December 1989 dollars in the same manner as costs (NTSP is included ~~if~~ where applicable).

Real return is determined by the difference between total real revenues and total real cost.

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[3] The derivation of the fixed costs can be found in Appendix C

$$RRev_t = (Sales_t + NTSP_t) * \frac{CPI_{Dec89}}{CPI_{t+3}} \qquad (28)$$

$$RReturn = Rev_t - TR\ expenses_t \qquad (29)$$

where:
TR expenses = total real expenses

The rate of return is also calculated.

$$Rrate\ of\ Ret = \left(\frac{Rev_t}{TR\ expenses_t} - 1\right) * 100 \qquad (30)$$

where:
Rrate of return = real rate of return

Returns per lot are reported in this study. Lot size is 110 pigs marketed at 101.8 kg (224 lbs.). The lot size is determined by the barn size and a capacity of 850 hogs. Specifics of the barn are located in Appendix C. The hogs marketed in this study have an average index of 104 and are finished over a 108 day period. The return per hundred weight is used when illustrating the results graphically. This is determined by dividing the real return by the hundred weight of dressed hogs marketed (78.5 dressing percentage). The annualized real rate of return is also reported in the results. This is determined in the following manner:

$$Rrate\ of\ Retann = \left(\left(\left(1 + \frac{Rrate\ of\ Ret}{100}\right)^{365/108}\right) - 1\right) * 100 \qquad (31)$$

where:
Rrate of Retann = annualized real rate of return

These returns are calculated with the NTSP when the NTSP is included in the strategy. With participation in the NTSP, the premium must be included in costs and the payout added to the revenue.

4.1.1 PREDICTIVE MODEL

To predict revenue, the same format is used as for actual returns calculations (equation 28). The actual price of hogs is replaced by the forecast price.

where:

$$PNP_{t+3} = (PHP_{t+3} * Q_{t+3} - TC_t) + Q_{t+3} * (FP_{j,t+3} - PFP_{j,t+3}) * PX_{t+3} \qquad (32)$$

PNP_{t+3} = predicted net profit
PHP_{t+3} = predicted hog price in month t+3
Q_{t+3} = quantity of hogs to be sold in month t+3
TC_t = total cost
$FP_{j,t}$ = futures price at time t with maturity month j (expires nearest month after t+3
$PFP_{j,t+3}$ = predicted futures price at time t+3 with maturity at month j
PX_{t+3} = predicted spot exchange rate converting U.S. to Canadian dollars

The predicted annual rate of return calculation follows the same format as equation 30, but with participation in the NTSP, 3 times the premium is substituted for the payout. Costs are known at the outset of the production period, thus no predicted costs are necessary.

4.2 DATA SOURCES

This study simulates a hog feeding operation in Alberta between January 1981 and July 1989. Marketing and production decisions are made every month. The data used in this study comes from various sources and may have a few limitations. A brief discussion of the data follows.

4.2.1 TIME PERIOD

Monthly price data were collected for the period January 1980 to July 1989. The first feeder hogs in the simulation were purchased in January 1981 to sell in April 1981. All feeder purchases were assumed to be contract purchases taking place at the beginning of each month. Hogs are fed for 108 days and marketed at 101.83 kgs.

The ex ante approach is used throughout the development of the model. Decisions are made based on information available at the onset of the feeding period.

Information starting from January 1980 is used to develop the first set of price and revenue forecasts. These predictions are updated monthly. The predictions are reported over the period from January 1981 - July 1989 as well as the two sub periods prior to and after the initiation of the NTSP.

4.2.2 FUTURES PRICES, LIVE HOGS

The sources of the futures prices were the CME Yearbook and the Toronto Globe and Mail Daily Newspaper. The data represent the closing price for the first Wednesday of every month. For each contract month, prices were collected on the contract starting 5 months prior to the contract month. Closing month prices were not collected. Prices were collected in U.S. nominal dollars.

The live hog contract is traded in units of 30,000 pounds. Trading terminates on the twentieth business day of the contract month. The contract specifies that hogs (barrows and gilts) must be USDA No. 1, 2, 3, and 4 with weights averaging 200 - 230 pounds. Discounts are specified for weights and grades which differ from contract specifications. Peoria, Illinois, is the par live hog delivery point, although deliveries at Omaha, East St. Louis, Sioux City, South St. Paul, Kansas City and St. Joseph are acceptable with the appropriate price discounts to put them approximately at par with Peoria (Hayenga et al., 1985). Contract months available for trading include: June, July, August, October, December, February, and April.

4.2.3 EXCHANGE RATE

The exchange rate was collected from the Cansim data base. The rate used is the noon spot rate (first Wednesday of the month) in Canadian $ per U.S. $. (nominal). Conversion to real dollars was done using the Consumer Price Index (CPI) which was also taken from the Cansim data base.

4.2.4 LIVE HOG PRICES

Alberta hog prices were collected for the first week of the month. Prices were listed in nominal dollars per hundred weight dressed. The Alberta Pork Producers Development Corporation (APPDC) and the 'Meat Market Review' provided the prices.

The APPDC and Alberta Agriculture provided the Omaha Hog Price. This was given in U.S. nominal dollars per pound liveweight and represented the first week of the month price.

Feeder prices in dollars per head, were obtained from Alberta Agriculture.

4.2.5 FEED PRICES

Alberta wheat and barley prices were collected from Alberta Agriculture. Prices for the 40% supplement were supplied by Co-op Feeds (Federated Co-operatives Ltd.).

4.2.6 NTSP

Information on the NTSP payments and premiums was located in the Hog Quarterly and from the APPDC. Background information for the NTSP was provided by <u>The National Tripartite Stabilization Program for Red Meats: The Hog Model</u> (Agriculture Canada). A brief outline of this program is found in section 3.4.

4.2.7 INDICES

Various price indices were collected from the Cansim database.

These indices include:

1. CPI
2. T-bill - 90 day rate
3. TSE 300
4. TSE 300 dividends
5. Prime lending rate
6. Farm Input Prices Indices

4.3 NTSP FORECASTS

The NTSP payouts and Alberta hog prices must be forecast before the MSE can be measured or price strategy forecasts can be simulated.

There are three possible choices of models for NTSP payouts. These include:

1. Building a model based on NTSP model data
2. Use the production function variables to model the relationship between these variables and the NTSP payouts.
3. Predict payouts based on the contribution of the 2 governments each being equal to the producer premium.

Based on the material reviewed by Unterschultz (1991) in a similar study, the third method is chosen. NTSP payouts are predicted to be 3 times the premium amount.

The NTSP payouts are converted to December 1989 dollars using the CPI.

4.4 HOG PRICE FORECASTING MODELS

A total of thirteen forecasting models are evaluated to determine the best price predictor for this study. Four cash price models are evaluated. The futures market is used to determine the remaining nine price forecasting models. The model with the lowest MSE is chosen to predict prices in the study.

4.4.1 CASH HOG PRICE FORECASTING

Four cash models were evaluated as to their ability to forecast hog price at time of marketing:

1. Current cash
2. Average cash
3. Cash ARIMA (2,1,2), begin January 1985
4. Cash ARIMA (1,0,0), begin January 1985

Two Autoregressive integrated moving average (ARIMA) models, a current hog price and an average current hog price model are compared to actual hog prices and each other. The MSE of these forecasts are compared to determine the most effective forecast.

The ARIMA models are an ARIMA (2,1,2) and an ARIMA (1,0,0). Both current hog price (at time t) and an average of historical hog prices up to including the most recent hog price (at time t) are used to predict hog price at marketing (period t+3).

4.4.2 FUTURES CASH PRICE PREDICTION

The futures price prediction of cash price is determined using an expected basis. Five models are evaluated to determine forecasting ability. Again, the lowest MSE is the determining criteria.

The futures price models require three predictions in order to act as a predictive model for cash price. These include the Canada-U.S. exchange rate, the nearby basis and the futures price at time t for the CME contract that expires at the nearest month after the date t+3. The exchange rate and nearby basis are needed to adjust the futures price to Alberta. In forecasting the exchange rate the current spot rates are used.

The predictive models are in the general form of:

$$PHP_{t+3} = FP_{t,t+3} * PX_{t+3} - PB_{t+3} \tag{33}$$

where:

PHP_{t+3} = predicted Alberta hog price at sale time

$FP_{t,t+3}$ = current CME live hog contract for month t+3, in U.S. dollars

PX_t = predicted spot exchange rate at t+3 which we model as spot at time t

PB_{t+3} = predicted Alberta basis at sale time

Alberta hog basis is tested for seasonality and trend in this study. This determines whether an historical mean basis is a suitable model. Testing for the mean requires that the basis be converted to a common price period to remove the effects of inflation. The seasonality test determines if a mean calculated for the same month for three consecutive years is appropriate.

No significant time trend was determined (t=0.8465), while the months of April (t=2.1606), May (t=2.1647), August (t=-3.7182), September (t=-4.1325) and October (t=-3.0359) were found to be significant (at a 0.05 level of significance).

The following models are evaluated to determine the best price predictor.

1. OLS with seasonal effect, begin January 1985
2. 12 month rolling average of nearby basis
3. 3 year rolling average of nearby basis
4. Current nearby basis
5. Nearby basis ARIMA (1,1,1) X (1,0,1), begin January 1985

The first two models which are evaluated include: an Ordinary Least Squares (OLS) updating model using monthly dummy variables, and a twelve month rolling average basis model. The twelve month rolling average basis model uses the rolling average of the nearby basis to predict the price at time of marketing.

$$PHP_{t,t+3} = FP_{t,t+3} - basis_t \tag{34}$$

where:
$PHP_{t,t+3}$ = predicted hog price at time t for time t+3
$FP_{t,t+3}$ = futures price at time t for time t+3
$Basis_t$ = nearby basis

A three year monthly rolling average model for basis is also tested. This model uses the average of the last three years for each month as a predictor of the basis. The next basis model uses the current nearby basis as the basis to provide the predicted hog price. The final basis model is an ARIMA (1,1,1) X (1,0,1) with forecasts beginning January 1985. This model is used to predict the nearby basis. Once all forecasts have been completed, they are compared on the basis of lowest MSE to select the best cash price predictor. The forecasting model with the lowest MSE is chosen for use throughout the rest of the simulation and risk management strategies.

Based on the MSE calculations of the predictive models, the twelve month rolling average of nearby basis (model 6, Figure 2) was chosen[4]. This model gave the lowest MSE when used to forecast cash prices. With the choice of this model it must be noted that although data was available for 1980, the predictions do not begin until January 1981. Thus, results are presented between January 1981 and July 1989. Figure 2 illustrates the mean square errors for the forecasting models over the complete time period of the study. Figures 3 and 4 show the results broken into the period before and after initiation of the NTSP.

The predictive models were reviewed in this section. Based on the MSE, the twelve month rolling average of nearby basis was the model chosen to predict prices in this study. The next section uses the production model and the predictive model to provide the results for two base models.

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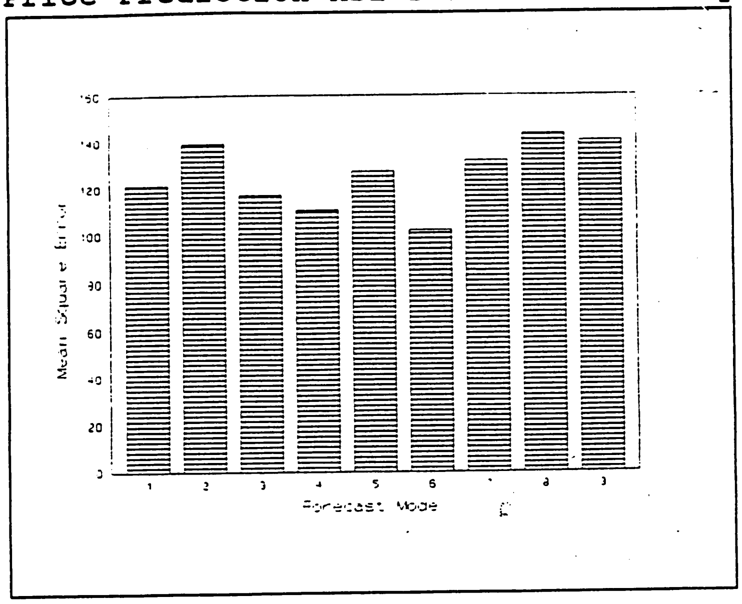
[4]The ARIMA (1,1,1) X (1,0,1) forecasting nearby basis (strategy 9 in figures 2-4) has the lowest MSE in the latter period of the study (figure 4). This model does not begin forecasting until January 1985, thus a fair amount of historical data is needed for the model to perform. Had more historical data been available, this model may have been the best predictor of cash price.

Figure 2
Cash Price Prediction MSE's Jan 1981 - July 1989



Price Forecast Models
1 Current cash
2 Average cash
3 Cash ARIMA (2,1,2), begin January 1985
4 Cash ARIMA (1,0,0), begin January 1985
5 OLS with seasonal effect, begin January 1985
6 12 month rolling average of nearby basis
7 3 year rolling average of nearby basis
8 Current nearby basis
9 Nearby basis ARIMA (1,1,1) X (1,0,1), begin January 1985 1985

Note: The key above reflects the legend for figures 2, 3, and 4.

Figure 3
Cash Price Prediction MSE's, January 1981 - June 1986.

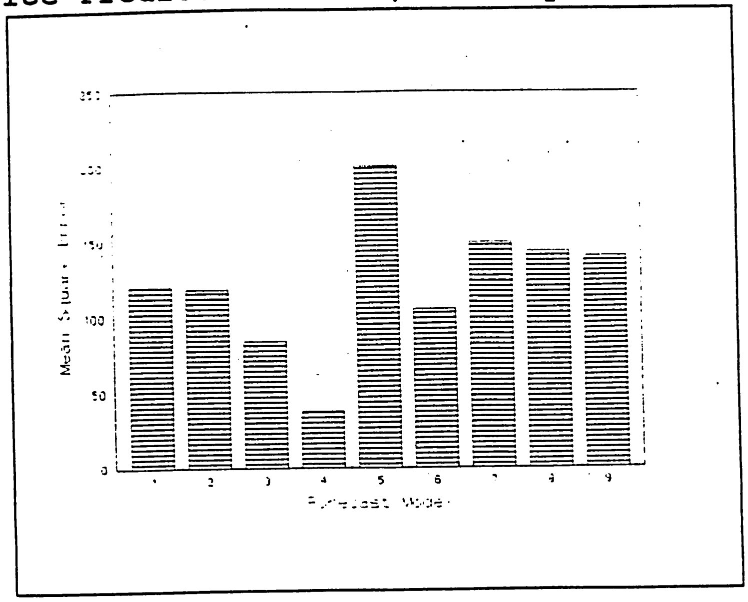
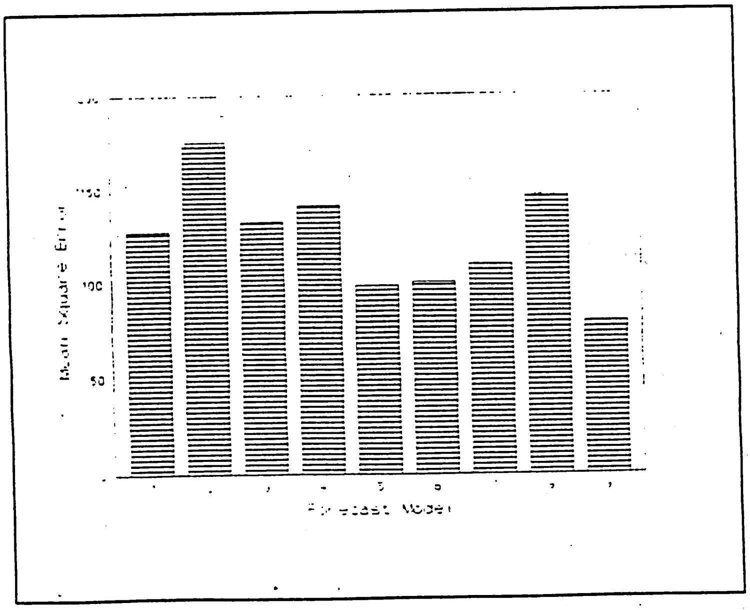


Figure 4
Cash Price Prediction MSE's, July 1986 - July 1989



4.5 BASE MODEL

The preceding sections provide the background for simulating and predicting real net returns for the Alberta hog finisher. A base model of hog finishing with no hedging is evaluated in this study. This model is reported with and without participation in the NTSP.

For the base model, variability of returns is reported with both standard deviation and root MSE measures. The standard deviation measure provides an historical and more long run approach to risk measurement. The futures market operates on a short run horizon with a forward price. For this reason Peck (1975) suggests that the MSE may provide a more suitable measure of risk. Since it is risk in the production period that this study aims to measure, the root MSE is compared rather than the standard deviation for the remaining strategies.

Returns are discussed throughout the study using the mean annual real rate of return. Returns are also represented per lot (110 hogs at 101.83 kg. live weight with an index of 104) in the tables and graphically.

The mean annual real rate of return over the whole period of the study for the base model without participation in the NTSP is 50.62%[5] (Table 2). This is much higher than the TSE 300 and T-bills returns (12.16% and 5.03% respectively) over this same period. Although some negative returns are present in the last year of the study (figure 5), the mean annual real rate of return based on our cost assumptions is positive throughout the study.

With participation in the NTSP, the mean annual real rate of return jumps to 56.69% annually over the period of the study. Participation in the NTSP increased the mean annual real return by 18.5% (60.07-41.62) over the period from July 1986 to July 1989.

Variability of returns over the long run (with participation in the NTSP) as determined by the standard deviation, was reduced from 102.16 to 80.37 over the same period. The root MSE shows only a slight decrease over this same period. Since the MSE uses the price prediction to determine variability, a poor prediction model will bias the MSE measurement. The MSE and standard deviation

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[5]Limitations exist in the production function and base model as reported in this study. Individual feeder operators may nave quite different cost functions that the set up in this simulation. Therefore hog feeding may be more or less profitable than the results shown in this study. However, variability of returns should not differ significantly from those illustrated.

Another restriction in this study is the lack of variability in the weaners purchased and the quality of hog produced. Theoretically hog indices would improve over the production years due to improved breeding and nutrition management. Variability between lots of hogs produced would also be expected. It is assumed however, that variability from produciton is small compared to the market variability.

measure different aspects of risk therefore direct comparisons of the standard deviation interpretation cannot be made to the root MSE resutlts.

The Alberta hog return results of the base model are reported graphically in returns per lot in figures 5 and 6. Figure 5 illustrates the return per lot without participation in the NTSP. Figure 6 includes NTSP from its inception in July 1986. The effect of the NTSP on returns is quite noticeable in Figure 6 from April of '88 to July of '89. Without the NTSP (Figure 5), returns during this period were all negative except for the month of April. With NTSP, returns are negative in September '88 and January '89 while the rest of the period has positive returns.

Table 2
Net Returns Base Model - No hedging and No NTSP.
(December 1989 dollars)

Year	Mean Net Return/Lot[1] Dec. 1989 $	Net Return Std. Dev.	MRRORA[2]	Std. Dev[3] MRRORA	RMSE[4]
Jan 1981-Jul 1989	1564.07	2770.16	50.62	87.73	85.36
Jan 1981-Jun 1986	1954.25	2613.30	55.66	78.89	84.10
Jul 1986-Jul 1989	868.07	2938.49	41.62	102.16	88.68

1. Lot size = 110 hogs at 101.83 kg market weight
2. MRRORA = annualized mean real rate of return
3. Std. Dev = standard deviation
4. RMSE = root mean square error

Table 3
Net Returns Base Model - No hedging, Participation in NTSP
(December 1989 dollars)

Year	Mean Net Return/Lot[1] Dec. 1989	Net Return Std. Dev.	MRRORA[2]	Std. Dev[3] MRRORA	RMSE[4]
Jan 1981-Jul 1989	1885.08	2408.03	56.69	77.67	82.18
Jan 1981-Jun 1986	1954.25	2613.30	55.66	78.89	84.10
Jul 1986-Jul 1989	1780.72	2062.90	60.07	80.37	84.47

1. Lot size = 110 hogs at 101.83 kg market weight
2. MRRORA = annualized mean real rate of return
3. Std. Dev = standard deviation
4. RMSE = root mean square error

Figure 5
Alberta Hog Returns per lot (110 hogs @ 101.8 kg liveweight) No hedging, No NTSP (Base Model)

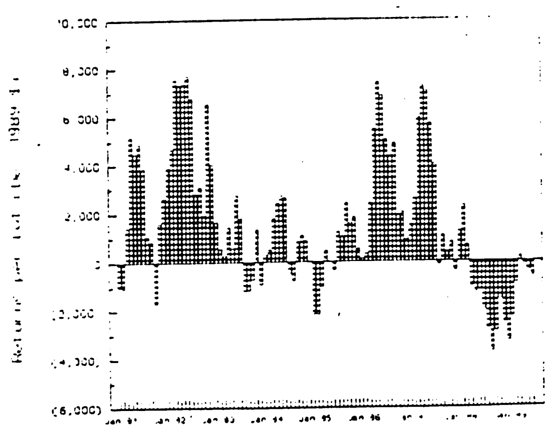
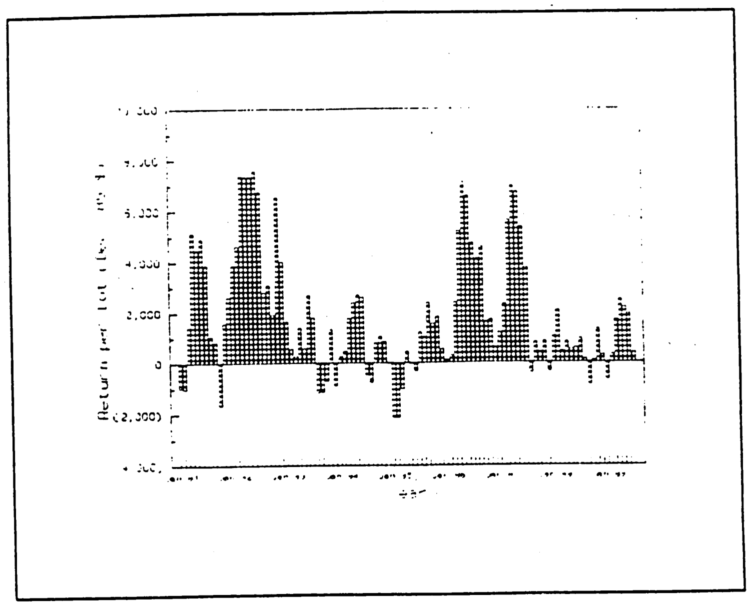


Figure 6
Alberta Hog Returns per lot (110 hogs @ 111 kg liveweight) No hedging, With NTSP (Base Model)



In this section the base model was reviewed. Variability was discussed in terms of standard deviations and the root MSE for this model[6]. The mean annual real rate of return over the period of the study was reported to be 50.62%. This is well above the TSE 300 and T-Bill returns (12.16% and 5.03% respectively) over the same period.

Participation in the NTSP increased returns from 50.62% to 56.69% and reduced variability (measured here by standard deviation) of returns by 11.46% ((87.73-77.67)/87.73))in the base case. The base model with and without NTSP provides the foundation to build and compare the different risk management strategies proposed in this study. Once all of the models have been reported, a comparison of the different strategies is discussed in section 4.8

In the following sections a selective investment strategy and the use of the futures market to reduce risk is evaluated. The futures market is used in a 100% hedge and hold strategy and an optimal hedge strategy.

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[6]Since this study aims to measure risk in the production period, or short run, risk will be measured and reported using the root MSE for the remaining strategies. A discussion of the standard deviation and root MSE risk measures in this study can be found in Appendix D.

4.6 Selective Investment Strategy

The base model provides the starting point from which the risk management strategies can be assessed. In the previous section, risk was measured using the standard deviation of the return and the root MSE. This study aims to determine management strategies which could enable producers to reduce risk over the production period. For this reason, the risk measure reported for the remaining strategies is the root MSE. A selective investment strategy is developed in this section.

The idea behind a selective investment strategy is that in order to find a more acceptable risk return tradeoff, the producer will determine whether to produce each month based on a predicted return compared to a known level of risk and return. In this case we use T-Bills as the known return. Since the 90 day T-Bill rate is known at the onset, the associated risk is zero. This type of model requires that the producer be flexible in terms of production.

The decision rule for the selective investment model is as follows:

> If the predicted returns from feeding hogs is less than the 3 month T-Bill return then invest in T-Bills and do not purchase or feed hogs. Otherwise, invest in and feed hogs.

It should be noted that no hedging occurs in this strategy.

The results for this model are reported in tables 3 and 4. Over the whole period of the study this model shows lower returns than the base model alone. However, during the period from July 1986 to July 1989 the selective investment model has a 14.43% higher mean annual rate of return. This is a period when there are many negative returns per lot (Figure 2). Thus, this strategy appears to increase returns during periods of low return.

The variability of return is also decreased when compared to the base model, no NTSP, as is illustrated by both the standard deviation and the root MSE. The variability of returns for this strategy is lower than the base model with or without NTSP since when the investment is made in T-Bills, the variability is known (risk = 0).

Participation in the NTSP does not increase the returns in this situation. This reflects the fact that with this strategy, investment in T-Bills is selected over hogs when predicted hog returns are lower than the T-Bill rate. During periods of negative or low returns investments would be made in T-Bills and no benefit would be received from participating in the NTSP.

The selective investment strategy followed a simple decision rule to determine whether hogs were fed or alternately the same money was invested in 91 day T-Bills. This strategy reduced the risk faced by finishers compared to the base model over the whole period of the study. The strategy was most effective during periods of negative returns such as the latter part of the study. Participation in the NTSP further reduced the risk when compared to the base model. Overall, both returns and risk were reduced compared to the base model[7]. These results are analyzed further in section 4.8.

The next sections develop and review the 100% hedge and hold and optimal hedge strategies.

Table 4
Net Returns - Selective Investment, Invest in T-Bills if Predicted Return < T-Bills, No NTSP
(December 1989 dollars)

Year	MRRORA[1]	RMSE[2]
Jan 1981-Jul 1989	48.94	74.51
Jan 1981-Jun 1986	44.95	67.61
Jul 1986-Jul 1989	56.05	86.47

1. MRRORA = annualized mean real rate of return
2. RMSE = root mean square error

[7]The reduction in returns suggests that the predictive model could be improved for future studies. The selective investment strategy should increase returns. When T-Bills are the selected investment, their return is predicted to be above that from feeding hogs.

Table 5
Net Returns - Selective Investment, Invest in T-Bills if Predicted Return < T-Bills, With NTSP
(December 1989 dollars)

Year	MRRORA[1]	RMSE[2]
Jan 1981-Jul 1989	47.70	68.05
Jan 1981-Jun 1986	44.95	67.61
Jul 1986-Jul 1989	53.62	73.20

1. MRRORA = annualized mean real rate of return
2. RMSE = root mean square error

4.7 100% HEDGE AND HOLD STRATEGY

The management alternatives which will be addressed in this section include: hedging in the futures market and participation in the NTSP. The first strategy which will be discussed is the 100% hedge and hold with and without involvement in the NTSP. Initially the market is tested for weak form efficiency to test for bias. This involves testing if hedge profits are significantly different from zero. With an efficient market one would assume that net profits from this strategy would be zero. Once this is determined the predictive model can be set up. The 100% hedge strategy is compared with the base model of hog feeding (hog feeding with no other risk management strategy) with both NTSP involvement and without.

The 100% hedge strategy is a simple strategy in which each lot of animals is hedged completely. The strategy is simulated over the period of the study with the hog feeder selling the market weight of hogs in CME futures at the start of the feeding period to match the predicted weight of hogs at marketing. The CME contract for hogs is 30,000 lbs. For the purposes of this simulation it is assumed that the contract is infinitely divisible so as to match the weight being marketed. The hog futures are bought back on the date of sale of the live hogs. Thus, the hedge period, 108 days, is the same as the feeding period. No margin costs are included in the evaluation of the strategy, but brokerage fees are accounted for.

Real revenues and expenses include any hedging real revenue and costs resulting in a total real return with hedging.

$$Hedgecost_t = \frac{(hogs * cwtdr * 100)}{(30,000 * 0.785)} * \$75 \qquad (35)$$

where:
hedgecost = brokerage fees
\$75 = fee per contract
30,000 = contract size in lbs liveweight
0.785 = dressing percent
hogs = # of hogs
cwtdr = hundredweight dressed

$$Hedgerev_t = \frac{(F_{t,t+4} - F_{t+3,t+1}) * Exchg_{t+3}}{dress\%} \qquad (36)$$

Where:
$Hedgerev_t$ = hedging revenue at time t
$F_{t,t+4}$ = futures price at time t for contract expiring at time t+4
$F_{t+3,t+1}$ = futures price at time of marketing for nearby contract
Dress% = dressing percentage (78.5%)
$Exchg_{t+3}$ = Canada US exchange rate at marketing

The revenue forecasts with 100% hedging use the same format as the actual revenue calculation. Hedging revenue and costs are calculated with the difference being added to the total returns to determine the net effect of this strategy. Only data which is available at the time of decision making is used to forecast net profits for the MSE. The forecasted net profits with hedging are calculated for each lot of hogs at the time of purchase in the following manner:

$$PNP_{t+3} = (PHP_{t+3} * Q_{t+3} - TC_t) + Q_{t+3} * (FP_{j,t+3} - PFP_{j,t+3}) * PX_{t+3} \qquad (37)$$

where:
PNP_{t+3} = predicted net profit
PHP_{t+3} = predicted hog price in month t+3
Q_{t+3} = quantity of hogs sold in month t+3
TC_t = total cost
$FP_{j,t}$ = futures price at time t with maturity month j (expires nearest month after t+3
$PFP_{j,t+3}$ = predicted futures price at time t+3 with maturity at month j
PX_{t+3} = predicted spot exchange rate converting U.S. to Canadian dollars

A t-test is carried out on the actual data to determine if mean hedge revenue (or profit) is significantly different from zero over the period in the study. This test is used to determine whether weak form efficiency exists in the market. The t statistic is calculated in the following manner:

$$t\ stat = \frac{mean\ revenue - 0}{\sigma_{revenue}} * \sqrt{n} \quad (38)$$

The mean hedge profit per hundred weight was not found to be significantly different from zero over the period tested (t statistic = -0.21311). This supports the idea of weak form efficiency in this market and supports the use of zero hedge profits in the predictive model. The rational investor would forecast zero hedge profits (excluding margins and brokerage fees) when going short in live hog futures.

The predicted hedging profits are zero since it is assumed that the market is efficient. Therefore, in the predicted model, returns would only be affected by the predicted hedging expenses or brokerage fees. Given an unbiased futures market and that the current futures price is used to forecast the futures price at t+3, equation 38 above, reduces to:

$$PNP_{t+3} = (PHP_{t+3} * Q_{t+3} - TC_t) \quad (39)$$

This in effect is the forecast with no hedging which is synonymous with hedging when the futures market is unbiased.

The root MSE is calculated from the forecast and simulated returns (equation 41) and is reported in tables 6 and 7.

$$MSE = \frac{\sum_{t=1}^{T} (NP_t - PNP_t)^2}{T-1} \quad (40)$$

where:
T = total number of production periods

The net revenue per lot and the annual mean rate of return for the 100% hedge strategy are reported in tables 6 and 7. The annual mean rate of return for this strategy without participation in the NTSP was 40.48%. Comparatively, annual returns over the same period with no risk management strategy or NTSP (base model), were higher at 50.62% (table 2). The variability of returns is decreased by 36.27% ((85.36-54.40)/85.36) over the whole period through the use of this strategy. From July 1986 - July 1989, the 100% hedge strategy reduced risk 39.26% compared to the base model. The mean annual rate of return was decreased 10.14% through the use of the 100% hedge strategy, but variability of returns is also reduced.

With participation in the NTSP, the mean annual real rate of return over the period of the study is reduced by 8.8% (56.69-47.89) through the use of the 100% hedge strategy. Variability of returns is reduced 28.49% by this strategy (Tables 3 and 7).

The root MSE increased with participation in the NTSP when compared to the same strategy without NTSP (tables 6 and 7). This is due to the model's inability to accurately predict the NTSP payouts. The base model illustrates that participation in the NTSP reduced the long term variability (Tables 2 and 3).

In this study risk is reduced through the 100% hedge strategy. However, a 10 percent drop in the annual rate of return seems to be a high cost for reduction of risk. The results of this section support Leuthold and Tomek's (1980) conclusions that the 100% hedge option reduces risk but also reduces returns to such a level as to make cattle feeding unprofitable. The return risk tradeoff is discussed further in terms of the Capital Market Line in section 4.8.

Table 6
Net Returns. 100% Hedge and No NTSP

Year	Mean Net Return/Lot Dec. 1989 $	MRRORA[1]	RMSE[2]
Jan 1981-Jul 1989	1397.42	40.48	54.40
Jan 1981-Jun 1986	1886.60	49.22	55.11
Jul 1986-Jul 1989	524.83	24.90	53.86

1. Annualized mean real rate of return
2. Root mean square error

Table 7
Net Returns. 100% Hedge and NTSP

Year	Mean Net Return/Lot Dec. 1989 $	MRRORA[1]	RMSE[2]
Jan 1981-Jul 1989	1718.43	47.89	58.77
Jan 1981-Jun 1986	1886.60	49.22	55.11
Jul 1986-Jul 1989	1437.47	46.13	65.92

1. Annualized mean real rate of return
2. Root mean square error

In this section the use of the 100% hedge and hold strategy as a risk reducing strategy was assessed. Hedge revenues were not significantly different from zero indicatin weak form efficiency in hog futures. The 100% hedge strategy results indicate that this option reduces variability of returns over the base model. The mean annual real rate of return was also reduced by this strategy. Involvement in the NTSP increased returns. The root MSE measure suggests that the NTSP did not decrease risk compared to the 100% hedge with no NTSP. However, this result reflects a shortcoming in the predictive model. The 100% hedge will be compared with the other strategies when all results have been reported. The use of an optimal hedge as a risk management strategy is reviewed in the next section.

4.8 OPTIMAL HEDGE STRATEGY

In the previous sections a base model was developed and provided a starting point for comparison of the proposed strategies. The 100% hedge and hold strategy was found to reduce risk and returns. In this section, the futures market is again used as a risk management tool through the use of an optimal hedge. The optimal hedging strategy provides an alternative to the 100% hedge and hold strategy. As outlined in the review of literature, in an efficient market, the minimum variance hedge ratio and the optimal hedge ratio will be the same. Assuming this to be the case, (as determined by the hedge profits in the previous section) the optimal hedge ratios are calculated. The NTSP is not included in the optimal hedge calculation.

The naive optimal hedging ratio is calculated from the price difference model.

$$\Delta cashprice = \alpha + \beta \Delta futures\ price_{Can\$} \quad (41)$$

where:
Δcash price = $(C_{t+3} - C_t)$
Δfutures price = $(F_{t,t+4} * E_t) - (F_{t+3,t+1} * E_{t+3})$
E = Exchange rate at time t and t+3 respectively
β = minimum variance hedge ratio estimated by OLS

From this equation the optimal hedge ratio was determined to be 67%. This figure is used throughout as the optimal hedge amount in this section and again in the selective investment strategies using the optimal hedge. Revenue and costs are calculated following the same format taking into account the 67% hedge.

$$Total\ Revenue = Rrev + 0.67 * hedging\ Rrev \quad (42)$$

where:
Rrev = real revenue Dec 1989 dollars

The predicted returns for optimal hedging uses the same format as the 100% hedge and hold strategy. The total revenue forecast is the same as the 100% hedge forecast adjusted with the optimal hedge ratio.

$$P\ Hedging\ expense = Total\ Expenses + 0.67 * Brokerage\ Fees \quad (43)$$

No other changes are required in the predictive model since the investor expects zero hedge profits.

The annual mean real rate of return without participation in the NTSP for the whole period was 42.39% (Table 8) with a root MSE of 58.41. This return is higher than that obtained by the 100% hedge strategy (1.91%) while the variability of returns is increased slightly[8]. With participation in the NTSP, the annual real rate of return is increased by the optimal hedge strategy by 3.31% over the 100% hedge strategy for the period of July 1986 to July 1989. The optimal hedge strategy does not noticeably change the variability of returns (with NTSP) over this same period (Tables 9 and 7).

Returns and variability are reduced by the optimal hedge strategy when compared to the base model.

In this section the use of the optimal hedge was reviewed. The optimal hedge strategy was simulated using a ratio of 67% (calculated from the price difference model, equation 42). The mean annual returns were increased by this strategy with no real impact on the variability of returns when compared to the 100% hedge strategy.

Table 8
Net Returns Optimal Hedge and No NTSP

Year	Mean Net Return/Lot Dec. 1989 $	MRRORA[1]	RMSE[2]
Jan 1981-Jul 1989	1452.42	42.39	58.41
Jan 1981-Jun 1986	1908.92	49.85	57.82
Jul 1986-Jul 1989	638.107	29.09	60.24

1. Annualized mean real rate of return
2. Root mean square error

[8]The increase in variability as measured by the root MSE is not surprising since the optimal hedge is variance minimizing not MSE minimizing.

Table 9
Net returns Optimal Hedge and NTSP

Year	Mean Net Return/Lot Dec. 1989 $	MRRORA[1]	RMSE[2]
Jan 1981-Jul 1989	1773.43	49.40	60.41
Jan 1981-Jun 1986	1908.92	49.85	57.82
Jul 1986-Jul 1989	1550.74	49.44	66.74

1. Annualized mean real rate of return
2. Root mean square error

4.9 NET RETURNS AND RISK MEASURES

The base model and risk management strategies have been reported in the preceding sections. In this section the root mean square errors and returns of the various strategies are reviewed. The CAPM beta for the strategies are also reported. This will indicate the management strategies risk comparatively to the market portfolio. Systematic and non systematic risk measures are reported as a further indication of the ways in which the risk management strategies may benefit producers.

The root MSE is used to compare the net returns of the different investment strategies following the mean-variance efficiency criteria. The root MSE on hog returns are reported collectively in Table 10. Returns are increased through participation in the NTSP, however RMSE is not always reduced. Comparing the base model with and without NTSP, it is evident that the NTSP reduces risk when no other risk management strategy is in place. The root MSE of the base model for the period of January 1981 - July 1989 is reduced by 3.73% ((85.36-82.18)/85.36) through participation in the NTSP. For the period after NTSP initiation, participation in the program reduced the RMSE by 4.75%. When other strategies are involved the NTSP does not decrease the RMSE, instead when compared to the same strategy without NTSP, the root MSE remains almost the same or increases slightly (figure 7). This occurs because the predictive model does not accurately forecast NTSP payouts.

All strategies reduce the root MSE when compared to the base model over the period of the study. The 100% hedge strategy with no NTSP reduces the root MSE by 36.27% over the base model (no

NTSP). The optimal hedge reduces the root MSE by 31.57%, while the selective investment strategy reduces the root MSE 12.71% over the base model (no NTSP). Slightly lower reductions of risk occur when the same strategies with involvement in the NTSP are compared to the base model with NTSP.

Figure 7 illustrates the root MSE comparisons of table 10 graphically. The 100% hedge (no NTSP) has the lowest root MSE for the whole period and the time leading up to the initiation of the NTSP.

With no other risk management strategy, participation in the NTSP does reduce the producer's exposure to risk. However, greater risk reduction can be found through using a hedging strategy. Specifically, the 100% hedge and hold strategy shows a large decrease in exposure to risk. All of the strategies show a greater reduction in risk than by participation in the NTSP alone when compared to the base model.

Until this point the discussion has centred either on returns or risk, but these must be considered together in order for an investor to make a rational decision. Figure 8 displays the strategies with mean annual real rate of return plotted against root MSE. The mean variance risk efficiency criterion (with RMSE replacing variance) is used to compare the strategies as discussed in chapter 3. Strategies are ranked including both risk and returns by dividing the graph into quadrants with point 1, the base model with no NTSP as the midpoint. Strategies in quadrant I dominate the base model. Only the base model with NTSP (#2) is located in this quadrant. Strategies in quadrant IV are dominated by the base model, while strategies in quadrants II and III do not dominate and are not dominated by the base strategy. An individual's degree of risk aversion and utility function will determine if any strategy in quadrant III is chosen over the base strategy.

The greatest reduction of risk is found through the use of the 100% hedge and hold strategy (#3). Unfortunately, the rate of return also drops by approximately 10%. However even if the producer has a high degree of risk aversion, other strategies in quadrants I and III offer large reductions of risk without the drastic reduction in returns.

The base model with NTSP dominates the base model with no NTSP. The remaining strategies all fall in quadrant III which indicates that they are neither dominated by nor dominate the base model.

Except for the selective investment strategy, all the strategies have increased returns with participation in the NTSP. The root MSE does not show a reduction in risk due to the NTSP, but a reduction in long term variability was indicated for the base model using standard deviation as the measure. Again, this result is most likely due to the predictive model's inability to accurately forecast the NTSP.

The Capital Market Line provides another method to assess the risk return tradeoff of the various strategies. The Capital Market Line (CML) tells us the relationship between the expected rate of return on an efficient portfolio and that portfolio's risk (standard deviation). The slope of the CML for a diversified portfolio such as the TSE 300 is approximately 0.40. The slope indicates the tradeoff between risk and return. For each 1 unit gain in return there will be a concurrent 2.5 unit gain in risk. The standard deviation is a special case of the root MSE hence for our purposes, the root MSE is used to compare the strategies using the CML. The CML (slope = 0.40) is drawn through the base model (point one) in Figure 8. For any given level of risk (in this case root MSE) a point above the CML would offer a better risk return tradeoff while those below the line would make the investor worse off. All of the strategies lie above the CML in figure 8. This indicates that all of the strategies offer a superior risk return tradeoff as an alternative to the base model. More specifically, for the proposed strategies compared to the base model, a decrease in 1 unit of risk has a smaller concurrent decrease in returns than exhibited by a similar move with a diversified portfolio including riskless and risky assets.

The greatest reduction in both risk and return is seen with the 100% hedge and hold strategy without participation in the NTSP. The selective investment strategy causes the least reduction in the level of returns and second lowest reduction of risk. The efficiency criterion suggest that none of the strategy are dominated by the base model and only the base model with NTSP clearly dominates the base case. Use of the CML indicates that all strategies offer an acceptable risk return tradeoff.

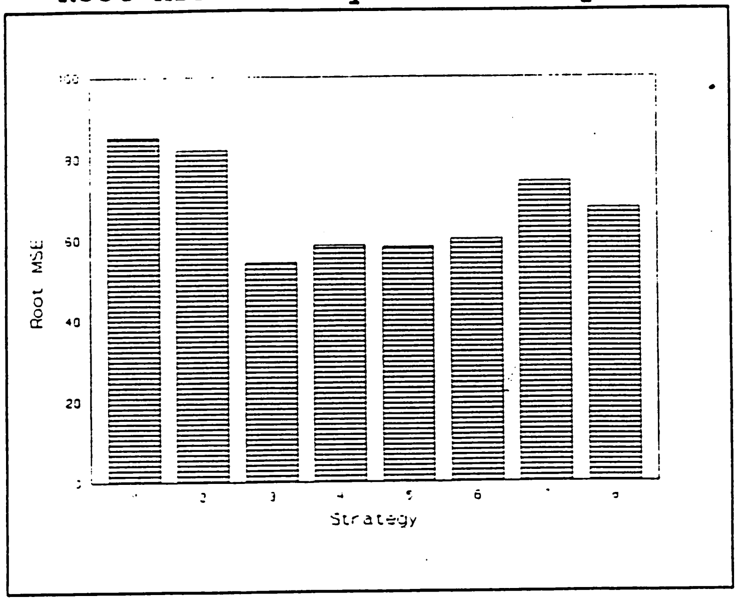
In this section risk has been reviewed in terms of the root MSE. The CAPM beta, systematic and non-systematic risk are reported and discussed next.

Table 10
Root Mean Square Error of Hog Investment Strategies

Strategy & Time Periods	No NTSP RMSE[1]	With NTSP RMSE[1]
Base Model		
Jan 81-Jul 89	85.36	82.18
Jan 81-Jun 86	84.10	84.10
Jul 86-Jul 89	88.68	84.47
100% Hedge		
Jan 81-Jul 89	54.40	58.77
Jan 81-Jun 86	55.11	55.11
Jul 86-Jul 89	53.86	65.92
Optimal Hedge		
Jan 81-Jul 89	58.41	60.41
Jan 81-Jun 86	57.82	57.82
Jul 86-Jul 89	60.24	66.74
Selective Inv No Hedge		
Jan 81-Jul 89	74.51	68.05
Jan 81-Jun 86	67.61	67.61
Jul 86-Jul 89	86.47	73.20

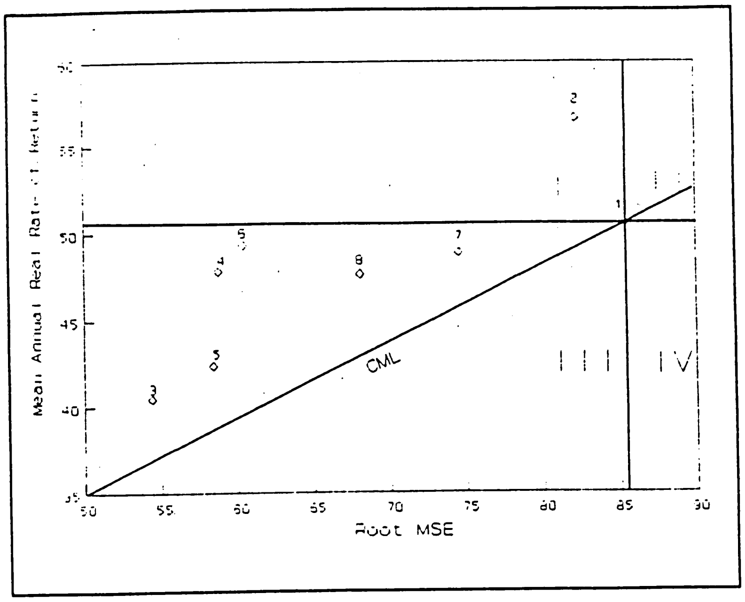
1. RMSE = root mean square error

Figure 7
Root MSE January 1981 - July 1989



Strategies: (Figure 7)
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. Selective Investment - Feed or T-Bills, No NTSP
8. Selective Investment - Feed or T-Bills, With NTSP

Figure 8
Return Versus Risk (Root MSE), January 1981 - July 1989



Strategies: (Figure 8)
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. Selective Investment - Feed or T-Bills, No NTSP
8. Selective Investment - Feed or T-Bills, With NTSP

4.10 CAPM BETA AND OTHER RISK MEASURES

The two measures used to measure risk in this study are the root MSE and the CAPM beta. The root MSE results have been reported in the preceding sections. This section reports the CAPM beta and systematic risk portions of the risk management strategies.

The net returns of the various risk management strategies and returns on the TSE 300 during the same period are used to determine the CAPM beta risk measure. The CAPM compares the hog feeding strategies as investments to the market portfolio (in this case, the TSE 300). The real TSE 300 returns are calculated in a similar manner to those of the hog returns (Appendix F). The returns are calculated to match the production period of the hogs.

The CAPM beta's, systematic and nonsystematic risk figures for each of the investment strategies are reported in tables 11 - 14. The CAPM beta is very low and often negative. Positive, but very low beta values are found during the period from July 1986 - July 1989 in the base model. Very low and negative betas indicate that the investment is not highly correlated with the TSE 300. A hog feeding operation could provide risk reduction through diversification holders of the TSE 300 portfolio.

The systematic and non systematic portion of the MSE risk is calculated using equations 7 and 8 from chapter 3. Systematic risk is affected by the economy and cannot be removed through diversification. An asset with a beta of one has the same systematic risk as the market portfolio. Non systematic risk is the majority of the risk in these strategies since correlations between strategy returns and the TSE 300 are close to zero.

The CAPM betas are compared in figure 10. This graph illustrates the nature of the hog investment compared to the TSE 300 over the period of the study. For the period studied, hog investments are not closely linked to the TSE 300, thus holders of the TSE 300 to diversify risk by investing in hof feeding operations. This also suggests that hog finishers can diversify some risk through investment in the TSE 300. This supports the results of Hirshleifer (1988) that returns in stocks and commodities have low negative correlations.

Table 11
Base Model: Annual Returns, CAPM betas, RMSE, Systematic and Non Systematic Risk

Strat. & Date	MRRORA[1]	RMSE[2]	Beta	Corr[3]	Sys. Risk	Non Sys. Risk
No NTSP						
Jan 81-Jul 89	50.62	85.36	-0.243	-0.112	-9.54	94.87
Jan 81-Jun 86	55.66	84.10	-0.281	-0.191	-16.03	100.13
Jul 86-Jul 89	41.62	88.68	0.151	0.058	5.11	83.57
NTSP						
Jan 81-Jul 89	56.69	82.18	-0.226	-0.108	-8.87	91.05
Jan 81-Jun 86	54.80	81.53	-0.368	-0.190	-15.49	97.02
Jul 86-Jul 89	60.07	84.47	0.163	0.065	5.51	78.96

1. MRRORA = annualized mean real rate of return
2. RMSE = root mean square error
3. Corr = correlation between hog net returns and the TSE 300

Table 12
Selective Investment, Feed or T-Bills
Annual Returns, CAPM beta, Systematic and Non-Systematic Risk

Strat. & Date	MRRORA	RMSE	Beta	Corr	Sys. Risk	Non Sys. Risk
No NTSP						
Jan 81-Jul 89	48.938	74.512	-0.101	-0.053	-3.97	78.48
Jan 81-Jun 86	44.953	67.614	-0.174	-0.108	-7.31	74.93
Jul 86-Jul 89	56.046	86.466	0.078	0.030	2.63	83.83
NTSP						
Jan 81-Jul 89	47.696	68.052	-0.104	-0.060	-4.12	72.17
Jan 81-Jun 86	44.374	65.568	-0.165	-0.106	-6.94	72.51
Jul 86-Jul 89	53.620	73.204	0.059	0.027	2.01	71.20

1. MRRORA = annualized mean real rate of return
2. RMSE = root mean square error
3. Corr = correlation between hog net returns and the TSE 300

Table 13
100% Hedge: Annual Returns, CAPM betas, RMSE,
Systematic Risk and Non Systematic Risk

Strat. & Date	MRRORA[1]	RMSE[2]	Beta	Corr[3]	Sys. Risk	Non Sys. Risk
No NTSP						
Jan 81-Jul 89	40.48	54.40	-0.148	-0.107	-5.80	60.20
Jan 81-Jun 86	49.22	55.11	-0.142	-0.108	-5.98	61.09
Jul 86-Jul 89	24.90	53.86	-0.133	-0.084	-4.50	58.37
NTSP						
Jan 81-Jul 89	47.89	58.77	-0.138	-0.092	-5.41	64.19
Jan 81-Jun 86	48.88	54.90	-0.137	-0.105	-5.77	60.67
Jul 86-Jul 89	46.13	65.92	-0.131	-0.068	-4.45	70.37

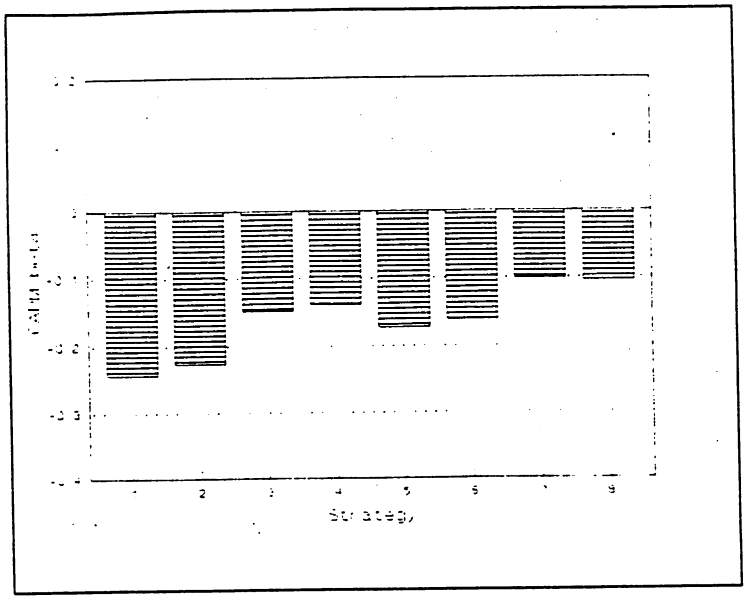
1. MRRORA = annualized mean real rate of return
2. RMSE = root mean square error
3. Corr = correlation between hog net returns and the TSE 300

Table 14
Optimal Hedge: Annual Returns, CAPM betas, RMSE, Systematic Risk and Non Systematic Risk.

Strat. & Date	MRRORA	RMSE	Beta	Corr	Sys. Risk	Non Sys. Risk
No NTSP						
Jan 81-Jul 89	42.39	58.41	-0.172	-0.116	-6.76	65.17
Jan 81-Jun 86	49.85	57.82	-0.211	-1.154	-8.88	66.71
Jul 86-Jul 89	29.09	60.24	-0.040	-0.023	-1.37	61.61
NTSP						
Jan 81-Jul 89	49.40	60.41	-0.160	-0.104	-6.29	66.70
Jan 81-Jun 86	4938	57.10	-0.204	-0.150	-8.59	65.68
Jul 86-Jul 89	49.44	66.74	-0.035	-0.018	1.18	67.92

1. MRRORA = annualized mean real rate of return
2. RMSE = root mean square error
3. Corr = correlation between hog net returns and the TSE 300

Figure 9
CAPM Beta, January 1981 - July 1989



Strategies: (Figure 9)

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. Selective Investment - Feed or T-Bills, No NTSP
8. Selective Investment - Feed or T-Bills, With NTSP

Within this section the risk and returns of the different Alberta hog finishing strategies have been reviewed. All of the strategies reduce risk compared to the base model of no hedging and no NTSP. The base model with NTSP and the two selective investment models with NTSP are superior to the base model using the mean - variance risk efficiency criterion. The remaining strategies do not dominate and are not dominated by the base model. Decisions about these strategies would depend on the individual's degree of risk aversion. The CAPM beta suggests that Alberta hog price movements are not correlated with the TSE 300. The low negative beta indicates that holders of a diversified portfolio such as the TSE 300 could benefit from investing in hog finishing. The variability of returns and the type of risk have been reviewed in this section.

4.11 SUMMARY

This chapter reviewed the methodology and results of the different risk management strategies. A base model was developed which provided a standard from which to assess the different strategies. Participation in the NTSP increased returns and decreased risk in the base case. All of the strategies reduced risk when compared to the base model with no hedging and no NTSP. The base model with NTSP dominated the base model when evaluated with the mean variance risk efficiency criterion. The 100% hedging and optimal hedging strategies reduced risk, but also reduced returns quite significantly. Participation in the NTSP increased returns, and reduced risk.

The final chapter sums up the results in response to the study objectives listed in chapter 1.

CHAPTER 5 CONCLUSIONS

Alberta hog finishers are price takers in a market with highly variable prices. This variation in price is termed risk in this study. There are several risk management strategies available to producers to reduce this risk. The strategies reviewed in this study include a public program (the NTSP), a selective investment strategy, and hedging in the futures market. The risk management strategies were compared using root MSE and the CAPM beta as measures of risk.

The risk management strategies were measured and reported in chapter 4. Four objectives were listed for this study in chapter 1. These objectives include: measuring the returns and variations of returns, identifying and measuring price risk, comparing the effectiveness of the NTSP with private risk management strategies and comparing hog finishing investment opportunities to other investments. The results of this study will be discussed in terms of the objectives in this chapter. Possibilities for further research in this area will complete this paper.

The base model illustrated the returns and variability of returns for the Alberta hog finisher without hedging over the period studied. The annualized mean real rate of return from January 1981 - July 1989 without the NTSP was 48.94 percent. Participation in the NTSP caused this figure to decrease slightly, to 47.70 percent. The mean annual return well surpasses returns available with the TSE 300 and T-Bills over the same time period. Although the mean annual return over the study period is positive, much variability of monthly returns is present. The root MSE for the base model is 85.36.

Participation in the NTSP in the base case reduced the variability of returns (root MSE = 82.18) without greatly reducing the level of returns. The NTSP removed a large portion of the negative returns while simultaneously reducing exposure to risk.

All of the private risk management strategies reduced risk when compared to the base model. The greatest reduction in risk was evident from the 100% hedge strategy. The smallest reduction in risk was produced by the selective investment strategy. All of the strategies except the base model with NTSP neither dominate nor are dominated by the base model. All of the strategies fell above the Capital Market Line indicating that the risk return tradeoff for any of the strategies compared to the base model is superior to the tradeoff represented by a portfolio such as the TSE 300. Decisions as to which strategy is used would depend upon producer preference. Using the risk efficiency criterion, the base model with participation in the NTSP is clearly superior to the base case with no risk management strategy.

Participation in the NTSP increased returns over no NTSP in all strategies excluding the selective investment model. In this case the participation in the NTSP reduced both the variability and level of returns. Based on the mean variance efficiency criterion, the base case with NTSP dominated the base model and all other strategies.

While the NTSP is available, it provides a superior risk management strategy for Alberta hog finishers. However, this program will not be continued indefinitely. Depending on the level of risk management sought, or the level of risk aversion, all of the proposed private risk management strategies provide viable alternatives.

Based on the CAPM beta measurements, the form of price risk present in Alberta hog finishing is mainly non-systematic risk. This risk is diversifiable. Over the whole period of the study, all strategies with and without participation in the NTSP exhibited very low negative betas. This is indicative of an investment which does not closely follow the patterns of the market portfolio (TSE 300). For an individual holding the market portfolio, hog finishing could reduce risk through diversification.

This study begins to address the idea of private risk management alternatives for Alberta hog finishers. Further research into this issue could greatly benefit Alberta producers facing a rapidly changing marketplace. Ideas for future research include:

1. Follow a similar set of strategies and objectives for the production period faced by farrow to finish operations.
2. Develop selective investment strategies from the selective investment strategy in this paper. These could follow the same decision criteria, but use the futures market to hedge when producing.
3. Assess basis risk and differences in basis risk due to different locations.
4. Evaluate the current level of use and shortcomings of private risk management strategies in Alberta hog production. Determine which areas or directions would provide the greatest benefit to producers.
5. Improve the model to provide better NTSP forecasts.
6. Evaluate the use of options contracts as an alternative risk management strategy.
7. Determine if there are optimal production sizes which would best suit the various strategies.
8. Include the cost of maintaining the margin in the various hedge strategies.
9. Identify the sources of price risk.

The research completed on risk management alternatives for Alberta hog producers has shown that there are viable opportunities for producers to reduce their exposure to risk. The public program, the NTSP, actually increases returns while reducing risk thus it is the only strategy which dominates the base model using the risk efficiency criterion. The private strategies using the futures markets or a production decision rule also offer workable risk management strategies for Alberta hog finishers. The 100% hedge strategy reduced risk to the greatest extent, but also reduced returns by about 10%. The selective investment model exhibited the best risk return tradeoff. Development of a selective investment model using the futures market may provide a very useful risk management tool for hog finishers in Alberta.

Bibliography

Alberta Agriculture. Alberta Pork Production Course, Chapter 7, Marketing. Pork Industry Branch, 1987.

Beauchamp, A. and U.C. Toensmeyer. Using Futures to Hedge Delaware Hogs. University of Delaware Agriculture Extension Station Bulletin #430, Newark, Delaware. August, 1979.

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

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

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

Brandt, J.A. "Forecasting and Hedging: An Illustration of Risk Reduction in the Hog Industry." American Journal of Agricultural Economics. 67:24-31, 1985.

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

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

Caldwell, J., Copeland, J., and M. Hawkins. " Alternative Hedging Strategies for an Alberta Feedlot Operator." Canadian Journal of Agricultural Economics. 30:257-272, 1982.

Carter, C.A. and R.M.A. Loyns. "Hedging Feedlot Cattle: A Canadian Perspective." American Journal of Agricultural Economics. 67:32-39, 1985.

Chee, K.C. "On the Use of Portfolio Theory to Hedge Optimally Using Futures." Working Paper Series CSFM #206, Center for Futures Markets, Columbia Business School, New York.

Chicago Mercantile Exchange. 1980-1988. Statistical Yearbook. Chicago Mercantile Exchange, Chicago, Illinois.

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, 1990.

Collins, R.A. "Expected Utility, Debt-Equity Structure, and Risk Balancing.: American Journal of Agricultural Economics. 67:627-629, 1985.

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

Dusak, K. "Futures Trading and Investor Returns: An Investigation of Commodity Market Risk Premiums." Journal of Political Economy. 84:1387-1406, 1973.

Elam, E., and D, Vaught. "Risk and Return in Cattle and Hog Futures." Journal of Futures Markets. 8:365-372, 1988.

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

Garcia, P., Leutlhold, R.M., Fortenbery, R. and G.F. Sarassoro. "Pricing Efficiency in the Live Cattle Futures Market: Further Interpretation and Measurement." American Journal of Agricultural Economics. 70:162-169, 1988.

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

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

Grant, D. "Theory of the Firm with Joint Price and Output Risk and a Forward Market." American Journal of Agricultural Economics. 67:630-635, 1985.

Harris, K.S. and R.M. Leuthold. "A Comparison of Alternative Forecasting Techniques for Livestock Prices: A Case Study." North Central Journal of Agricultural Economics. 7(1):40-50, 1985.

Hayenga, M., "Profitable Hedging Opportunities and Risk Premiums for Producers in Live Cattle and Live Hog Futures Markets." Journal of Futures Markets. 4:141-154, 1984.

Hirshleifer, D. "Residual Risk, Trading Costs, and Commodity Risk Premia. Review of Financial Studies. 1(2):179-193, 1988.

Holt, M.T., Brandt, J.A., and C.A. Hurt. "Managing Risk with Forecasts and the Futures Market: An Application to Hog Production. " Journal of the American Society of Farm Managers and Rural Appraisers." 49(1): 6-11, 1985.

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

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

Leuthold, R.M. 1979. "An Analysis of the Futures-Cash Price Basis For Live Beef Cattle." North Central Journal of Agricultural Economics. 1:47-52, 1989.

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

Leuthold, R.M. and P. Hartmann. "A Semi-Strong Form Evaluation of the Efficiency of the Hog Futures Market." American Journal of Agricultural Economics. 61:482-489, 1979.

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

Lintner, J. "The Valuation of Risk Assets and Selection of

Risky Investments in Stock Portfolios and Capital Budgets." Review of Economics and Statistics. 47:13-37, 1965.
Longworth, D., Boothe, P., and K. Clinton. A Study of the Efficiency of Foreign Exchange Markets. Bank of Canada, 1983.
Martin, L. and P. Garcia. "The Price-Forecasting Performance Futures Markets for Live Cattle and Hogs: A Disaggregated Analysis." American Journal of Agricultural Economics. 63:209-215, 1981.
Naik, G. and R.M. Leuthold. "Cash Futures Price Relationships for Nonstorable Commodities: An Empirical Analysis Using a General Theory. Western Journal of Agricultural Economics. 13(2):327-338, 1988.
Peck, A.E. "Hedging and Income Stability: Concepts, Implications, and an Example." American Journal of Agricultural Economics. 57:419-410, 1975.
Sharpe, W.F. "Capital Asset Prices: A Theory of Market Equilibrium Under Conditions of Risk." Journal of Finance. 19:425-442, 1964.
Tan, M.H. The National Tripartite Stabilization Program for Red Meats: Hog Model. Working Paper 5/88, Market Outlook and Analysis Division, Policy Branch, Agriculture Canada, Ottawa, Ontario, 1988.
Thompson, S.R. and G.E. Bond. "Offshore Commodity Hedging Under Floating Exchange Rates." American Journal of Agricultural Economics. 69:46-55, 1987.
Tomek, W.G. "An Analysis of the Futures-Cash Price Basis for Live Beef Cattle: Comment." North Central Journal of Agricultural Economics. 2:81-82, 1980.
Toronto Globe and Mail Daily Newspaper. Toronto, Ontario. Various dates 1988-1989.
Turvey, C.G. and H.C. Driver. "Systematic and Nonsystematic Risks in Agriculture." Canadian Journal of Agricultural Economics. 35:386-401, 1987.
Unterschultz, J.R. Risk in Cattle Feeding in Alberta. Unpublished M.Sc. Thesis. Department of Rural Economy, University of Alberta. Edmonton, Alberta, 1991.
Working, H. "Futures Trading and Hedging." American Economic Review. 43:214-343, 1953. Reprinted in Selected Writings of Holbrook Working. 1977. Board of Trade of the City Of Chicago, Chicago.
Young, D.L. "Risk Concepts and Measures for Decision Analysis." In Risk Management in Agriculture. P.J. Barry (editor). Iowa State University Press, Iowa, 1984.

APPENDIX A FEED INGREDIENTS AND TONNES FED

The three rations are made up of varying proportions of wheat, barley and protein supplement. The table below outlines the proportions per ration.

Rations

Feed	Starter	Grower	Finisher
% Supplement	33	27	16
% Barley	10	60	40
% Wheat	57	13	44

An average daily gain of 0.757 kg is assumed over the 108 day feeding period. Days on feed and amounts consumed are reported below.

Feed Consumed

Ration	Days on Feed	kg per pig	tonnes per lot (110 pigs)
Starter	10	10.85	1.227
Grower	31	49.11	5.402
Finisher	67	200.6	22.067

APPENDIX B FIXED COSTS AND EXPENSES USED IN THE MODEL

Wage$_t$ — \$7.00/hour * $fipil_t/fipil_{Dec\ 89}$ (fipil = fipi labour)

Total Hours — 0.60 hrs/cwt dressed * cwt dressed * # hogs

Paid Labour$_t$ — (total hours * 0.20) * $wage_{t+1}$ * $(1+r_{t+1})^{-1}$

Hog Trucking$_t$ — (\$2.25/hog) * $fipi_t/fipi_{Dec\ 89}$
Trucking cost = (hog $trucking_{t+3}$ * hogs) * $(1+r_{t+3})^{-3}$

NTSP Premium$_t$ — $premium_{t+3}$/hog * hogs * $(1+r_{t+3})^{-3}$

APPDC$_t$ — $APPDC_{t+3}$/hog *hogs * $(1+r_{t+3})^{-3}$

Phif$_t$ — $Phif_{t+3}$ * $sales_t$/100 * $(1+r_{t+3})^{-3}$
premiums - charged as \$0.14 per \$100 of income
payouts - lose 1-6 hogs per quarter, receive market price therefore included in sales calculation

Maintenance$_t$ — \$1.90$_{Dec.89}$/hog * $fipi_t/fipi_{Dec\ 89}$
Maint $cost_t$ = ($maint_{t+1}$ * hogs) * $(1+r_{t+1})^{-1}$

Vet$_t$ — \$1.82/hog * $fipi_t/fipi_{Dec\ 89}$
Vet $cost_t$ = (Vet_{t+1} * hogs) * $(1+r_{t+1})^{-1}$

fuel — \$3.23/hog * $fipi_t/fipi_{Dec\ 89}$
Fuel $cost_t$ = ($Fuel_{t+1}$ hogs) * $(1+r_{t+1})^{-1}$

licences$_t$ — \$0.75/hog * $fipi_t/fipi_{Dec\ 89}$
Licence $cost_t$ = ($licence_{t+1}$ * hogs) * $(1+r_{t+1})^{-1}$

Fixed Costs$_t$/hog \$6.00/cwt dressed * cwt dressed * $fipi_t/fipi_{Dec\ 89}$
Fixed $costs_t$ = (Fixed $cost_t$/hog * hogs) * $(1+r_{t+1})^{-1}$

APPENDIX C BARN SPECIFICS

Barn Capacity	850 hogs
36' x 165'	
66 pens (5' x 16')	
Lagoon manure system	
Percentage Barn Utilization	100%
Days on Feed	107
Hogs Marketed per Year	2899.5

Barn located 30 miles from slaughter house and 5 miles from feed mill

Capital Investment

Buildings	
Barn	$102,500
Manure Pit	5,700
Feed Storage	8,000
Total Buildings	116,200
Equipment	
Half-ton truck	10,000
Machinery and tools	2,000
Feeding equipment	15,000
Water well	8,000
Small tractor	25,000
Total Equipment	60,000
Total Investment	$176,200

Fixed Costs determined by amortizing the Total Investment at 12% over 10 years.

Fixed cost/year	$ 31,149
Fixed cost/hog	10.74
Fixed cost/cwt dressed	6.00

APPENDIX D STANDARD DEVIATION RESULTS OF THE STRATEGIES

The table below lists the standard deviation of the mean annual real rate of return (MRRORA) for the various strategies. The root MSE was chosen as the measure to report risk in this study since it more accurately reflects risk in the short run (Peck, 1975). The standard deviation is based on historical data providing a measure of risk in the long run. It is interesting to note that the results would be slightly different if the standard deviation was the measure use to report risk in this study.

Looking at the different investment strategies with and without NTSP, the Root MSE shows an increase in risk with the NTSP (Table 13, Figure 10) while the same conditions measured with the standard deviation show a decrease in risk. In this case the standard deviation more accurately reflects the effects of the NTSP. The reason for the inaccuracy of the root MSE is that the predictive model is not accurately forecasting the NTSP payouts.

Strategy & Time Periods	No NTSP St. Deviation MRRORA	With NTSP St. Deviation MRRORA
Base Model		
Jan 81-Jul 89	87.73	77.67
Jan 81-Jun 86	78.89	78.89
Jul 86-Jul 89	102.16	80.37
100% Hedge		
Jan 81-Jul 89	66.07	59.89
Jan 81-Jun 86	60.71	60.71
Jul 86-Jul 89	72.99	59.15
Optimal Hedge		
Jan 81-Jul 89	67.57	59.89
Jan 81-Jun 86	60.10	60.10
Jul 86-Jul 89	78.31	60.78
Selective Investment No Hedging		
Jan 81-Jul 89	80.73	76.00
Jan 81-Jun 86	74.73	74.73
Jul 86-Jul 89	91.13	81.66

APPENDIX E ALBERTA OMAHA BASIS

The variability of the Alberta and the Omaha basis is listed in the tables below. The standard deviation is used as a measure of variability.

The Alberta and Omaha nearby and distant basis are reported in the tables below. Thompson and Bond (1985) suggest that it is the perceived basis variance that is important when comparing an offshore hedger to an hedger in the United States.

Alberta Nearby and Distant Basis

Time Period and Basis	Mean	Std. Deviation
Jan 1980 - Oct 1989		
Nearby	8.925	8.278
Distant	8.624	10.004
Jan 1980 - June 1986		
Nearby	8.987	8.172
Distant	10.333	9.099
July 1986 - Oct 1989		
Nearby	8.802	8.594
Distant	5.106	10.896

Omaha Nearby and Distant Basis

Time Period and Basis	Mean	Std. Deviation
Jan 1980 - Oct 1989		
Nearby	-0.240	4.750
Distant	-0.329	6.574
Jan 1980 - June 1986		
Nearby	8.718	7.379
Distant	10.383	9.099
July 1986 - Oct 1989		
Nearby	-2.251	5.373
Distant	-4.387	6.940

APPENDIX F TSE and T-BILL RETURN CALCULATIONS

Monthly TSE 300 index = $((TSE\ 300_{i+1}/TSE\ 300_{1})-1) * 100$
Monthly TSE 300 dividends = $((1+TSE\ 300_{Div\ i+1}/TSE\ 300_{i})-1) * 100$
Total TSE 300 returns (mtrtse) = monthly TSE 300 index + monthly TSE 300 dividends
Total TSE returns $index_1$ (ttseri) = 1000 Jan 1980
Total TSE returns $index_i = ttseri_{(i-1)} * (mtrtse_{(i-1)}/100+1)$
TSE returns per production period
$tsern_i = ((ttseri_{i+3}/ttseri_i)-1) * 100$
Tse returns in real dollars per production period
$tserr_i = ((1+ tsern_i/100) * (CPI_i/CPI_{i+3})-1) * 100$
TSE returns in real dollars annuallized
$tserra = (((1+tserr_i)/100)^4)-1) * 100$

Predicted TSE return per year
ptserra = mean (tserra)

Mean square error
MSE TSE = $\Sigma(tserra_i - ptserra_i)^2/(n-1)$
where n = # observations

T-Bill returns per production period (4 month period)
$tbn_i = ((1+ tbill_i/100)^4-1) * 100$
T-Bill returns in real dollars per production period
$tbr_i = ((1+tbn_i/100) * (CPI_i/CPI_{i+3}))-1) * 100$
T-Bill returns annualized
$tbra_i = ((1+tbr_i/100)^4)-1) * 100$

Predicted tbra
ptbra = mean (tbra)

TSE and T-Bill Mean Annual Real Rate of Returns

Date	TSE Returns	T-Bill Returns
Jan 1981 -July 1989	12.17	5.03
Jan 1981 - June 1986	10.86	5.03
July 1986 - July 1989	14.49	4.49

Capital Market Line

The Capital Market Line (CML) illustrates the risk return tradeoff for a given portfolio. It traces the efficient set of portfolios formed from both risky assets and the riskless asset. Each point on the line represents an entire portfolio. The equation for the CML is:

$$E(R_p) = R_f + \left(\frac{E(R_m) - R_f}{\sigma_m}\right)\sigma_p$$

where:
$E(R_p)$ = expected return on portfolio
R_f = risk free rate
$E(R_m)$ = expected return on market
σ_m = standard deviation of returns on market portfolio
σ_p = standard deviation of returns on the portfolio

Thus the slope of the CML is equal to the expected return on the market portfolio of risky stocks minus the risk-free rate (the market risk premium) all divided by the standard deviation of the market portfolio.

In this study the slope of the CML is assumed to be 0.40.