University of Alberta

Evaluating Risk Management Strategies for Alberta Cow/Calf Operations

by

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Dedication

I dedicate this project to my husband and children. Your patience, encouragement, understanding, love and support helped me achieve this dream. You were there for me every single way and I deeply thank you so much.

Abstract

This research evaluated alternative risk management strategies for Alberta cow/calf operations. Representative farms based on region and herd size was used. Monte Carlo simulation was used in calculating average gross margins as well as the degree of variability surrounding the average annual gross margins for each alternative risk management strategy. Subsequently, each management strategy was examined to assess its effectiveness in supporting average gross margins over a multi-year time frame as well as decreasing the variability surrounding the average gross margins. The risk management strategies considered in the current study were participation in CAIS, feed storage and heifer retention scenarios. The last two strategies were also considered in combination with participation in CAIS. Overall, the analysis shows that the CAIS program has the potential of increasing returns as well as providing stability. The combination strategies also performed well.

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1.0: CHAPTER 1: INTRODUCTION

1.1: Background and Statement of the Problem

Understanding the risks faced by producers is very important to help producers make better decisions in risky situations and to assist policy makers in assessing the effectiveness of different types of risk protection tools. According to Hardaker et al. (1997), understanding risk in farming is important for two reasons: first, most producers are risk-averse when faced with risky outcomes and therefore consider risk when making decisions; secondly, identifying sources of uncertainty helps farmers and others address the most important strategies for mitigating risk, and aids in circumventing extreme outcomes such as bankruptcy.

The types of risk that are most important to consider when making decisions may vary from farmer to farmer. Among the types of risk faced by agricultural producers are production risks (i.e., uncertainty in output or yields related to adverse weather conditions, plant or animal diseases or pests), institutional risks (i.e., uncertainties with respect to changes in government laws and regulations) and price risks (i.e., uncertainty in commodity or input prices). Production risks can be associated with uncontrollable events that occur because of weather, drought, hail, diseases, pests, technological change, etc. In the case of beef operations, production risk can be associated with uncertain feed conversion, morbidity (i.e., reduced physical response due to illness) and mortality. Production risks can be managed through sound production practices that reduce risk. They could also be managed through improvement in husbandry skills and technological improvements in production.

Price or marketing risks can be attributed to variability of returns due to unpredicted changes in output or input prices. Price risk can be managed through the use of several different investment strategies such as diversification into other activities or investments, or investing in market derivatives (Brealy et al., 1992).

Institutional risk includes uncertainty related to government policy. For example, uncertainty surrounding access to U.S. export markets due to U.S. imposed bans associated with the Bovine Spongiform Encephalopathy (BSE) crisis could be considered as institutional risk for beef producers. As well, if there is uncertainty with respect to continued public support for agricultural production through safety net programs such as CAIS, that would also be construed as institutional risk.

Attitudes towards risk are important in many economic decisions. Farmers vary in their attitudes toward risk and their perception of the riskiness of various enterprises. The notion of an individual's attitude towards risk and their objectives are important in dealing with risk management. Research on risk management situations often assumes risk-averse behavior on the part of producers. A risk-averse farmer will prefer to take actions that have a lower potential or likelihood of a loss or disaster, all other things being equal. Conversely, risk-loving individuals are prepared to take actions in which the potential for large gains are higher, but also the potential for large losses may be greater. Finally, some decision makers may have risk neutral attitudes and will give no consideration to the riskiness of an alternative but rather base their decision on the expected outcomes. The focus of this study is on the risks faced by beef producers, and on the potential benefits from managing those risks, given an assumption of risk-averse behavior.

1.2: An Overview of the Alberta Beef Industry

Canada's beef cattle industry remains the largest single source of farm cash receipts. Cattle and calf cash receipts in 2005 totaled $6.4 billion or 17% of the total cash farm receipts. This was, however, down from $7.6 billion in 2002 but higher than $5.1 billion in 2004. Beef production also contributed $25 billion to Canada's economy in 2005, down from $30 billion in 2002 but up by 25% in 2004[1].

Canada is a very important importer and exporter of beef cattle. Beef and cattle exports in 2004 totaled 1 billion pounds (455 million kg). Canada's major export market for beef and cattle is the USA which in 2004 accounted for about seventy-four percent of the exports of beef and nearly all the exports of cattle (Canfax, 2004). Canadian beef imports in 2004 were 199 million pounds (90 million kg). Canadian cattle and beef production for export to other countries in 2005 was valued at $2 billion, which was down from $4 billion in 2002.

The province of Alberta has a diverse agricultural economy, but the livestock sector plays a major role in generating agricultural income for the province and the country as a whole. With only nine percent of the country's population, the province currently accounts for 22 percent of the nation's primary agricultural production. Approximately 60 percent of Alberta's farm cash receipts come from livestock and livestock products. Livestock production includes beef, dairy, hogs and poultry for meat and eggs. Toma and Bouma (2002) report that over six million head of livestock worth an estimated $6 billion are bought and sold each year. Alberta cash farm receipts totaled $7.8 billion in 2005 which represented 21.3% of the value of Canada's total agricultural production. Livestock and livestock products accounted for about 56.4 percent of these

[1] This was taken from Canadian Cattlemen's Association and Beef Information website (2006).

receipts, with crops and direct program payments accounting for 29.4 percent and 14.2 percent, respectively.

In 2005, Alberta contributed 47.8% ($3.1 billion) of total Canadian cattle and calf market receipts (Alberta Agriculture and Food, 2006). Alberta is the largest cattle-producing province in Canada. It led the nation in cattle and calf inventories, with 5.9 million head at January 1, 2006, or nearly 40 per cent of the national total (Alberta Agriculture and Food, 2006).

Alberta's cattle industry has evolved over several decades and has experienced both significant growth and change. The industry began in the late 1800s (Alberta Beef Producers, 2003) with English and American settlers discovering the many advantages that make Alberta a good location to raise cattle. The province has been described as playing a major role in the Canadian beef industry because of the availability of all the necessary ingredients for beef production, including fresh air and water, frosty winters and warm summers, an abundant supply of inexpensive feed grains and thousands of acres of grazing land (Alberta Beef Producers, 2003).

Nearly two-thirds of Canadian beef processing occurs in Alberta. In 2005, cattle slaughter in federally and provincially inspected plants (excluding calves) were 2.5 million head or about 63 per cent of the Canadian total. The Alberta slaughter also represented roughly 87 per cent of the Western Canadian total of 2.8 million head. Much of Alberta's beef is shipped out of the province, with about 30 percent exported to the United States, 8 percent to other countries and 49 percent to other provinces in Canada.

1.3. Statement of the Problem

Beef production continues to be a major component of the Alberta agricultural economy but like all agribusinesses, the environment in which beef production firms operate is complex. Alberta's beef industry has experienced tremendous growth and structural change in the past thirty years (Alberta Beef Council Initiative, 2003) and these changes bring with them many challenges. These challenges may include increased production costs, lower cash receipts, lower consumer confidence and a declining market share.

The cow-calf sector has a historical record of low and variable profitability (Jones, 2000). Producers have always had to deal with price risks due to uncertainty in beef prices, production risks due to weather (drought and climatic variability are inevitable features of agricultural production on both cattle health and pasture/crops), uncertainty in other production parameters (e.g. conception rate, calving rate, weaning rate) and policy risks among others.

Problems and degree of risk has been exacerbated in recent years due to events such as drought and cases of Bovine Spongiform Encephalopathy (BSE). For example, the discovery of BSE in an Alberta dairy herd has had a significant impact on the overall Canadian beef industry and will continue to do so (Ontario Ministry of Agriculture, 2003). A report from the Agriculture and Agri-Food Canada on the Canadian Livestock and Beef Pricing in the aftermath of the BSE Crises (2004) suggested that the discovery of BSE resulted in the immediate closure of borders across the industrialized world to

Canadian cattle and beef products and decreased cattle prices. This situation therefore led to increased cattle inventories, significantly reduced chances for profitability.

The economic risk faced by agricultural producers is mostly captured by variability in annual net income levels (Blank, 1996). Margins for beef commodities have been falling and becoming more variable (more risky), while at the same time governments have been asking producers to take greater responsibility for their own risk management. There are fewer ad hoc programs and direct support due to budgetary considerations as well as pressure from trading partners. The focus of government intervention is moving toward allowing the market to determine the returns and then focusing on stabilization through the use of such programs as CAIS.

Cow-calf producers have available to them broad and different types of risk management strategies, both public and private. The risk management tools are in the form of government programs, termed safety-net programs, and private risk management strategies such as hedging, forward contracting, futures, and feed inventory/stocks. Rios and Patrick (2003) write that a number of studies have determined the benefits, costs, and possible consequences associated with the implementation of a particular strategy or combination of strategies in different geographic locations and time periods. They note that some of these studies have reached conflicting conclusions due in part to differences in the risk environments analyzed. Gloy and Baker (1999) also note that many research and extension programs have been dedicated to risk management and although agricultural economists have provided producers assistance in identifying risks and risk management strategies, they have provided little assistance in choosing among these strategies.

Producers in the industry have tried to overcome the challenges associated with the riskiness of their businesses by using a variety of production management practices and risk management tools It is not clear, however, how effective these have been to the operations of the producers. Rios and Patrick (2003) also write that it is not fully understood how risk management strategies may affect the level and variability of net farm income. Also, some of the tools available to these producers are not widely used. There is lack of information in this regard for Alberta beef producers, particularly those producers in the cow-calf sector. There are also information gaps related to risk management opportunities, effectiveness of different strategies, and the degree to which alternative strategies are substitutes versus complements. These gaps provide the motivation of the current study.

1.4 Study Objectives

This study sets out to evaluate the effectiveness of alternative public and private risk management strategies for Alberta beef producers. The specific objectives are to:

- develop a dynamic, stochastic bio-economic model that can be used to simulate biological and economic relationships for Alberta cow-calf operations;
- identify alternative risk management strategies (both public and private) that are either typically used or may be considered by Alberta cow-calf producers;
- model the performance of these risk management strategies; and
- evaluate the ability of the risk management strategies to stabilize and/or support returns for Alberta cow-calf producers.

It is hoped that the outcomes of the analysis will provide the industry with valuable information that will assist in identifying management practices that would improve returns on their investments. As well, they will serve as guidelines in the Alberta beef industry to assist producers make informed decisions with regard to their operations.

1.5 Organization of the Thesis

This thesis is organized into six chapters. Chapter 1 presents the background of beef production in Alberta and the problem statement. Chapter 2 contains a review of beef production in Alberta, and an overview of available risk management strategies. Chapter 3 explains the theoretical and conceptual economic framework used in the study. Chapter 4 presents the price and production data used in the analysis, and provides a discussion of the results from analysis of the price data. Chapter 5 provides a presentation and discussion for the results of the analysis. Chapter 6 summarizes the results, presents the study conclusions, and suggests areas for further study.

2.0: CHAPTER 2: LITERATURE REVIEW

2.1: Introduction

Contributions made by this chapter are primarily in terms of providing insights into identifying some considerations with respect to risk management strategies that need to be incorporated in the study. In other words, this chapter provides information that will help better understand cow-calf operations and identify potential risk management strategies to consider for these operations. The discussion in this chapter also provides insights to allow for rigorous modeling of cow-calf operations.

The literature review provides an overview of studies that discuss potential causes of variability in cow-calf operation. Analysts have used a variety of data sources to document differences in performance and costs among cow-calf operators. Some of the studies discuss factors that most influence the profitability of cow-calf operation. Others also discuss risk management strategies that have been proposed and used, including reports on the findings of using futures and retaining cows beyond weaning as management strategies. There are also some obstacles for wider use of risk management strategies identified which may include low awareness of the technology, limitations of existing risk management approaches and lack of empirical evidence of the usefulness of risk management strategies.

The chapter begins with a brief overview of beef cattle production in Alberta. Cattle production in Alberta contributes significantly to the province and also to the country as a whole. This overview of the industry enables a better understanding of how the operation of this industry works in Alberta, what risks are normally faced by these farmers, and how farmers may be able to deal with the associated risks.

2.2: Beef Cattle Production in Alberta[2]

Beef cattle production in Alberta occurs at three basic levels: cow-calf production, backgrounding, and finishing. Cow-calf operations are normally the starting point for commercial beef production; producers own the breeding stock and produce beef calves. Operations focused on cow-calf production are common in the province. In the past the cow-calf sector was concentrated in the south of Alberta but it is now more widely spread throughout the province.

Cow-calf production starts with cows usually producing one calf per year. Most cow-calf producers in Alberta breed their animals in June, July or August. As such calving occurs nine months later in February, March or April of the following year. This pattern does, however, vary by producer, with some producers preferring their animals to calve in the fall. For cow-calf production to be successful, the animals must receive proper care and nutrition. Producers must also make sure that their breeding females are maintained on a nutritional program with enough nutrients for the mother cow to give birth to a strong, healthy calf, supply milk to the calf and be in condition to rebreed about 80 to 85 days after calving.

Calves are normally weaned at about six months of age. Cows and calves graze pasture during the spring, summer and fall. In typical operations, calves are weaned from their mothers in the fall, from September to November, when they reach a weight of about 230 kg. Weights at weaning can range from about 160 kg to 295 kg, depending on

[2] Information obtained from Alberta Beef Producers (2003)

age, genetic background of the calf and pasture conditions during the grazing season. After weaning these calves may move directly into a feedlot or they may enter a backgrounding program. It is noted that at least half of the weaned calves produced in Alberta each year are backgrounded before they are placed on a feedlot finishing program.

Backgrounding refers to the growing, feeding and managing of steers and heifers from weaning until they enter a feedlot and are placed on a high concentrate finishing ration. The process of backgrounding is used to control weight gains so cattle acquire enough muscle and bone before gaining fat covering and marbling. For example, a backgrounding operation might feed 227 kilogram steers for approximately 150-200 days with the goal of having a daily rate of gain of 0.45 – 1.02 kilograms. This would result in 340-408 kilogram feeders that would then be moved into feedlots to be finished. The diets for these backgrounded cattle are typically forage based. The objective is to put additional pounds on the animals by utilizing forages that would otherwise either be unharvested or underutilized. Average daily gain of cattle in backgrounding operations is directly affected by the amount of energy consumed daily.

Feedlot finishing is the final phase of beef cattle production in Alberta. The only intensive part of conventional beef production takes place at the feedlot where cattle are brought to be finished to slaughter weight. Finishing rations consist of grains such as barley or corn, forages such as silage and hay, and mineral supplements. There are two fundamental types of feeding systems in the feedlot industry (Canada Beef Export Federation, 2004). The system used depends on the weight of the animals when they are placed on the finishing program. A multi-stage feeding system is used for those steers and heifers that enter the feedlot at lighter weights. These cattle are started on a higher forage-lower grain feed ration to initially gain weight at about one kilogram per day. They are fed at this level for a few weeks following which the proportion of grain in the feed ration is slowly increased to 85 percent to 90 percent. Heavier feeder cattle begin at this high percentage grain feed rations.

Cattle will gain weight at about 1.7 kilograms per day on these high energy rations. Almost all cattle in feedlots are fed high energy grain feed rations for a minimum of 120 days. The average live weight at slaughter for steers is about 630 kilograms, while the average weight for heifers is about 590 kilograms.

The feedlot sector is more concentrated than the cow-calf sector and is characterized by intensive operations with large numbers of cattle being finished in confined areas. These range in size from a few hundred head on feed at any one time to 40,000 head (Toma and Bouma, 2002). As of the year 2002, Alberta had approximately 4,000 feedlot operators.

2.3: Cost (Profit) Variability in Cow-Calf Production

Jones (2000) writes that there is a large degree of cost (and therefore profit) variability in the cow-calf production enterprise. From the perspective of an individual producer operating in a competitive environment, the variability question is of utmost importance in order to maximize the opportunity for positive profits. As such, the individual producer must strive to be better than average at some aspect of business management or marketing.

The cost (profit) variability issue has two distinct dimensions; cost (profit) variation over time, and cost (profit) variation between producers. Average costs and net returns to cow-calf production over time are affected by broad factors (e.g., feed prices, weather) and overall cattle price levels resulting from the cattle cycle and seasonal variations. A measure of average total costs over time illustrates that the largest share of variable cost variability over time is due to changes in feed costs (Jones, 2000).

Perhaps a more important consideration when examining cost variability, or profit variability of the cow-calf sector, is the large variation in cost between operations in a given year (Jones, 2000). Individual producers sometimes assume that managing calf price risk and feed price risk will address the greater part of their profit risk issues. While these components are obviously important they may in fact, account for only a small portion of the total profit in cow-calf production. Profit variability is strongly related to variability in per unit cost of production which has been shown to be related to economic efficiency. It is argued that the cow-calf industry generates relatively little income compared to the required investment in land, cattle feed, and facilities (Kunkle et al., 2002)

A number of analysts have used various data sources to document differences in performance and costs among cow-calf operators. Prevatt (1998) reports that dramatic cost differences exist among U.S. cow-calf producers with current annual financial cow-cost data from the cow-calf IRM-SPA programs ranging from $156 to $969 per breeding cow. The differences he notes are due to the variety of inputs, resources, production practices, and management used by cow-calf producers.

Jones (2002) reports that one comprehensive data set documenting cost differences among cow-calf producers is maintained by Harlem Hughes. Jones (2002) writes that the preliminary analysis by Hughes suggests that high cost producers tend to be high cost in all categories, and only about 35 percent of the difference in net income per cow between the high cost group and the low cost group can be explained by production efficiency as measured by pounds weaned per exposed female. The remaining 65 percent is explained by cost differences.

Corah et al. (1989) report four factors that influence the profitability of cow-calf operations; percentage of cows weaning calves, weaning weights of calves, price received per pound for calves and cost of owning and maintaining cows. Jones and Simms (1997) also write that primary factors identified as having an influence on cow-calf profitability are production costs, percentage of cows weaning a calf, weaning weights of calves and prices received for calves. Miller et al. (2001) identified feed costs, selling price of calves and the number of cows in the herd as the three most important factors explaining variation in profit.

Other writers speculate that the geographic location of the beef cow-calf operation may have an effect on profitability. For example Short (2001) writes that in some parts of the United States, snow cover prevents grazing during winter. In other regions, growth or nutritive content of pasture and range plants varies during the year due to plant dormancy and temperature or moisture fluctuations. Thus most producers feed their cows with harvested forage almost every year. Short (2001) again notes that annual costs of production are more variable particularly because of differences in the cost of providing forage for grazing, which is the principal feed source in cow-calf production.

Some researchers have suggested that economies of scale in cow-calf production may explain differences in profitability (e.g., Miller et al., 2001). Jones (2000) also points out that an examination of the summary of the 1998 average cow-calf financial information from the Kansas Farm Management Association reveals that larger cow-calf operations tend to have slightly lower variable costs per cow, significantly lower fixed costs per cow, but perhaps somewhat lower revenues per cow as well.

In their report, Langemeier et al. (1995) used data from the National Cattlemen's Association-Integrated Resource Management-Standard Performance Analysis (NCA-IRM-SPA) to measure economies of size in cow-calf production. They defined economies of size as a measure of the relationship between the size of the operation (number of cows) and the average cost of production or break-even price. They examined differences in cost of production among different cow-calf herd size groups. The size categories examined included the following herd sizes: 1-49, 50-59, 100-199, 200-299, 300-499, 500-599, and 1000+. Their findings revealed that larger herds definitely have a cost advantage. Herds with more than 500 cows, on average, had lower feed costs (in terms of economic cost of production) and lower average total costs of production than herds with less than 500 cows. The most cost-competitive herd size group was the 500-999 head group because it had the lowest financial and economic cost of production. They report however that neither high nor low levels of production, geographic region or year were factors that explained differences in profitability.

Other factors found to contribute to cost variability in cow-calf production include age of the farmer, managerial skills of the farmer and ability to adopt technology (Langemeier et al., 1995). Further inefficiencies in reproductive and health management of calves, heifers, and cows also limit profitability of cow-calf enterprises. These inefficiencies may result from excessive or inadequate investments in management tools and/or improper application of management practices (Paterson et al., 2000)

Basarab (1999) used data for production, cost and income from over 200 cow-calf herds collected by the Production Economics Branch of Alberta Agriculture, Food and Rural Development during the early 1990's to examine factors influencing cow-calf profits. Twenty-eight production traits, 16 variable cost and four fixed cost traits were studied. The production traits included weaning weight, death loss of calves, culling rate, pregnancy rate, calving rate, weaning rate, pounds calf weaned per cow exposed to breeding, calving span, calving pattern and number of open cows. Fixed costs included insurance on buildings and machinery, property taxes, term loan interest and depreciation on buildings, machinery and equipment. The analysis showed that fixed cost was the single most important factor affecting profit, accounting for 28.5 percent of the variability in profit of Alberta cow-calf operations. The next most important cost factor was feed cost per cow wintered, which accounted for 20.6 percent of the variability in profit. This result indicated that grazing and feeding strategies that reduce winter feeding cost are critical to the profitability of a cow-calf operation. Failure to calve was the third most important factor affecting profit (Basarab, 1999).

Basarab (1999) noted that cost of maintenance and repairs, pounds calf weaned per cow exposed and utility costs were less significant, each only accounting for 3-4 percent of the variation in profit. There were other factors such as differences in weather, pasture productivity, winter feeding strategies and selling methods and prices that accounted for about 30 percent of the variability. Basarab determined that these were inconsistent and unpredictable among herds. The study concluded that controlling fixed costs, winter feed costs and maintaining high fertility herds were critical factors influencing the profitability of cow-calf production.

The discussion so far has revealed some important factors that may be rigorously considered in modeling for the farms. For example geographic location has been cited as having a significant effect on beef profitability. In modeling cow-calf operations, geographic location should therefore be taken into consideration. Feed cost was also mentioned as an important factor in terms of profitability. In the current study, therefore, risk management strategies related to feed will be considered. For example, should the farmer store all excess feed in times of plenty, or sell everything and purchase when needed? The findings from the literature also suggest that larger herds have a cost advantage. The model will therefore take into account herd size when incorporating the different risk management strategies to determine if size has an influence on effectiveness of risk management strategies. These are some of the factors that will be considered in the analysis. The findings from the model will provide further evidence in terms of addressing questions identified in the literature so far as Alberta is concerned.

2.4: Overview of Risk Management

Beef production occurs within a complex environment in which the beef producers have little or no control over some important variables such as conception rate, forage quality and weather. Risk management is an important part of operating a beef production business. Managing risk does not necessarily mean avoiding risk. For an individual farmer, risk management may be defined as the process of finding the preferred combination of activities with uncertain outcomes and varying levels of expected returns (Harwood et al., 1999). A variety of strategies and/or tools are potentially available for use by agricultural producers.

Farmers normally adopt a portfolio of strategies to manage production, price and income risk. Risk management cannot be viewed as a "one size fits all action" activity (Kaan, 1999). Several key decision-making criteria that come into play in the risk management planning process include the goals established for the operation, the risk bearing ability of the ranch, and the manager's attitudes towards risk.

In managing beef operation risks, farmers normally have many options available to them. These may include adjusting the enterprise mix (e.g., diversification) or the financial structure of the farm (i.e., the mix of debt and equity capital). Other tools accessible to farmers include such things as insurance and hedging which may help reduce farm-level risks. Risk management strategies can include private and public strategies, marketing and production strategies. Private strategies are those undertaken by the producer on his/her own, or through the "market". Public strategies are offered/funded by the "public" (i.e., through some level of government). It must be noted however that there are costs and benefits associated with each strategy.

In this section some risk management strategies that beef producers may put in place in order to minimize risks are reviewed. When these tools are used separately or as a combination, they are able to provide farmers with a measure of protection from uncertain prices and yield. The purpose of this discussion is to identify possible strategies to evaluate within the empirical analysis undertaken in the current study.

2.4.1: Overview of Private Risk Management Tools Available to Cow-Calf Producers

2.4.1.1: Diversification

Diversification is a risk management strategy that involves combining different assets or enterprises into a portfolio. Diversification can be contrasted with specialization which involves concentrating resources in a single enterprise/asset. In the case of beef production, diversification may take several forms. It might involve combining different agricultural enterprises in the farm business, such as combining beef production with hog production, or with cropping enterprises. Alternatively, combining income earned through off-farm income with farm income is another form of diversification. Finally, beef producers might diversify through investment of some capital in off-farm investments (e.g., stocks), along with the investment in agricultural production assets.

The idea behind diversification as a risk management strategy is that returns from different enterprises or assets are not perfectly positively correlated. In other words, when income from one enterprise/asset is lower than expected, it may be simultaneously offset by satisfactory or higher incomes from other enterprises/assets. Thus a favorable result in one enterprise may help to cope with a loss in another enterprise. As such, diversification can be said to potentially reduce risk as measured by the overall variability in returns or income. Effectiveness of diversification is influenced by a number of factors such as the number of enterprises/assets in the portfolio (i.e., greater number increases the effectiveness) and the correlation between returns of each enterprise/asset (i.e., the lower or more negative the correlations, the greater the effectiveness).

While diversification can be an effective risk management strategy, it is not without costs; that is, there are tradeoffs involved in its use. For example, a downside to enterprise diversification is that costs can increase due to the capital investments required to add or convert over to new enterprises. Diversification may require additional resources (e.g., labor) that are limited in availability. Novak and Viney (1995) noted that for many farmers, diversification with stocks or other investments is not a practical alternative due to limited amount of capital available. These factors, combined with the availability of alternative private and public risk management strategies, have resulted in agricultural producers making limited use of diversification as the primary source of risk management (Novak and Viney, 1995).

2.4.1.2: Vertical Integration

Vertical integration is the situation in which several steps in the production and/or distribution of a product or service are controlled by a single company or entity, in order to increase that company's or entity's power in the marketplace. Vertical integration generally reduces the risk that is associated with the quantity and quality of inputs (outputs) because the vertically integrated firm retains ownership control of a commodity across two or more levels of activity. Vertical integration also diversifies profit sources across two or more production processes. Vertical integration is noted to reduce risk by guaranteeing supplies and market outlets in terms of quantity, price, quality and timing of delivery. These benefits may be larger when markets are imperfect as marketing risk is greater in those situations (OECD, 2000).

Vertical integration can occur in different ways. A beef producer can choose to grow cereals and forage to feed his own animals, which is termed backward integration. If however, a beef producer decides to extend his control of the product beyond the cow-calf enterprise, then this is termed forward integration. For example, many cow-calf producers sell their calves at weaning but some producers keep their calves for placement into some kind of post weaning grazing or feeding program. This is referred to as retained ownership. Davis et al. (1999) write that market integration or retained ownership involves carrying over a production activity into the next phase of preparation for the market place. Thus cow-calf producers may have an alternative of retaining ownership of calves beyond weaning through the backgrounding and/or feedlot phases. The justification of retained ownership is the opportunity to capture a larger part of the potential profit available from all phases of the beef production cycle.

Some benefits of vertical integration includes improving supply chain coordination, providing more opportunities to differentiate by means of increased control over inputs as well as capturing upstream and downstream profits. The downside of vertical integration however, includes potentially higher costs due to low inefficiencies resulting from lack of supplier competition and decreased flexibility due to previous upstream or downstream investments.

2.4.1.3: Production Contracts

An agricultural production contract is a contract by which a producer agrees to sell or deliver all of a chosen crop raised in a way set forth in the agreement to a contractor and is paid according to a method established in the contract; or agrees to feed and care for livestock (e.g., calves or feeders) owned by the contractor until such time as the animals are removed, in exchange for a payment based on a formula that is typically tied to the performance of the animals. A production contract generally specifies in detail the production inputs to be supplied by the contractor, the quality and quantity of the particular commodity involved, the production practices to be used, and the manner in which compensation is to be paid to the producer (Kunkel and Larison, 1998).

The contractor owns and provides the inputs for the product and typically bears the costs associated with all the inputs. The producer uses his/her own facilities and is compensated on a fee basis. The producer thus reduces the risk by sharing the risk between the producer and contractor. The risk shifting or reducing characteristics of the contract depend very much on its terms. When the price is fixed, the price risk is shifted to the contractor but some risks remain for the farmer if the quality or the quantity cannot be met.

There are several potential advantages for producers who may consider a production contract. Such contracts may provide a more stable income for the producer by reducing traditional marketing risks. Such contracts may also allow a producer to benefit from technical advice, managerial expertise and access to technological advances provided by the contractor. An agricultural production contract may provide the producer with a guaranteed market, provided that the commodities are produced in accordance with the contract. Finally, such contracts may allow a producer to increase the volume of his or her business with limited capital since the contractor may supply the necessary production inputs. Thus financing is normally more readily available because funds may be obtained directly from the contractor.

There are also some downsides to this types of contract. Kunkel and Larison (1998) noted that as with any contractual relationship, the producer will always be subject to risk of nonpayment. The farmer depends to a large extent, on one buyer thus incurring a risk of losing his only outlet following contract termination. Production contracts have also been criticized because they limit farmers' entrepreneurial capacity and may increase other types of risks such as quality, investment and contractual risks. Contracts can also be terminated on short notice.

2.4.1.4: Marketing Contracts

This is an oral or written accord involving the farmer (contractee) and the buyer (contractor) that sets a price (or pricing mechanism) and determines an outlet for a specified quantity of the commodity. Most management decisions remain with the farmer, who retains ownership during the production cycle. The farmer assumes all risks of production, but shares price risk with the contractor. A marketing contract is one way to reduce market risk faced by farmers. It is an agreement involving two parties whereby one contracts to purchase a specified asset from the other at a specified price, on a specific date in the future. A market contract is a type of risk management instrument that has potential benefits for both parties. For example, a market contact between a cow-calf producer and a feeder cattle producer is an agreement to sell a stated quantity and quality of calves for a stated period into the future, at a stated price. The cow-calf producer and the feeder producer are able to lock in prices, thereby reducing risk associated with the price and income volatility and enhancing their ability to obtain new or continued financing.

Marketing contracts can reduce the income risks faced by producers through the terms specified in the contract's pricing mechanism. Depending on contract terms, marketing contracts can insulate farmers from most output price risks and many input price and yield risks. Input price risk is particularly important in the livestock sector, where feed costs constitute a large portion of the total costs. Besides reducing risk, contracting provides the farmer with an opportunity to differentiate his products from mass production (European Commission, Agriculture Directorate-General, 2001). The (opportunity) costs borne by the farmer result from forgoing the opportunity of achieving a higher price on the open market (OECD, 2000).

2.4.1.5: Futures Contracts

Some risk management strategies can also be implemented using futures. Agricultural producers can use commodity futures markets to hedge the potential costs of commodity price volatility. By definition, a futures contract is a legally binding agreement made between two parties to buy or sell a commodity or financial instrument, at an agreed price, on a specified date in future. The quality and quantity of each contract is standardized and hence the price at which the contract is traded is the only variable and is determined between the buyer and seller at the time when the contract is traded.

Farmers can use futures contracts to reduce price variability. Such tools allow farmers to shift price risk to speculators willing to accept it in exchange for possible higher profits. For a livestock producer, using futures typically involves locking in the value of animals to be sold in the cash market some time in the future by selling futures contracts in the present.

In the futures transaction, the buyer who is sometimes referred to as "long" agrees to purchase a specified commodity and the seller often referred to as "short" also agrees to supply a specified commodity according to the terms in the contract. Usually, a producer would not actually deliver on the contract. Instead, the producer would "sell short" in the contract that is closest to when the cattle would be marketed. When this date approaches, the producer "buys long" to offset his position in the futures market, effectively eliminating the position. If the cash price has gone up during the hedging period, then the producer makes more in the cash market and likely loses in the futures market (since the futures price would likely have gone up as well). If the cash price drops during this period, then the producer makes less in the cash market but makes up for this with the profits from the futures position (i.e., since price dropped, he would have sold short for a higher price he had to subsequently buy long). The improvement in one market (cash or futures) offsets the poorer performance in the other market.

Although price risk is reduced or eliminated; in turn, the producer faces basis risk. The basis is the difference between the futures price and the cash price of the commodity (i.e. Basis= Cash Price - Futures Price). If the basis is negative, the futures price is greater than the cash price. On the other hand, a positive basis indicates the futures price is less than the cash price. If the basis is different from what is expected at the time that the futures position is offset, then it is possible that the hedge will not be effective (or it might be more effective than expected, depending on whether the basis is bigger or smaller than expected). Thus one form of risk is exchanged for another. Also, in the case of cattle, the futures contract is specified for slaughter cattle, not weaned calves. This introduces another form of risk; the possibility that weanling prices will not track slaughter cattle prices exactly.

For buyers of a futures contract, futures markets provide a means of locking in the price at which they will purchase a commodity of financial asset in the future. For sellers of futures contract the opposite is true.

A downside associated with futures contracts is that gains from price declines are limited and there is the risk that actual basis will differ from the projected basis. Futures positions require a margin deposit and margin calls are possible. Contract quantity is standardized and may not match quantity produced.

2.4.1.5: Holding Feed Reserves

Holding feed reserves is one way that producers may use to mitigate risks associated with the cattle operation. Variable costs, especially winter feed costs have been found to be one of the largest contributors to production costs for the cow-calf industry. Although farmers are not able to control adverse situations like bad weather and prices, they may be able to control feed costs. For example, drought, which is a production risk, can result in a high feed cost for the cow-calf operation, especially if the farmer is not well prepared for these kinds of adverse situations.

Options to these farmers when faced with this situation may be to lease additional grazing land or to purchase supplemental feed. In some cases they may need to cull the least productive cows or sell all of them. During periods of severe drought, many Alberta cow-calf producers may be forced to alter cow numbers to fit existing feed supplies. The cost of replacement feed and increased grazing costs during feed shortages may be too much for the farmers to bear (AAFRD, 2004). Some factors to consider as an opportunity to lower costs may include minimizing the need for the use of purchase feed, or purchasing feed in volume and at seasonal low prices when storage is feasible.

Management of the ranch during drought may depend on the balance between stock density and the availability of feed. Is the farmer better off buying feed or leasing land to produce his own feed? Paterson et al. (2000) found that among factors that affect risk management during a drought include total population of cattle in relation to feed availability as well as evaluation of cash flow needs through drought to maintain traditional herd. They also noted that some questions these farmers asked when faced by drought are: what feeds are available to the ranch? If I need to purchase supplemental feed, are they available and if they are available, at what costs? Will there be enough feed resources to allow for full feeding? Is the farmer better off buying feed or raising it? If the farmer decided to sell the excess feed, would that be the best use for it? Also, if the farmer produces high quality of hay and sells it, can an adequate replacement be bought at a lower cost? There have not been many empirical studies done to verify whether storing excess feed or selling the excess feed help reduce feed costs associated with the cow-calf operation.

2.4.1.6: Heifer retention

Another strategy that producers may adopt is the use of heifer retention; that is, keeping heifers to replace culled breeding stock. This is a form of backward vertical integration. Replacement heifers can be an essential component of successful cow-calf operations and about 10 to 20 percent of the cow herd is typically replaced by heifers each year. A relevant question, however, is whether it is more economical to buy replacement heifers than raise them? Some producers may want to purchase while others may want to develop their replacement heifers for different reasons.

Among the factors to consider in making the decision will be current and future market prices, herd size, feed, facilities and management, cow genetics and economics. Dhuyvetter and Lardy (1999) report that costs associated with heifer development represent a significant up-front investment. An article by Cleere (2006) emphasizes that, usually small producers find buying replacement heifers to be more cost-efficient because of economies of scale while larger producers discover that developing replacement heifers could be a more economical choice.

In terms of risk and risk management, heifer retention may be considered as a form of integration; that is, integrating the replacement raising enterprise into the business. Heifer retention may assist producers in mitigating the impact of price variability for beef animals. In times of higher beef prices, replacement heifer prices would also be higher. The opposite would be true in times of lower beef prices. By raising and retaining heifers, a producer would reduce the impact of that price uncertainty on the variability of returns.

2.4.2: Public Safety Net Programs

Safety net programs are programs intended to stabilize and/or support farm gross margin or net income. Economists view safety nets as policy instruments that ensure a minimum income, consumption, or wage level, and which would provide farmers protection against production and market risks. Public safety nets in agriculture are established in situations where there is a perceived need because of issues such as low commodity prices, variable incomes, uncertain markets and forces of nature, and overall risks in the production of livestock and crops. These safety nets may complement other risk management strategies. An agricultural safety net can be made up of one or more public programs aimed at supporting commodity prices, yields, revenues and/or net farm income.

Measuring the economic justification for a farm safety net begins with assessing the purpose of that instrument. One rationale given by European Commission, Agriculture Directorate-General (2001) for providing public safety nets is to assist producers in avoiding drastic and widespread income downturns in a given year, which might otherwise potentially force farms out of business, jeopardize production (potential) and destabilize those rural economies which depend on the farm sector. Widespread income downturns are a result of systematic risks for which private instruments may not be available.

In the OECD (2000) report, Tom Richardson of Agriculture and Agri-Food Canada reports that the main objectives of the Canadian agricultural safety nets are risk management and income stabilization but they also involve income support. Formerly, safety nets included programs such as crop insurance, Net Income stabilization Account (NISA), Alberta Disaster Assistance Loan Program (ADALP), Farm Income Disaster program (FIDP)[3]. Currently, most of these safety nets have been replaced by the Canadian Agricultural Income Stabilization Program (CAIS).

2.4.2.1: Canadian Agricultural Income Stabilization (CAIS) Program

Recently, a joint federal-provincial program has been developed that is intended to provide a comprehensive framework which will aid in agricultural policy implementation. This program is the Agricultural Policy Framework (APF). It is intended to help build a strong, profitable agricultural sector in Canada by providing a structural means of developing and implementing agricultural policies. It is also meant to provide a vehicle for the implementation and regulation of public safety net programs related to the agricultural sector (Agriculture and Agri-Food Canada, 2004). In terms of risk management, the instrument introduced through the APF is the Canadian Agricultural Income Stabilization (CAIS) program.

[3] Agriculture and Agri-Food Canada, 2004

The objective of the CAIS program is to integrate stabilization and disaster protection into a single program, helping producers protect their farming operations from both small and large drops in income. Generally, individuals or entities that derive income from primary production of agricultural commodities, as defined by the program, are eligible to participate in the CAIS program.

This program is designed in such a way that the greater the loss of income endured by the producer the larger the share of the payment from the federal and provincial governments. For producers enrolled in CAIS, payouts are based on a comparison of the production margin and the reference margin. The production margin for that year is defined as the difference between allowable income and allowable expenses for the farm business. It tends to be similar, in terms of method of calculation, to the margin between farm income and farm variable expenses, which is sometimes referred to as the gross margin. The reference margin is calculated as the average of the producers' previous five years of production margins, using an Olympic Average; that is, the highest and the lowest margins are removed from the calculation.

Within the CAIS program participants are allowed to select a protection level for their operation and then make the necessary deposit to secure that protection level. Program payments, which include funds from their account and a government contribution, are made when the participant's production margin in the program year falls below their reference margin.

Participation in the program requires a producer to select a protection level. This protection level ranges from 70%-100%. The deposit required to secure program protection increases with the level of protection selected. The proportion of the payout coming from a withdrawal of producer funds versus government funds is determined by the level of protection selected and the degree to which the production margin is below the reference margin. A detailed discussion of the mechanics of CAIS is provided by the Canadian Agricultural Income Stabilization Program Handbook (AAFC, 2004).

Depending on the protection level selected as well as the average level of returns, the producer is required to deposit a specified amount of money into a CAIS accepted institution. There are three levels of protection, referred to as tiers. Tier 1 provides coverage for >85% - 100% of the reference margin, tier 2 provides coverage for >70%-85% of the reference margin, while tier 3 provides coverage from 0%-70% of the reference margin.

In each tier, in the event of a payout a portion comes from funds contributed by the producer and the remainder comes from funds contributed by the government. In tier 1, for every dollar withdrawn from the producer account (i.e., producer contributions), the producer will receive 1$ from the governments (i.e., cost-share of 50-50). The protection level is shared at a ratio of 30:70 between farm operator and the government for tier 2 (i.e., the producer portion is 30% and the government portion is 70%), while for tier 3, the protection level is shared at a ratio of 20:80 between the producer and government, respectively. In situations where the producer encounters negative margins, payments will be made at a rate of $0.60 for every dollar of negative margin.

All participants are required to have at least tier 3 protection level (i.e., the minimum). For example, if a farmer is covered by the tier 3 protection level, the producer must deposit a dollar amount equal to 20% of this 0-70% range of the reference margin (i.e., the contribution is equal to 20%*70%*reference margin). This implies that a producer with a reference margin of $60,000 would be required to deposit $8,400.

In the current study, it is assumed the cow-calf producers adopt a coverage level of 85 percent (i.e., tiers 2 and 3). This strategy helps the farmer to recover some losses in the event that there are even the smallest losses from the farm income. This seemed like an acceptable and reasonable option for producers.

A protection level of 85 percent requires the producer to deposit a dollar amount equal to 20% of the 0-70% range of their reference margin, plus 30% of the 70%-85% range of their reference margin. To illustrate this, along with the mechanics of payouts, a producer with a reference margin of $60,000 is used as an example. Given the reference margin of $60,000, the producer will be required to deposit:

$$(\$60{,}000*0.7*0.2) + (\$60{,}000*0.15*0.3) = \$11{,}100 \quad (2.1)$$

that is, 20% of (70% of $60,000) as a deposit for tier 3 coverage plus 30% of (15% of $60,000) as a deposit for tier 2 coverage.

In this example if the producer's program margin falls below the 85% protection level (i.e., below $51,000), then a CAIS payment or payout is triggered. The amount of the payout and the calculations used to determine that amount depend on the degree to which the program margin is below the 85% level.

If the producer's margin declines to between 70% and 85% of the producers reference margin (i.e., in tier 2 of coverage), the payout is equal to the difference between the program margin and 85% of the reference margin. Of that amount, the producer withdraws 30% from their account while the remaining 70% comes from government funds. For example, suppose that the program margin is $45,000 (i.e., 75% of the reference margin). The total payout triggered is equal to $6,000 (i.e., $51,000-$45,000). Of that amount, $1,800 comes from the producer account while the remaining $4,200 comes from government funds. Of the original deposit made by the producer ($11,100), $9,300 remains in the producer account.

If the producer's margin declines to between 0% and 70% of the producers reference margin (i.e., in tier 3 of coverage), the payout is again equal to the difference between the program margin and 85% of the reference margin. Of that total amount, the payout required to bring the margin up to 70% of the reference margin is based on tier 3 coverage (i.e., 20% from producer contributions and 80% from government) while the remaining payout required to bring the margin from 70% up to 85% of the reference margin is based on tier 2 coverage (i.e., 30% from producer contributions and 70% from government).

For example, suppose that the program margin is $24,000 (i.e., 40% of the $60,000 reference margin). The total payout triggered is $27,000 (i.e., $51,000-$24,000). Of that, the first $18,000 comes from tier 3 coverage; that is, $42,000 - $24,000 where $42,000 is 70% of the reference margin. Of that $18,000, $3,600 or 20% comes from the producer account while the remaining $14,400 or 80% comes from government funds. The remainder of the payout, or $9,000, comes from tier 2 coverage; that is, $51,000 (85% of reference) - $42,000 (70% of reference). Of that $9,000, $2,700 or 30% comes from the producer account while the remaining $6,300 or 70% comes from government funds.

For this second example, the total payout of $27,000 is made up of $6300 from the producer account and $20,700 from government funds. Of the original deposit of $11,100 made by the producer, $4,800 remains in the account.

One advantage of the CAIS program is that the producer shares the cost of stabilizing their farm income with the government. Another advantage of the CAIS program is that coverage is broader and includes overall losses rather than losses specific to production of particular commodities; that is, it addresses whole farm risk rather than commodity-specific risk. In the end there would only be a smaller share of the income to be shared equally by the producer and the government.

The CAIS program, however, also has disadvantages. Although CAIS coverage is broader and includes overall losses rather than specific losses, a major problem is that the coverage requires that farmers have money in the bank to begin with and some producers may not have sufficient money to spare to be able to participate effectively. The higher the farmer's protection level, the greater the farmer's deposit required for the coverage level. Finally, the margins are calculated using the Olympic Average of the last five years. The last five years may not be representative of a successful farming year. Again, because there is no provision covering numerous successive years of poor productivity and profitability, producers might end up running a deficit.

Changes to the CAIS program have occurred since this research project was initiated. The CAIS deposit requirement has been eliminated and replaced with a participation fee. Producers now pay $4.50 per $1,000 of reference margin protected. For maximum (100%) protection of a $60,000 reference margin, the CAIS participation fee is $270, calculated as ($60,000 * 0.45*100%). An 85% protection level for the same reference margin would require a fee of $229.50, calculated as ($60,000*0.45*85%). Similarly, the participation fee for minimum protection (70%) of the same reference margin is $189 ($60,000*0.45*85%). The analysis of CAIS in this thesis makes use of the previous provisions for producer contributions. However, this change in the program does not affect the level of coverage for producers or the way in which payouts are calculated. As a result, it is expected that the change to a participation fee would have minimal impact on the results discussed later in this thesis.

2.5: Empirical Studies of Risk Management

This section provides a review of empirical studies for risk management in beef production. In particular, these studies are examined to identify questions that are addressed, questions that have not been addressed previously, as well as to gain insights into the methodological approaches used in risk analysis for beef production.

Marsh and Feuz (2002) write that retained ownership is one action some producers take in response to low prices at the time they would normally sell their cattle. Cow-calf producers usually will market the bulk of their calf crop at weaning. However, considering calf retention beyond weaning may widen the production and marketing alternatives existing to cow-calf producers. Some studies have shown that retaining beyond weaning can sometimes be more profitable than selling the calves at weaning. By selling the calf crop at weaning, the cow-calf producer forgoes the opportunity for higher profits later if prices go up. However, the producer also removes the risk of potential future price declines. Marsh and Feuz (2002) again, note that positive returns to retained ownership are possible but then so are losses. Their paper indicated that, in considering retaining ownership of calves many factors must be evaluated per each producer by each situation. They were quick to note that not all the factors may be important to all producers. Factors mentioned included availability of labor and facilities, feed and pasture. Producers may need to compare estimated extra costs with extra returns. As well, market dynamics would require the producer to account for risk and uncertainty which may arise from the calves gaining weight, issues with health and death losses, costs associated with feed, cattle prices among others. Marsh and Feuz (2002) found that the longer any product is kept, the greater the price risk. The impact of retained ownership on cash flow was also a factor that needs to be evaluated for the short term and long term consequences.

Sewell et al. (1993) also considered retained ownership as an alternative to the cow-calf business for producers who want to use excess forage or other roughages, or want to add extra flexibility to the current cattle operation. In essence, there are a number of retained ownership options for cow-calf producers to consider after weaning their calves. One consideration is selling at weaning if there are not facilities to keep the weaned calves. Lawrence (2000) also noted that selling some of the cattle at weaning, some as feeders, and some as fed cattle, spreads marketing and price risks over time. For example, backgrounding is one way cattle producers adopt to increase profit and minimize risks. It allows them to hold onto cattle when selling prices are at their seasonal low, in favor of higher prices when the market rebounds.

Hall et al. (2003) conducted analysis to investigate perceptions of sources of risk and the effectiveness of risk management strategies. The analysis used questionnaire surveys of beef cattle producers in Texas and Nebraska. The survey included questions about the efficacy of alternative risk management tools in mitigating risks that affect producers. Specific risks included drought, cold weather and diseases. Drought and cattle prices variability were the two highest concerns. Presented with a list of nine potential alternative risk management strategies the producers were asked to rank the risk management strategies in terms of their ability to reduce risk. The producers ranked maintaining animal health as the most effective strategy. Included in the top ranked strategies were maintaining financial credit and off-farm investment. The least effective risk management strategies from their point of view were forward contracting and the use of futures markets.

Hall et al noted that the findings were paradoxical, taking into consideration beef producers' view of the high potential for price variability to affect ranch or farm income. The most effective management strategies to mitigate drought and cold perceived by producers were understocking pasture and storing a hay reserve. They noted that adjusting stocking rate, weaning calves early, reducing the breeding herd were ranked slightly less effective. Purchase of hay during drought was ranked as the least effective, indicating in their analysis that beef cattle producers perceive stocking rate as one of their most important risk management tools.

Lawrence (2001) writes that futures for fed cattle have existed since the mid 1960s, but notes that relatively few producers use them. In his report "Live Cattle Futures and Options: How Have They Done?" Lawrence (2001) estimated the returns to finishing yearling steers in Iowa under various futures hedging strategies from 1991-1999. He observed that a 100% routine hedging strategy reduced average returns by $7.05/head compared to no hedging but also reduced the worst case year from a loss of -$139.38 with no hedge to -$92.99 with a hedge.

Lawrence and Smith (2001) conducted a similar analysis. They used data from 1987-2000. Similar to Lawrence, they found that average returns with routine hedging were $16.25/head lower than with no hedging. However, in this case the difference between the worst case years was only $13/head compared to not hedging. In this analysis a routine hedger would give up an average of $16.25/head every year to avoid a $13/head larger loss in the worst-case year – hardly an effective risk management strategy, they concluded.

Nardi et al. (2006) used a non-parametric simulation model to determine per cow gross revenue less risk management costs for alternative phases of cattle production. The analysis identified the revenue risk protection provided by futures for feeder cattle producers in South Carolina. The main variable considered in the analysis was gross revenue. Variable costs of production were assumed to be the same for all phases of the cattle production. The analysis was conducted using an excel spreadsheet. They used a uniform distribution to determine the prices used for the iteration of the simulation analysis. The simulation model was developed in @Risk using 10,000 iterations per simulation.

Among the general risk management strategies conducted was hedging with futures. Their study, along with others, simulated the effectiveness of alternative price risk management strategies for cow-calf producers selling 500 pound feeder calves in September; winter stockering operations that purchase feeder calves in September and sell 800 pound calves in January; and operations retaining ownership of the heavy-weight feeders and finishing them in a feedlot in Kansas. Likewise, combinations of the three separate production phases were simulated including cow-calf operations winter stockering their own produced feeder calves and winter stockering and retained ownership through the finishing stage. There were different scenarios including scenario 1, which was the base case of no risk management strategies.

Their findings indicated that the no-risk management strategy for both the cow-calf and winter stockering operations had the largest average revenues and largest minimum revenues. They suggested that naïve risk management strategies did not provide any truncation of the simulated distribution for the cow-calf winter stocking operations. Combination price risk management strategies for the cow-calf operations choosing to winter stock their own calves provided improvement in the minimum gross revenue over the no-risk management strategy. Hedging with futures for both phases of production also improved the minimum gross revenue over the no-risk management strategy. Using futures for cow-calf producers retaining ownership through the finishing production phase improved the minimum gross revenue over the no-risk management scenario.

Nardi et al concluded that more evaluation of the timing of the naïve strategies is required before broad conclusions can be reached on the effectiveness of price risk management for cattle producers. As well, the period studied 1988-2004 was mostly a period of decreasing inventories and generally increasing prices.

The reviews of these empirical studies provide insights into some tools that could be considered in this analysis. As such, the risk management tools including holding reserves in terms of feed, buying or raising replacement heifers and safety nets would be considered in this analysis to determine if these risk management strategies meet the objective of increasing and or stabilizing income over a period of time. In many situations, one particular approach may not be the best option all the time. It is imperative that producers develop the capability to assess various strategies utilizing different risk management tools. Do these options or strategies used by farmers vary by the size of the farm? How effective are these risk management strategies in improving or stabilizing income? The answers to these questions might be helpful to the producers and policymakers who are interested in monitoring risk management strategies.

2.6: Limitations in Adopting Risk Management Strategies by Producers

Agricultural policy analysts are often interested in the kind of factors that make producers adopt risk management strategies on their farms. Why do some farmers adopt risk management strategies whiles others do not? Why do some farmers adopt particular risk management strategies? Kontio and Basili (1997) reported that although there are several individual reports of successful use of risk management practices, many people seem not to put into practice risk management methods actively and systematically. They cite three primary reasons for the lack of practice. The first reason pointed to is the fact that, even with recent publications and conferences on risk management, knowledge about risk management and tools has not reached most practitioners. The second reason was that many existing risk management applications have both practical and underlying, theoretical limitations that hinder the usability of these methods. Finally, they note that whiles there have been several descriptions of risk management practices; there are a few reports on systematic and scientifically sound evaluations to provide empirical feedbacks on their feasibility and benefits. While their study is almost ten years old, there has been little in the way of more recent research examining the frequency with which beef producers use risk management strategies.

Nardi et al. (2006), report that producers can become besieged and confused by the number of available price risk management strategies. They note that producers need to consider whether it is better to hedge with commodity futures or not. Producers may have to deal with the timing of implementation for the risk management strategy, which can be confusing. The use of futures may not work for all producers. For example, the usefulness of futures in reducing price risk may work better for a cow-calf producer selling calves in the fall compared to another producer selling in winter. Also, a risk reducing option may work for producers in one particular region but not for others in a different region.

Other reports indicate that adoption of risk management strategies may depend on a number of factors including age of the farmer, experience of the farmer, farm size and knowledge about the use of risk management strategies in question. Farm size can be a key factor in adopting risk management strategies. As farm size increases, the probability of a producer making more extensive use of risk management strategies is likely to increase. Micheels and Barry (2005) write that this reflects the greater absolute risk taken on by the producer. They indicate that as farms become larger, producers might place greater value on the use of marketing contracts and diversification. For example, research conducted by Micheels and Barry (2005) in rating average importance of risk management strategies suggested that all the risk management practices receive the lowest ratings in the smallest acres-farmed class. Their analysis concluded that increases in farm size lead to greater importance placed on risk management, especially in situations of forward contracting. For smaller farms, they suggest that the more advanced risk management practices may be unnecessary or infeasible to use.

Age and experience might play role in adopting risk management strategies. Older farmers might have more experience working on the farm but have less formal education. Younger farmers may have more formal education and less experience with risk management strategies. In this case younger farmers may want to apply their knowledge of risk management.

Again not everyone has the skills and managerial ability to follow the risk management strategies. For example Bossman (1999) writes that hedging with futures necessitates training, and some expertise. Some producers may require technical assistance in order to make effective use of risk management strategies.

2.7: Chapter Summary

This chapter began with a discussion of the different stages of beef cattle production; cow-calf production, backgrounding, and finishing. The chapter also reviewed the various aspects of variability in cost (profit). Some factors presented as influencing the profitability of cow-calf production included percent cows weaning calves, weaning weights of calves, price received per pound for the calves and cost of owning and maintaining cows. Other writers speculated geographic location as having an effect on the profitability. Some researchers suggest that economies of scale could also explain some differences in profitability.

An overview of risk management alternatives available to beef producers, particularly cow-calf operators were also discussed. Public safety net programs were also discussed, in particular the CAIS program.

Empirical studies of risk management studies were discussed to help identify potential strategies to consider in the current study. The chapter also provided an insight to some limitations in adopting risk management strategies by beef producers. Some of the limitations mentioned included the lack of familiarity with the markets which breeds a distrust of the markets. Another limitation indicated that not everyone has the skills and managerial ability to follow the risk management strategies.

This chapter, amongst others, has given an idea of what risk management strategies have been employed, how they were conducted, and the effectiveness of the tools used. It also helped to identify some potential empirical questions that need to be addressed. With these in mind the analysis for this study is based around some of these empirical issues, including taking into consideration the models applied for their analysis.

3.0: CHAPTER 3: THEORETICAL/CONCEPTUAL MODEL

3.1: Introduction

Risks faced by farmers have been studied and discussed by economists for many years. Responses to risk have been identified, and strategies that integrate them have also been developed to permit more efficient farm management when risk is encountered. The focus of the current study is to examine these issues as they pertain to cow-calf production in Alberta. This chapter provides a discussion of the theoretical and analytical model used in the analysis.

This chapter begins by defining risk. The chapter also introduces some basic ideas of choice under uncertainty (i.e., expected utility theory) as well as a discussion about farmers' attitudes towards risk and why these attitudes are important in economic decisions affecting production activities. Simulation, which is the main analytical tool used in this analysis, is discussed. The particular simulation model developed for this analysis is a bio-economic model which will also be explained. Finally, a conceptual description of the simulation model is provided.

3.2: Definition of Risk

"Risk" and "uncertainty" are two terms that are basic to the decision making framework for this study. There are several definitions of risk and uncertainty provided in economics literature. Risk can be defined as imperfect knowledge where the probabilities of the possible outcomes are known, and uncertainty exists when these probabilities are not known (Hardaker et al., 1997). Risk may also be defined as the probability of a loss in income. This study however, adopts the definition of risk from

OECD, 2000; in particular, risk is the potential for uncertain income that arises as a result of variations in production and prices. In other words, risk is defined as variability in income. For the purposes of this analysis however, risk and risky are being used interchangeably with uncertain and uncertainty.

3.3: Conceptual Economic Model

Often in economics it is assumed that there is no uncertainty when managers make their production decisions. This assumption, however, seldom holds in the real world. Managers are faced with uncertainty with respect to prices, output and input relationships, etc. This has led to an effort to describe individual behavior under uncertainty. The conventional approach to modeling behavior under risk in economics is through the use of the Expected Utility Theory (EUT). The EUT describes the relationship between an individual's scale of preference for a set of acts and their associated consequences. The theory maintains that, facing uncertainty, people behave as if they are maximizing the expectation of some utility function of the possible outcomes. Robinson and Barry (1987) report that expected utility approach is the major analytical tool for solving decision problems under risk and that if a unique utility function for decision makers is known, then it is possible to identify a unique risk efficient solution.

The EUT states that if decision maker behavior satisfies certain axioms, then a utility function exists such that a decision maker will choose actions that maximizes their expected utility (Fishburn, 1984). These axioms require that preferences satisfy completeness and transitivity, the certainty equivalent hypothesis and independence (Shoemaker, 1982). Figure 3-1 illustrates the concept of expected utility and associated concepts/measures.

In Figure 3-1, the risky choice under consideration (X) has two outcomes, $X1$ and $X2$, each equally likely. The expected outcome is $\overline{X}$; the expected utility of the risky choice is EU= 0.5U ($X1$) + 0.5U ($X2$). The certainty equivalent (CE) associated with X is the outcome that, if received with certainty, is equivalent in utility terms to the risky choice itself; that is, U (CE) = EU. Greater levels of expected utility are associated with greater values of the certainty equivalent (Mas-Colell et al., 1995); that is, the risky choice that maximizes expected utility will also maximize the certainty equivalent.

If the utility function is concave as in Figure 3.1, then the certainty equivalent for risky choice X is less than the expected value ($\overline{X}$). The difference between the two values is called the risk premium (RP). The RP is the amount that the decision maker would be willing to pay in expected value terms in order to eliminate risk (i.e., a premium) and be just as well off in utility terms. It can be shown (Mas-Colell et al., 1995) that the greater the curvature in the utility function, the greater the risk premium for a given risky choice; that is, the greater the degree of risk aversion. Arrow and Pratt (Arrow, 1965, Pratt, 1964) developed a measure of "risk aversion", based on the curvature of the utility function, called the absolute risk aversion function (APARA). The APARA quantifies the degree of risk aversion for an individual decision maker. The APARA is defined by the following formula:

$$APARA = -\frac{U''(X)}{U'(X)} \qquad (3.1)$$

where $U''(X)$ and $U'(X)$ are the second and first derivatives, respectively, of the utility function with respect to outcome X. The greater the curvature of the utility function, the greater the absolute value of this function and the higher the level of risk aversion associated with it.

Given certain assumptions such as a) normality of returns and constant absolute risk aversion or b) quadratic utility function, the certainty equivalent can be approximated as follows (Freund, 1956):

$$CE = \overline{X} - \frac{r}{2}\sigma^2(X) \tag{3.2}$$

where $\overline{X}$ is the expected outcome, r is the level of absolute risk aversion and $\sigma^2(X)$ is the variance of X (i.e., the level of risk). This expression illustrates the tradeoff between expected returns and variability of returns. Greater levels of expected utility (i.e., greater values of CE) are associated with higher expected returns and/or lower variability in returns. The nature of the tradeoff between risk and returns for a particular decision maker is determined by "r"; that is, the level of risk aversion.

In this thesis, the impact of risk management strategies on the risk and return associated with beef production is examined. For the purposes of this analysis, it is assumed that a) producers behave as if they maximize expected utility in making decisions, and b) variance of returns is an appropriate conceptual measure of risk. For each risk management strategy considered for the cow-calf operations, the tradeoff between expected returns and the riskiness of returns will be subjectively assessed.

3.4: Simulation

In this study, dynamic simulation techniques are used to study alternative risk management strategies for cow-calf operations in Alberta. Zhang (2001) defines simulation as a numerical technique for conducting experiments on a digital computer which involves certain types of mathematical and logical models that describe the behavior of a business or economic system (or some component thereof) over extended periods of time. Other literature defines simulation as the execution of a model, represented by a computer program that gives information about the system being investigated. In other words, simulation imitates a "real life" system. The purpose of using simulation in the current analysis is to replicate or imitate the "systems" used in producing beef on Alberta cow-calf operations.

Simulation modeling has received considerable attention and a number of researchers have used simulation techniques to analyze a variety of different problems and issues in agricultural production, due to its flexible nature. For example, Dzama et al., (2001) used simulation to select beef cattle for growth and milk production, and Pang et al., (1999) used a dynamic simulation model to examine the effects of calving season and weaning age on bio-economic efficiency. Other examples of beef simulation analysis include Jeffrey and Novak (1999), who used simulation to evaluate the effectiveness of alternative safety net programs in Alberta, as well as Munro (1993) who also used simulation to analyze retained ownership of beef calves in Alberta. Tess and Kolstad (2000) used simulation to demonstrate and evaluate the model performance of cow-calf production systems in a range environment. Williams et al. (2006) used simulation models to predict feed intake in cattle.

The purpose of simulation is to produce results which can be interpreted and lead to improved understanding of the system being studied. Unfortunately, circumstances can easily arise in a simulation study that may lead to misinterpretation of the data and consequently to a misunderstanding of the system (Zhang, 2001). These may include poorly chosen pseudorandom number generators, input parameter misspecification, programming errors, model misspecification, poor choice of descriptors and numerical calculation errors. Thus it is important to recognize that the advantage of simulation modeling (i.e., flexibility) can also be a disadvantage in that it can also provide more opportunities for "error".

Computer simulation becomes a legitimate research tool when known analytical methods cannot supply a solution to a problem (Fishman, 1973). An example of this would be the situation where there are insufficient data points to use a suitable analytical method for modeling. Many problems are so complex that they cannot be solved analytically. Thus simulation often provides the only practical approach to such problems. Detailed behavioral observation of a system being simulated may lead to a better understanding of the system and to suggestions for improving the system. Simulation of complex systems can yield valuable insight into how variables, which represent system attributes, interact with one another.

Simulations can take many forms. A simulation can be stochastic or deterministic. Stochastic models incorporate probabilistic elements (i.e., uncertainty) in a system or process. Deterministic models have no randomness. Simulation can be further categorized as being either static or dynamic. Although deterministic simulation models have no randomness, they can be classified as being dynamic in terms of having multiple time periods. In a static system, the occurrence of events is independent of the passage of time. Dynamic simulation modeling involves simulating over multiple time periods, and requires the ability to understand the implications of change over time. As a result, dynamic simulation tends to be relatively more complicated.

A diagrammatic presentation adapted from Zhang (2001), showing the basic concept of simulation is represented in Figure 3-2. "System" refers to a collection of repeatedly interacting or independent mechanisms acting as a unit in carrying out an implicitly or explicitly defined mission. Input refers to stimuli external to a system that induces changes in the system state and output refers to measures of these state changes.

One type of stochastic simulation analysis used is Monte Carlo Simulation. Monte Carlo is a type of simulation that makes use of internally generated (pseudo) random numbers. Monte Carlo simulations typically involve many "runs", referred to as iterations, for given input values. Monte Carlo simulation generates probability distributions of outcome variables that depend on other variables or parameters which also may be represented as probability distributions. Monte Carlo involves many calculations and the repetitive calculations take many randomly selected combinations of the inputs. As a result, Monte Carlo methods provide more information than do deterministic point estimate calculations.

However, Monte Carlo has some disadvantages as well. This type of simulation requires more data; otherwise the uncertainties in the input parameters may result in large uncertainties in the resulting risk estimates. That is, they require a greater level of mathematical and computer sophistication. As a result, checking the accuracy or validity of Monte Carlo simulations is often difficult.

Given the nature of the questions and issues addressed in this study, stochastic, dynamic simulation methods are employed. Further, Monte Carlo simulation techniques are used to generate distributions of outcomes which are then assessed in terms of expected outcomes and variability (i.e., risk) of outcomes.

3.5.1: Bio-economic Simulation Modeling

The term bio-economics can mean different things to different people. In this study, the definition provided by Allen et al. (1984) is used; that is, bio-economics is the use of mathematical models to relate the biological performance of a production system to its economic and technical constraints. A number of researchers have used bio-economic approaches in investigating problems in agriculture. In the beef industry sector, researchers have used simulation methods to evaluate different aspects of the industry. For example, Pang et al. (1999) developed a dynamic deterministic model for simulating beef cattle production systems to evaluate the effects of production traits and management strategies on the bio-economic efficiency of beef production system. In their report Dzama et al. (2001) developed an index selection of beef cattle for growth and milk production using computer simulation model.

Bio-economic analysis in cow-calf production requires using a combination of biological and economic models to provide a more complete examination of the cow-calf industry. Biological analysis can be used to simulate the levels and interactions of animal "stocks" within a cow-calf operation. Economic analysis can be used to predict the impact of the biological population dynamics (i.e., the biological analysis) on net returns in terms of profit. The use of a bio-economic framework can incorporate not only the critical biological relationships but also the dynamic and stochastic characteristics of an agricultural system.

3.5.2: Conceptual Simulation Model

The objective of this study is to examine and assess risk management strategies for Alberta cow-calf operators. In order to do this, distributions of "gross margin", or the margin between income and variable costs, are calculated under different risk management scenarios. These distributions are then compared in terms of the expected returns and risk of returns so as to be able to choose, from amongst them, the "best" alternatives. The simulation model built for this analysis must therefore be sufficiently flexible to simulate different production and risk management strategies/scenarios.

The model developed in this study is built primarily around the cow-calf enterprise and associated production activities. However, it must also incorporate crop activities because of the nature of these operations; that is, cow-calf producers often grow crops to provide feed for their animals. As well, although the cow-calf producer primarily obtains revenue from the sale of animals, additional income may also be obtained from the sale of crops. These may be crops grown specifically for sale or may be excess production of crops grown for feed.

The expenses or costs considered in this study are mainly variable costs. Although some literature reviewed earlier suggests fixed costs are a significant factor in profit variability, fixed costs will not be considered in this analysis. Jones (2000) writes that in order to obtain a true measure of average profitability, the fixed cost component of total costs needs to be taken into account. However, while fixed costs vary significantly between producers, for an individual producer they do not vary nearly as much over time as do variable costs. It is for this reason that fixed costs are not considered in this analysis.

The model is dynamic in that it simulates the biology and economics of the operation over a period of several years. Having a dynamic simulation model was deemed to be important given the nature of the population dynamics for the beef enterprise (i.e., individual animals moving from one age category to another) Also, dynamics may be important in modeling some risk management strategies in order to assess their effectiveness over a period of time.

Finally, the model requires a risk component. This is important given that these farmers are assumed to have little or no control over many parameters that affect gross margin. For example, although parameters such as conception rate, calving rate and weaning rate of the animals can be influenced through managerial ability, ultimately the producer has limited control over these parameters. The farmer has also no control over extreme weather conditions such as drought which can have a great impact on crop production and the resulting gross margin. Output and input prices are typically beyond the control of the individual producer. As such these variables are modeled as being stochastic so as to account for this variability and uncertainty surrounding them.

Figures 3-3a, b and c provide a diagrammatic representation of the simulation model used to model risk management strategies for Alberta cow-calf production. This figure shows the relationship components in the model. Figure 3-3a shows the bio-physical relationships in the model; Figure 3-3b shows the economic relationships, and Figure 3-3c provides an overview of the different components of the model and how they are interconnected in the simulation process. In Figures 3-3a, b, c, rectangular shapes represent values and/or relationships that are calculated within the model; oval shapes represent model parameters. In some cases these parameters may be "exogenous" (i.e., beyond the control of the producer) while in other cases they may be "endogenous" (i.e., managerial decision) in nature.

Figure 3-3a illustrates the two main bio-physical components of the cow-calf operations modeled in this study; the beef enterprise and cropping enterprises/activities. For the beef enterprise, in each year of the simulation there is a beginning herd population distribution (i.e., number of cows, bulls, bred heifers, yearling heifers, etc.). From the beginning to the end of each simulated year, the numbers in each class are influenced by model parameters; exogenous parameters such as conception rates, death loss rates, weaning rates, etc., and management parameters such as the culling rate. The result is an ending herd population distribution. The numbers of animals in each class at the end of the year are also influenced by any animal purchases (e.g., replacement heifers) and sales (e.g., weaned calves, culled breeding stock). The ending distribution for any year t becomes the beginning distribution for year t+1. The other component of the simulation model is the set of cropping activities. Total crop production in any year of the simulation is influenced by model parameters. Again, some of these are exogenous (i.e., yields) while others are assumed to be based on managerial decisions (i.e., selection of crops and acreage of each crop). Some of the crops are grown for use as feed in the beef enterprise (e.g., forages) while others may be grown for sale (e.g., canola).

The two components of the model are linked through the "feed balance" calculations. A ration is specified for each type of animal in the beef herd (e.g., mature cows, yearling heifers) and this ration is assumed to be chosen by the producer (i.e., endogenous parameter). The total number of animals in each class, combined with per animal rations, determines the total feed requirements for the beef herd (i.e., amounts of each feed ingredient such as hay, barley, etc.). These requirements are then compared to the amounts of each feed ingredient available from crop production and beginning stored feed. This comparison is calculated as the "feed balance". If there is a deficit for any particular feed ingredient (i.e., more is required than is available), then additional feed is purchased. If there is a surplus for any ingredient, then the excess is sold and/or stored for future use. The emphasis on storage versus sale of excess feed production is assumed to be a managerial parameter.

In Figure 3-3a, the boxes with underlined labels represent variables or relationships that result in costs being incurred by the cow-calf operation. Conversely, those boxes with bold labels represent variables that contribute to farm revenues. These represent links between the bio-physical side of the simulation and the economic side. Figure 3-3b provides more details for the structure of the economic side of the model. As with Figure 3-3a, it is divided into two components; the beef herd and the cropping enterprises.

With respect to the beef herd enterprise, weaned calves and other culled animals are sold to generate revenue. The amount of revenue from animal sales is determined by beef prices, which are stochastic exogenous parameters in the model. Per animal non-feed variable costs are specified in the model (i.e., parameters). These, along with the numbers of animals in each class (e.g., cows, bred heifers) determine total non-feed costs. Explicit feed costs are determined by any feed purchases calculated within the bio-physical side of the model, along with feed ingredient prices which are exogenous stochastic parameters. Total beef revenue minus total beef costs equals the explicit gross margin associated with the beef enterprise.

On the crops side, similar calculations are performed. The amount of revenue from cropping activities is determined by crop prices, which are stochastic exogenous parameters, and physical crop sales from the bio-physical side of the simulation model. As discussed previously, some crops are grown for sale purposes. In cases where feed crops are in surplus, they may be sold to generate income as well. Per acre variable costs are specified in the model (i.e., parameters) for each crop. These, combined with the acres of each crop from the bio-physical side of the model, determine total cropping variable costs. Total crop revenue minus total cropping variable costs equals the explicit gross margin associated with the cropping enterprise. Total farm gross margin in each year is the sum of the gross margins from the beef and cropping components of the model.

Figure 3-3c provides an overview of the simulation model used in this study and its component. Initial conditions are specified for the model. These include initial beef herd population distribution, assumed beginning feed storage inventory, historical revenues and variable costs for the beef and cropping enterprises[4], etc. These initial conditions are used, along with other model parameters, in carrying out the calculations included in the bio-physical module for the first year of the simulation (i.e., numbers of calves born and weaned, production of crops, etc.). The results from the bio-physical module are then used to carry out the calculations in the economic module of the model

[4] These revenues and costs are actually calculated using the simulation model, but are considered as part of the initial conditions for the first formal year of simulation. These values are used in modeling participation in the CAIS program because of the need for historical financial information to calculate the reference margin for the first year of participation.

(i.e., beef and crop costs, beef and crop revenues). The final "result" from simulation of any particular year in the model is farm gross margin.

The results from the bio-physical module also represent the ending conditions for the first year (i.e., herd population distribution, ending feed inventory stocks, etc.). As discussed earlier, the model is dynamic in that it simulates the cow-calf operation over a multi-year time horizon. After the first year of the simulation, the ending conditions for any particular year represent the initial conditions for the following year, as indicated in Figure 3-3c. While not obvious from the schematic outlined in this figure, the process is repeated for each year of the time horizon, resulting in a series of annual farm gross margins being generated as simulation results.

Also not explicitly apparent from the relationships outlined in Figure 3-3c is the fact that the dynamic simulation process is repeated numerous times; that is, multiple iterations of the simulation are performed. The results from each of these simulations are different, in that the values of stochastic parameters (i.e., prices and yields) are different each time. Thus, the ultimate result from simulating the cow-calf operation is a series of distributions of annual gross margin.

The last element of the simulation model outlined in Figure 3-3c is the implementation of risk management strategies. As suggested in the schematic provided in this figure, these strategies may be applied to elements of the bio-physical and/or economic modules of the simulation model. This depends on the nature of the strategy. For example, one strategy examined is the role of feed inventory stocks in managing risk for the operation. This involves changing the managerial parameter controlling how much of any feed balance surplus is stored versus sold. This parameter is part of the bio-physical module of the simulation model. Price parameters are part of the economic module of the model.

3.6: Chapter Summary

Expected utility is used as the basis for the conceptual economic model. From this theoretical model, a conceptual approach is developed that is used to evaluate the tradeoff between risk and expected return. This approach is used to assess the different risk management strategies and evaluate their performance.

A dynamic stochastic bio-economic simulation is used as the modeling technique in this study; specifically this study uses Monte Carlo simulation. This is done to reflect the complexity of the systems involved in cow-calf production, and to be able to rigorously replicate/imitate the processes in these systems. A general conceptual representation of the simulation model is provided, outlining the links between bio-physical and economic modules, and beef and cropping enterprise components. In the next chapter, the model is explicitly laid out in terms of the relationships included in the simulation and the model parameters.

Figure 3-1: Utility Function with Risk Aversion

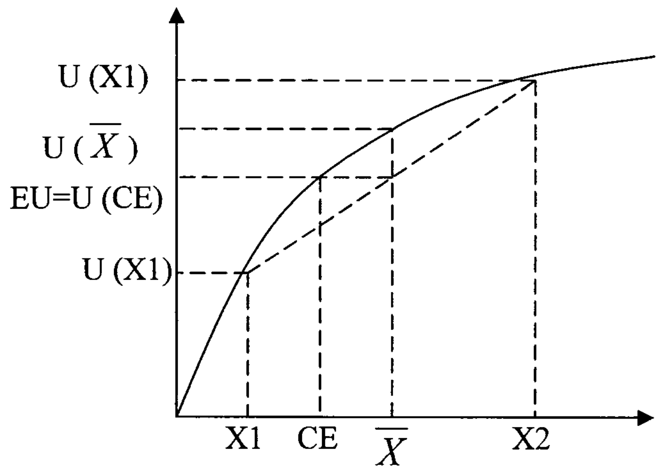


Figure 3-2: Basic Concept of Simulation

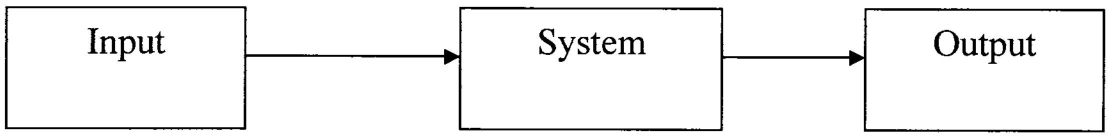


Figure 3-3a: Bio-physical relationships in the Simulation Model

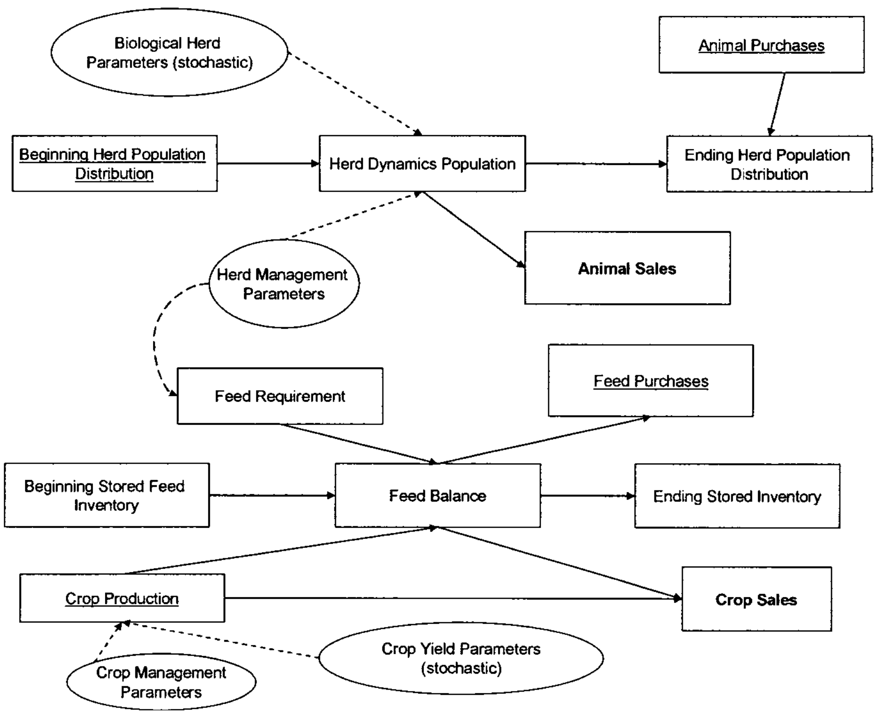


Figure 3-4b: Economic Relationships in the Simulation Model

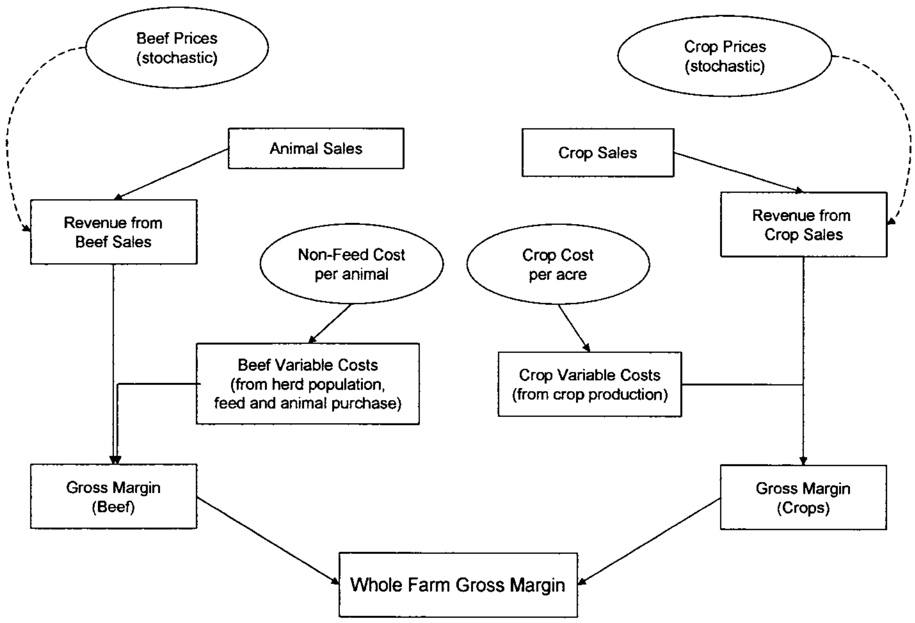
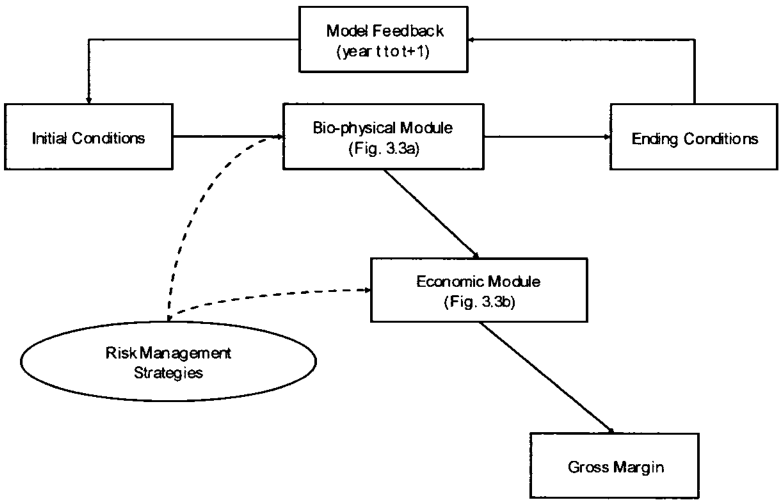


Figure 3-5c: Overview of the Different Components of the Model and how they are interconnected in the Simulation Process



4.0: CHAPTER 4: EMPIRICAL METHODOLOGY

4.1: Introduction

This chapter presents a detailed description of the simulation model used to analyze the risk management strategies for Alberta cow-calf operators. A dynamic stochastic bio-economic simulation model was used to simulate the performance of selected risk management strategies for representative Alberta farms. The simulation was conducted using a 10-year time horizon. Microsoft Excel©, with an add-in software program @Risk©, was used as the platform for the bio-economic simulation model. The @Risk© software was used because of the added flexibility in modeling stochastic relationships. Given the objectives of this study, this was an essential component.

Risk was incorporated into the analysis through specification of stochastic model parameters. The two main sources of risk modeled were production and prices. Risky production parameters included those from both beef and crop enterprises. Production parameters from the beef enterprise assumed to be stochastic included conception rate, calving rate, animal death loss and weaning weight. For crop production, yield per acre was assumed to be risky. Both beef and crop prices were assumed to be stochastic.

Other model parameters were deterministic. Typically, these were parameters assumed to be determined by the producer; that is, parameters related to managerial decisions. For example, in the beef enterprise, culling rate and heifer retention rate were modeled as deterministic parameters. For crop production, acres of each crop were deterministic.

The model was simulated 10,000 times (i.e., iterations) for all risk management cases/scenarios. Most of the parameters used for the model were generated from data provided by the Alberta Agriculture and Food **AgriProfit$** Business Analysis and Research Program database.

As discussed in the previous chapter, the bio-economic simulation model calculated gross margin for each year in each iteration. At the end of each simulation "run", distributions of gross margin for each of the 10 years were generated. From these distributions annual average gross margin as well as the standard deviation of annual gross margin were calculated for each of the 10 years.

A dynamic model was developed because of the dynamics within the beef herd and because of the characteristics for some of the risk management strategies. Within the beef herd, animals move from being calves to being weaned calves at which time some are sold. Retained animals move into the beef herd as yearling heifers, then bred heifers and ultimately mature cows. A multi-year model is required to accurately model these relationships over time. As well, some of the risk management strategies have implications over time (e.g., CAIS) that necessitates the use of a dynamic model. A time horizon of 10 years was chosen because it was felt that this would be sufficient to allow for the impact of these dynamic considerations to be felt in the results.

There were number of risk management strategies employed in the analysis. It was assumed that the producer would decide whether or not to adopt a particular strategy based on its impact on the level and variability of gross margin. A mean-variance (E-V) framework is used to assess the effectiveness of the risk management strategies. The following discussion is based on the characteristics of the representative farms used for the analysis.

4.2: Representative Farms

This section details the characteristics of the representative farms used in the analysis. These farms are representative in that they are assumed to have characteristics that would be consistent with cow-calf operations in the area under study. These are not necessarily "average" farms, as average values may or may not be representative of any real operations. Instead, if defined appropriately, these farms should be "typical" of many cow-calf operations in the study region.

The process of defining these farms was done using farm data for cow-calf production in Alberta. The data used to describe these representative farms were obtained from Alberta Agriculture and Food **AgriProfit$** Business Analysis and Research Program database. The data contained detailed information for both physical and financial inputs and outputs collected through an on-farm interview process with Alberta beef producers. The data cover a time span of eight years, 1995 – 2002.

For the purposes of this study, the main characteristics used to define the representative farm operations are cow herd size and geographic location. Herd size is important in that it defines the "size" of the operation, at least with respect to the beef enterprise. It is likely that there will be a relationship between herd size and management practices and other production characteristics (e.g., parameters such as culling rate, calving rate). Also, there is evidence that size economies exist in Alberta cow-calf production (Kaliel, Jeffrey and Yang, 2005). Therefore, average costs of production likely differ by herd size. Finally, results from the literature review in Chapter 2 suggested that herd size may be related to the choice of risk management strategies by managers. This may indicate that herd size has an impact on effectiveness of different strategies.

Geographic region refers to the part of the province in which the representative operation is located. Geographic location will affect the climate faced by the manager (i.e., temperature and precipitation). There is also a relationship between geographic location and soil type. Therefore, location within the province will influence cropping activities by the representative operations; specifically, types of crops grown, resulting yields, costs of production, etc. Related to this is the pasture enterprise. The geographic location influences how long animals can graze during the summer period and into the fall. Also, there is evidence from the whole-farm data that the range of herd sizes differs by region within Alberta. For example, an initial inspection of the data suggests the Boreal/Peace Lowland region is characterized by larger herd sizes than in other regions.

4.2.1: Geographic Location

Geographic location for the cow-calf operations was defined using data for grass type and soil type. Expert opinion from Alberta Agriculture and Food was used to identify three geographic regions to define the representative farms.[5] The data used for this definition were obtained from AAFRD's **AgriProfit$** Business Analysis and Research Program database. Depending on the grass type and soil type provided by each operator, they were placed into one of three geographic regions; Southern Alberta, Aspen Parklands or Boreal/Peace Lowlands. The grass types used to define each region are represented in Table 4-1. Southern Alberta is assumed to be characterized by fescue grassland, moist mixed grassland and mixed grassland. Aspen Parklands is its own grass

[5] Dale Kaliel from AAFRD provided the expert opinion.

type whereas Boreal/Peace Lowlands is characterized by Boreal Transition and Peace Lowlands grass types.

The categorization by grass type is generally consistent with soil types found in the different regions. The grass types associated with soil types for each geographic region are presented in Table 4-2. As can be seen from this table, the soils characterizing the Southern Alberta region were brown, dark brown and thin black. The Aspen Parkland region was characterized by black soil whereas Boreal/Peace Lowlands were characterized by black and grey wooded soils.

4.2.2: Cow Herd Sizes

The other criterion used to define the representative cow-calf operations is size of the breeding herd. As discussed above, this is used as a measure of "firm size" in terms of the main enterprise under consideration in the study. In the data set, the variable for number of wintered cows is used as the measure of herd size. For each geographic region, the distribution of herd size is examined to determine "representative" values. In order to reflect the diversity in size of cow-calf operation within each of these regions, three representative herd sizes were identified; small, medium and large. Upon initial inspection of the distributions for each region, it was obvious that they were each unique in terms of their shape and position (i.e., range). Therefore, each geographic region was examined separately and different herd sizes were established as being small, medium and large in each case.

In defining the cow herd sizes a number of histograms were developed to facilitate visualization of the distributions. Data from some selected years were used for the histogram analysis; in this case years 1999, 2000 and 2002[6] were chosen for every representative region. These years were chosen because they contained consistent information on producers from the selected years. As noted earlier, the AAFRD data contained information on producers from 1995 to 2002. However, data records were not available for all these producers over the entire time period; that is, the data contained information on some producers for only a particular year while others had records for multiple years. The selected years therefore provided information on producers who appeared throughout 1999, 2000, and 2002. This was done to provide sufficient information on producers so as to provide as accurate results as possible to justify the inclusion of the wintered cow numbers used for the analysis.

For each region, the same general process was used to identify the representative herd sizes. First, all observations were included in the histogram and these were grouped into a relatively small number of herd size ranges. This was done to identify the range of herd size that would represent the majority of the observations. Although ideally the analysis should capture all producers and all herd sizes, the possibility of some outliers existed; that is, producers with very large or very small herd sizes. Elimination of these observations allowed for more homogeneity within each representative herd size.

Once the outliers for a particular region were eliminated, a more detailed histogram of the herd size distribution was created. Within this histogram, herd size ranges with larger numbers of observations (i.e., approximate modes) were identified and used as the basis for determining the exact ranges of herd size that corresponded to the small, medium and large representative herds in each region. After this assessment was

[6] Data from year 2001 was not used because the data from the other selected years contained more consistent information needed for the analysis.

completed, the specific herd size for each representative cow-calf operation was calculated as the approximate average for the relevant range.

The initial histogram for Southern Alberta is provided in Figure 4-1. The histogram represents data for all sample producers in this region from 1999, 2000, and 2002. The greatest concentration of herd sizes was in the range from 21 to 160. The frequencies of the other herd sizes were very low and as such were deemed to be outliers and not typical of farmers in the sample from the Southern Alberta region. They were therefore excluded from further analysis.

Figure 4-2 provides a more detailed histogram for Southern Alberta herd sizes with 21 as the minimum herd size and 160 as the maximum herd size. The histogram reveals that the highest frequencies of wintered cows for producers in Southern Alberta are in the range of 51 to 160. With results from the histogram, decision was made to have producers with herd sizes greater than 50 but up to 80 represent small herds in Southern Alberta. Producers with herd sizes greater than 80 but up to 120 were deemed to be representative of medium herds in the region. Finally, herd sizes greater than 120 but up to 160 represented the large herd group.

The same procedures from Southern Alberta were employed in the other two regions which were Aspen Parklands and Boreal/Peace Lowlands. Figure 4-3 contains the histogram results of wintered cows and their frequencies for the Aspen Parklands region. The highest frequencies were for farmers with wintered cow herd sizes of between 11 through to 250. Producers with wintered cows between 11- 250 were therefore chosen to represent producers in Aspen Parklands.

A breakdown of these numbers can be found in Figure 4-4. The histogram revealed that the highest frequency of the wintered cow herd sizes fall between 71 and 250. Again looking at the histogram, a decision was made to select farmers whose herd sizes fall between those ranges to represent the Aspen Parklands region. The small herd sizes ranged from greater than 70 but up to 130 cows. Herd sizes greater than 130 but up to 190 cows were chosen as the range for the medium herd size while the large herd size group consisted of herds greater than 190 but up to 250 cows. Again it was assumed that this range of herd sizes were typical of farmers in the sample from the Aspen Parklands region.

The results from the histograms representing the Boreal/Peace Lowland region are found in Figures 4-5 and 4-6. The initial histogram, using all Boreal/Peace Lowland producers in the sample, is represented in Figure 4-5. The results indicated that herd sizes between 21 and 392 cows had the highest frequency of occurrence. As such producers with herd sizes that fell between those ranges were chosen and a further histogram analysis was conducted. The histogram result is found in Figure 4-6. From this histogram it was decided that the small herd size group was characterized by herd sizes greater than 115 but less than 165 cows. Herd sizes greater than 165 but less than 215 cows were chosen to represent the medium herd size group while herd sizes greater than 215 but less than 265 cows represented the large herd size group. As can be seen, the sample for the Boreal/Peace Lowland region is characterized by larger herd sizes when compared to the other two regions. In all cases, the results from the histograms were used for the breakdown into the various herd sizes categories and these herd sizes were assumed to be typical of farmers from the three representative regions.

The results from the histograms are summarized in Table 4-3. This table contains the range of herd sizes considered for the analysis. The observations included in each of these ranges are used to establish values for many of the other characteristics of the representative farms. For example, values for production parameters such as culling rate, non-feed enterprise costs, etc., are derived from the individual values for these herds. As well, distribution information for stochastic parameters (e.g., conception rate, weaning weight) are derived from the distributions of actual values from these herd size ranges.

The actual herd sizes used for the simulation analysis are provided in Table 4-4. These values were calculated by averaging the herd sizes that fall into each herd size range for the three geographic regions and rounding to the nearest integer value. As can been seen from the table, the average herd sizes differed between regions; that is, what constituted a small, medium and large herd size was different for each region. The herd sizes were smallest for Southern Alberta and largest for the Boreal/Peace Lowlands region.

4.3: Overview of Data and the Farm Model Parameters

The following sections in this chapter present information pertaining to the estimation of model parameters. The two main types of parameters required are price and production elements. Production parameters include technical coefficients for the cow-calf and crop production enterprises. These production parameters are classified as being exogenous/stochastic, exogenous/deterministic, or endogenous. Exogenous parameters are assumed to be beyond the direct control of the producer and, if also stochastic, are assumed to vary from year to year for specific operations. Endogenous parameters are those parameters thought to be controllable (i.e., determined) by the producer.

The parameters in the cow-calf enterprise used in the simulation calculations included conception rates and calving rates for both cows and heifers. Other production factors consisted of percentage death loss of yearlings, cows and heifers over winter and weaning weights for the calves. Other parameters included weight per animal of culled cows, weight per animal of open heifers sold, average weight per weaned heifers and average weight per weaned steers. Feed requirements, inputs and input costs were also among the parameters used for the analysis. Yield per acre and acre of land used for cultivation were some parameters considered in the crop enterprise. The parameters also included output prices such as beef prices and crop prices.

The primary source of data used to develop the model production parameters was AAFRD's **AgriProfit$** Business Analysis and Research Program database. The data consisted of farm information from Southern Alberta, Aspen Parklands and Boreal/Peace Lowland, over a period of eight years (1995 – 2002). Observations were used for the farms associated with each of the nine representative beef farm operations, as defined earlier in this chapter. Except where noted, unique parameters were estimated for each representative farm, to allow for differences in technology and management by herd size and geographic region with the province.

In the case of stochastic production parameters, where individual farm data were available, testing was done to determine the appropriate distribution to use in modeling the exogenous/stochastic parameters. In determining the appropriate distribution, the "fit distribution to data" function in @Risk was used to fit the data by performing a series of statistical tests and ranking how well alternative distributions fit the appropriate distribution function to the data. Specifically, three tests were performed to define the distribution which bests fit the data; chi-square, Kolmogorov-Smirinov, and Anderson-Darling.

In some cases, individual firm observations were not available. In these instances, means and standard deviations from the data were available from reports generated from the AAFRD database. These statistics were used to represent the distributions for the exogenous/stochastic parameters in question. For example, yields produced from the crops were assigned means and standard deviations using descriptive statistics obtained from the **AgriProfit$** data set over the 1995 – 2002 time span.

In a few cases, exogenous parameters were assumed to be deterministic; that is, they were assumed not to vary significantly from year to year for particular beef operations. In these cases, average values calculated from the AAFRD database were used to represent the model parameters.

Finally, some production parameters used in the model simulation were assumed to be determined by managerial decisions. These were considered to be endogenous/deterministic parameters. These included parameters such as the culling rate, the percentage of heifer calves retained for breeding purposes and target herd size (cows and bred heifers). The values of these parameters were calculated as averages from the data where available. In cases where no reliable farm level data were available, expert opinion was used instead.

Prices were treated separately. Price data were collected from independent sources. Time series models were used to develop price relationships used in the simulation models. Details of these are provided in Section 4.6.

4.4: Cow-Calf Model Parameters

4.4.1: Conception Rates

Conception rate is defined as bred females per exposed cow. Conception is the first step that must take place for the following year's calves to be produced. Given the importance of producing a calf per cow in terms of financial performance for the operation, this makes conception rate a very significant factor in the cow-calf production. Factors that can affect conception rate include nutrition, reproductive management practices, and age of the cow. Insufficient nutrition for the cows prior to calving can create problems for the cows on their next conception rates.

In the simulation model, conception rate is used to calculate the number of bred cows and heifers versus the number of open cows and heifers in the herd during any particular year. This influences the number of cows/heifers culled for breeding reasons. Farmers can influence conception rate through proper breeding management, but ultimately this is an exogenous parameter, and one that will vary from year to year for a particular producer.

For the purposes of this analysis, two conception rate parameters were considered; one for mature cows and another for young cows or bred heifers. Corah and Lusby (1999) write that the age of the female can influence first service and overall conception rates. They write that research studies document the fact that first service and overall conception rates may tend to be higher in yearling heifers than in cows, provided the heifers have reached puberty and are cycling. However, studies have shown that when heifers calve as two year olds, first service conception rates and overall conception rates can be considerably lower, compared to mature cows. When cows are very old, and are at the end of their production life, they tend to have lower conception rates. These differences necessitated the use of different conception rates.

The conception rate in the model analysis was used to calculate the percentage of wintered cows that were bred after being exposed. The conception rate was important in that it determines the number of calves that will be calved. The "best fit" function in @Risk was used to define the distributions for the conception rates. The distribution chosen for the simulation was a normal distribution. The resulting distribution parameters for the representative farms are provided in Table 4-5. It must be noted that values for the conception rate parameters drawn from the distribution were capped at 1. This was done to ensure that the draws from the distribution did not result in a conception rate greater than 1.

4.4.2: Calving Rates

Calving rate is defined as live births per bred female. As such, it represents the proportion of females giving birth to a live calf. This is a very important parameter in the cow-calf operation since the number of calves born largely determines the income generated by the cow-calf operation. Calving difficulty (dystocia) may contribute heavily to production losses in beef cow-calf operation. Age of dam, calf birth weight, and size of the dam are some factors that contribute to the incidence of dystocia.

Calving can occur in the fall or in the spring. Rather than calve during the fall period, some farmers choose to calve during the spring period. There are advantages and disadvantages with fall calving and spring calving. Kastner et al. (2004) report on research concerning the advantages of one versus the other. For example they report that fall calving cows may require more protein supplementation in winter than spring calving cows, but fall calving cows are better able to utilize warm season grasses to increase body energy reserves prior to calving. Research results also indicated that fall born calves had lighter birth weights than spring born calves as well tended to have greater value than spring born calves at weaning. Ultimately, the decision concerning fall versus spring calving would be based on the farmers' lifestyle. This analysis assumes spring calving since this has been the more common option chosen by cow-calf producers.

In the model, the calving rate parameter was used to calculate the number of calves born alive to mature cows and bred heifers. As with the conception rate, while the farmer has some managerial influence on calving rate, it is considered to be exogenous. Since calving rates will vary from year to year, it is also modeled as a stochastic parameter.

Again, separate parameters were considered for mature cows and bred heifers. Data corresponding to each region and herd size were used to generate the resulting parameters for each representative farm. The "best fit" function in @Risk was used to define the distributions for the calving rates. The distribution chosen for the simulation was a normal distribution. The resulting parameters are provided in Table 4-6. These parameters are assumed to be typical of the representative areas and herd sizes and as such can be used for the analysis. As with the conception rate parameters, the calving rate parameters were capped at 1.

4.4.3: Weaning Rates

Weaning rate is defined as the number of weaned animals per live birth. Weaning rate is also an important variable in the analysis in that it determines the number of animals that are actually weaned for sale in the market. Death loss for calves between birth and weaning causes weaning rates to be less than 1. Corah and Lusby (1999) write that cow productivity is closely related to two factors; weaning weights and percentage of cows weaning calves. Thus cow weaning rates are important in this analysis.

In the simulation model, weaning rate is multiplied by the number of calves born to determine the number of calves actually weaned by each representative farm. As with the previously discussed beef production parameters, and for similar reasons, weaning rate is assumed to be exogenous and stochastic.

The parameters for the various representative farms were calculated in the same manner as the conception rate and calving rate. Data corresponding to the regions and herd sizes were used to generate the resulting parameters for each region. The "best fit" function in @Risk was used to define the distributions for the weaning rates. The distribution chosen for the simulation was a normal distribution. The resulting parameters are provided in Table 4-7. As with the previous parameters, separate weaning rates were established for mature cows and bred heifers. Values for the weaning rate parameters drawn from the distribution were also capped at 1.

4.4.4: Death Loss Rate

Death loss refers to the number of animals that die within a particular year because of illness, disease, accident, injuries and other causes. Death loss is obviously an important parameter in that it can affect the revenue generated by the producers. More cows dying imply fewer calves for sale and less revenue generated.

In the simulation model, death loss rate was used to calculate the number of animals that die over the winter period. Calf deaths were assumed to be accounted for through the calving rate and weaning rate parameters. Given the uncertainty associated with the causes of death loss, death loss was treated as both exogenous and stochastic in the model.

Death loss rates were computed using information from the **AgriProfit$** data. Initial inspection of the data suggested very little variability in death loss rates between the representative farms. As such a common parameter was used for all herd sizes and locations. The "best fit" function in @Risk was used to define the distributions for the death loss rate. The resulting distribution was assumed to be normal with a mean of 0.02 and a standard deviation of 0.001. This was assumed to be typical for all the herd sizes from the different geographic locations. A mean of 0.02 implies that on average 2 percent of the animals die. In order not to draw negative death loss for a particular year, the distribution was specified to truncate the minimum death loss at zero.

4.4.5: Animal Weights

Animal weight refers to the weight for various types of beef animals present on the representative farm; calves, heifers, cows, etc. Probably the most important of these for the current analysis, is the weaned weight for calves. Calves are assumed to be weaned at six months of age. Calf weaned weight is a very important production parameter because it is directly tied to the revenue generated from the cow-calf enterprise.

Weaned calf weight in this analysis is used to calculate the revenue generated on the farm by multiplying the average weight of the calf by the output price. For the purposes of the simulation analysis, an average weight across all calves for a particular farm operation is used; that is, the same weight is used for each calf marketed by a particular representative farm in a particular year. However, this weight will vary from year to year due to biological factors, environmental factors and genetics (i.e., breed of animal which is not stochastic but will affect weaning weight). Hence average weaned weight is modeled as a stochastic parameter.

Data from the AAFRD database were used to calculate the average weaned weight for use in the analysis. Average weaned weight was calculated for each observation for each representative herd size/geographic location. The @Risk "fit data to distribution" function was again used to generate distribution parameters corresponding to each representative farm. The distribution chosen was a normal function. Table 4-8 contains the results of the average weaned weights of the calves.

Other animal weights used in the analysis included culled cow weight, open heifer weight and bred heifer weight. These were primarily used to calculate revenue from the sale of these animals. Average cull weight was obtained from the **AgriProfit$** data. Data for bred and open heifer weights were not readily available and so estimates were obtained from the Alberta Agriculture, Food and Rural development website (2004). Because of the lack of farm level data, these parameters were assumed to be exogenous and deterministic. Average sale weight of culled cows was assumed to be 1,200 pounds while open heifer weight was assumed to be 1,100 pounds. The average sale weight of bred heifers was also assumed to be 1100 pounds.

4.4.6: Cow Cull Rate

Culling refers to the removal and sale of cows and heifers from the breeding herd. Culling of animals is done for several reasons, including age, health, performance, genetic renewal and improvement, etc. Animals may also be culled if they are still "open" (i.e., not pregnant) at the end of the breeding season. Obviously, then, culling decisions have an important potential influence on the physical and financial performance of the cow-calf operation.

For the purposes of this analysis, the culling rate parameter refers to the rate at which animals are regularly removed (on an annual basis) from the breeding herd. It therefore accounts for animals removed because of age, health, etc. Animals culled because they are "open" are accounted for separately, using the assumption that all such animals are removed and sold from the breeding herd; that is, the culling rate for open animals is 100%. Given the rationale behind culling, it is considered to be a managerial parameter in the current study and as such, is a deterministic parameter.

In practice, culling rates will vary greatly between individual producers and possibly from year to year for individual producers. However, for the purposes of the simulation analysis in this study, a single culling rate is used for all representative beef operations. This value was determined by calculating the cull rate for each herd size and then averaging the values for each herd size group. An overall average was calculated from these averages to obtain a single culling rate percentage for all representative farms. The culling rate[7] specified in the model was 10%; that is, 10% of the mature cows in the breeding herd were culled and sold each year.

4.4.7: Heifer Retention Rate

Heifer retention rate refers to the percentage of weaned heifers kept as potential replacements for culled cows in the breeding herd. It is assumed in this study that the primary source of replacement animals in the breeding herd is retained heifers. This assumption is deemed reasonable as retained heifers represent a secure and relatively inexpensive source (as opposed to purchasing bred heifers) source of breeding stock. As with the culling rate, the heifer retention rate was assumed to be a management parameter that is controlled and determined by the producer. As a result, it was modeled as a deterministic parameter.

The heifer retention rate is influenced by a number of factors, such as the culling rate, target breeding herd size, etc. The link between the culling rate and the heifer retention rate is fairly obvious, assuming that the place of culled cows is taken by replacement breeding stock. In the current analysis, the target herd size for each representative farm is assumed to be stable; that is, there is no intentional growth or contraction in the breeding herd. Therefore, the main determining factor for the heifer retention parameter is the culling rate. Given a culling rate of 10% and the assumption that 50% of the calf crop will be female, having a heifer retention rate that is twice as

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[7] Culling rates were initially calculated for each herd size. An inspection of the culling rates numerically for the various herd size were similar. As such a single culling rate parameter was used for all the herd sizes.

large as the culling rate would result in the number of replacements available being approximately equal to the need for replacements.

For the purposes of the current study, it is therefore assumed that the farmer retains 20% of the weaned heifer calves for replacement purposes. Obviously the exact balance regarding replacements will vary from year to year due to factors such as additional culling of open animals and death loss of heifers or cows. In instances where the supply of replacements exceeds the need in a particular year, excess bred heifers are sold. In cases where there is a "negative" balance, additional bred heifers are purchased.

4.4.8: Nutrient Requirement and Rations

During summer and parts of spring and fall, the main source of nutrition for weaned and mature beef animals is pasture. Young calves derive nutrition from a combination of pasture and milk. However, during the rest of the year, beef animals must be provided with a "winter ration" in order to meet requirements for maintenance, growth and/or pregnancy. The summer pasture requirements for the animals, along with the winter rations, represent model parameters for the beef enterprise. The per animal pasture and winter ration amounts are used, along with the number of animals present in any particular year of the simulation, to develop total feed requirements for the herd.

In Alberta, rations for beef animals vary greatly between individual producers, for a variety of reasons. Nutrient requirements (e.g., protein, energy) vary between animals based on age, gender, weight, breed, breeding status (i.e., open versus pregnant), etc.

Factors influencing the choice of feed ingredients to meet these requirements include climate[8], convenience, tradition, and cost.

This degree of variability creates a challenge in developing rations for the representative farms in this study. The AAFRD database has information about feeds for individual herds. However, the range of feed ingredients used and amounts of each ingredient fed varies greatly over the data base. As a result, developing representative rations for the various types of animals on the representative farms using these data was problematic.

Because of this problem, an alternative approach was used to develop rations. In particular, expert opinion was used. Dr. Erasmus Okine, an animal science professor in the Department of Agricultural, Food & Nutritional Science at the University of Alberta, was consulted regarding typical rations for beef animals in Alberta. Dr. Okine provided information on typical composition of rations (i.e., types of ingredients) and how much of each ration should be provided for the different animals on the farm. This information was used to develop rations that were deemed to be acceptable for use for the various regions. The rations developed using this method made use of ingredients that were consistent with those represented in the historical data from the AAFRD's database.

The daily rations for all types of beef animals present on the representative farms (i.e., mature cows, bred heifers, open heifers, bulls and calves) were calculated based on the information provided by Dr. Okine. A total dry matter intake (DMI) was specified for each type of animal. For example, it was assumed that DMI for a 1,000 pound cow was

[8] Climate influences ration formulation in a number of ways. It determines what crops can be grown and their resulting yields and the length of the grazing season and pasture quality. Climate even influences nutrient requirements (e.g., energy requirements would be higher in cold climates, due to higher maintenance requirements).

30 pounds. The total daily DMI was then apportioned to various ration ingredients; hay, silage, barley and straw. The proportions for the ingredients were determined in such a way to ensure that nutrient requirements for the animals were satisfied. Total daily DMI was scaled up or down for each class of beef animal, based on weight relative to the "base" 1000 pound beef cow. The relative composition of each ingredient within the different rations remained the same, however. The daily rations used in the simulation analysis, for each type of beef animal, are presented in Table 4-9.

Total winter feed requirements for each animal (and for the whole enterprise) were determined by a combination of the daily ration and the number of days on winter feed. Winter feeding is varied by geographic region due to differences in climate. Grazing periods were much longer in Southern Alberta than in the Northern regions represented by the Aspen Parklands and the Boreal/Peace Lowland region. In calculating the number of days on winter feed, these differences were taken into consideration.

Information about the length of grazing period for each sample farm is provided in the AAFRD database. In order to determine the length of the grazing period, and thus the length of time on winter feed, the information about grazing period for the observations used to define the representative farms was examined. It was assumed that there would be no significant difference in length of grazing period between herd sizes within a particular region.

Table 4-10 provides the average length of time for each period (i.e., winter feeding and pasture grazing), along with an indication of the variability in this measure, for the three regions. As can be seen, the length of the winter feeding period increases from south to north. While there is some variability in these measures, when compared to the magnitude of the average values, the variability between observations within a particular region is relatively low.

If the average days in each category are summed, the number of days does not add up to 365 days[9]. For the purposes of defining the length of time for grazing versus winter feeding in the simulation model, these values were adjusted to sum to 365 days, while maintaining the relative length of each period. This was done by dividing each average value by the summed total days for that region and then multiplying the resulting proportion by 365. The resulting values are provided in Table 4-11. These values were then incorporated and used in the simulation analysis, for each representative farm, in order to determine total feed and pasture requirements.

4.4.9: Beef Enterprise Costs

Beef enterprise costs are the non-feed input costs per animal used in the simulation analysis. These costs included veterinary and medicine, repairs allocated to the beef enterprise, bedding, trucking and marketing charges, fuel, utilities, custom work and specialized labor, breeding fees / bull rental and miscellaneous expenses. Information from the historical data was used to calculate the average cost per wintered cow for each region and each herd size.

The cost information provided by the historical data was a total cost for the enterprise. This therefore necessitated the calculation of the average cost per mature cow. It was assumed that these costs calculated included those of the other livestock (e.g. bred heifers, calves, bulls). This implied that the cost values calculated and used in the simulation are greater than the actual cost for a single cow; that is, it had costs for

[9] It is not clear why the days don't sum up to 365. This may be due to data input error or probably due to the calculations used for the various herd sizes (e.g., rounding up).

associated animals incorporated in the value. This was done for each representative farm to allow for cost per animal to vary across herd sizes and also to capture and account for any potential economies of size (i.e., decreasing average cost per cow with increased herd size). This approach also allows any regional cost differences to be reflected in the simulation analysis. The enterprise cost per cow was then multiplied by the number of wintered cows to obtain total enterprise costs for the farm.

The resulting cost per cow for each of the nine representative farms is provided in Table 4-12. In terms of herd sizes and region, the pattern exhibited in the costs is that the larger the herd sizes have lower average costs per cow. As can be seen from Table 4-12, in almost all the regions, the average cost of production per cow declines with increased herd size.

4.5.: The Cropping Enterprise Parameters

It was assumed that, along with the cow-calf enterprise, each of the nine representative farms also included cropping enterprises. The primary purpose of these cropping activities was to provide feed for the beef enterprise; that is, the output from crop production was an input into beef production. This assertion was supported by data from the sampled cow-calf producers. However, there was evidence from the farm data that these producers also typically grew crops for sale. These types of cropping activities were therefore also incorporated into the simulation analysis.

Three main types of parameters were required for modeling the cropping enterprises in the simulation analysis; acres of each crop, yield per acre and variable cost per acre. Since it was assumed that the farmers grew crops primarily to feed the beef animals, the main crops considered in the analysis were hay and barley, as well as silage. Crops assumed to be grown primarily for sale purposes were canola and wheat. While farm level information from the AAFRD database suggested that a number of different crops were grown by Alberta cow-calf producers (e.g., oats and rye), hay, barley, wheat, canola, and silage were the most common and therefore the analysis was limited to these five crop enterprises.

The information used to calculate the crop simulation model parameters came from historical observations in the AAFRD database. The following sub-sections provide discussion surrounding the calculation or estimation of crop acres, crop yields and crop costs.

4.5.1.: Crop Acres Grown

The crop acres grown were obtained from historical data as previously mentioned. From the historical data, crops were grown on owned or rented land. Acres chosen were based on what was typical for the alternative farms. For instance, if the majority of producers used owned land for a particular crop, then the acres specified in the model were the average owned acres from the AAFRD report. Likewise if the majority used rented land then those acres were used.

Since it was assumed that producers grow crops to feed the animals, the average acres grown for these crops were used as a starting point. These values were then adjusted if necessary to ensure that the farms were, on average, self-sufficient for feed requirements. To achieve this, the feed demanded and supplied for the first year was used as the starting point. The number of acres required to produce that amount of feed demanded by the animals to be at least self-sufficient was then established. This average therefore served as a benchmark for the rest of the years. Acres grown were made deterministic for the purposes of this analysis. The resulting crop acres used in the simulation analysis are presented in Table 4-13.

4.5.2.: Yield per Acre

Crop yields were assumed to be stochastic. The parameters for the probability distributions for each crop's yield were taken from the descriptive statistics contained in the summary reports generated from AAFRD **AgriProfit$** database for the 1995 -2002 time period. These reports contained means and standard deviations for each crop, by region. These means and averages were used because there were no data on yield observations for individual farms. As such, by using the means and standard deviations it was implicitly assumed that crop yields followed a normal distribution. Also implicit in the analysis was the assumption that crop yields did not vary by herd size; crop yield parameters varied by geographic region only. Table 4-14 presents the means and standard deviations by geographic region for each crop. The yields are in tons per acre.

4.5.3.: Crop Enterprise Costs

The crop cost structure included all of the variable costs associated with each crop enterprise. Costs for the enterprise were made up of expenses for seed, fertilizer, chemicals, hail / crop insurance and fuel. Also included were trucking and marketing, repairs, utilities and expenses as well as custom work and specialized labor. The costs associated with these variables were obtained from the summary reports generated from AAFRD **AgriProfit$** database for the period 1995 -2002 since there were no data provided for individual farms. Each per acre cost for each cost category was then multiplied by the total acres for the farm to generate the total enterprise cost for each variable. Tables 4-15 to 4-17 provide the costs per acre for each crop in each geographic region.

4.5.5.: Pasture

Pasture requirements were calculated based on expert opinion provided by Dr. Erasmus Okine an animal science professor in the Department of Agricultural, Food & Nutritional Science at the University of Alberta. Requirements were calculated for the different type of animals in the analysis, based on the intake of mature cows. Forage dry matter intake of grazing animals is affected by the body weight. A 1000-pound cow with a calf is the standard, defined as one animal unit (AU); one AU has a daily dry matter requirement of approximately 26 pounds of pasture forage. The amount of forage dry matter consumed in one month by one animal unit, a 1000-pound cow with a calf, is an animal unit month (AUM). To estimate accurate daily forage demand of the other livestock on grazing lands, metabolic weight of the animal was used. Metabolic weight is equal to $BW^{0.75}$, where BW is live body weight. The resulting animal units for each animal used in the simulation analysis are provided in Table 4-18. To calculate the monthly requirement for each type of animal, daily pasture intake was multiplied by the number of days in the month. Total monthly intake was also multiplied by the total months of grazing period in the year to get the actual total of pasture grazed in the year. This value was then used in the simulation analysis.

The acres, yield and costs used in the analysis for pasture grazing were from the summary reports generated from AAFRD **AgriProfit$** database for the 1995 -2002 time period, since there were no individual farm data available. As with the other crops grown purposely as feed for the animals, the average acres were adjusted if necessary to ensure that the farms were self-sufficient, on average. The acres used for the simulation for the various geographic regions are provided in Table 4-19.

Pasture yield was assumed to be stochastic. The parameters for the probability distributions for pasture yield were taken from the descriptive statistics contained in the summary reports generated from AAFRD **AgriProfit$** database for the 1995 -2002 time period. In using the means and standard deviations from these reports, it was therefore implicitly assumed that pasture yields were distributed normally. As with the other crops it was assumed that pasture yields did not vary by herd size but instead varied by geographic region only. Table 4-20 presents the means and standard deviations by geographic region for pasture. The yields are in AUM. Given the amount of pasture land on each farm, it is expected that the amount of pasture available for the representative herds will be sufficient; that is, the likelihood of shortage is minimal.

Pasture costs included all variable costs associated with the enterprise. Enterprise costs were made up of seed, fertilizer, chemicals, hail / crop insurance and fuel. Also included were trucking and marketing, irrigation fuel and electricity, repairs, utilities and expenses as well as custom work and specialized labor. The cost per acre was then multiplied by total pasture acres on the farm to generate the total cost. Table 4-21 provides the costs per acre for the silage crop in each geographic region.

4.6 Price Parameters

One set of parameters needed for the simulation analysis are prices, both crop and beef. These prices are used in the calculation of revenues (i.e., beef and/or crop sales) and costs (i.e., purchase of feed). Price uncertainty is an important source of risk for most agricultural producers, including beef producers. Therefore prices are included as exogenous, stochastic parameters in the current analysis.

Based on evidence from previous empirical research (e.g., Mohanty et al., 1996; Chang and Griffith, 1998; Bessler, 2005) prices were modeled using time series relationships. This implies that prices followed a certain pattern over time where the current year's price was influenced by previous prices. Statistical analysis was used to estimate time series price equations. In order to identify the appropriate pricing model, testing was conducted for stationarity, lag length selection and correlation of input and output prices. The following sub-sections provide a detailed presentation regarding the price data used, how the price data was analyzed and transformed, and the resulting pricing equations used in the simulation analysis.

4.6.1 Price Data

Estimation of the time series price relationships was conducted using historical price data for Alberta. Prices used for this analysis were obtained from the AAFRD AGDATA database for the period 1980-2002. Historical data included prices for weaned heifer and steer calves, slaughter cattle, bulls, barley and hay. These prices are used to represent sale and purchase prices for both livestock and crops.

With the exception of steer and heifer calves, all prices were provincial in nature (i.e., Alberta prices). Historical prices for heifer and steer calves were provided for Northern Alberta and Southern Alberta. However, no specific region definitions are available. It was decided that Southern Alberta prices would be used for the Southern Alberta representative farms whereas Northern Alberta prices would be used for representative farms in both the Aspen Parkland and Boreal Peace Lowland regions.

The price data were deflated to real values using the Consumer Price Index (CPI) for All-Items, with the base year being 1996. Prices for wheat and canola used for the analysis were obtained from the summary reports generated from the AAFRD **AgriProfit$** database for the year 1995-2002 time period. Wheat, canola and silage prices were not deemed to be as important to this analysis as hay and barley. Therefore, these prices were not included in the time series analysis. However, the prices were made stochastic by using the means, standard deviations, minimums and maximums provided from the AAFRD **AgriProfit$** database and were assumed to follow normal distributions. The historical price data obtained were on a monthly basis but were transformed into annual prices. Simple averages were calculated to generate the annual prices. This was done because the simulation was conducted using annual calculations. Also the price data were transformed into logs using natural logs. This approach prevented price forecasts from being negative (Hull, 1989).

4.6.2: Stationarity of the Price Data

A common assumption in many time series techniques is that the data are stationary; that is, the data are generated by a stationary process. A stationary process has the property that the mean, variance and autocorrelation do not change over time. If a time series of prices is stationary, then it follows a mean reverting pattern. Mean reversion is consistent with the idea that prices eventually move back towards an average or equilibrium value. This, in turn, provides direction in terms of the appropriate approach in modeling uncertain or risky prices.

While most time series statistical techniques require that data are stationary, in fact data are often non-stationary. If a time series is not stationary it can often be transformed into a stationary series through the use of a trend stationary process (TSP) or difference stationary process (DSP). However, before performing such a transformation it is first necessary to establish whether or not the original series is stationary.

A unit root test may be used as a diagnostic tool to test for stationarity. The results of this type of test provide guidance as to what type of forecasting model should be used for the price series. For example, a determination that the data are stationary might indicate that Ordinary Least Squares (OLS) regression can be used to estimate the price model parameters.

4.6.2.1: Unit Root Tests

Before proceeding with the estimation of the time series price models, the various beef and price series data used in this study were tested for stationarity. Specifically, Augmented Dickey-Fuller (ADF) tests and Phillips-Perron (PP) tests were used to test if the data exhibited stationarity. The test results also provide guidance as to what transformation should be performed in the event that the series is non-stationary.

The ADF test is implemented through the estimation of a regression equation. For a time series Y_t there are two alternative forms of the ADF regression equations, as follows:

$$(1)\ \Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \sum_{j=1}^{p} \gamma_j \Delta Y_{t-j} + \varepsilon_t \qquad (4.1)$$

$$(2)\ \Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2 t + \sum_{j=1}^{p} \gamma_j \Delta Y_{t-j} + \varepsilon_t \qquad (4.2)$$

where ΔY_t is the change in Y from time t-1 to time t, Δy_{t-j} is the lagged difference between the Y values at time t and t-j (i.e., lagged j periods), the α's and γ's are parameters to be estimated, and ε_t is assumed to be Gaussian white noise; that is, independent and identically distributed errors ($i.i.d$). Equation 4.1 assumes no trend in the time series while equation 4.2 has a time trend. The number of lagged terms p is chosen to ensure the errors are uncorrelated. The null hypothesis of the test is $\alpha_1 = 0$ which implies that the time series Y_t is non-stationary. Both versions of the ADF test are used for the price series in this study. The number of lagged terms, p, was not specified beforehand. As such, SHAZAM automatically sets the order to the highest significant lag order (SHAZAM, 1997).

As noted earlier, the Phillips-Perron unit root test was also employed to evaluate the stationarity of the series. Details of this test are provided by SHAZAM (1997). In brief, the Phillips-Peron method uses a non-parametric approach to calculate the unit root tests from regression equations with p=0. The statistics are then transformed to remove the effects of serial autocorrelation on the asymptotic distribution of the test statistic (SHAZAM, 1997).

4.6.2.2: Unit Root Test Results

The results of the ADF and PP unit root tests for the price series from Southern and Northern Alberta are provided in Table 4-22. The ADF and PP statistics used in the test are negative numbers. The more negative the values, the stronger the rejection of the hypothesis that there is a unit root at some level of confidence. The critical test statistic value for both the ADF and PP tests, at a 5 percent level of significance, is -2.86 for the model without a trend variable, and -3.41 for the model with a trend variable.

The results for the two tests and two models are consistent for steer and heifer calves in both Northern and Southern Alberta; specifically, the null hypothesis of unit root behavior is rejected in all cases. For the other prices (slaughter cattle, bull, barley and hay), the results are mixed, with the null hypothesis not being rejected in at least one test-model scenario. However, overall the pattern is generally consistent with rejection of unit root behavior. As can be seen from the table, results for slaughter cattle, bull, barley and hay all reject the null hypothesis of unit root test in at least one of the models used for the test. As a result it was concluded that none of the price series had unit roots, indicating that the prices used will likely follow a mean reversion pattern.

In evaluating these results it should be noted that commodity prices have often been found to be non-stationary in previous research. For example, Unterschultz (1996) determined that Alberta steer prices were non-stationary. Fabiosa (1999) also tested price variables for unit roots and concluded that price series for beef and wheat were non-stationary. The different conclusion in this case may simply be attributed to the differences in data used for the analysis. Since there was no unit root behavior found in the beef, barley and hay prices, it can be concluded that the prices mean-revert and that logged price data and OLS regressions may be used to estimate the coefficients, given no autocorrelation.

4.6.3: Autoregressive Price Models

Given that the time series of prices are stationary, an autoregressive (AR) approach is used to model stochastic prices in the current study.[10] The use of an AR model requires the assumption that current price is a function of own lagged prices. Autoregressive models are used widely in forecasting throughout economics and finance and have proved so successful and difficult to outperform that they are often used as benchmarks in forecast competitions (Pesaran and Timmermann, 2003). Due in large part to their parsimonious form, autoregressive models are normally found to produce only minor forecast errors when compared to those associated with models allowing for more complex nonlinear dynamics or additional predictor variables (Pesaran and Timmermann, 2003).

In this study, linear AR models are used for beef and crop prices. An autoregressive of order p $(AR(p))$ may be written as follows:

$$y_{t+1} = \mu + \alpha_1 y_t + \ldots.. + \alpha_p y_{t-p+1} + \varepsilon_{t+1} = \mu + \alpha(L) y_t + \varepsilon_{t+1} \quad (4.3)$$

where y_t is the value of the relevant variable at time t, $(\mu., \alpha_1, \ldots.., \alpha_p)$ are unknown parameters, L is the lag operator, $\alpha(L)$ is the lag polynomial, and ε is the independently and identically distributed $(i.i.d)$ error term. If y_t is observed at all dates, $t = 1, \ldots., T$, and is stationary, these parameters are readily estimated by ordinary least squares (OLS). The

[10] The single equation autoregressive (AR) model used in this study is a building block for the vector autoregressive (VAR) model that has enjoyed extensive use (Bewley, 2000) in empirical economic analysis. The fundamental difference between AR and VAR models is that the latter captures interactions between variables allowing for a much richer dynamic structure and causal relationships between the fitted and the forecast periods. The AR model approach is chosen over the VAR approach in this study because the AR approach is easier to estimate and explain. Also it was assumed that the random errors in the equation system follow the same AR path, meaning they have same autocorrelation coefficient.

stationarity of the data will also enable the lag length to be determined.

4.6.3.1: Lag Length Selection

A critical element in the specification of AR models is the determination of the lag lengths. The importance of the lag length determination is demonstrated by Braun and Mittnik (1993) who show that the estimates of a VAR whose lag length differs from the true lag length are inconsistent as are the impulse response functions and variance decompositions derived from the estimated VAR. Lutkepohl (1993) indicates that overfitting (i.e., selecting a higher order lag length than the true lag length) causes an increase in the mean-square-forecast errors of the VAR and that underfitting the lag length often generates auto-correlated errors.

The lag length is frequently selected using an explicit statistical criterion such as the Akaike's Information Criterion (AIC), Schwarz's Criterion (SC), coefficient t-tests, or adjusted R^2. The lag selections considered in this analysis are determined using Akaike's information criterion (AIC) and Schwarz's criterion (SC). The lag length is selected by choosing the lag that results in the minimum value for the AIC or SC test statistic. Judge et al. (1998) discuss these criteria, which may be calculated as follows:

$$AIC(n) = \ln \tilde{\sigma}_n^2 + 2n / T \quad (4.4)$$

$$SC(n) = \ln \tilde{\sigma}_n^2 + n \ln T / T \quad (4.5)$$

where is $\tilde{\sigma}_n^2$ the residual variance, n is the number of lags and T is the number of observations. The criteria uses a rigorous framework of information analysis to quantify the relative goodness-of-fit of previously derived statistical models, given a sample of data. The AR equations are modeled and then the residual variance is calculated. For each lag, the test statistic is then calculated.

The results from the tests for optimal length of lag for both Southern and Northern Alberta prices are presented in Table 4-23. These results indicate that the optimal lag lengths for steer, heifer and hay prices are AR (1); that is, current price is best explained by the previous year's price. For the rest of the prices (i.e., slaughter cattle, bulls and barley) the optimal lag is AR (3). For these commodities, current price is explained by the previous three year's prices.

The results from the AIC and SC tests are consistent, with one exception. The optimal lag length implied by the AIC test is AR (3) while the result from the SC test suggests AR (4) would be best for bull prices. This difference occurs for both Southern and Northern Alberta prices. In cases where the results from these two tests differ, the AIC is considered to be the "stronger" of the two criteria (Bewley, 2000). For this reason, an AR (3) model is used for bull prices.

4.6.3.2: Testing for Autocorrelation

Different definitions of autocorrelation are in use depending on the field of study. In statistics, the autocorrelation function (ACF) of a random process describes the correlation between the processes at different points in time. In regression analysis using time series data, autocorrelation of the residuals (error terms) can be a problem leading to an upward bias estimate of the statistical significance of coefficient estimates such as the t-statistics. The traditional test for the presence of first-order autocorrelation is the Durbin-Watson statistics. Under the null hypothesis of no autocorrelation, the test statistic is asymptotically distributed as χ^2 Responses to autocorrelation include differencing of the data and the use of lag structures in estimation.

SHAZAM recommends that the Lagrange Multiplier Test (LM-stat) be used when lagged dependent variables are included. The LM-stat tests for residual autocorrelation. In SHAZAM, the tests for serial correlation in the residuals use the autocorrelation function. The command then produces an LM tests for serial correlation for the various price variables.

The LM-stat for Southern and Northern Alberta prices is provided in Table 4.24. The LM-stat identified autocorrelation for all but heifer prices from Southern Alberta and Northern Alberta and slaughter cow prices. The LM tests indicate that autocorrelation exists in the series for Southern and Northern Alberta steer price serror term at lag 1 up to 15 and 14, respectively. For bulls, autocorrelation existed in the error term at lag 1 up to 23 while that for barley and hay were from 1 up to 15 and 23, respectively. The LM-stat for steer prices in Southern and Northern Alberta, bulls, barley and hay are all greater than the 5% critical chi-square value of 3.84.

Given the results of these two tests, it was concluded that the data display serial autocorrelation in the error terms for steer, bull, barley and hay prices. For example, test results suggest autocorrelation in the 15 and 14 lag for steers in the Southern and Northern Alberta regions, respectively. Even if autocorrelation is present in the error terms of an OLS regression the resulting coefficient estimates are unbiased. However, the OLS estimates are inefficient. As a result, the AR (n) model, in which estimates are asymptotically efficient, will be used instead.

4.6.3.3: Single Price Equation Model

The presence of serial auto correlation implies that the error terms for each price variable have different autoregressive lag structures and can therefore not be estimated as a system of equations. Single equation price models were therefore estimated. The data were corrected for the serial auto regression before generating different coefficient estimates for the AR (n) model. This was achieved by using SHAZAM econometric program. The Auto command function was used to correct for this problem. For example, in Table 4-24, the LM tests indicate that autocorrelation exists in the steer for Southern and Northern Alberta error term lag 1 up to 15 and 14, respectively. In the SHAZAM program the order was therefore set to 15 for Southern Alberta and 14 for Northern Alberta. That is, the error term was lagged 15 times for Southern Alberta and 14 times for Northern Alberta. The same approach was used to correct the other prices. Using the correct lag structures for all the price variables, estimates of the coefficients were generated using AR (1) for steer, heifer and hay prices and AR (3) for slaughter, bulls and barley prices. It must be noted that in situations where autocorrelation exists for all 23 lags, specifically for bull and hay, in estimating the coefficients the order was set to the highest maximum possible.

Prices were assumed to be stochastic in the simulation model. As a result, random draws for the "error term" were used to model the stochastic element in the time series relationships for prices. However, prices for different commodities are often correlated with each other. If significant correlations between prices exist, these statistical relationships should be incorporated into the calculation of simulated prices.

The sample correlations between all price variables for Southern and Northern Alberta are provided in Tables 4-25 and 4-26, respectively. The results indicate a strong relationship between the various beef prices. There was also a strong relationship between the crop prices. In modeling the beef price equations for each price therefore, the prices of the other livestock were included in the model. Likewise, in modeling the crop price equations, the prices of the other crops were included in the model.

The equations for the stationary price models were estimated as follows:

$$P_t^{HE} = \gamma_0^{HE} + \gamma_1^{HE} P_{t-1}^{HE} + \beta_S P_{t-1}^{S} + \beta_C P_{t-1}^{C} + \beta_B P_{t-1}^{B} + \varepsilon_t^{HE} \tag{4.6}$$

$$P_t^{S} = \gamma_0^{S} + \gamma_1^{S} P_{t-1}^{S} + \beta_{HE} P_{t-1}^{HE} + \beta_C P_{t-1}^{C} + \beta_B P_{t-1}^{B} + \varepsilon_t^{S} \tag{4.7}$$

$$P_t^{B} = \gamma_0^{B} + \gamma_1^{B} P_{t-1}^{B} + \gamma_2^{B} P_{t-2}^{B} + \gamma_3^{B} P_{t-3}^{B} + \beta_C P_{t-1}^{C} + \beta_S P_{t-1}^{S} + \beta_{HE} P_{t-1}^{HE} + \varepsilon_t^{B} \tag{4.8}$$

$$P_t^{C} = \gamma_0^{C} + \gamma_1^{C} P_{t-1}^{C} + \gamma_2^{C} P_{t-2}^{C} + \gamma_3^{C} P_{t-3}^{C} + \beta_B P_{t-1}^{B} + \beta_S P_{t-1}^{S} + \beta_{HE} P_{t-1}^{HE} + \varepsilon_t^{C} \tag{4.9}$$

$$P_t^{H} = \gamma_0^{H} + \gamma_1^{H} P_{t-1}^{H} + \beta_t P_{t-1}^{BA} + \varepsilon_t^{H} \tag{4.10}$$

$$P_t^{BA} = \gamma_0^{BA} + \gamma_1^{BA} P_{t-1}^{BA} + \gamma_2^{BA} P_{t-2}^{BA} + \gamma_3^{BA} P_{t-3}^{BA} + \beta_H P_{t-1}^{H} + \varepsilon_t^{BA} \tag{4.11}$$

where P_t is the current price, P_{t-1} is the previous year's price, P_{t-n} is the price lagged n times, γ_0 represented the constant, γ_1 through γ_n were the coefficients on the lagged price terms whiles β_{HE}, β_S, β_C, β_B, β_H, β_{BA} represent the estimated coefficients of the other prices in the specific price equations. HE, S, B, C, H and BA represent heifer, steer, bull, slaughter cattle, hay and barley, respectively.

The parameter estimates for the for the AR (n) price equations for steers (Southern and Northern Alberta) and other livestock are presented in Table 4-27. With the exception of the natural log of bull prices, the p-values indicate that the estimated coefficients are significant. An R-Square value of 0.9656 and 0.9405 respectively, for

Southern and Northern Alberta suggests that over 90% of the variation in the dependent variables in each case is explained by the independent variables. Clearly, this is a strong relationship.

The parameter estimates for the for the AR (n) price equations for heifers (Southern and Northern Alberta) and other livestock are presented in Table 4-28. The same explanation as in the case of steer prices applies to heifer prices. The p-values indicate that the estimated coefficients were all significant with the exception of bull. Again, an R-square of 0.9479 and 0.9512 indicates that over 90% of the variance in the dependent variables was explained by the independent variables.

The parameter estimates for bull price indicate that the estimated coefficients are statistically significant. However, the estimated coefficients for steer and heifer prices are not statistically significant. This is presented in Table 4-29. In the case of the slaughter cattle, the estimated coefficients are all significant, as is the case of other livestock. In both cases the R-square suggests that over 95% of the variation of the dependent variable is explained by the independent variables.

The estimated coefficients for both hay and barley are all statistically significant. The results are provided in Table 4-30. The R-square of 0.9783 and 0.9808, respectively, for hay and barley indicate that the variations in the dependent variables were strongly explained by the independent variables.

The standard errors of the individual equations are provided in Table 4-31. The standard error for each specific price equation is multiplied by the randomly generated draws and used in calculating the simulation analysis.

4.6.4 Testing the Price Equations

The price equation estimates were tested to assess their accuracy and appropriateness for use in the simulation model. Monte Carlo simulations of 10000 draws were used to evaluate performance of the price model over a ten year period. The minimum, maximum and average simulated prices for each commodity were calculated and compared to the equivalent values for historical real prices over the period 1980 to 2002. The starting price used for the simulation was the year 2002. The historical and forecast values for both Southern and Northern Alberta are reported in Tables 4-32.

In order to ensure that the simulated values and the real values are similar in nature, a test of equality of Mean and Variance was conducted using SHAZAM (1997). The null hypothesis tests whether the means of the variables, likewise the variance of the real and simulated prices, are significantly different. The results from the test are provided in Table 4-33. The t-statistic was tested at a 5% critical level. In all cases, the null hypotheses of equal means and variances were not rejected as the calculated values did not exceed the critical value of 1.96. This is also evident from the p-values. It can therefore be concluded that the autoregressive model AR (n) is performing well and is appropriate for use in the cow-calf simulation model.

4.7: Model Structure and Calculations

4.7.1: Beef Population Dynamics

The "heart" of the biophysical part of the simulation model is the section dealing with calculations related to the beef enterprise. At the start of each simulated year there are beginning numbers for each category of beef animal; mature cows, bred heifers, yearling heifers and bulls. These values are used, along with beef enterprise parameter values to calculate changes in numbers of animals through the year.

Birth rate values for mature cows and bred heifers are drawn from the pre-specified distributions in the model. These are then multiplied by the number of cows and heifers, respectively, to calculate the number of calves born for that year. The ratio of heifer calves to bull calves born is assumed to be 1:1. When the number of calves born is odd (versus even), the extra calf is assumed to be a bull. In the event that the birth rate results in a non-integer number of calves, the figure is rounded to an integer value accordingly, using standard rounding practices.

Weaning rate values are also drawn from pre-specified distributions. These values are multiplied by the numbers of calves to calculate the number of weaned calves at the end of the summer. The difference between the number of calves born and the number weaned represents death loss for calves. Death losses between calving and weaning are assumed to affect heifer and bull calves equally.

Weaning weight values for heifer and bull calves are drawn from pre-specified distributions to determine the average weight of weaned animals for that year.[11] A certain number of weaned heifer calves are kept for breeding purchases. This number is calculated using the heifer retention rate parameter; that is, 20 percent of weaned heifers are kept as potential replacement breeding animals. These animals become yearling heifers. The remaining female weaned calves and all weaned bull calves are sold for beef. The average weights per animal (i.e., the values for heifer and bull calves) are multiplied by the numbers of animals sold to calculate total sold weight.

[11] An implicit assumption of the model is that all weaned bull calves are sold as steers.

Beginning yearling heifers are those female calves kept for breeding purposes from the previous year. These heifers are then bred during the current year. The number of heifers that become pregnant is determined by multiplying the number of yearling heifers by the conception rate value for bred heifers drawn from the pre-specified distribution in the simulation model. At the end of the current year these animals are now considered bred heifers. Any "open" heifers (i.e., those not pregnant) are assumed to be sold by the farmer by the end of the current year.

Beginning bred heifers, once they have calved, are assumed to move into the breeding herd as mature cows. These animals, along with the existing mature cows are bred during the current year. The number of pregnant animals is determined by multiplying the number of cows by the conception rate value for mature cows drawn from the pre-specified distribution in the simulation model. Any "open" cows are assumed to be sold by the farmer by the end of the current year.

The target number of cows to be culled is determined by multiplying the pre-specified culling rate (i.e., 10 percent) by the number of cows in the herd. This number is compared to the number of open cows from the breeding calculations. If the number of cows to be culled is greater than the number of open cows, then additional bred cows are sold to make up the difference. If the number to be culled is less than the number of open cows, then the total culled is equal to the total number of open cows (i.e., the cull rate for that year will be greater than 10 percent).

Since an assumed objective of the farmer is to maintain a constant herd size, any cows leaving the herd are replaced by bred heifers. The total number of cows being culled in the current year is compared with the number of new bred heifers (i.e., yearling heifers from the beginning of the year that are now pregnant). If the number of new bred heifers is greater than the number of culled cows, then the excess bred heifers are sold. If the opposite is true, then additional bred heifers are purchased to make up the difference.

The final beef herd population calculation is death loss over winter. The ending numbers of mature cows, bred heifers and yearling heifers are multiplied by the death loss parameters drawn from the pre-specified distributions. The resulting numbers represent the animals that die over the winter period between the current year and next year. The death losses are subtracted from the year ending numbers to obtain the beginning herd population distribution for next year. In the case of bull replacement, since bulls are such a small part of the beef enterprise, it was assumed that bulls will be purchased periodically at every three years. This replacement therefore was included in the simulation analysis.

4.7.2: Crop Production

Crop production is an important part of the overall simulation model. One of the underlying assumptions in the model was that farmers produce feed for their animals. Feed crops included in the analysis are hay, barley and silage. Crops grown specifically to generate direct crop revenues include canola and wheat. Crop production is modeled by drawing yields from pre-specified distributions and then multiplying each yield by the pre-specified number of acres for the corresponding crop. The resulting product represents total production for that crop for the current year.

4.7.2.1: Feed Balance

Feed balance is the difference between the amount of feed required by the beef enterprise and the amount produced from the crop enterprises. Total feed required for each ration ingredient is calculated by multiplying the amount specified per animal in the appropriate ration by the number of animals in each beef animal category (e.g., cows, calves) and the number of days in the year the animal stays on that feed. This is then summed over the beef animal categories to obtain total feed requirements.

As discussed earlier, hay and barley and silage are grown primarily for use as ration ingredients in the beef enterprise. Within the simulation model, total production of these crops is compared to total feed requirements for these ingredients. This is done using a feed balance calculation. In the event that requirements exceed production for either of these crops/ingredients, it is assumed that the producer will purchase feed to make up the shortage. However, if there is surplus of hay, silage or barley due to production exceeding requirements, the producer is assumed to store at least some of the surplus for use in the next year.

The maximum proportion of surplus feed in any one year carried over to the next year is a managerial parameter in the simulation model. Obviously, the proportion of excess feed production stored will vary from producer to producer. An arbitrary decision was made, for the purposes of this analysis, that a producer would carry over or store 80 percent of any annual surplus production of feed crop for potential future use. The remaining 20 percent of the surplus is assumed to be sold.

The maximum excess amount of any feed crop that will be stored by the producer is also specified as a model parameter. Again, this is a managerial parameter and will likely vary significantly between producers. For the purposes of this analysis, it is assumed that an individual producer will never store excess feed ingredients totaling more than 100 percent of the expected annual requirement for a particular feed. For example, the amount of hay required for winter feed in a particular year of the simulation represents the upper limit on the amount of excess hay production that would be stored by a producer. Any surplus over and above that amount is assumed to be sold.

Feed storage may be considered as a form of risk management; that is, maintaining reserves.[12] The degree of feed storage used by each of the representative farms is one type of risk management strategy considered in the analysis in this study. As a result, the assumption of 80 percent of surplus feed being stored by the producer is varied in the simulation analysis, as discussed below in the section outlining the risk management strategies. In the case of pasture, as mentioned previously, it is expected that the amount required for the herd size will be enough and the likelihood of shortage, even if there is will be minimal.

4.7.3: Economic Calculations

4.7.3.1: Revenue Calculations

Revenue is calculated for both beef and crop enterprises. Revenue from weaned animals is calculated as number of animals sold multiplied by average weight per animal multiplied by the price for the current year, where prices are calculated using the pre-specified stochastic price equations for heifers and steers. These values are then summed over heifers and bulls.

[12] To be clear, producers are assumed to always store feed for use during the upcoming winter feeding season. The reserves referred to here are for potential use in the subsequent year.

Revenue from sale of each category of breeding stock (i.e., open heifers, excess bred heifers, culled cows) was calculated as the number of animals sold multiplied by the pre-specified average weight per animal multiplied by the price for the current year, calculated using the pre-specified stochastic price equations. These values are then summed over the categories to obtain total breeding stock revenue.

Crop revenue is calculated as total production of crops grown for sale multiplied by the pre-specified price, summed over the crops, plus the amount of surplus feed crops sold multiplied by the price for the current year, where the price is calculated using the pre-specified stochastic price equations. These values are then summed over all crops to get total crop revenue.

4.7.3.2: Cost Calculations

The non-feed beef costs are calculated by multiplying the number of animals in each category at the beginning of the current year by the appropriate pre-specified non-feed variable cost per animal. These values are summed over the different animal categories to get total non-feed beef cost. Purchased feed costs, if any, are calculated as the amount of ration ingredient purchased, multiplied by the feed price for the current year, where the price is calculated using the pre-specified stochastic price equations. These are summed over all feed ingredients to obtain total purchased feed cost. Crop costs are calculated as the acres of each crop multiplied by the pre-specified cost per acre, summed across crops.

4.7.3.3: Gross Margin Calculations

Revenue from all sources (i.e., weaned animals, breeding stock and crops) is summed to obtain total farm revenue. All beef costs, including non-feed and purchased feed, are summed along with crop costs to obtain total variable costs. Total farm revenue minus total farm variable costs is equal to farm gross margin.

4.8: Risk Management Strategies

This section provides a discussion of the risk management strategies considered in the current study. The initial farm risk management scenario is referred to as the BASE scenario. Using the BASE scenario as a starting point, three different risk management strategies are identified and modeled using stochastic simulation analysis; participation in CAIS, feed storage, and heifer retention. In the following sub-sections, each of these strategies is introduced and explained in turn.

Participation in CAIS represents the use of a public safety net program by the cow-calf producers. The other two strategies, conversely, are private (versus public) in nature. Feed storage involves varying the degree to which the farmers store excess feed production for future use, versus selling any excess production. This is a form of holding reserves.[13] Heifer retention refers to whether or not the farmer retains female calves for use as breeding stock versus purchasing all replacement breeding stock. As such, this strategy is a form of vertical integration.

Besides the use of individual strategies, each of the two private strategies are considered, in turn, in combination with participation in CAIS. This is done to examine

[13] As noted earlier, constant in the analysis is the assumption that producers store sufficient feed for the current year. The reserves referred to in this strategy are for potential use in the subsequent year.

the degree to which CAIS may be complementary or redundant relative to private risk management strategies.

4.8.1: BASE Scenario

As noted above, the BASE scenario is the initial risk management scenario modeled for each representative farm. The results from this scenario are used as benchmarks against the other strategies. For the BASE scenario, the farmer is assumed to not implement any explicit risk management strategy, such as participation in safety nets. However, this is not to say that the BASE scenario does not involve any risk management elements at all, as discussed below.

As noted earlier, it is assumed in the base model that the representative cow-calf producers store some excess feed for use in future years; specifically, 80 percent of excess feed is stored for future use, up to a maximum of 100 percent of total annual expected requirements. Thus, the BASE scenario does assume a degree of risk management through holding of feed reserves. This managerial parameter (i.e., the assumption of 80 percent) is varied in the feed storage strategies to examine the impact of feed storage on performance and risk management.

Similarly, in the base model, the cow-calf producers are assumed to retain 20 percent of heifer calves for use as replacement breeding stock. This is an implicit risk management strategy, whereby the cow-calf operator is using a form of vertical integration (as discussed in Chapter 2). This managerial parameter is varied, when examining and discussing heifer retention as a risk management strategy in the sub-section below.

4.8.2: CAIS Scenario

The CAIS scenario involves participation in the program by the producer. The protection level chosen for the simulation was 85%, which implied that if the farm operator participated in the CAIS program and the level of returns fell below 85% of their average level of returns, a payment was triggered. This level of protection represented the second and third tiers of the CAIS program.

In order to calculate an initial reference margin, five historical margins were needed. To obtain these, simulation calculations were done to generate five years of data points. The simulation model for the base scenario was first run over the ten year time horizon. The simulated gross margins from this run were then used to generate a mean and standard deviation. This process was repeated for each of the representative beef operations.

The resulting gross margin mean and standard deviation were used to generate historical values for the five years previous to the start of each simulation run; that is, for each iteration of the model, five values were drawn from this distribution and used to calculate the initial reference margin for CAIS participation. As such each time the model started a new ten year simulation, a different set of values for the historical gross margins were generated and used.

As discussed earlier in the review of risk management strategies, payouts from the CAIS program "kick in" if the producer's program margin falls below the 85% protection level. In particular, CAIS payments received by the producer are calculated in this manner; if the producer's margin is between 70% and 85% of the reference margin, the deficit will be made up through a combination of producer withdrawals (30% of the total difference) and government funds (70% of the total difference) to bring the producer back up to 85% of the reference margin. This is Tier 2 of the CAIS program.

If the producer's margin is less than 70% of the reference margin, the difference between the program margin and 70% of the reference margin will be also be made up through a combination of producer withdrawals (20% of the difference in this case) and government funds (80% of the difference) to bring the producer up to 75% of the reference margin. This is Tier 3 of the CAIS program. The remaining difference (i.e., from 70% up to 85% of the reference margin) will be made up as per the discussion above concerning Tier 2.

Protection in each tier requires producers to contribute to the pool of funds for producer withdrawals. To secure protection for Tier 3, the producer must deposit a dollar amount equal to one-third of 20% of the reference margin that falls within this tier. If the producer wants to secure protection for Tier 2 in addition to Tier 3, then the producer will be required to deposit an additional dollar amount equal to one-third of 30% of the reference margin that falls within this tier. Finally, if the producer wants to secure protection for Tier 1 in addition to Tiers 2 and 3, then the producer will be required to deposit additional dollar amount equal to one-third of 50% of the reference margin that falls within this tier.

4.8.3: Feed Storage

As discussed earlier, an assumption made in the simulation analysis for the BASE scenario is that up to 80 percent of excess crop production intended for use as feed (i.e., production over and above the amount required for rations in the current year) is stored for future use. The practice of storing feed can be construed as a form of risk management. In particular, it is a form of holding reserves against the possibility of reduced availability of feed in future years. Given the importance of feed costs in determining profit levels for cow-calf production, this is a potentially significant strategy.

In this study, the effectiveness of feed storage as a risk management strategy is assessed by simulating alternative feed storage scenarios in which the level of feed reserves maintained by the producer is varied. In this way, the analysis addresses the question of whether the producer is better off maintaining feed reserves or whether he/she would be just as well off by selling excess feed and buying in times of shortage. In order to examine this question, two feed storage strategies were modeled to compare against the BASE strategy. A scenario called 100% Feed Storage is modeled, in which the producer stores all excess feed production from the crop enterprise for future use (again, up to the limit of having a full year's requirement of feed in storage). This represents a more "extensive" version of the risk management strategy as modeled in the base scenario.

An alternative scenario, called No Feed Storage, is also modeled. In this scenario the farmer does not retain any excess feed beyond current year requirements but rather sells it all to generate additional income. In years when crop production is insufficient to meet the ration ingredient requirements, additional feed is purchased at current market prices. The results from these two scenarios are compared with each other and with those for the BASE scenario in order to assess the impact of feed storage on performance.

4.8.4: Heifer Retention

Within the BASE scenario it is assumed that the cow-calf producer retains 20 percent of heifer calves for use as replacement animals in the cow herd. There are costs associated with this practice, in terms of feed, bedding, etc. for the animals as they grow from calves to yearling heifers to bred heifers. As well, there is lost revenue because these heifers are not sold as weaned animals. However, the benefit of this practice is that the producer does not have to rely on purchased animals for replacement breeding stock. If the producer were to sell all heifer calves, then he/she would face additional risk associated with the availability and cost of these replacement animals. Heifer retention, therefore, is a form of risk management. In terms of classifying this strategy, it may be considered as a form of vertical integration, in that it integrates an additional part of the overall process of producing beef into the cow-calf operation.

In order to assess the effectiveness of heifer retention as a risk management strategy, an additional heifer retention scenario is modeled. This strategy, called No Heifer Retention, assumes that no heifer calves are retained by the producer. Instead, all weaned calves are sold. All replacement animals (i.e., bred heifers) are purchased by the producer at current market prices. The results from this scenario are compared to those from the BASE scenario.

4.8.5: Combination of CAIS and all Risk Management Strategies Employed

In reality, it is likely that producers do not consider single risk management strategies, but instead look at combinations of risk management strategies. This may be particularly true for public versus private strategies. For example, some producers may use private strategies while participating in public safety net programs. A relevant consideration, then, is whether this would result in "better" management of risk, or whether there is some redundancy in terms of risk management. In other words, do public safety net programs duplicate, to a certain extent, the protection that is potentially provided by private strategies? This question is addressed in the current study through the modeling of combinations of risk management strategies.

For each representative farm, two additional "combination" scenarios were modeled. In each case, the combination included participation in CAIS plus one of the other risk management scenarios described earlier in this section. The combination risk management strategies were:

- CAIS and No Feed Storage
- CAIS and No Heifer Retention

The results from these combination scenarios are compared to the individual scenarios to determine effectiveness and the degree to which adding a second (private) risk management strategy on top participation in CAIS improves the degree of "protection" against risk.

4.9: Evaluation of Risk Management Strategies

As discussed earlier, each risk management scenarios is modeled for the representative farms using stochastic dynamic simulation methods. Each scenario was simulated 10000 times over a ten year time horizon. The "results" from each simulation run were distributions of annual gross margin. These distributions were then compared and evaluated to determine the impact of the various risk management strategies on firm performance.

The criterion used to evaluate the risk management strategies were based on the theoretical discussion from Chapter 3; specifically, Expected Utility theory. As discussed in that chapter, under certain assumptions maximization of expected utility is equivalent to maximization of certainty equivalent (CE) which may be expressed as follows:

$$CE = E(\pi) - \frac{r}{2}V(\pi) \tag{4.21}$$

where π is profit (or gross margin, in the case of the current study), E() is the expected value and V() is the variance. The parameter r is a measure of absolute risk aversion. Assuming risk averse behavior (i.e., $r > 0$), then higher values of expected profit and/or lower values for the variance of profit would result in greater expected utility. This tradeoff between risk and return is used to assess the impact of risk management strategies on the performance of the various risk management strategies.

If a single measure of performance were calculated from the simulation results, then this framework could be implemented through the use of some type of risk efficiency criterion (e.g., E-V criterion), whereby the expected value and variance for each scenario could be directly compared. However, the results of the simulation analysis in this study are expected values and variances for gross margin in each of the ten years of the analysis. Therefore, a different approach is required.

An ad hoc visual examination is used to implement the E-V framework for the risk management strategies in this study. The averages and variances for annual gross margin are used to calculate 95% confidence intervals over time for each scenario. These are presented in tabular and graphical form. These confidence intervals are then compared between scenarios to assess the effectiveness of each strategy. Obviously, a strategy that provides higher expected profit and lower variance of profit in each of the ten years will clearly be preferred by a risk averse producer. However, in cases where expected profit and variance are either higher or lower, or if the pattern changes over the ten years, then a subjective assessment of the tradeoff is required. In presenting the simulation results in the next chapter, these tradeoffs (when they occur) are noted and discussed, and a subjective assessment is provided.

4.10: Chapter Summary

This chapter provides a detailed discussion of the empirical methods used in this study. Specifically, the process of defining the representative farms, and the resulting characteristics of these farms are provided. The methods used to develop the various parameters required for the simulation model are presented, along with the values for these parameters. Details regarding the structure of the model, in terms of the calculations made using the model parameters, are presented and discussed. Finally, the risk management scenarios modeled using the simulation model, along with the evaluation criteria used to assess the performance of these strategies, are presented and discussed. The results from implementation of these empirical methods are presented and discussed in the next chapter.

Figure 4-1: Histogram of Wintered Cows for Producers in Southern Alberta, from 1999, 2000, and 2002

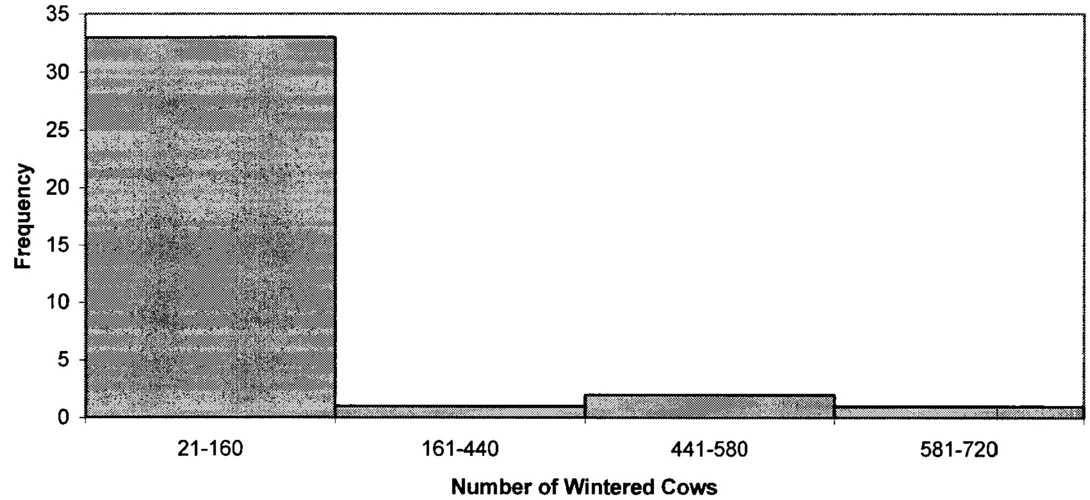

Figure 4-2: Histogram of Herd Sizes between 21 and 160 for Producers in Southern Alberta, from 1999, 2000, and 2002

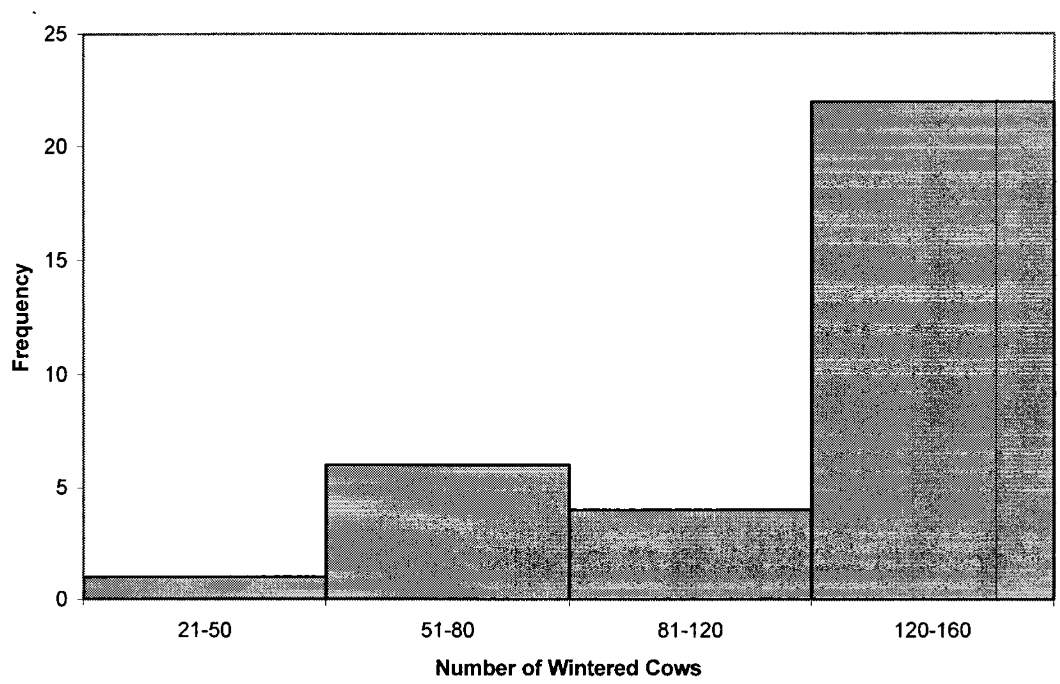

Figure 4-3: Histogram of Wintered Cows for Producers in Aspen Parklands, from 1999, 2000, and 2002

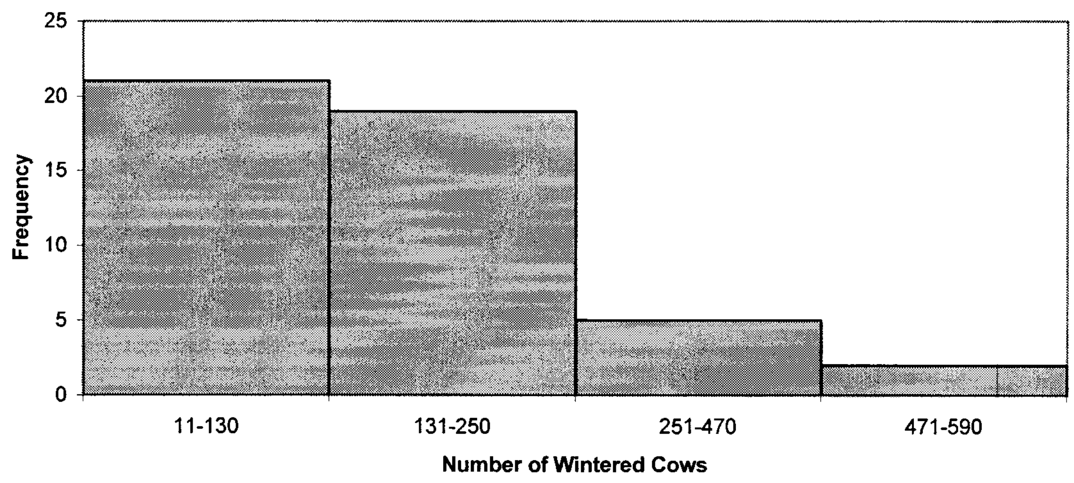

Figure 4-4: Histogram of Herd Sizes between 11 and 250 for Producers in Aspen Parklands, from 1999, 2000, and 2002

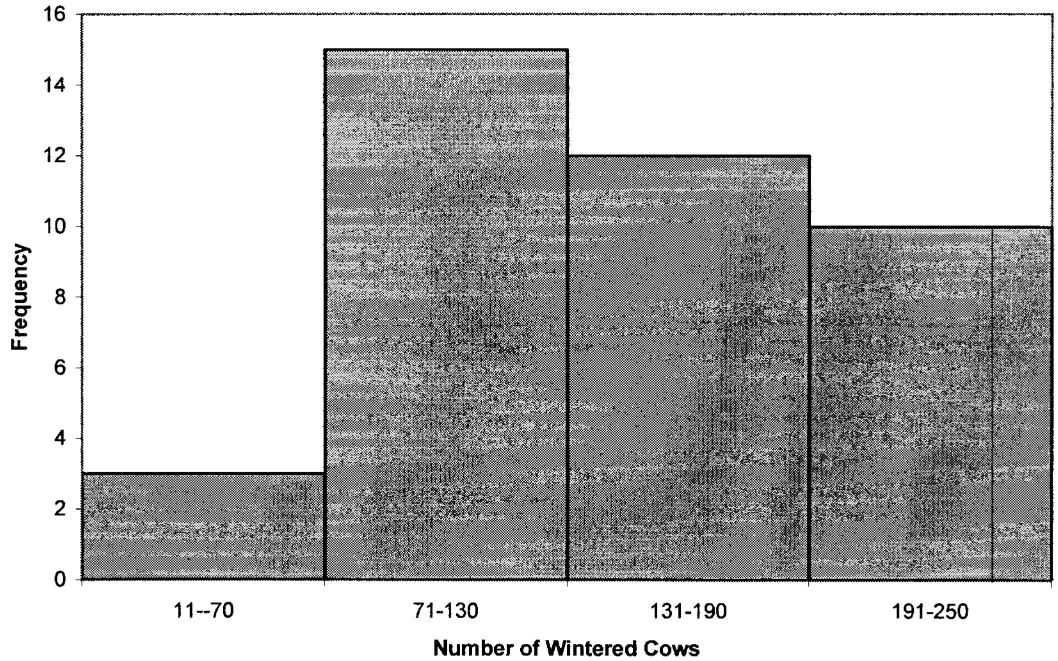

Figure 4-5: Histogram of Wintered Cows for Producers in Boreal/Peace Lowlands, from 1999, 2000, and 2002

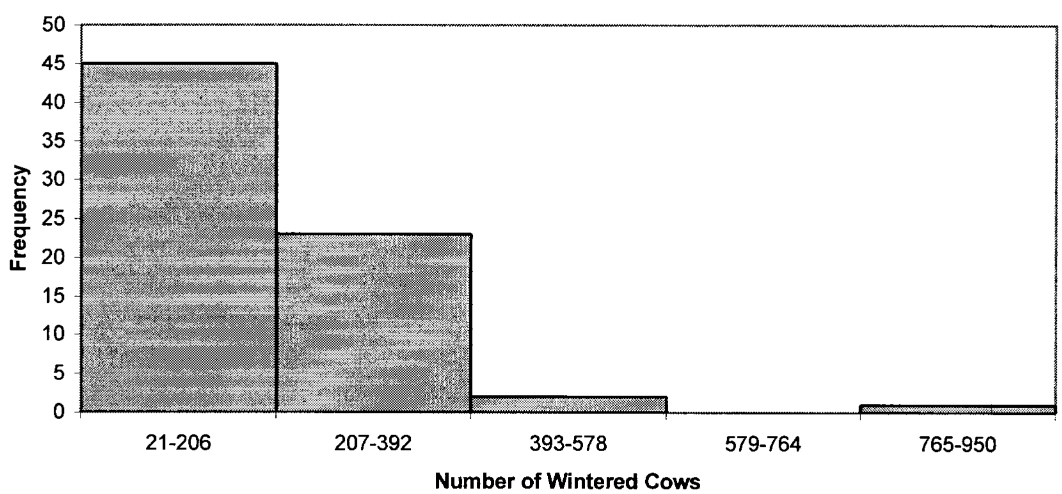

Figure 4-6: Histogram of Herd Sizes between 26 and 392 for Producers in Boreal/Peace Lowlands, from 1999, 2000, and 2002

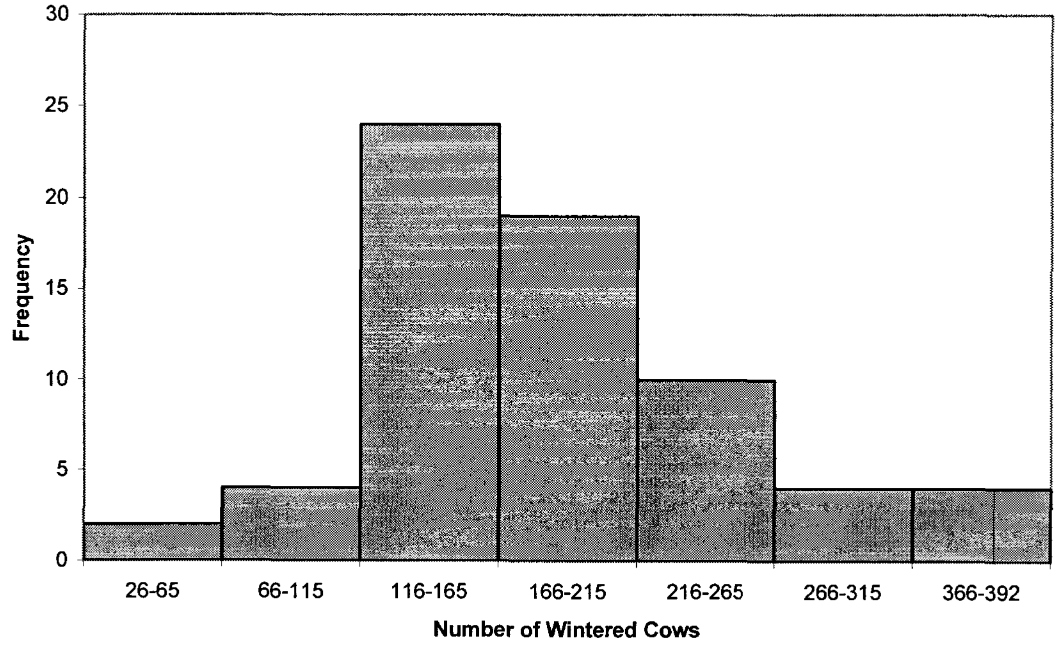

Table 4-1: Grass Types defining the Geographic Regions

Geographic Region	Grass Types
Southern Alberta	Fescue Grassland, Moist Mixed Grassland, Mixed Grassland
Aspen Parklands	Aspen Parkland
Boreal/Peace Lowlands	Boreal Transition, Peace Lowland

Table 4-2: Grass Types and Corresponding Soil Types

Grass Types	Soil Type
Fescue Grassland, Moist Mixed Grassland, Mixed Grassland	Brown, Dark Brown, Thin Black
Aspen Parkland	Black
Boreal Transition, Peace Lowland	Black and Grey Wooded

Table 4-3: Range of Herd Sizes used to define initial herd size for Representative Farms, by Geographic Region

Region/Representative Farm	Herd Size Range	Number of Observations
Southern Alberta		
Small	>50 to 80	15
Medium	>80 to 120	21
Large	>120 to 160	20
Aspen Parklands		
Small	>70 to 130	22
Medium	>130 to 190	17
Large	>190 to 250	15
Boreal/Peace Lowlands		
Small	>115 to 165	27
Medium	>165 to 215	25
Large	>215 to 265	20

Table 4-4: Initial Herd Sizes, by Representative Farm, Used in the Simulation Analysis

Region/Representative Farm	Initial Herd Size	Number of Observations
Southern Alberta		
Small	70	15
Medium	105	21
Large	140	20
Aspen Parklands		
Small	100	22
Medium	160	17
Large	220	15
Boreal/Peace Lowlands		
Small	140	27
Medium	195	25
Large	245	20

Table 4-5: Conception Rates for Mature Cows and Bred Heifers, by Representative Farm

		Small			Medium			Large		
		Mean	Std. Dev	N	Mean	Std. Dev	N	Mean	Std. Dev	N
Southern Alberta										
	Mature Cow	0.97	0.05	15	0.94	0.05	21	0.93	0.06	20
	Bred Heifer	0.99	0.05	15	0.94	0.06	21	0.97	0.04	20
Aspen Parklands										
	Mature Cow	0.92	0.09	22	0.91	0.07	17	0.93	0.04	15
	Bred Heifer	0.95	0.09	22	0.94	0.06	17	0.91	0.08	15
Boreal/Peace Lowlands										
	Mature Cow	0.92	0.06	27	0.91	0.06	25	0.89	0.07	20
	Bred Heifer	0.94	0.05	27	0.93	0.05	25	0.93	0.06	20
N= Number of Observations										

Source: AAFRD AgriProfit$ Data

Table 4-6 : Calving Rates for Mature Cows and Bred Heifers, by Representative Farm

		Small			Medium			Large		
		Mean	Std. Dev	N	Mean	Std. Dev	N	Mean	Std. Dev	N
Southern Alberta										
	Mature Cow	0.97	0.03	15	0.93	0.08	21	0.98	0.03	20
	Bred Heifer	0.99	0.05	15	0.98	0.02	21	0.94	0.06	20
Aspen Parklands										
	Mature Cow	0.99	0.03	22	0.98	0.03	17	0.99	0.01	15
	Bred Heifer	0.99	0.04	22	0.97	0.04	17	0.95	0.04	15
Boreal/Peace Lowlands										
	Mature Cow	0.99	0.03	27	0.99	0.03	25	0.99	0.03	20
	Bred Heifer	0.95	0.05	27	0.95	0.05	25	0.99	0.04	20
N= Number of Observations										

Source: AAFRD AgriProfit$ Data

Table 4-7: Weaning Rates for Mature Cows and Bred Heifers, by Representative Farm

		Small			Medium			Large		
		Mean	Std. Dev	N	Mean	Std. Dev	N	Mean	Std. Dev	N
Southern Alberta										
	Mature Cow	0.93	0.03	15	0.97	0.09	21	0.98	0.12	20
	Bred Heifer	0.99	0.05	15	0.99	0.2	21	0.95	0.07	20
Aspen Parklands										
	Mature Cow	0.99	0.05	22	0.98	0.02	17	0.98	0.02	15
	Bred Heifer	0.99	0.03	22	0.99	0.03	17	0.96	0.06	15
Boreal/Peace Lowlands										
	Mature Cow	0.96	0.04	27	0.96	0.04	25	0.96	0.04	20
	Bred Heifer	0.95	0.06	27	0.95	0.06	25	0.98	0.03	20
N= Number of Observations										

Source: AAFRD AgriProfit$ Data

Table 4-8: Average Weaned Weights for Steers and Heifers, by Representative Farm (Pounds per animal)

		Small			Medium			Large		
		Mean	Std. Dev	N	Mean	Std. Dev	N	Mean	Std. Dev	N
Southern Alberta										
	Steers	587.54	30.43	15	553.54	51.96	21	545.24	60.94	20
	Heifers	550.14	44.33	15	509.96	51.71	21	514.34	53.96	20
Aspen Parklands										
	Mature Cow	605.64	79.82	22	578.35	88.39	17	562.13	60.33	15
	Bred Heifer	546.46	69.55	22	530.88	77.94	17	516.60	53.39	15
Boreal/Peace Lowlands										
	Mature Cow	568.24	83.09	27	568.24	83.9	25	595.16	66.0	20
	Bred Heifer	525.27	79.93	27	525.27	79.92	25	559.24	52.05	20
N= Number of Observations										

Source: AAFRD AgriProfit$ Data

Table 4-9: Daily Winter Rations, by Type of Beef Animal

Ration Ingredient	Mature Cow	Bred Heifer	Yearlings	Calves	Bulls
Hay (pounds/day)	10	7.5	6.6	5.0	15
Silage (pounds/day)	10	7.5	6.6	5.0	15
Barley (pounds/day)	5	3.8	3.3	2.5	7.5
Straw (pounds/day)	5	3.8	3.3	2.5	7.5
Total Dry Matter Intake	30	22.6	19.8	15	45

Table 4-10: Winter and Pasture Feeding Days

		Winter Feeding Days	Pasture Grazing Days	Total Days
Southern Alberta				
	Average	152.30	215.15	367.45
	Std. Dev.	5.15	6.86	
Aspen Parklands				
	Average	183.09	187.06	370.15
	Std. Dev.	4.85	6.53	
Boreal/Peace Lowlands				
	Average	204.60	163.9	368.50
	Std. Dev.	3.12	3.91	

Source: AAFRD AgriProfit$ Data

Table 4-11: Winter and Pasture Feeding Days used in the simulation

		Winter Feeding Days	Pasture Grazing Days	Total Days
Southern Alberta				
	Average	154	211	365
Aspen Parklands				
	Average	184	181	365
Boreal/Peace Lowlands				
	Average	204	161	365

Table 4-12: Costs -Feed Costs per Cow, by Representative Farm

	Southern Alberta			Aspen Parklands			Boreal/Peace Lowlands		
	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Input	Cost/Cow (C$)	Cost/Cow (C$)	Cost/Cow (C$)	Cost/Cow (C$)	Cost/Cow (C$)	Cost/Cow (C$)	Cost/Cow (C$)	Cost/Cow (C$)	Cost/Cow (C$)
Bedding	13.21	7.70	9.21	14.97	16.90	15.94	17.91	21.63	16.61
Veterinary & Medicine	15.15	16.98	15.37	15.31	20.07	18.70	24.35	17.08	15.92
Breeding Fees / Bull Rental	1.03	1.04	0.93	0.94	0.91	0.67	0.90	0.29	0.09
Trucking & Marketing Charges	18.21	13.75	23.19	10.78	11.56	12.67	16.15	11.66	9.73
Fuel	16.11	17.69	14.57	18.01	14.18	11.56	13.62	12.05	13.56
Repairs - Machine	21.83	18.45	16.33	23.34	11.61	13.55	14.45	13.76	17.90
Repairs - Corrals & Buildings	21.67	11.05	16.79	8.78	11.98	7.42	4.96	9.18	7.70
Utilities and Miscellaneous Exp.	28.14	27.08	27.63	25.81	22.12	19.17	25.66	27.91	19.52
Custom Work and Specialized Labor	5.93	11.91	5.18	7.09	11.34	11.14	9.91	4.62	7.84
Total Cost per Cow	141.28	125.65	129.2	125.03	120.67	110.82	127.91	118.18	108.87

Source: AAFRD AgriProfit$ Data

Table 4-13: Crop Acres, by Representative Farm

	Southern Alberta			Aspen Parklands			Boreal/Peace Lowlands		
	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Crop	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Hay	66	102	140	100	150	205	130	180	220
Barley	115	172	240	175	260	360	230	315	390
Canola	110	166	230	165	245	350	225	310	380
Wheat	95	145	200	142	215	300	190	260	320
Silage	60	90	115	85	125	135	140	155	165

Table 4-14: Crop Yields, by Geographic Region (tons/acre)

		Hay	Barley	Canola	Wheat	Silage
Southern Alberta	Mean	1.26	0.82	0.63	0.79	3.47
	SD	0.7	0.42	0.29	0.32	1.56
Aspen Parklands	Mean	1.74	1.46	0.66	1.17	6.22
	SD	0.89	0.39	0.26	0.42	2.33
Boreal/Peace Lowlands	Mean	1.67	1.31	0.73	1.16	4.84
	SD	0.76	0.38	0.19	0.32	2.00

Source: AAFRD AgriProfit$ Data

Table 4-15: Crop Costs per Acre, by Crop: Southern Alberta

	Southern Alberta				
Input	Hay	Barley	Canola	Wheat	Silage
Seed	0.00	7.01	20.73	8.34	6.86
Fertilizer	3.63	14.22	20.82	15.50	10.78
Chemicals	0.18	5.65	4.09	8.65	2.55
Hail/ Crop Insurance	0.85	1.60	7.05	4.46	6.42
Trucking and Marketing	0.32	3.59	0.92	2.58	0.29
Fuel	5.52	5.23	5.09	5.35	5.16
Repairs - Machine	8.21	5.58	4.74	6.84	0.00
Repairs - Buildings	1.39	0.47	0.14	0.62	8.07
Utilities & Misc. Expenses	4.31	8.45	2.28	8.33	0.07
Custom Work & Specialized Labor	0.55	0.78	1.15	0.61	1.46
Total Cost per Acre	24.96	52.58	67.01	61.28	41.66

Source: AAFRD AgriProfit$ Data

Table 4-16: Crop Costs per Acre, by Crop: Aspen Parklands

	Aspen Parklands				
Input	Hay	Barley	Canola	Wheat	Silage
Seed	0.00	5.97	20.85	7.74	7.45
Fertilizer	2.95	19.44	24.37	17.97	12.30
Chemicals	0.09	8.15	8.66	10.21	2.03
Hail/ Crop Insurance	0.00	3.30	0.79	3.10	1.51
Trucking and Marketing	0.46	4.75	1.29	3.44	0.00
Fuel	8.05	9.65	8.58	8.63	9.80
Repairs - Machine	4.40	7.85	7.95	8.97	0.00
Repairs - Buildings	0.26	0.54	0.00	0.59	4.87
Utilities & Misc. Expenses	5.01	7.71	6.95	5.92	0.56
Custom Work & Specialized Labor	0.98	0.84	2.46	0.76	2.23
Total Cost per Acre	22.2	68.2	81.9	67.33	40.75

Source: AAFRD AgriProfit$ Data

Table 4-17: Crop Costs per Acre, by Crop: Boreal/Peace Lowlands

	Boreal/Peace Lowlands				
Input	Hay	Barley	Canola	Wheat	Silage
Seed	0.00	7.80	16.26	11.00	10.93
Fertilizer	4.71	22.49	26.62	21.76	14.87
Chemicals	0.04	10.31	10.61	12.43	2.92
Hail/ Crop Insurance	0.61	3.94	8.59	4.36	1.43
Trucking and Marketing	0.19	1.19	1.31	5.66	0.04
Fuel	10.48	12.67	9.08	10.28	10.59
Repairs - Machine	5.92	9.35	10.01	10.55	0.00
Repairs - Buildings	1.18	1.03	0.80	1.05	10.95
Utilities & Misc. Expenses	0.05	6.83	6.67	8.66	0.69
Custom Work & Specialized Labor	1.02	1.17	2.55	2.09	3.63
Total Cost per Acre	24.2	76.78	92.5	87.84	56.05

Source: AAFRD AgriProfit$ Data

Table 4-18: Pasture Intake, by Animal Type (Animal Units or AU)

Animal Type	AU	Daily Forage Dry matter intake (lb)
Mature Cow	1.15	30
Bred Heifer	0.85	25.5
Yearlings	0.77	23.1
Calves	0.68	20.4
Bulls	1.55	46.5

Table 4-19: Pasture Acres, by Representative Farms

	Southern Alberta			Aspen Parklands			Boreal/Peace Lowlands		
	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Crop	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Silage	60	100	125	100	142	200	125	170	210

Table 4-20: Pasture Yield, by Geographic Region (AUM/acre)

Southern Alberta	Mean	0.94
	SD	0.57
Aspen Parklands	Mean	1.77
	SD	0.98
Boreal/Peace Lowlands	Mean	1.79
	SD	1.03

Source: AAFRD AgriProfit$ Data

Table 4-21: Pasture Costs per Acre, by Geographic Region

	Southern Alberta	Aspen Parklands	Boreal Peace Lowlands
Input			
Fertilizer	0.00	0.56	0.49
Trucking and Marketing	0.00	0.03	0.07
Fuel	0.93	0.84	0.38
Repairs - Machine	0.23	0.67	0.47
Repairs – Buildings	1.11	0.52	0.80
Utilities & Misc. Expenses	0.31	0.56	0.96
Custom Work & Specialized Labor	0.00	0.10	0.12

Source: AAFRD AgriProfit$ Data

Table 4-22: Dickey-Fuller and Philips-Perron Unit Root Test Statistics (5%) for Prices

	Southern Alberta		Northern Alberta					
	Steers	Heifers	Steers	Heifers	Slaughter Cattle	Bull	Barley	Hay
CONSTANT, NO TREND								
Dickey-Fuller A(1)=0 T-TEST	-3.5957	-3.6612	-3.8207	-3.6614	-2.6886	-2.6205	-3.2006	-2.5963
Phillips-Perron A(1)=0 T-TEST	-3.5441	-3.6660	-3.5493	-3.666	-3.2601	-2.8494	-2.5812	-2.5934
CONSTANT,TREND								
Dickey-Fuller A(1)=0 T-TEST	-3.4514	-3.4639	-3.7975	-3.4642	-4.0773	-3.8063	-3.0802	-3.26233
Phillips-Perron A(1)=0 T-TEST	-3.3815	3.4761	-3.2808	-3.4765	-4.5352	-3.8572	-3.8929	-3.4415

Note: 5% critical levels for "No Trend" and "Trend" are **-2.86** and **-3.41** respectively for both Dickey-Fuller and Philips-Perron tests. Rejection implies there is no unit root

Table 4-23: AR (n) Lag Specification Test Results for Prices Using AIC and SC

		Lag1		Lag2		Lag3	Lag4	Lag5	Lag6	Lag7
		Southern Alberta	Northern Alberta	Southern Alberta	Northern Alberta					
HEIFER	AIC	**-6.190**	**-6.459**	-6.189	-6.440	-6.182	-6.171	-6.164	-6.16	-6.153
	SC	**-6.177**	**-6.446**	-6.163	-6.413	-6.143	-6.118	-6.098	-6.08	-6.059
STEER	AIC	**-6.454**	**-6.669**	-6.438	-6.661	-6.432	-6.417	-6.408	-6.402	-6.403
	SC	**-6.441**	**-6.656**	-6.412	-6.635	-6.392	-6.364	-6.341	-6.321	-6.309
SLAUGHTER CATTLE	AIC	-5.833	-5.834	-5.871	-5.867	**-5.938**	-5.866	-5.931	-5.929	-5.871
	SC	-5.82	-5.821	-5.845	-5.841	**-5.865**	-5.813	-5.831	-5.849	-5.844
BULLS	AIC	-6.078	-6.08	-6.229	-6.226	**-6.282**	-6.270	-6.238	-6.276	-6.278
	SC	-6.065	-6.067	-6.202	-6.199	-6.198	**-6.217**	-6.215	-6.196	-6.184
BARLEY	AIC	-5.852	-5.851	-6.138	-6.138	**-6.227**	-6.22	-6.221	-6.227	-6.224
	SC	-5.838	-5.838	-6.112	-6.112	**-6.187**	-6.167	-6.155	-6.146	-6.131
HAY	AIC	**-6.395**	-6.395	-6.392	-6.392	-6.386	-6.391	-6.385	-6.378	-6.371
	SC	**-6.382**	-6.382	-6.365	-6.365	-6.346	-6.338	-6.319	-6.298	-6.277

Bold and underlined values indicate optimal lag structure for each test

Table 4-24: LM-Stat Test Statistics for Error Autocorrelation in AR (n) Price Models

Lag (p)	Heifer Southern Alberta	Heifer Northern Alberta	Steer Southern Alberta	Steer Northern Alberta	Slaughter Cattle	Bulls	Barley	Hay
	LM-STAT	LM-STAT	LM-STAT	LM-STAT	LM-STAT	LM-STAT	LM-STAT	LM-STAT
1	1.3479	0.7739	**15.1188**	**14.2991**	0.2955	**15.5655**	**15.6693**	**10.5213**
2	1.1056	0.8157	**13.9872**	**12.9704**	1.2302	**14.1437**	**14.4053**	**10.3282**
3	0.2535	0.9317	**13.0418**	**11.9819**	1.2569	**11.3578**	**10.2575**	**10.5743**
4	0.5643	1.2395	**12.4861**	**11.5392**	3.4809	**10.7192**	**9.7081**	**10.1243**
5	0.8872	0.7145	**11.9629**	**11.1541**	1.0599	**10.1276**	**9.1529**	**9.9363**
6	1.3726	2.2186	**11.153**	**10.8221**	1.446	**9.692**	**8.6165**	**9.6471**
7	0.3227	0.5525	**10.4627**	**9.9132**	0.0963	**9.2939**	**8.2379**	**9.0859**
8	1.1375	1.4446	**9.9594**	**9.4394**	3.2146	**8.9991**	**7.7307**	**8.9789**
9	0.7208	0.8349	**9.1334**	**8.2247**	0.4283	**9.0796**	**6.8849**	**8.6878**
10	1.82	0.5927	**8.2798**	**7.3163**	1.4762	**9.2014**	**6.4896**	**8.3492**
11	0.7784	2.4151	**7.3744**	**6.6205**	3.4907	**9.2563**	**6.1342**	**7.9543**
12	1.8066	0.8021	**6.5859**	**5.863**	7.0484	**9.1239**	**5.7465**	**7.743**
13	2.0768	1.3949	**5.6655**	**4.9262**	2.3103	**8.5353**	**5.2581**	**7.5648**
14	0.2606	1.7507	**4.7879**	**3.8632**	0.0467	**7.7715**	**4.6198**	**7.0761**
15	1.9761	0.1921	**4.0505**	3.2155	1.5999	**6.8764**	**4.1536**	**6.74**
16	0.2261	0.322	3.5312	2.5357	4.3866	**6.4564**	3.7026	**6.4072**
17	2.5225	1.4901	3.1536	2.2359	0.726	**6.169**	3.0732	**6.4201**
18	0.4315	0.1502	2.6245	1.7546	0.0978	**5.6326**	2.7624	**5.8028**
19	0.1285	1.5588	2.1295	1.3621	1.5972	**5.1496**	2.5508	**5.6403**
20	2.0689	1.3774	1.7648	0.6373	1.1452	**5.3318**	2.1384	**5.593**
21	0.7777	0.801	1.4692	0.2521	0.4293	**5.2999**	1.8039	**5.5569**
22	1.0254	0.0717	1.2361	0.0041	0.7178	**5.7312**	1.5647	**5.3668**
23	2.7037	0.8319	0.7845	0.4066	3.1923	**6.0517**	1.4148	**5.3287**

The X^2_1 critical value for the LM stat at 5% level significance is (3.84)
Bold and underlined values indicate the null hypothesis of no autocorrelation is rejected

Table 4-25: Matrix of Price Correlations (Southern Alberta)

	Heifer	Steer	Slaughter Cattle	Bulls	Barley	Hay
Heifer	1					
Steer	0.96546	1				
Slaughter Cattle	0.81245	0.7523	1			
Bulls	0.81786	0.76846	0.96662	1		
Barley	0.29699	0.19689	0.51927	0.41726	1	
Hay	0.41456	0.34431	0.56269	0.50683	0.83187	1

Table 4-26: Matrix of Price Correlations (Northern Alberta)

	Heifer	Steer	Slaughter Cattle	Bulls	Barley	Hay
Heifer	1					
Steer	0.95697	1				
Slaughter Cattle	0.8125	0.74414	1			
Bulls	0.81795	0.75765	0.96662	1		
Barley	0.2971	0.17227	0.51927	0.41726	1	
Hay	0.41468	0.31209	0.56269	0.50683	0.83187	1

Table 4-27: Parameter Estimates for AR (n) Steer Price Equations (Southern and Northern Alberta)

Variable Name	Estimated Coefficient	Standard Error	T-Ratio	P-Value	R-Square	R-Square Adjusted
Southern Alberta						
LNST1	0.3324	0.0454	7.3295	0.0000	0.9656	0.9650
LNHF	0.5873	0.0389	15.0960	0.0000		
LNSLT	0.1158	0.0365	3.1763	0.0017		
LNBULLS	-0.0248	0.0364	-0.6826	0.4955		
CONSTANT	0.0563	0.0728	2.5727	0.0404		
Northern Alberta						
LNST1	0.2144	0.0545	3.9341	0.0001	0.9405	0.9396
LNHF	0.8020	0.0527	15.2220	0.0000		
LNSLT	-0.0806	0.0535	-2.5079	0.0327		
LNBULLS	0.0172	0.0555	0.3107	0.7563		
CONSTANT	0.1106	0.1216	2.1101	0.0636		
LNST1= Natural log of steer price lagged once, LNHF= Natural log of heifer price at time t, LNSLT= Natural log of slaughter cattle price at time t, , LNBULLS= Natural log of bull price at time t						

N= 273

Table 4-28: Parameter Estimates for the AR (n) Heifer Price Equations (Southern and Northern Alberta)

Variable Name	Estimated Coefficient	Standard Error	T-Ratio	P-Value	R-Square	R-Square Adjusted
Southern Alberta						
LNHF1	0.3633	0.0407	8.9314	0.0000	0.9479	0.9472
LNST	0.6465	0.0430	15.0440	0.0000		
LNSLT	-0.0978	0.0378	-2.5893	0.0101		
LNBULLS	0.0417	0.0363	1.1505	0.2510		
CONSTANT	0.1269	0.0662	2.1173	0.0463		
Northern Alberta						
LNHF1	0.4848	0.0407	11.9220	0.0000	0.9512	
LNST	0.4619	0.0375	12.3010	0.0000		
LNSLT	0.0844	0.0392	2.1548	0.0321		
LNBULLS	-0.0310	0.0381	-0.8129	0.4170		
CONSTANT	0.0801	0.0657	2.2192	0.0239		

LNHF1= Natural log of heifer price lagged once, LNST= Natural log of steer price at time t, LNSLT= Natural log of slaughter cattle price at time t, , LNBULLS= Natural log of bull price at time t

N=273

Table 4-29: Parameter Estimates for AR (n) Price Equations for Bulls, Slaughter Cattle and other Livestock

Variable Name	Estimated Coefficient	Standard Error	T-Ratio	P-Value	R-Square	R-Square Adjusted
Bull						
LNBULLS1	0.8680	0.1485	5.8447	0.0000	0.9751	0.9745
LNBULLS2	-0.4133	0.2028	-2.0385	0.0425		
LNBULLS3	0.1472	0.1045	2.0085	0.0462		
LNHF	0.1087	0.0575	1.8923	0.0595		
LNST	-0.0546	0.0621	-0.8794	0.3800		
LNSLT	0.3912	0.0455	8.5910	0.0000		
CONSTANT	-0.1474	0.0736	-2.0038	0.0461		
Slaughter Cattle						
LNSLT1	0.6956	0.0662	10.5140	0.0000	0.9531	0.9520
LNSLT2	-0.1364	0.0775	-1.7604	0.0795		
LNSLT3	-0.0830	0.0494	-2.0052	0.0444		
LNHF	-0.1948	0.0673	-2.8936	0.0041		
LNST	0.2344	0.0715	3.2766	0.0012		
LNBULLS	0.4276	0.0402	10.6340	0.0000		
CONSTANT	0.1111	0.0834	2.0320	0.0340		

LNBULLS (n)= Natural log of bull price lagged n times, LNSLT (n)= Natural log of slaughter cattle price lagged n times, LNHF= Natural log of heifer price at time, LNST= Natural log of steer price at time t

N=273

Table 4-30: Parameter Estimates for AR (n) Price Equations for Hay and Barley

Variable Name	Estimated Coefficient	Standard Error	T-Ratio	P-Value	R-Square	R-Square Adjusted
Hay						
LNHAY1	0.9867	0.0092	54.9270	0.0000	0.9783	0.9782
LNBAR	0.0571	0.0144	3.9697	0.0001		
CONSTANT	0.1472	0.1045	2.4085	0.0302		
Barley						
LNBAR1	1.6224	0.0581	27.9120	0.0000	0.9808	0.9805
LNBAR2	-0.9444	0.0992	-9.5223	0.0000		
LNBAR3	0.3008	0.0578	5.2044	0.0000		
LNHAY	0.1020	0.0448	2.2764	0.0236		
CONSTANT	0.5231	0.2623	1.9942	0.0471		
LNHAY1= Natural log of hay price lagged once, LNBAR= Natural log of barley price at time t, LNBAR (n)= Natural log of barley price lagged n times, LNHAY= Natural log of hay price at time						

N=273

Table 4-31: Coefficient Estimates for the Error Terms for Prices

Variable	Standard Error of the Estimate Sigma
Steer (Southern Alberta)	0.0280
Steer (Northern Alberta)	0.0382
Heifer (Southern Alberta)	0.0331
Heifer (Northern Alberta)	0.0348
Bull	0.0326
Slaughter Cattle	0.0419
Hay	0.0398
Barley	0.0382

N=273

Table 4-32: Comparison of AR (n) Price Forecasting Model Results and Historical Price Data

	Mean	Minimum	Maximum	Standard Deviation	Variance
Steer ($/lb @100 index) (Southern Alberta)					
Historical Data	1.1196	0.6200	1.6600	0.2039	0.0416
AR Model	1.1583	0.9900	1.3300	0.1932	0.0373
Steer ($/lb @100 index) (Northern Alberta)					
Historical Data	1.1230	0.7300	1.5900	0.1621	0.0263
AR Model	1.1791	0.9600	1.3800	0.1327	0.0176
Heifer ($/lb @100 index) (Southern Alberta)					
Historical Data	1.0522	0.6800	1.4600	0.1475	0.0218
AR Model	0.9991	0.7800	1.1700	0.1018	0.0104
Heifer ($/lb @100 index) (Northern Alberta)					
Historical Data	1.0248	0.6500	1.4100	0.1426	0.0203
AR Model	1.0309	0.8700	1.2000	0.1012	0.0102
Slaughter Cattle ($/lb @100 index) (Southern Alberta)					
Historical Data	0.5700	0.3900	0.6800	0.0794	0.0063
AR Model	0.5378	0.4600	0.6100	0.0450	0.0020
Slaughter Cattle ($/lb @100 index) (Northern Alberta)					
Historical Data	0.5700	0.3900	0.6800	0.0794	0.0063
AR Model	0.5557	0.5000	0.6600	0.0581	0.0034
Bulls ($/lb @100 index) (Southern Alberta)					
Historical Data	0.7000	0.4600	0.9400	0.1169	0.0137
AR Model	0.6665	0.6100	0.7200	0.1027	0.0105
Bulls ($/lb @100 index) (Northern Alberta)					
Historical Data	0.7000	0.4600	0.9400	0.1169	0.0137
AR Model	0.6626	0.6300	0.7000	0.1035	0.0107
Barley ($/ton)					
Historical Data	132.3700	84.2300	230.6000	39.6750	1574.1000
AR Model	140.4200	75.2335	210.6380	36.1789	1308.9128
HAY ($/ton)					
Historical Data	83.4560	54.5500	128.9100	23.5160	553.0100
AR Model	78.6610	58.8300	125.3872	20.0837	403.3550

Table 4-33: Two Sample Test Results for AR (n) Price Forecasting Models and Historical Price Data

	Difference Between Two Samples Tests	Statistics	P-Value
Steer (Southern Alberta)	Approximate T-Test of Equal Means	-1.2840	0.2061
	Equal Variance T-Test of Equal Means	-1.2840	0.2059
Steer (Northern Alberta)	Approximate T-Test of Equal Means	-0.8279	0.4141
	Equal Variance T-Test of Equal Means	-0.8279	0.4122
Heifer (Southern Alberta)	Approximate T-Test of Equal Means	1.4195	0.1637
	Equal Variance T-Test of Equal Means	1.4195	0.1628
Heifer (Northern Alberta)	Approximate T-Test of Equal Means	-0.1754	0.8618
	Equal Variance T-Test of Equal Means	-0.1754	0.8616
Slaughter Cattle (Southern Alberta)	Approximate T-Test of Equal Means	1.6900	0.1000
	Equal Variance T-Test of Equal Means	1.6900	0.0981
Slaughter Cattle (Northern Alberta)	Approximate T-Test of Equal Means	0.7760	0.4434
	Equal Variance T-Test of Equal Means	0.7760	0.4419
Bull (Southern Alberta)	Approximate T-Test of Equal Means	1.3390	0.1930
	Equal Variance T-Test of Equal Means	1.3390	0.1875
Bull (Northern Alberta)	Approximate T-Test of Equal Means	1.5194	0.1424
	Equal Variance T-Test of Equal Means	1.5194	0.1358
Barley	Approximate T-Test of Equal Means	-0.9615	0.3463
	Equal Variance T-Test of Equal Means	-0.9615	0.3416
Hay	Approximate T-Test of Equal Means	0.9695	0.3425
	Equal Variance T-Test of Equal Means	0.9695	0.3376
Coefficient t-test were tested at a 5% critical level			

5.0: CHAPTER 5: RESULTS AND DISCUSSION

5.1: Introduction

This chapter provides a discussion of the results from the simulation analysis for the nine representative Alberta cow-calf operations. As discussed in the previous chapter, the results are based on simulating the representative farms over a 10-year time period, repeating each simulation 10,000 times (i.e., iterations) using the @Risk software. For each farm, several simulation scenarios are modeled, including a BASE scenario and alternative risk management strategies.

The simulation results are presented in two different ways; tabular and graphical forms. For each simulation scenario and each farm, the mean value and standard deviations for annual gross margin are provided in accompanying tables, along with an overall mean and standard deviation.[14] The simulation results are presented graphically using 95% confidence intervals. For each scenario, the upper and lower bounds of the 95% confidence interval are calculated as follows:

$$UB = \overline{GM} + 1.96\,SD \qquad\qquad LB = \overline{GM} - 1.96\,SD$$

where UB and LB are the upper and lover bounds, respectively, of the confidence interval, $\overline{GM}$ is the average annual gross margin, SD is the standard deviation of annual gross margin, and 1.96 is the value of the t distribution for a 97.5% level of significance (one-sided) and 9999 degrees of freedom.

In the discussion concerning the risk management strategies, "performance" or "effectiveness" is assessed in terms of the impact on average annual gross margin and the

[14] The overall mean was calculated by summing all simulated values in all years and then dividing by the total number of observations (10,000). The overall standard deviation around the overall mean is produced during the simulation process.

variability of gross margin, as discussed in the previous chapter. In the accompanying graphs, the confidence intervals are used to depict both of these considerations. If the average for one strategy is greater than another, then the confidence interval will tend to be “higher”. If the variability for one strategy is greater than for another, the confidence interval will tend to be “wider”. The information from the graphs, along with the tabular information for each strategy, is thus used to assess the performance or effectiveness of alternative strategies.

The remainder of the chapter proceeds in the following way. The BASE scenario results for all representative farms are presented and briefly discussed in section 5.2. The discussion provides a description and explanation for the pattern of gross margin over time in terms of the level and variability. The results for the risk management scenarios are presented and discussed in section 5.3. Each risk management strategy is dealt with in turn, with the discussion focusing on the general pattern of gross margin compared to the BASE scenario. These comparisons are used to determine if the risk management strategies employed in the analysis improve the performance for the representative farm operations. In each risk management strategy employed, the overall discussion of herd size impact and region will also be discussed to address the effects of these factors. In other words, is there a consistent pattern in terms of the effect of increasing herd size on the effectiveness of strategies, or does it vary , or is there a pattern at all? The same will apply to regional effects.

Section 5.4 focuses on the combination strategies of the CAIS strategy and each of the individual risk management strategies. The main aim is to explore if producers could do better if they adopt CAIS scenario in addition to the other risk management strategies. Finally, section 5.5 provides some additional discussion and an overall summary of the simulation results

5.2: BASE Results

The simulation results for the BASE scenarios (i.e., BASE, as defined in the previous chapter) are summarized in Tables 5-1 to 5-3, and Figures 5-1 to 5-3. From these results, several general trends or patterns are evident. Since the BASE scenario is used as the point of reference for the different risk management strategies, it is important to recognize and understand the general pattern of financial performance for these representative farms, given the initial risk management assumptions.

Figures 5-1 to 5-3 provide graphs of the average annual gross margins and variability for each representative farm, by region. The numerical values are provided in Tables 5-1 to 5-3, as previously mentioned. One obvious characteristic that is common to all nine representative farms is that average gross margin is positive in all years. This result suggests that, on average, producers were able to generate more than enough revenue from the beef and cropping enterprises, to cover variable costs of production. However, since fixed costs are not considered in this analysis, it is not possible to determine from these results if average net farm income (i.e., profit) would be positive.

A second general pattern that emerges from the tables and graphs was that average annual gross margin tends to increase with increasing herd size. As one moves from small to medium to large herd size, in each region, the level of average gross margin in each year tends to be higher. There are two likely reasons for this pattern. Obviously, with a larger herd size, the farm generates greater beef sales leading to higher farm revenues. Secondly, if economies of size exist in cow-calf production, the average cost of production will decrease with increasing herd size. If these economies exist for variable costs of production, this pattern could also contribute to the larger gross margins for the larger herd sizes. While not explicitly explored in this particular analysis, there is some evidence of economies of size illustrated through the pattern of non-feed variable costs for the beef enterprise, as shown in Table 4-12. Kaliel, Jeffrey and Yang (2005) provide more rigorous evidence of the existence of economies of size in cow-calf production in Alberta.

Also obvious from the tabular and graphical results is that average gross margin fluctuates from year to year. This pattern is due to the stochastic nature of many of the parameters of the simulation model (i.e., as discussed in Chapter 4). Year to year variability in beef prices, weaning weights, conception rates, death loss, etc. all contribute to variability in gross margin.

This year to year variability also varies across herd size within each region. As can be seen from Figures 5-1 to 5-3, the fluctuation in average annual gross margin tends to be greater for larger herd sizes. This is not surprising as the absolute impact of a change in a production or price parameter will be greater if the size of the enterprise in question is also greater; for example, if price goes up by a certain amount from one year to the next, the dollar impact on gross margin will be directly linked to the number of animals being sold.

Finally, the degree of variability in gross margin for a particular year is directly linked to herd size; that is, as herd size increases, so does the variance of gross margin. This can be seen through an examination of the 95% confidence intervals for annual gross margin for herds in each region, also provided in Figures 5-1 to 5-3. In all three cases, the confidence interval "widens" with increasing herd size. This pattern is confirmed through a comparison of standard deviations for annual gross margin, provided in Tables 5-1 to 5-3. Again, this result is not unexpected. For most types of production or investment, greater levels of return are typically associated with a greater degree of variability in those returns.

It should be noted that comparisons of the BASE results cannot easily be made across regions; for example, comparing results for small herds in each region. This is due to the fact that there are differences in the characteristics of the representative farms across region. What constitutes a "small" herd size differs significantly between regions, for example. As well, the size and structure of the cropping enterprises differ between regions.

5.3: Risk Management Strategy Results

This section deals with results for the alternative risk management strategies used for the analysis. As mentioned earlier, there were three main types of risk management strategies analyzed; feed storage, heifer retention and participation in CAIS. Feed storage and heifer retention as risk management strategies potentially decrease risk in that they reduce the impact of unfavorable conditions (i.e., poor crop yields in the next year or higher heifer prices in the following year). CAIS on the other hand transfers risk to others; particularly, risk is transferred to tax payers.

Each of the risk management strategies is examined in terms of its ability to a) support returns and b) reduce variability in returns. The ability of the risk management strategies to support returns is assessed in terms of changes in expected gross margin. The ability of the risk management strategies to reduce variability in returns is assessed in terms of the impact on the standard deviation of gross margin.

Discussion of the results is structured by risk management strategy; that is, for each risk management strategy, the results for the various herd size groups are assessed for the three geographic groups. The discussion also focuses on the impact of herd size and region on the expected returns and variability. The discussion is broken into two phases for each risk management strategy. The first phase deals with the expected gross margins whiles the second phase deals with the variability surrounding the expected gross margins. The following discussion is based on the CAIS scenario. In all cases, the results from the risk management strategies are compared to the BASE scenario.

5.3.1: Analysis of Annual Gross Margins for the BASE versus CAIS Scenarios

The simulation results for the expected gross margins for the CAIS scenario for the small, medium and large herd size groups in all three geographic regions are discussed in this section. The results are provided in Tables 5-4 to 5-12. The results from the table indicate that in all cases, the CAIS scenario was able to increase expected gross margins for all nine farms, which was to be expected. That is, the year to year values increased compared to the BASE scenarios for the individual farms. The impacts were quite considerable in almost all years.

The results from the Southern Alberta region for all herd sizes are provided in Tables 5-4 to 5-6. In all cases, the CAIS strategy as a risk management strategy was able to provide an increase in expected gross margins in almost all years, with the exception of a few years where the impact of CAIS was not substantially felt. However, as can be seen from the tables, this happened when the average annual gross margins were higher and the producers did not need to be supported by the CAIS strategy. This occurred mostly between years 4-6. However, it appears that CAIS has a greater impact in years when the gross margin is lower which is expected as there will be more iterations when payouts are triggered. In the small herd size group, the increases in average annual gross margins were from $64 to almost $7,000 when the CAIS strategy was compared to the BASE strategy. In the medium herd size, the increase in average annual gross margins ranged from almost $150 to $8,400 while that for the large size ranged from almost $947 to $9,000. The results indicated a tendency for the percentage improvement in average gross margin for the CAIS strategy to increase with increased herd size.

The results for the Aspen Parklands region are provided in Tables 5-7 to 5-9. Again the figures from the tables indicate that the CAIS strategy was able to increase the average annual gross margins for the three herd size groups. As in the case of the Southern Alberta region, in the years where the average annual gross margins from the farm were higher, the support from the CAIS strategy was not felt as much and the same explanation can be provided as for the situation in the Southern Alberta region. However, in years where the average annual gross margin was low, the CAIS strategy was able to increase the average annual gross margins and this was seen in all three herd sizes. That is, CAIS strategy had a greater impact in years when the gross margin was lower which again was expected as there will be more iterations when payouts are triggered. In the small herd size group the support from the CAIS strategy when compared to the BASE scenario was anywhere from $1,000 to almost $9,500 in the 10-year simulation period. For the medium herd size the increase was from $1,500 to $14,000. In the case of the large herd size group, the increase in average annual gross margin was from $478 to about $15,300. Thus, as can be seen from the figures the CAIS strategy was able to increase average annual gross margin for the herd sizes indicating that the CAIS strategy was able to provide support when needed.

The tables containing the figures for the Boreal Peace Lowlands are presented in Tables 5-10 to 5-12. The same pattern in terms of increase in average annual gross margins emerged for all three herd sizes. The CAIS strategy was able to provide support for all three herd sizes by providing increased average annual gross margins. This occurred in almost all years. Where the average annual gross margin was higher, the increase in support was not as pronounced, due to reduced need for support from the CAIS strategy. The increase in average annual gross margin for the small herd size was from $1,780 to $8,530. The increase in the medium herd size was from $2,290 to $9,075, whereas the increase for the large herd size group ranged from $2,700 to $10,300.

The 10-year average gross margin increase in returns for the small herd size group comparing the CAIS strategy to the BASE scenario for the Southern Alberta region was $3,023.08. For the medium and large herd size groups the overall average increases were $4,253.20 and $4,787.50, respectively. This indicates that the overall support from the CAIS strategy increased as one moves from the smaller herd size group to the larger herd size group. This may be attributed to average cost of production which may be decreasing with increasing herd size thereby causing higher average annual gross margins for the large herd size group than for the small herd size group, which in turn causes the overall average annual gross margins to increase as well.

The same pattern was seen in the Aspen Parklands region. The 10-year average gross margin for the small, medium and large herd size groups were, respectively, $3,295, $4,553.50 and $7,397.90 when the CAIS strategy was compared to the BASE strategy. The Boreal Peace Lowlands region was also no exception. When the CAIS strategy was compared to the BASE strategy, the increase in 10-year average gross margin for the small herd size was $4,174.20; that of the medium herd size was $5, 828.90 and the large herd size group was $7,183.60. In all cases, the increase in the 10-year average gross margins increased with increasing herd size. That is, as one moves from the small herd size to the large herd size, the overall increase in the 10-year average gross margins increased as well.

In terms of regional differences, as can be seen from the figures, as one moves from the Southern Alberta region to the Boreal Peace Lowland regions, the 10-year average gross margins when the CAIS strategy was compared to the BASE strategy also increased. The only exception was the large herd size group from the Boreal Peace Lowlands region where the 10-year average gross margin was slightly lower than that of the Aspen Parklands region. This may be attributed to changes in variable costs, specifically, increased feed costs which may be causing a decrease in average annual gross margins. A measure of average total costs over time as illustrated by Jones (2000), indicates that the largest share of variable cost variability over time is due to changes in feed costs

CAIS as a risk management strategy was expected to substantially increase the average annual gross margins by providing support for the average annual gross margins. Without exception, average annual gross margins for each farm was greater with participation in CAIS versus the BASE scenario which assumes no participation. Therefore, it can be said that participation in the CAIS strategy may be a good risk management strategy from the perspective of support for expected gross margin.

5.3.2: Analysis of Annual Variability for the BASE versus CAIS Scenarios

The simulation results for the average annual variability for the CAIS scenario for the small, medium and large herd size groups in all three geographic regions are detailed in this section. The results are provided in Tables 5-5 to 5-12. The results from the table indicate that in all cases, the CAIS scenario was able to decrease variability (measured using standard deviation) surrounding the average annual gross margins in all the years for the representative farms. The Confidence Interval (CI) graphs detailing these scenarios are provided in Figures A-1 to A-9 in Appendix A.

The results from the Southern Alberta Region are provided in Tables 5-4 to 5-6. The results in Table 5-4 representing the small herd size groups indicated that the decrease in variability for the average annual gross margin associated with the CAIS strategy when compared to the BASE scenario was anywhere from 1.45% to 37.5%. For the medium herd size (Table 5-5) the decrease in variability was anywhere from 1.92% to almost 29%. For the large herd size (Table 5-6) the decrease in variability surrounding the average annual gross margins was from 5.94% to about 24%.

The CI graphs for the variability in average annual gross margins are provided in Figures A-1 to A-3 in Appendix A. The figures provide graphical representation of the pattern of variability in gross margin for the various herd sizes. The lines in the graphs for the CAIS scenario as a risk management strategy are represented by the upper and lower values that are likely to be encountered by the producer 95% of the time. The graph shows that there was a consistent decrease in variability with participation in the CAIS strategy. This can be seen in that the gap between the lines for the CAIS scenario is narrower than for the BASE scenario suggesting that there was some element of risk reduction from participation in the CAIS scenario. The 10-year decrease in standard deviation surrounding the average gross margins when CAIS strategy was compared to the BASE strategy was $2,847.59 for the small herd size, $3,892.41 for the medium herd size and $4,764.86 for the large herd size. This indicated that as one moved from the small herd size to the large herd size, the protection from the CAIS strategy increased.

A similar pattern can be seen in terms of the impact on variability in returns for the Aspen Parklands region. The results are provided in Tables 5-7 to 5-9. For the small herd size (Table 5-7) the results suggest that the decrease in variability was from 6.22% to 16.1%. The results from Tables 5-6 and 5-7 for the medium and large herd sizes, respectively, show a decrease in variability of between 7.62% to 18.52% and 2.86% to 31.30%. The CI graphs for the variability in average annual gross margins are provided by Figures A-4 to A-6 in Appendix A. The graphs provide a graphical representation of the pattern of variability in gross margin for the various herd sizes. Again, the lines in the graphs for the CAIS scenario as a risk management strategy represent the upper and lower values that are likely to be encountered by the producer 95% of the time.

The graph shows that, in the Aspen Parkland region, there was a consistent decrease in variability with participation in the CAIS strategy. This pattern holds for all three herd size groups. The dashed lines tended to be above the solid lines for the BASE scenario. Also, the gap between the lines for the CAIS scenario is narrower than for the BASE scenario suggesting that there was some element of risk reduction from participation in CAIS. The 10-year decreases in standard deviation around the average gross margins for the small, medium and large herd size groups were $3,539.53, $4,835.97 and $7,106.39, respectively. Again, as in the case from the Southern Alberta region, the protection from the CAIS strategy increased as one moved from the small to the large herd size.

Results for the Boreal Peace Lowland were consistent in terms of the impact on variability in returns. Tables 5-10 to 5-12 contain the results for the various herd size groups. The decrease in variability for the small, medium and large herd size groups were respectively, 10.08% to 23.73%, 9.90% to 20.50%and 10.76% to 22.32%. The CI graphs for the variability in average annual gross margins are provided by Figures A-7 to A-9 in Appendix A. The graphs provide a graphical representation of the pattern of variability in gross margin for the various herd sizes.

The dashed lines from the graph represented by the CAIS strategy tended to be higher in all three herd size groups. As well, the gap between the lines for the CAIS scenario was narrower than for the BASE scenario, suggesting an element of risk reduction from participation in CAIS. The 10-year decrease in standard deviation surrounding the average gross margins was $4,253.71 for the small herd size group. The decreases for the medium and large herd size groups were $5,899.31 and $7,306, respectively. This indicates that as one moves from the small herd size to the large herd size, the protection from the CAIS strategy increases.

The overall conclusion drawn from the CAIS scenario is that this strategy has potential to increase average annual gross margins. As well, the strategy has potential to decrease variability in returns. The results from the tables and graphs therefore suggest that participation in the CAIS strategy provides support and stability for gross margin.

Worth noting here is the variability for the 10-year average gross margins for all representative herd sizes. As can be seen from Tables 5-4 to 5-12, the variability was substantially lower for CAIS when compared to the BASE scenarios. This suggests that the CAIS strategy had the tendency to decrease the potential risk surrounding the average annual gross margins in the long run. Also in terms of herd sizes, the tendency for the CAIS scenario to decrease the variability surrounding the average annual gross margins compared to the BASE scenario was higher as the herd size increased. Again, the decrease in variability from the CAIS scenario compared to the BASE scenario indicated that the decrease in the 10-year variability increased as one moves from the Southern Alberta region to the Boreal Peace Lowlands region.

These patterns shown by the CAIS scenario in terms of herd sizes and regions are not surprising. As one moves from small to medium to large herd size in each region, the level of average gross margin in each year tends to be higher which in turn causes the overall average gross margin to be higher. This can lead to greater fluctuation in average annual gross margins; that is, as herd size increases, so does the variance of gross margin. Since the CAIS strategy is designed to help protect farmers from both small and large drops in income, the degree of compensation is greater.

It must be noted here that the risk reduction element of CAIS results from the ability of the producer to collect funds from the program when market returns are low, thus reducing the overall variability in farm returns. Also there is a subsidy element in the program that provides support.

5.3.3: Analysis of Annual Gross Margin for the BASE Scenario versus 100% Feed Storage and No Feed Storage Scenarios

The simulation results for expected gross margins for the 100% feed storage and no feed storage scenarios for the small, medium and large herd size groups in all three geographic regions are discussed in this section. The results are provided in Tables 5-4 to 5-12. To reiterate, the BASE scenario involves a degree of risk management in that it is assumed that the producer stores 80% of excess feed production for potential future use. This scenario is compared to two alternatives; storage of 100% of excess feed production, and no storage of excess feed production.

The results from the Southern Alberta region for the small, medium and large herd size groups are provided in Tables 5-4 to 5-6. Looking at the results from the tables, there was a decrease in average annual gross margins for the different herd size groups when the 100% feed storage scenario was compared to the BASE scenario for most of the years. The negative impact on average annual gross margins from the 100% feed storage scenario when compared to the BASE scenario were consistent among the herd sizes as well as across regions. The results from the Aspen Parklands region are provided in Tables 5-7 to 5-9 while those for the Boreal Peace Lowlands region are provided in Tables 5-10 to 5-12.

Although the expectations regarding the effect of the 100% feed storage scenario was not clear, the simulation results indicate that adopting this scenario may not be beneficial for producers in terms of average gross margin. The negative impact on the annual gross margins may be attributed to input price changes from crop production. Producers may want to store feed because of the fact that crop yield as well as feed prices vary from year to year in the simulation. In this analysis, producers generate additional income from sale of excess crops. However in the event that there was insufficient feed, they may be required to purchase at a higher price which implies that expected gross margins may decrease.

There was no consistent pattern in terms of the effect of increasing herd size or changing geographic region on the effectiveness of the strategy when the 10-year average gross margin for the 100% feed storage scenario was compared to the BASE scenario. It may be difficult to explain the lack of pattern in this strategy in terms of herd size or region. Storing feed may depend on having enough in a given year, given production practices, managerial practices as well as adverse situations among others. It is not clear how production practices, managerial practices as well as adverse conditions in each given year, represented by the different herd size group from the representative regions, affect how much feed can be stored.

Again, Tables 5-4 to 5-12 contains the simulation results for the no feed storage scenario for all representative farms. The results indicate that not storing excess feed resulted in increased average annual gross margins in most years for the representative farms. The pattern was again consistent across herd sizes as well as across regions. That is, for most of the 10-year simulation period, the no feed storage strategy increased average annual gross margins except for a few years when the BASE scenario proved to be superior. As discussed above, the pattern of results is occurring because of the input price changes and the output from crop yields.

As with the 100% feed storage scenario, there was no consistent pattern in terms of the effect of changing herd size or region on the effectiveness of the strategy when 10-year average gross margins for the no feed storage scenario were compared to the BASE scenario. Selling excess feed may depend on having enough in a given year, given production practices, managerial practices as well as adverse situations among others. It is not clear how these practices or conditions in each given year, represented by the different herd size group from the representative regions affect how much feed can be sold.

Although there were little differences between the three strategies (BASE, 100% feed strategy and no feed strategy) on the impact on average annual gross margins, having no feed storage provided the greatest support in average annual gross margin of the three scenarios. This was followed by the BASE scenario and the 100% feed storage.

5.3.4: Analysis of Annual Variability for the BASE Scenario versus 100% Feed Storage and No Feed Storage Scenarios

The simulation results regarding variability for the BASE scenario versus the 100% feed storage and no feed storage scenarios for the small, medium and large herd size groups in all three geographic regions are discussed in this section. The results for the 100% feed storage scenario are provided in Tables 5-4 to 5-12 for all the representative regions. The results indicated that there was a decrease in variability around average annual gross margin for the 100% feed storage strategy, relative to the BASE scenario. This was consistent across herd sizes and regions. Thus the 100% feed storage strategy has the potential to decrease the variability surrounding the average annual gross margins when compared to the BASE scenario. The results for the no feed storage scenario are provided in the same tables. The opposite pattern emerges in terms of variability of returns. In all cases there was an increase in variability surrounding the average annual gross margins for the no feed storage when compared to the BASE scenario. Again, this was consistent across herd sizes and regions.

Figures B-1 to B-9 in Appendix B provide graphical representations of the pattern of variability in gross margin for the three feed storage scenarios in the different regions. As with the previous graphs, the lines for each risk management strategy represented the upper and lower values that are likely to be encountered by the producer 95% of the time. In all cases, the graph indicated that there were little differences in risk surrounding the average gross margins between the scenarios. This stems from the fact that the gaps between the lines for the various scenarios do not differ much. In all cases, the lines almost overlap each other. The simulation results indicate that while there is some element of risk reduction from feed storage it is not very significant; that is, the benefit from this scenario is small. This implies that this particular risk accounts for only a small part of the overall level of risk faced by producers.

It should be noted here that there was no consistent pattern in terms of the effect of increasing herd size on the effectiveness of the strategy when variability surrounding the 10-year average gross margins for the 100% feed storage and no feed storage scenarios were compared to the BASE scenario. The same applied to comparisons across regions.

5.3.5: Analysis of Annual Gross Margin for the BASE Scenario versus the No Heifer Retention Scenario

The simulation results for the expected gross margins for alternative heifer retention scenarios are discussed in this section. As discussed earlier, the BASE scenario assumes that the producer retains 20% of heifer calves for breeding purposes. This is a form of vertical integration, incorporating a heifer enterprise into the overall cow-calf part of the business. An alternative scenario, called No Heifer Retention, is modeled in which all heifer calves are sold as weaned animals. In this scenario, all replacement breeding animals are purchased by the producer.

The results with respect to average gross margin are provided in Tables 5-4 to 5-12. The results from the simulation analysis produced mixed results. The results in the table indicated that there were years when the BASE scenario fared better than the no heifer retention scenario in terms of average gross margin. In other years, the no heifer retention was a better scenario than the BASE scenario. This lack of consistent pattern or trend was reflected in all the herd sizes and regions.

The expectation for the no heifer retention on the average annual gross margins was not certain as there were no previous empirical studies for the use of this strategy on which to base hypotheses. It is very difficult to tell from the result which was a better strategy. The upward and downward pattern on the average annual gross margins over the 10-year simulation period may be attributed to the stochastic nature of the model component involving conception rates, calving rates, weaning rates and death rates but most importantly price changes from heifer sales. Producers may want to retain heifers because of the fact that heifer prices vary from year to year in the simulation. In this analysis, producers generate additional income from sale of all the weaned heifers. However in the event that there were insufficient cows and there was a need for bred heifers, they may be required to purchase at a higher price which implies that expected gross margins may decrease. In the event that there are excess bred heifers and the market price is high, producers may sell these animals and gain extra income which may cause the average annual gross margins to rise. However, heifer calf prices and replacement animal prices are correlated, which would offset some of the risk in the heifer sale scenario. In this situation it is not certain which strategy may be best for the producer in terms of supporting gross margin due to the mixed results provided from the simulation analysis. Since there is no clear cut as to which was a better strategy, the decision to retain or not to retain may depend on the producer.

The 10-year average gross margins indicated that in almost all herd sizes there was a decrease in gross margin when the no heifer retention scenario was compared to the BASE scenario. A similar result occurs if regional comparisons are made.

5.3.6: Analysis of Annual Variability for the BASE Scenario versus the No Heifer Retention Scenario

The results regarding variability surrounding average annual gross margin for the no heifer retention scenario and the BASE scenario are provided in Tables 5-4 to 5-12. Again, there was no clear cut pattern as to which scenario was better able to reduce variability surrounding average annual gross margins. There were years when the variability associated with the BASE scenario was lower and other years when the no heifer retention scenario had lower variability.

Figures C-1 to C-9 in Appendix C provide a graphical representation of the pattern of variability in gross margin for the heifer retention scenarios in all representative farms. As with the previous graphs, the lines for each risk management strategy represent the upper and lower values that are likely to be encountered by the producer 95% of the time. The graphs show that over the 10 year simulation period, there was a decrease in variability in some of the years for the no heifer retention scenario and also for the BASE scenario where 20% of the heifers are kept as replacement heifers. However, on the whole, there was lower variability in returns for the heifer retention scenario (i.e., the BASE scenario) relative to the no heifer retention scenario. This was because in most of the years the gap between the lines for the no heifer retention scenario was wider than in the BASE scenario. Although the numerical differences were not large, the heifer retention may be of interest to producers from this perspective (i.e., lower variability of returns).

The potential risk reduction element of heifer retention is due to the reduced exposure to the variability in replacement animal prices as indicated earlier. If the producer was to sell all the heifer calves and in subsequent years the price of replacement heifers decreases, the producer may be better off. The opposite may hold, however, if the prices of the replacement heifers increase. The conclusion is that the strategy of retaining heifer calves in order to reduce risk provides mixed results. The impact of this scenario for the representative farms is relatively low, implying that heifer retention decisions contribute only a small part to the overall level of risk faced by the producers.

5.4: Results for CAIS Combined with Feed Storage or Heifer Retention Strategies

This part of the analysis reports the results from the simulation when the private risk management strategies (i.e., feed storage and heifer retention scenarios) were combined with the CAIS scenario. In particular the analysis focuses on comparing participation in CAIS without the private strategy with CAIS and the private strategy combined. The main aim was to investigate if producers could do better if they adopt the private strategy in addition to participation in CAIS. In other words, is there any benefit to combining strategies if CAIS is already being used?

In each case, the new "base" scenario is participation in CAIS without the relevant private strategy. The results from these scenarios are compared to the original CAIS scenario which included both feed storage and heifer retention. For example, CAIS is modeled in combination with No Feed Storage. The simulation results for this "base" scenario are then compared to the original CAIS results, which also include storage of 80% of excess feed in order to determine if feed storage provides any risk management benefits if the producer already participates in CAIS. Similarly, CAIS is also modeled in combination with No Heifer Retention. This "base" scenario is then compared to the original CAIS scenario, which includes heifer retention. This comparison allows an examination of whether heifer retention provides any risk management benefits if the producer is already participating in CAIS.

5.4.1: Analysis of Annual Gross Margin for CAIS combined with Feed Storage Scenarios

This section provides a discussion for the average annual gross margin results for CAIS combined with alternative feed storage strategies for the nine representative herd sizes in the various regions. The simulation results for the average annual gross margins are presented in Tables 5-13 to 5-15.

The results for representative farms in Southern Alberta are provided in Table 5-13. As mentioned earlier, the "base" in this case is the combination of CAIS plus no feed storage scenario which is compared to the original CAIS scenario which included 80% of the feed storage. The results from the table indicate that combining feed storage with

CAIS actually reduces average gross margin. The same pattern was found for the Aspen Parklands and Boreal Peace Lowland representative farms, as shown in Tables 5.14 and 5.15, respectively. In fact, the numerical differences were quite considerable, especially in years when lower average gross margins were recorded. The pattern was consistent across herd sizes and regions. It may be concluded then that adding combining feed storage with CAIS does not provide benefits in terms of supporting average annual gross margin.

5.4.2: Analysis of Annual Variability for CAIS combined with Feed Storage Scenarios

The simulation results regarding variability of annual gross margin for these combination strategies are presented in Tables 5-13 to 5-15. The results in these tables show that the combining feed storage with CAIS results in decreased variability associated with annual gross margin, compared to CAIS without feed storage, in most of the 10-year simulation period. This pattern was reflected in almost all the herd sizes and regions.

The CI graphs for the CAIS/feed storage combination strategies are provided in Figures D-1 to D-9 in Appendix D. The graphs provide a graphical representation of the pattern of variability in gross margin for the various herd sizes across regions. The lines in the graphs for these strategies represent the upper and lower values that are likely to be encountered by the producer 95% of the time. The graphs indicate that utilizing feed storage in combination with participation in CAIS provided less support for average annual gross margins, reflected by the relative position of the CI's on the graphs. However, combining the two strategies does improve "stability" in gross margin, as reflected by the differences in the width of the gap between the upper and lower bounds, which is wider for the "base" CAIS scenario (i.e., with no feed storage).

Overall, it would seem that there is some gain to be had from combining feed storage with participation in CAIS, as there is further risk reduction. However, this gain comes at the "cost" of lower average annual gross margins. Therefore, it is debatable as to whether there is a significant net benefit from adding this private strategy into the mix of risk management strategies, assuming that the producer participates in the public safety net.

5.4.3: Analysis of Annual Gross Margins for CAIS combined with Heifer Retention Scenarios

This section provides a discussion regarding average annual gross margin results for CAIS in combination with alternative heifer retention scenarios for the nine representative herd sizes in the various representative regions. The results for average annual gross margins are presented in Tables 5-13 to 5-15.

The results for representative farms in Southern Alberta are in Table 5-13. As mentioned earlier, the "base" in this case is the combination of CAIS plus no heifer retention scenario which is compared to the original CAIS scenario which included 20% heifer retention. The results for these scenarios are "mixed". In about one-half of the years in the 10-year simulated period, adding heifer retention to the base CAIS scenario (which assumes no heifer retention) results in lower average annual gross margin. A similar pattern was found for representative farms in the Aspen Parklands and Boreal Peace Lowland regions (Tables 5.14 and 5.15, respectively). In other words, about half the time CAIS by itself provided greater support for average gross margin, while CAIS combined with heifer retention provided greater support the other half of the time.

5.4.4: Analysis of Annual Variability for CAIS combined with Heifer Retention Scenarios

Results with respect to variability in annual gross margin for the combination strategies involving CAIS and heifer retention scenarios are presented in Tables 5-13 to 5-15. The results in these tables suggest that the variability surrounding the annual gross margins is reduced, relative to CAIS by itself, if heifer retention is added as an additional risk management strategy. This was reflected in most representative herd sizes and regions.

The CI graphs for CAIS combined with alternative heifer retention scehારios are provided by Figures E-1 to E-9 in Appendix E. These provide a graphical representation of the pattern of variability in gross margins for the various herd sizes, across regions. As with the previous graphs, the lines represent the upper and lower values that are likely to be encountered by the producer 95% of the time. As can be seen from the graphs, in terms of "supporting" annual gross margin, there is no clear advantage for CAIS versus CAIS with heifer retention, confirming the earlier discussion. As well, it would appear that combining heifer retention with participation CAIS does tend to reduce the width of the confidence intervals, indicating reduced variability (i.e., risk).

Overall, as was the case with CAIS/feed storage combinations, it would seem that there is some gain to be had from combining heifer retention with participation in CAIS, as there is further risk reduction. However, this gain comes at the "cost" of lower average annual gross margins, at least in some years. Again, then whether or not there is a significant net benefit from adding this private strategy into the mix of risk management strategies, assuming that the producer participates in the public safety net is debatable.

5.5: Chapter Summary

This chapter has presented and explained the simulation results for the different risk management strategies employed in the analysis. These were made up of a BASE scenario, CAIS scenario, feed storage scenario and heifer retention scenario. In all cases the individual strategies were compared to the BASE scenario. There were also combination strategies which were made up of the CAIS scenario plus (in turn) the two "private" strategies.

The BASE scenarios for all the herd sizes from the representative regions indicate that the average annual gross margin was positive for all herd sizes and average annual gross margin tended to increase with increasing herd size. Also obvious from the tabular and graphical results was that average gross margin fluctuated from year to year. This year to year variability differed across herd size within each region, with variability in average annual gross margin tending to be greater for larger herd sizes.

CAIS as a risk management strategy was able to increase average annual gross margins for all herd sizes in all regions. The impacts were quite significant in most years. It appeared that CAIS had a greater impact in years when the gross margin was lower which was expected as there were more iterations when payouts were triggered. The graphical representation of the pattern of variability in gross margins for the various herd sizes showed that there was a consistent decrease in variability with participation in the CAIS strategy. This pattern was the same for all three herd sizes in all regions.

The results from the feed storage scenario for all farms indicated that there was a decrease in average annual gross margin for all herd sizes for the 100% feed storage scenario relative to the BASE scenario in most years and this pattern was the same among the herd sizes and across regions. In the case of no feed storage, the results indicated that not storing feed resulted in increased average annual gross margins in most years for the representative farms. The opposite pattern emerged in terms of the variability surrounding the average annual gross margins. The 100% feed storage had the potential of decreasing the variability surrounding average annual gross margins whereas there was an increase in variability in annual gross margins for the no feed storage scenario when compared to the BASE scenario.

The results for the heifer retention scenarios indicated that there were years when the BASE scenario fared better than the no heifer retention scenario. In other years, the no heifer retention was a better scenario than the BASE strategy. This pattern in the no heifer retention strategy was reflected in all nine representative farms. As such, there was no clear cut choice as to which was the better strategy. In terms of the strategy to reduce variability surrounding the average annual gross margins, there was a decrease in variability of returns for the heifer retention scenario relative to the no heifer retention scenario.

In terms of combining strategies, two different comparisons were made. First, participation in CAIS (with no feed storage) was compared with participation in CAIS plus storage of 80% of excess feed production. It was found that adding feed storage did not provide benefits in terms of additional support for annual gross margin. In fact, average annual gross margin decreased under this scenario, relative to CAIS alone. Conversely, adding feed storage did result in reduced variability in annual gross margin, again compared to the "base" scenario of CAIS in isolation. Whether combining the two strategies would be considered preferable to only participating in CAIS would depend on the degree of risk aversion for individual producers, but there is not a clear advantage to combining the strategies.

The second comparison involved participation in CAIS (with no heifer retention) versus participation in CAIS plus retention of 20% of heifers for use as replacement breeding animals. The results in terms of support for annual gross margin were found to be mixed, as there was no consistent pattern as to which scenario provided greater support. Conversely, as was the case with feed storage, retaining heifers for breeding purposes did result in reduced variability in annual gross margin, again compared to the "base" scenario of CAIS in isolation. Also similar to the CAIS/feed storage combinations, the decision as to which scenario (i.e. CAIS or CAIS plus heifer retention) would be considered preferable by individual producers would depend on their degree of risk aversion, but there is not a clear advantage to combining the strategies.

Figures 5- 1: Average Annual Gross Margin ($) and Variability (95% Confidence Interval or CI) in Annual Gross Margin ($) for Representative Cow-Calf Operations, by Herd Size (Years 1-10) for Southern Alberta

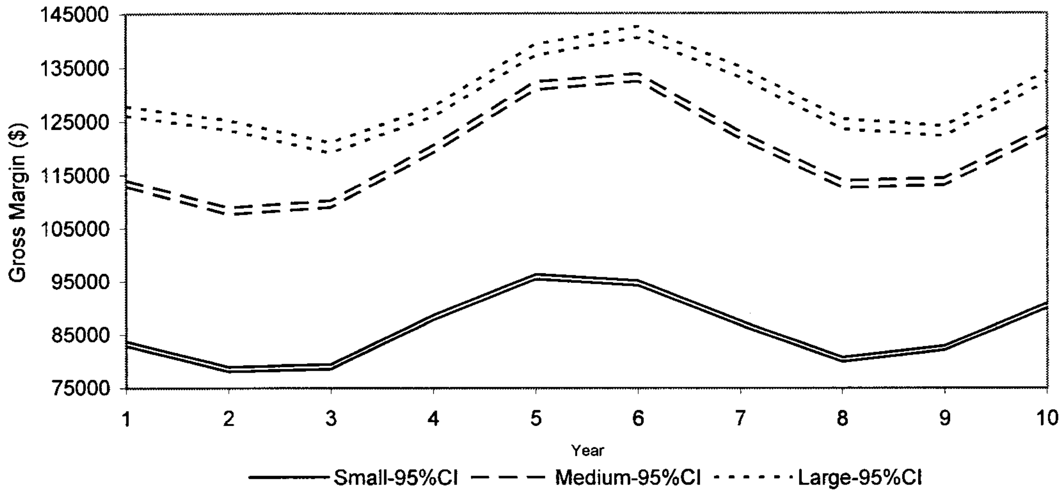

Figure 5-2: Average Annual Gross Margin ($) and Variability (95% Confidence Interval or CI) in Annual Gross Margin ($) for Representative Cow-Calf Operations, by Herd Size (Years 1-10) for Aspen Parklands

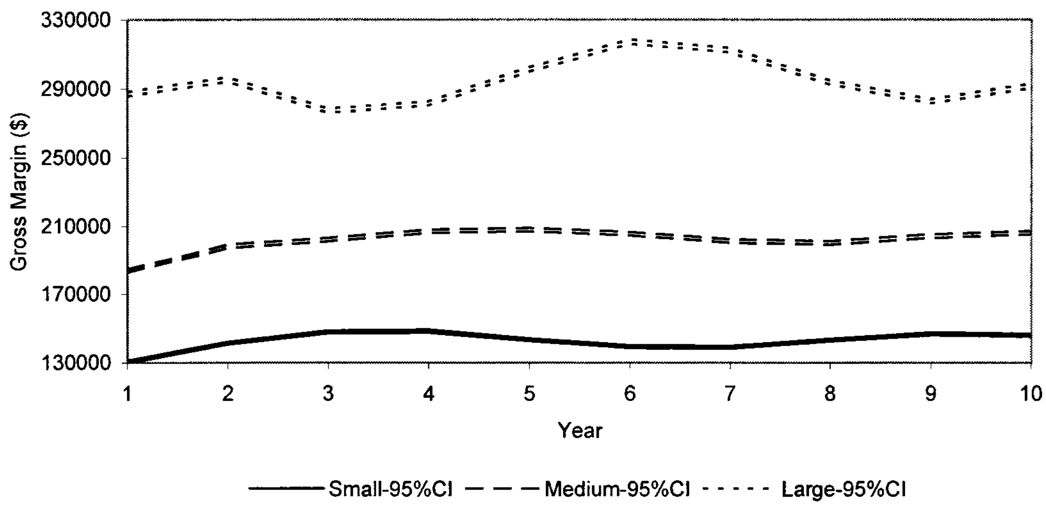

Figure 5-3: Average Annual Gross Margin ($) and Variability (95% Confidence Interval or CI) in Annual Gross Margin ($) for Representative Cow-Calf Operations, by Herd Size (Years 1-10) for Boreal/Peace Lowlands

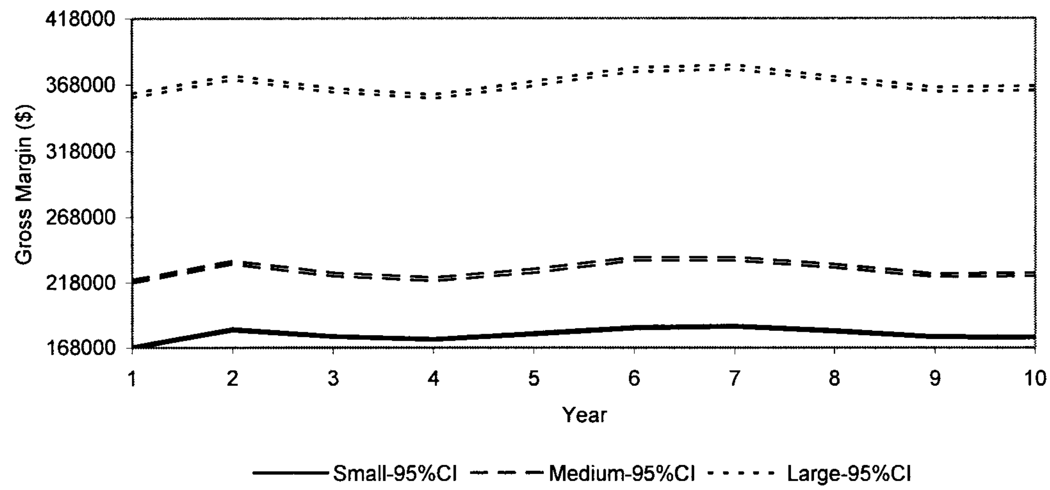

Table 5-1: Annual Gross Margin (Mean and Standard Deviation) for the Base Scenario by Herd Size for Southern Alberta

	Herd Size					
	Small		Medium		Large	
Year	Mean	Standard Dev.	Mean	Standard Dev.	Mean	Standard Dev.
1	83,301.85	6,535.92	113,466.10	9,593.53	126,964.50	14,392.45
2	78,495.25	6,653.58	108,365.90	10,099.01	124,346.80	14,715.52
3	78,966.02	6,958.21	109,612.70	10,524.64	120,093.00	15,004.79
4	88,239.51	7,241.62	119,860.60	11,049.17	126,836.50	15,329.43
5	95,857.38	7,392.01	131,682.00	12,088.78	138,289.80	16,398.62
6	94,690.10	7,348.50	133,161.80	11,550.89	141,574.00	16,244.33
7	87,172.25	6,804.92	122,363.30	10,774.90	134,115.30	15,357.94
8	80,310.19	6,607.02	113,257.40	10,493.46	124,492.80	15,410.12
9	82,487.34	6,561.46	113,754.50	10,260.47	123,170.50	14,799.08
10	90,454.31	7,086.45	123,131.30	11,190.39	133,288.80	15,981.00
10 Year Mean	85,997.42	8,732.32	118,865.50	12,378.08	129,317.20	14,213.70

Table 5-2: Annual Gross Margin (Mean and Standard Deviation) for the Base Scenario by Herd Size for Aspen Parklands

	Herd Size					
	Small		Medium		Large	
Year	Mean	Standard Dev.	Mean	Standard Dev.	Mean	Standard Dev.
1	130,553.40	11,908.87	183,616.40	14,923.09	287,110.90	19,392.57
2	141,280.50	11,731.65	198,354.30	15,899.45	295,402.50	20,428.79
3	147,808.40	12,357.89	202,319.50	16,670.13	277,282.80	19,915.59
4	148,301.00	12,846.86	207,338.20	16,750.00	281,601.70	19,686.03
5	143,429.70	12,767.79	208,203.30	17,421.58	301,317.40	20,989.13
6	139,350.30	11,902.10	205,846.20	16,353.74	317,423.90	21,269.07
7	138,928.90	11,740.23	201,445.00	16,466.63	312,319.10	21,010.07
8	143,194.40	12,397.12	200,465.00	16,208.48	293,631.70	19,240.65
9	146,719.70	12,215.83	204,421.70	16,651.01	282,843.50	20,000.35
10	146,065.00	12,195.24	206,298.90	16,188.96	291,755.10	20,869.02
10 Year Mean	142,563.10	10,152.69	201,830.80	14,145.53	294,068.90	21,543.51

Table 5- 3: Annual Gross Margin (Mean and Standard Deviation) for the Base Scenario by Herd Size for Boreal/Peace Lowland

	Herd Size					
	Small		Medium		Large	
Year	Mean	Standard Dev.	Mean	Standard Dev.	Mean	Standard Dev.
1	168,149.20	14,974.45	218,990.70	20,437.28	360,122.90	25,103.63
2	181,690.50	14,676.38	233,367.60	20,623.49	373,240.00	24,741.97
3	176,429.60	14,649.64	224,245.60	21,026.72	363,823.80	23,800.39
4	174,200.40	14,652.31	220,594.20	21,047.75	358,999.80	25,530.50
5	178,500.40	14,969.07	227,038.80	21,941.91	368,692.00	26,242.20
6	183,113.60	15,217.21	236,070.30	21,581.91	379,387.70	25,906.81
7	184,240.70	15,302.04	236,080.40	21,378.66	381,034.70	26,816.82
8	180,698.30	15,153.28	230,806.40	20,538.65	372,214.50	24,569.02
9	176,214.00	14,862.17	223,586.60	20,597.77	364,525.70	24,837.96
10	175,976.50	14,799.62	224,246.40	21,228.63	365,376.00	26,677.65
10 Year Mean	177,921.30	12,661.81	227,502.70	17,401.27	368,741.70	21,747.25

Table 5- 4: Annual Gross Margin (Mean and Standard Deviation) for the Small Herd Size, by Risk Management Scenario: Southern Alberta

	BASE		CAIS		100% Feed Storage	
Year	Mean	Standard Dev.	Mean	Standard Dev.	Mean	Standard Dev.
1	83,301.85	6,535.92	86,586.86	5,170.29	82,000.08	6,508.94
2	78,495.25	6,653.58	84,099.50	5,001.01	77,879.98	6,520.82
3	78,966.02	6,958.21	83,345.78	5,103.36	78,145.45	6,681.52
4	88,239.51	7,241.62	88,888.34	6,563.56	87,505.20	7,153.65
5	95,857.38	7,392.01	95,921.50	7,284.82	96,658.44	7,248.51
6	94,690.10	7,348.50	94,876.63	7,080.93	94,943.04	6,936.29
7	87,172.25	6,804.92	89,341.59	5,239.65	86,717.67	6,586.92
8	80,310.19	6,607.02	87,274.31	4,129.17	80,046.13	6,720.74
9	82,487.34	6,561.46	88,135.27	4,228.94	82,378.16	6,920.65
10	90,454.31	7,086.45	91,735.19	5,938.59	89,713.36	6,940.65
10 Year Mean	85,997.42	8,732.32	89,020.50	5,884.74	85,598.75	9,046.04

	No Feed Storage		No Heifer Retention	
Year	Mean	Standard Dev.	Mean	Standard Dev.
1	87,269.76	7,119.81	86,789.23	6,665.74
2	79,161.32	6,837.18	82,427.05	6,844.66
3	78,993.36	6,773.63	79,913.38	6,808.71
4	88,397.48	7,258.59	83,472.28	7,129.03
5	95,807.28	7,539.69	89,425.18	7,294.58
6	94,999.75	7,232.32	90,600.84	6,917.69
7	86,228.66	6,988.89	86,203.75	6,836.14
8	80,079.95	6,889.06	81,137.25	6,465.22
9	82,918.74	6,899.59	80,852.68	6,690.73
10	90,272.31	7,391.75	85,145.35	7,088.14
10 Year Mean	86,412.86	8,786.30	84,596.70	7,202.71

Table 5-5: Annual Gross Margin (Mean and Standard Deviation) for the Medium Herd Size, by Risk Management Scenario: Southern Alberta

	BASE		CAIS		100% Feed Storage	
Year	Mean	Standard Dev.	Mean	Standard Dev.	Mean	Standard Dev.
1	113466.10	9593.53	118837.70	7750.53	113107.40	10035.73
2	108365.90	10099.01	116117.90	7577.96	107103.80	9747.75
3	109612.70	10524.64	115301.50	8097.51	108400.30	10430.05
4	119860.60	11049.17	121159.50	9853.87	119335.30	11131.70
5	131682.00	12088.78	131831.90	11856.92	131737.20	12136.86
6	133161.80	11550.89	133316.70	11302.65	132508.30	11290.26
7	122363.30	10774.90	124649.50	9189.83	122874.90	10937.61
8	113257.40	10493.46	121651.30	7464.85	112348.40	10551.80
9	113754.50	10260.47	122156.00	7370.55	112891.30	10526.78
10	123131.30	11190.39	126164.80	8999.26	122294.30	11545.54
10 Year Mean	118865.50	12378.08	123118.70	8485.67	118260.10	12680.42

	No Feed Storage		No Heifer Retention	
Year	Mean	Standard Dev.	Mean	Standard Dev.
1	118161.40	10074.05	119355.40	10124.42
2	112064.10	10590.81	113731.80	10448.88
3	109847.30	10686.95	111111.90	10387.44
4	119653.30	11033.36	113370.50	10632.89
5	131255.50	12064.92	122353.30	10952.50
6	131712.50	11538.65	127153.20	11585.74
7	122774.00	11262.05	122716.20	10840.96
8	113595.80	10474.76	114769.80	10783.64
9	114223.90	11305.30	112078.60	11077.81
10	122911.10	11350.16	117357.20	10821.31
10 Year Mean	119619.90	11773.36	117399.80	10548.52

Table 5-6: Annual Gross Margin (Mean and Standard Deviation) for the Large Herd Size, by Risk Management Scenario: Southern Alberta

	BASE		CAIS		100% Feed Storage	
Year	Mean	Standard Dev.	Mean	Standard Dev.	Mean	Standard Dev.
1	126964.50	14392.45	131773.00	12181.86	124887.30	14450.91
2	124346.80	14715.52	130279.90	11652.17	122960.90	14856.51
3	120093.00	15004.79	127770.40	11465.12	118791.10	14838.71
4	126836.50	15329.43	130720.50	12755.43	126092.20	15398.75
5	138289.80	16398.62	139378.80	15248.25	137496.00	16692.06
6	141574.00	16244.33	142521.90	15279.92	141266.60	16200.39
7	134115.30	15357.94	136942.70	13215.28	134202.00	15387.36
8	124492.80	15410.12	132312.10	11722.57	124456.90	14440.77
9	123170.50	14799.08	132132.30	11159.80	123710.80	14889.73
10	133288.80	15981.00	137215.10	13205.23	133244.00	16177.17
10 Year Mean	129317.20	14213.70	134104.70	9448.84	128710.80	14340.30

	No Feed Storage		No Heifer Retention	
Year	Mean	Standard Dev.	Mean	Standard Dev.
1	134831.10	15211.86	133952.70	15032.07
2	124719.10	14587.92	130934.40	15235.44
3	120287.10	15091.87	125316.10	15503.17
4	127336.90	16315.84	123778.80	14780.66
5	138409.10	16552.03	129285.00	15206.56
6	140601.90	16576.97	136100.50	15397.96
7	134127.90	15283.47	135798.70	15781.52
8	125049.30	14770.66	129840.10	14878.29
9	123838.90	15730.69	124833.40	15427.35
10	133489.40	16749.68	125942.10	15352.36
10 Year Mean	130269.10	14392.31	129578.20	13235.15

Table 5-7: Annual Gross Margin (Mean and Standard Deviation) for the Small Herd Size, by Risk Management Scenario: Aspen Parklands

	BASE		CAIS		100% Feed Storage	
Year	Mean	Standard Dev.	Mean	Standard Dev.	Mean	Standard Dev.
1	130553.40	11908.87	140009.50	9992.10	127913.20	10978.07
2	141280.50	11731.65	144045.00	10580.71	140495.90	11645.47
3	147808.40	12357.89	148810.80	11588.85	146935.30	11629.12
4	148301.00	12846.86	149433.50	12021.98	147848.30	12160.25
5	143429.70	12767.79	146072.80	11322.31	143390.50	12019.67
6	139350.30	11902.10	143727.80	10049.71	138496.00	11802.30
7	138928.90	11740.23	144078.10	9965.81	138575.90	11740.35
8	143194.40	12397.12	146341.20	10897.83	143064.20	11991.18
9	146719.70	12215.83	148329.10	11177.32	146449.60	11943.14
10	146065.00	12195.24	147737.00	11054.07	146569.80	11904.45
10 Year Mean	142563.10	10152.69	145858.50	6613.16	141973.90	10340.75

	No Feed Storage		No Heifer Retention	
Year	Mean	Standard Dev.	Mean	Standard Dev.
1	118161.40	10074.05	119355.40	10124.42
2	112064.10	10590.81	113731.80	10448.88
3	109847.30	10686.95	111111.90	10387.44
4	119653.30	11033.36	113370.50	10632.89
5	131255.50	12064.92	122353.30	10952.50
6	131712.50	11538.65	127153.20	11585.74
7	122774.00	11262.05	122716.20	10840.96
8	113595.80	10474.76	114769.80	10783.64
9	114223.90	11305.30	112078.60	11077.81
10	122911.10	11350.16	117357.20	10821.31
10 Year Mean	119619.90	11773.36	117399.80	10548.52

Table 5-8: Annual Gross Margin (Mean and Standard Deviation) for the Medium Herd Size, by Risk Management Scenario: Aspen Parklands

	BASE		CAIS		100% Feed Storage	
Year	Mean	Standard Dev.	Mean	Standard Dev.	Mean	Standard Dev.
1	183616.40	14923.09	196716.70	12225.62	179861.80	14817.62
2	198354.30	15899.45	202528.70	13834.12	197728.20	15927.08
3	202319.50	16670.13	204942.20	14931.67	201886.90	15914.74
4	207338.20	16750.00	208859.90	15473.07	206439.30	16574.96
5	208203.30	17421.58	209909.60	16151.58	207629.90	17657.35
6	205846.20	16353.74	208208.60	14703.70	205685.10	16891.66
7	201445.00	16466.63	206916.10	13576.50	200913.90	16188.92
8	200465.00	16208.48	206534.80	13206.28	201044.40	16313.80
9	204421.70	16651.01	208596.80	14063.95	204707.10	17064.12
10	206298.90	16188.96	209629.20	14021.32	207381.80	17016.23
10 Year Mean	201830.80	14145.53	206384.30	9309.56	201327.80	14984.38

	No Feed Storage		No Heifer Retention	
Year	Mean	Standard Dev.	Mean	Standard Dev.
1	197845.20	16895.04	193063.80	15869.77
2	199360.50	16834.28	208270.40	16697.54
3	202422.00	16296.82	207180.50	16736.36
4	206691.70	17687.11	196959.20	15953.81
5	207263.10	17588.22	190260.90	15448.42
6	204637.10	16865.64	193336.90	16196.61
7	200764.00	16332.94	203485.00	17523.56
8	200532.90	16634.85	209879.50	16843.42
9	203438.20	17005.33	205608.10	16146.02
10	206110.80	18006.99	195341.30	15942.83
10 Year Mean	202906.50	11278.39	200338.60	14393.65

Table 5-9: Annual Gross Margin (Mean and Standard Deviation) for the Large Herd Size, by Risk Management Scenario: Aspen Parklands

	BASE		CAIS		100% Feed Storage	
Year	Mean	Standard Dev.	Mean	Standard Dev.	Mean	Standard Dev.
1	287110.90	19392.57	295942.90	15683.58	284164.10	19744.42
2	295402.50	20428.79	300257.90	17489.40	295013.60	19579.95
3	277282.80	19915.59	290973.20	14606.04	276533.40	20277.57
4	281601.70	19686.03	290924.30	14766.24	279556.20	20611.29
5	301317.40	20989.13	303362.90	18972.84	300143.30	21525.89
6	317423.90	21269.07	317902.20	20660.99	317098.60	21199.31
7	312319.10	21010.07	313715.20	19498.93	310774.40	20749.22
8	293631.70	19240.65	301240.20	14877.50	293842.50	19896.19
9	282843.50	20000.35	298148.70	13739.56	284777.50	20709.95
10	291755.10	20869.02	302200.90	15122.53	289213.00	20376.97
10 Year Mean	294068.90	21543.51	301466.80	14437.12	293111.70	21849.68

	No Feed Storage		No Heifer Retention	
Year	Mean	Standard Dev.	Mean	Standard Dev.
1	307942.50	21107.27	301128.50	20569.60
2	296706.70	19943.62	307549.70	20242.86
3	279984.60	20228.25	282421.20	20300.89
4	283096.30	21264.12	264775.30	20625.13
5	303631.10	21831.15	275542.80	20609.31
6	316282.00	21840.26	302185.40	21625.32
7	310922.70	21455.90	315482.20	21329.20
8	293189.40	20767.27	303006.30	20982.08
9	283363.10	19581.64	277859.00	20363.06
10	289664.30	21889.04	266936.40	19418.75
10 Year Mean	296478.30	21985.24	289688.70	25129.41

Table 5-10: Annual Gross Margin (Mean and Standard Deviation) for the Small Herd Size, by Risk Management Scenario: Boreal/Peace Lowlands

	BASE		CAIS		100% Feed Storage	
Year	Mean	Standard Dev.	Mean	Standard Dev.	Mean	Standard Dev.
1	168149.20	14974.45	176688.80	11420.74	164483.20	14262.79
2	181690.50	14676.38	183740.80	13138.99	180921.70	14937.05
3	176429.60	14649.64	180495.80	12186.90	176068.00	14645.83
4	174200.40	14652.31	178989.80	12020.71	173387.20	14935.87
5	178500.40	14969.07	181411.50	12793.62	177744.20	15390.67
6	183113.60	15217.21	184895.90	13683.13	182630.30	15276.84
7	184240.70	15302.04	186575.00	13248.49	183974.30	14979.31
8	180698.30	15153.28	184216.00	12686.70	179433.50	14465.72
9	176214.00	14862.17	181914.30	11758.15	175583.90	14322.26
10	175976.50	14799.62	182026.90	11902.59	175195.70	14882.66
10 Year Mean	177921.30	12661.81	182095.50	8408.10	176942.20	13179.74

	No Feed Storage		No Heifer Retention	
Year	Mean	Standard Dev.	Mean	Standard Dev.
1	180661.30	15595.01	175540.40	15229.28
2	182171.70	14644.58	190586.70	15234.82
3	176301.20	15188.36	179958.90	15096.89
4	173774.30	14671.77	163904.80	13967.73
5	177775.10	15804.94	162496.50	14752.91
6	181905.80	16140.56	175108.10	14961.16
7	182893.80	15209.99	188615.50	15364.88
8	180181.20	14540.88	188951.00	15336.85
9	175977.20	15132.49	174313.70	14311.51
10	175885.60	15243.76	163325.20	14542.04
10 Year Mean	178752.70	12750.13	176280.10	16055.34

Table 5-11: Annual Gross Margin (Mean and Standard Deviation) for the Medium Herd Size, by Risk Management Scenario: Boreal/Peace Lowlands

	BASE		CAIS		100% Feed Storage	
Year	Mean	Standard Dev.	Mean	Standard Dev.	Mean	Standard Dev.
1	218990.70	20437.28	228065.70	16626.51	216380.10	21554.57
2	233367.60	20623.49	236320.60	18581.26	233324.90	20658.55
3	224245.60	21026.72	230791.90	17592.21	223431.90	19712.65
4	220594.20	21047.75	228603.10	16966.37	220050.10	20807.84
5	227038.80	21941.91	232006.90	18231.37	227300.90	22290.28
6	236070.30	21581.91	238364.50	19437.09	235945.80	22474.35
7	236080.40	21378.66	239010.50	19076.29	238463.80	21445.96
8	230806.40	20538.65	235743.40	17457.73	230307.50	20660.77
9	223586.60	20597.77	231929.20	16383.25	224621.90	20771.70
10	224246.40	21228.63	232480.60	16877.61	223912.50	21885.76
10 Year Mean	227502.70	17401.27	233331.60	11502.14	227373.90	17843.91

	No Feed Storage		No Heifer Retention	
Year	Mean	Standard Dev.	Mean	Standard Dev.
1	237371.10	21285.79	229479.70	21859.33
2	233837.00	20867.86	242938.10	21648.95
3	224056.90	20232.71	229733.10	20752.76
4	220856.00	21111.40	212160.90	20305.97
5	226433.40	21398.29	209756.00	20873.09
6	235556.30	22454.47	224881.10	21183.10
7	236774.20	21545.97	241527.50	21826.39
8	231319.30	21448.54	241483.70	20832.70
9	224943.10	21745.57	224867.00	20031.39
10	224929.70	21100.62	210796.20	20289.89
10 Year Mean	229607.70	17660.45	226762.30	20904.28

Table 5-12 Annual Gross Margin (Mean and Standard Deviation) for the Large Herd Size, by Risk Management Scenario: Boreal/Peace Lowlands

	BASE		CAIS		100% Feed Storage	
Year	Mean	Standard Dev.	Mean	Standard Dev.	Mean	Standard Dev.
1	360122.90	25103.63	370230.50	20478.76	356178.30	24216.87
2	373240.00	24741.97	377821.30	21320.35	374447.80	24138.58
3	363823.80	23800.39	372094.30	19831.03	362671.70	25445.89
4	358999.80	25530.50	369293.10	19832.09	358607.50	25829.40
5	368692.00	26242.20	374330.70	22114.44	368341.00	25216.23
6	379387.70	25906.81	382146.20	23118.79	379505.50	25708.92
7	381034.70	26816.82	384544.30	23634.85	380826.80	25141.11
8	372214.50	24569.02	378341.50	20773.01	371396.00	23430.54
9	364525.70	24837.96	374762.20	19434.47	364450.40	25834.72
10	365376.00	26677.65	375689.00	20760.69	364425.90	25708.17
10 Year Mean	368741.70	21747.25	375925.30	14441.25	368085.10	22027.96

	No Feed Storage		No Heifer Retention	
Year	Mean	Standard Dev.	Mean	Standard Dev.
1	383597.70	27077.61	374898.90	25907.93
2	375944.30	24731.08	390020.20	26712.65
3	363759.40	24492.19	363606.30	25669.23
4	361877.30	26379.82	338253.50	24436.29
5	368857.80	26225.09	339155.70	25816.23
6	379080.50	25598.28	366386.40	25860.66
7	379698.40	25405.52	389020.10	26088.82
8	372446.80	25804.81	381428.30	25607.25
9	364375.10	24963.83	355786.70	25436.19
10	363160.80	26035.48	339025.80	26127.82
10 Year Mean	371279.80	22516.99	363758.20	28932.64

COMBINATIONS OF STRATEGIES

Table 5-13: Annual Gross Margin (Mean and Standard Deviation) for the Herd Size Groups, by Combination of Risk Management Scenarios: Southern Alberta

Small						
	CAIS		CAIS + No Feed Storage		CAIS + No Heifer Retention	
Year	Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.
1	86,586.86	5,170.29	89,142.36	5,932.95	88,089.91	5,662.14
2	84,099.50	5,001.01	85,186.47	4,865.07	85,640.06	5,004.58
3	83,345.78	5,103.36	84,226.35	4,817.68	84,255.93	4,837.66
4	88,888.34	6,563.56	89,215.90	6,473.14	85,714.41	5,495.82
5	95,921.50	7,284.82	95,963.98	7,305.43	90,076.78	6,531.78
6	94,876.63	7,080.93	95,266.48	6,842.65	91,116.06	6,304.39
7	89,341.59	5,239.65	88,903.36	5,128.32	87,935.80	5,463.35
8	87,274.31	4,129.17	87,045.15	4,207.69	85,481.02	4,312.90
9	88,135.27	4,228.94	88,151.41	4,474.09	85,508.92	4,219.83
10	91,735.19	5,938.59	91,682.64	6,101.37	87,523.16	5,328.65
10 Year Mean	89,020.50	5,884.74	89,478.41	5,787.38	87,134.20	4,665.66
Medium						
	CAIS		CAIS + No Feed Storage		CAIS + No Heifer Retention	
Year	Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.
1	118837.70	7750.53	121884.10	8765.53	121533.60	8855.82
2	116117.90	7577.96	118882.90	8196.99	118608.70	8079.28
3	115301.50	8097.51	116896.70	7901.87	116978.10	7626.17
4	121159.50	9853.87	121599.70	9403.98	117424.60	8151.66
5	131831.90	11856.92	131510.40	11717.56	123420.30	9890.29
6	133316.70	11302.65	132024.50	11133.71	127749.50	10884.87
7	124649.50	9189.83	125270.50	9356.33	124257.80	9374.11
8	121651.30	7464.85	121596.10	7649.84	119934.30	7783.08
9	122156.00	7370.55	122220.80	8113.59	119009.50	7554.19
10	126164.80	8999.26	125908.80	9294.39	121509.50	8320.46
10 Year Mean	123118.70	8485.67	123779.40	7773.74	121042.60	6928.92
Large						
	CAIS		CAIS + No Feed Storage		CAIS + No Heifer Retention	
Year	Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.
1	131773.00	12181.86	137438.50	13282.14	136379.10	13162.05
2	130279.90	11652.17	131713.80	11459.01	134997.20	12584.93
3	127770.40	11465.12	129076.10	11577.29	131973.10	12090.92
4	130720.50	12755.43	131933.70	13056.49	130826.70	11546.03
5	139378.80	15248.25	139915.70	15021.67	133387.30	12597.89
6	142521.90	15279.92	141972.50	15131.26	138005.10	13659.04
7	136942.70	13215.28	137118.50	13122.25	138170.40	13622.77
8	132312.10	11722.57	132594.80	11379.35	134101.60	12188.77
9	132132.30	11159.80	132665.20	11539.87	131840.70	11738.24
10	137215.10	13205.23	137537.90	13692.27	132390.90	11632.96
10 Year Mean	134104.70	9448.84	135196.70	9387.44	134207.20	8527.15

Table 5-14: Annual Gross Margin (Mean and Standard Deviation) for the Herd Size Groups, by Combination of Risk Management Scenarios: Aspen Parklands

Small						
	CAIS		CAIS + No Feed Storage		CAIS + No Heifer Retention	
Year	Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.
1	140009.50	9992.10	145400.80	10094.96	141658.00	9810.08
2	144045.00	10580.71	146335.20	10386.91	149443.50	11417.73
3	148810.80	11588.85	150412.00	11349.17	152088.70	11606.55
4	149433.50	12021.98	150844.90	11406.04	145322.50	9619.06
5	146072.80	11322.31	147524.80	10527.60	140883.20	9046.24
6	143727.80	10049.71	145538.00	10087.73	139332.50	8819.64
7	144078.10	9965.81	145526.00	9576.54	144036.60	10113.94
8	146341.20	10897.83	147419.40	10347.75	151357.00	11736.31
9	148329.10	11177.32	149332.20	10850.01	149784.10	11328.06
10	147737.00	11054.07	148992.40	11176.75	142114.50	9161.66
10 Year Mean	145858.50	6613.16	147732.60	6280.52	145602.10	7646.34

Medium						
	CAIS		CAIS + No Feed Storage		CAIS + No Heifer Retention	
Year	Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.
1	196716.70	12225.62	204352.20	13773.06	200428.60	13099.46
2	202528.70	13834.12	204707.90	13979.65	209877.90	15520.01
3	204942.20	14931.67	206255.50	13972.09	209441.70	15100.96
4	208859.90	15473.07	209315.30	15692.24	203193.50	13295.69
5	209909.60	16151.58	209880.90	15464.03	199843.90	12287.52
6	208208.60	14703.70	208436.80	14362.71	200019.50	12946.15
7	206916.10	13576.50	206343.20	13471.91	206382.90	15196.99
8	206534.80	13206.28	206665.80	13311.84	210956.30	15821.83
9	208596.80	14063.95	207916.40	14270.80	207689.30	14577.94
10	209629.20	14021.32	209631.90	15259.68	201852.00	12772.18
10 Year Mean	206384.30	9309.56	207350.60	8985.22	204968.50	9596.87

Large						
	CAIS		CAIS + No Feed Storage		CAIS + No Heifer Retention	
Year	Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.
1	295942.90	15683.58	310920.20	19092.80	303768.10	19111.85
2	300257.90	17489.40	304517.80	16216.73	309591.20	18691.53
3	290973.20	14606.04	295843.80	14876.85	295324.90	15887.32
4	290924.30	14766.24	294976.00	15713.80	287863.80	14424.98
5	303362.90	18972.84	306572.60	19009.35	288644.90	15022.90
6	317902.20	20660.99	317483.60	20355.89	304021.40	19743.11
7	313715.20	19498.93	313404.90	18404.52	315997.90	20616.61
8	301240.20	14877.50	302231.90	15450.13	304901.20	19136.61
9	298148.70	13739.56	299054.00	13998.25	291207.60	14383.28
10	302200.90	15122.53	302274.40	15121.48	288347.60	12936.48
10 Year Mean	301466.80	14437.12	304727.90	14188.87	298966.90	15627.92

Table 5-15: Annual Gross Margin (Mean and Standard Deviation) for the Herd Size Groups, by Combination of Risk Management Scenarios: Boreal/Peace Lowlands

Small						
	CAIS + 100% Feed Storage		CAIS + No Feed Storage		CAIS + No Heifer Retention	
Year	Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.
1	176688.80	11420.74	183949.10	13374.04	179906.90	12789.25
2	183740.80	13138.99	185075.00	12686.37	191391.90	14448.39
3	180495.80	12186.90	181754.40	12111.43	183636.80	12875.34
4	178989.80	12020.71	180246.00	11431.30	176418.80	10854.69
5	181411.50	12793.62	182017.80	12777.08	174393.00	10706.54
6	184895.90	13683.13	184989.50	13617.43	178897.60	12483.03
7	186575.00	13248.49	185598.00	13081.78	189511.90	14327.35
8	184216.00	12686.70	183635.10	12150.16	189723.30	14448.95
9	181914.30	11758.15	181589.60	11969.53	178943.50	11432.52
10	182026.90	11902.59	181518.40	11938.32	175066.30	10081.39
10 Year Mean	182095.50	8408.10	183037.30	8369.05	181789.00	10338.91

Medium						
	CAIS + 100% Feed Storage		CAIS + No Feed Storage		CAIS + No Heifer Retention	
Year	Mean	Standard Dev.	Mean	Std Dev.	Mean	Std Dev.
1	228065.70	16626.51	240137.40	19400.06	234390.50	19192.14
2	236320.60	18581.26	238332.30	18201.55	244655.60	20254.36
3	230791.90	17592.21	233069.00	16359.28	236039.80	17559.29
4	228603.10	16966.37	230967.00	16555.84	227816.60	15517.31
5	232006.90	18231.37	232909.30	17190.66	225162.20	15584.69
6	238364.50	19437.09	239015.10	19650.12	230589.50	17312.44
7	239010.50	19076.29	239791.90	19215.33	242832.70	20656.80
8	235743.40	17457.73	235969.50	18265.67	242834.90	19541.44
9	231929.20	16383.25	232687.00	17130.46	230996.50	16339.98
10	232480.60	16877.61	233234.50	16840.44	225515.80	14595.46
10 Year Mean	233331.60	11502.14	235611.30	11577.06	234083.40	13362.46

Large						
	CAIS + 100% Feed Storage		CAIS + No Feed Storage		CAIS + No Heifer Retention	
Year	Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.
1	370230.50	20478.76	387063.80	24055.08	378545.50	23433.51
2	377821.30	21320.35	381977.40	21124.44	391515.40	25229.38
3	372094.30	19831.03	375671.40	18929.75	374366.30	21131.72
4	369293.10	19832.09	374098.80	20076.66	363788.70	18351.21
5	374330.70	22114.44	376767.00	21100.21	360878.10	18640.92
6	382146.20	23118.79	383429.30	22207.16	371821.60	21957.83
7	384544.30	23634.85	383902.20	21668.53	389767.80	25291.82
8	378341.50	20773.01	378888.20	21106.19	383023.40	23919.40
9	374762.20	19434.47	374978.70	19391.86	365791.70	19574.80
10	375689.00	20760.69	374332.80	19665.82	361013.80	18252.26
10 Year Mean	375925.30	14441.25	379111.00	14758.01	374051.20	18304.29

6.0: CHAPTER 6: Conclusions and Limitations

6.1: Introduction

The overall goal of this study was to evaluate the effectiveness of alternative public and private risk management strategies for Alberta beef cow-calf producers. The specific objectives of the study were to: (1) develop a dynamic, stochastic bio-economic model that could be used to simulate biological and economic relationships for Alberta cow-calf operations; (2) identify alternative risk management strategies (both public and private) that were either typically used or may be considered for use by Alberta cow-calf producers; (3) model the performance of these risk management strategies; and (4) evaluate the ability of the risk management strategies to stabilize and/or support returns for Alberta cow-calf producers.

A dynamic stochastic bio-economic simulation was used as the modeling technique in this study; specifically Monte Carlo simulation. This was done to reflect the complexity of the systems involved in cow-calf production, and to be able to rigorously replicate/imitate the processes in these systems. The model simulated the performance of farm representatives over a 10-year period. The results obtained provided insights into the potential ability of risk management strategies to increase average annual gross margins as well as decrease the variability surrounding the average annual gross margins.

6.2: Representative Farms

The characteristics of the representative farms used in the analysis had to be defined. The farms defined for use in the study were said to be representative in that they were assumed to have characteristics that would be consistent with Alberta cow-calf operations. They were not necessarily "average" farms, but instead these farms were "typical" of many cow-calf operations in the study region. The process of defining these farms was carried out using farm data for cow-calf production in Alberta. For the purposes of this study, the main characteristics used to define the representative farm operations were geographic location and cow herd size.

6.2.1: Geographic Location

Geographic location for the cow-calf operations was defined using data for grass type and soil type. Expert opinion from Alberta Agriculture, Food and Rural Development (AAFRD) was used to identify three geographic regions to define the representative farms; Southern Alberta, Aspen Parklands and Boreal/Peace Lowlands. Southern Alberta was assumed to be characterized by fescue grassland, moist mixed grassland and mixed grassland, with associated soils being brown, dark brown and thin black. Aspen Parklands was characterized by its own grass type, and black soils. The Boreal/Peace Lowlands were characterized by Boreal Transition and Peace Lowlands grass types, and black and grey wooded soils.

6.2.2: Cow Herd Sizes

The other criterion used to define the representative cow-calf operations was size of the breeding herd. This was used as a measure of "firm size" in terms of the main enterprise under consideration in the study. For each geographic region, the distribution of herd size was examined to determine "representative" values. In order to reflect the diversity in size of cow-calf operation within each of these regions, three representative herd sizes were identified; small, medium and large. In defining the cow herd sizes a number of histograms were developed to facilitate visualization of the distributions. The herd sizes were smallest for Southern Alberta and largest for the Boreal/Peace Lowlands region.

6.3: Data and the Farm Model Parameters

The two main types of parameters required for the simulation analysis were production and price elements. These production parameters were classified as being either exogenous/stochastic, exogenous/deterministic, or endogenous. Both beef and crop price parameters were needed for the simulation analysis.

6.3.1: Production Elements

A variety of production parameters were required for the simulation analysis. Stochastic parameters for the cow-calf enterprise included conception rates and calving rates for both cows and heifers, percentage death loss of yearlings, cows and heifers over winter and weights for weaned steers and heifers. Other cow-calf enterprise parameters included weight per animal of culled cows and open heifers sold, culling rates and rate of retention for heifers. Feed requirements, inputs and input costs were also among the deterministic cow-calf parameters used for the analysis. For crops, yield per acre and acres grown of each crop were required, as were per acre costs of production.

6.3.2: Price Elements

Based on evidence from previous empirical research, prices were modeled using time series relationships. This included price relationships for steers, heifers, culled cows and open heifers, replacement bulls, barley and hay. Estimation of the time series price relationships was conducted using historical price data for Alberta. Results of unit root tests determined that the price series were stationary, suggesting that the prices mean-revert and that logged price data were in the proper form to proceed with the estimation of the forecasting models using regression analysis. An autoregressive (AR) approach was used to model stochastic prices in the current study. The lag lengths most appropriate for the AR (n) model were determined using Akaike's information criterion (AIC) and Schwarz's criterion (SC). Single equation price models were used in the simulation analysis, taking correlations between prices into account.

6.4: Risk Management Strategies and Results

The risk management strategies considered in the current study were participation in CAIS, feed storage and heifer retention scenarios. These were compared to a BASE scenario which did not involve participation in any public safety net program. However, the BASE scenario did have elements of risk management through feed storage and heifer retention. Besides looking at strategies in isolation, the feed storage and heifer retention strategies were also considered, in turn, in combination with participation in CAIS.

6.4.1: BASE Results

One obvious characteristic that was common to all nine representative farms was that average annual gross margin was positive in all years. A second general pattern that emerged from the simulation results and graphs was that average annual gross margin tended to increase with increasing herd size. This year to year variability in annual gross margin also varied across herd size within each region with the variability being greater for larger herd sizes.

6.4.2: BASE versus CAIS

The simulation results indicated that in all cases, participation in CAIS resulted in increased expected gross margins relative to the BASE scenario, which was to be expected. The impacts were significant in almost all years. In terms of variability, the results indicated that in all cases, CAIS was able to decrease variability surrounding the average annual gross margins in all the years for all representative farms.

6.4.3: Feed Storage Scenarios

Compared to the BASE scenario (i.e., storage of 80% of excess feed), there was a decrease in average annual gross margins associated with adopting a strategy of storing 100% of excess feed. This pattern was consistent over herd size and region. Conversely, adopting a strategy of storing no excess feed (i.e. selling it instead) resulted in increased average annual gross margins in most years for the representative farms.

The opposite pattern emerged in terms of variability for annual gross margins. There was a decrease in variability of annual gross margins for the 100% feed storage scenario relative to the BASE scenario. Conversely, there was an increase in variability for the no feed storage scenario. This strategy is therefore "typical" in that it involves a tradeoff; reduced variability in returns for reduced expected returns.

6.4.4: Heifer Retention Scenarios

The BASE scenario included retention of heifers for use as replacement breeding stock. This was compared to a scenario (No Heifer Retention) where all weaned heifers were sold and all replacement breeding animals were purchased as bred heifers. The results indicated that there were years when the BASE scenario fared better than the no heifer retention scenario in terms of increased average annual gross margins. However, the opposite was true for other years of the simulation. This lack of a definite trend or pattern was reflected in all nine farms. There was also no clear cut choice on a year to year basis as to which scenario was better able to reduce the variability for annual gross margin. However, on the whole there was lower variability in gross margin (i.e., over the 10-year simulation period) for the heifer retention scenario (i.e., the BASE scenario) relative to the no heifer retention scenario. Once again, the tradeoff between expected returns and variability of returns is at least somewhat evident in the results for this strategy.

6.4.5: CAIS in Combination with other Risk management Strategies

The use of CAIS as the sole risk management strategy was compared with participation in CAIS and then adding on one or the other of the two "private" strategies (i.e., feed storage or heifer retention). These alternative scenarios were analyzed to explore if producers could do better if they adopt CAIS scenario in addition to the other risk management strategies. That is, was there any benefit to combining strategies if CAIS was already being used?

A comparison of the single CAIS strategy to the combination strategy of CAIS plus feed storage indicated that CAIS by itself (i.e., no feed storage) resulted in higher average annual gross margins when compared to the CAIS in combination with storage of 80% of excess feed. This was consistent across herd sizes and regions.

Although CAIS with no feed storage had higher average annual gross margins, the down side to this was that the variability was also higher when compared to CAIS in combination with feed storage, at least in most years. However, the difference between the two was relatively small, suggesting that the gains to be had from combining the strategies were also relatively small.

Similar results were found for the combination of CAIS and heifer retention. In about half of the 10 years in the simulation, CAIS by itself (i.e., no heifer retention) resulted in higher average annual gross margins when compared to combination of CAIS and heifer retention. This was consistent across herd sizes and regions. The results also indicated that variation surrounding annual gross margins of CAIS plus no heifer retention scenario was higher than CAIS plus heifer retention. This was reflected in most of the herd size and region combinations. Once again, the degree of improvement was small, suggesting that the gains to be made in risk management from combining the two strategies were also small.

6.5: Conclusions

As previously mentioned, the risk management strategies included in the analysis included participation in CAIS, storage of excess feed, and heifer retention. Also included were comparisons involving combination strategies of CAIS plus feed storage and CAIS plus heifer retention. The ability of the risk management strategies to stabilize and/or support returns for Alberta cow-calf producers was the main focus in the analysis.

While some strategies emerged as providing support as well as stability for the long term average annual gross margin, others produced mixed results. The findings of the study indicated that the participation in the CAIS program emerged as the best overall strategy. In terms of support the CAIS strategy was able to increase average annual gross margins over the 10-year simulation period.

The CAIS program is designed to help producers protect their farming operation from both small and large drops in income. As modeled in this study, the program appeared to be able to accomplish that objective. Especially in years where the income drop was large, the CAIS strategy was able to cushion the producers' income back to the level of protection level. In terms of variability, the CAIS program proved superior above the other strategies by providing stability in average annual gross margins. The result obtained for the 10- year mean implied that in the long run the CAIS program is able to stabilize income for producers. As noted in the discussion of the simulation results, however, at least some of this stabilization occurs because of the subsidization aspects of CAIS.

For the other two strategies (feed storage and heifer retention) it can be said that although they exhibit the tradeoff typical of many risk management strategies; that is, there is a potential reduction in variability of returns, but at the cost of reduced expected returns. Therefore, whether or not it makes sense to adopt them depends on the risk preferences of producers (i.e., the degree of risk aversion).

In terms of combining strategies, it may be concluded that with participation in CAIS the "incentive" to use private strategies is reduced. There does not appear to be a large additional reduction in risk associated with storing excess feed or retaining heifers for breeding purposes if the producer is already participating in CAIS. Additionally, the simulation results in this study suggest that the level of expected returns is actually lower.

6.6: Model Limitations

Due to limited data, several assumptions were made in the process of developing and using the simulation models. It is possible that the outcome of this study would have been different if some of these assumptions could have been avoided. The following sections provide a discussion of some of these limitations.

6.6.1: Production Parameter Assumptions

Although most of the production parameters used in the simulation, model were generated from historical data, some had to be based on average values provided in the AgriProfits database. These included crop yields. Yields for individual farms were not available; instead, available means and standard deviations had to be used in generating stochastic values for the simulation. Having actual yield values might have resulted in better modeling of these stochastic values, as it would have been possible to incorporate correlations between crop yields.

Some production parameters used in the model simulation were assumed to be determined by managers. One example was the percentage of heifer calves retained for breeding purposes. Producers may be retain more or less heifers for breeding purposes and the percentage retained may be different across herd size and regions. However, with no data available for this parameter, the assumption was made that the value was the same for all producers regardless of herd size or geographic location.

6.6.2: Price Assumptions and Forecasting Models

Both crop and beef prices were used in the simulation analysis. With the beef prices actual historical data were used to develop pricing model parameters. This was also the case for hay and barley prices. In the case of prices for wheat and canola used in the analysis, however, average values and associated measures of variability (i.e., variance) were obtained from the summary reports available through AgriProfits. As discussed in Chapter 4, wheat and canola prices were not deemed to be as significant to the main issues being addressed in the thesis as hay and barley. This was due to the fact that hay and barley are central to the cow-calf enterprise as ration ingredients. However, making use of historical price data for wheat and canola, and using that data to incorporate these crop prices into the overall pricing model analysis might have produced different (and potentially "better") simulation results.

6.7: Suggestions for Further Research

Overall, the CAIS program was deemed to have the potential of increasing returns as well as providing stability. However, only one level of participation was considered in the analysis. One area of research that could be explored is the impact of varying the level of participation over all three tiers in terms of the effectiveness of the program for these cow-calf producers. Given the changes that have occurred to CAIS since the start of this research project, it would also be useful to assess how these changes would affect the effectiveness of participating in CAIS. It would also be useful for policymakers to assess the impact of these changes in terms of costs to producers and taxpayers.

It would also be useful to explore other risk management strategies, both in isolation and in combination with CAIS and with each other. While feed storage and heifer retention are relevant risk management strategies, they focus on specific aspects of risk. It would be useful to identify and model strategies that manage other types of risk.

For example, risk management strategies that consider market price risk (e.g., forward contracting or hedging) might be modeled.

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APPENDIX A - Variability in Annual Gross Margin for the BASE Scenario versus CAIS

Figure A-1: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Small Herd Size, Base Scenario and Participation in CAIS (Years 1-10) Southern Alberta

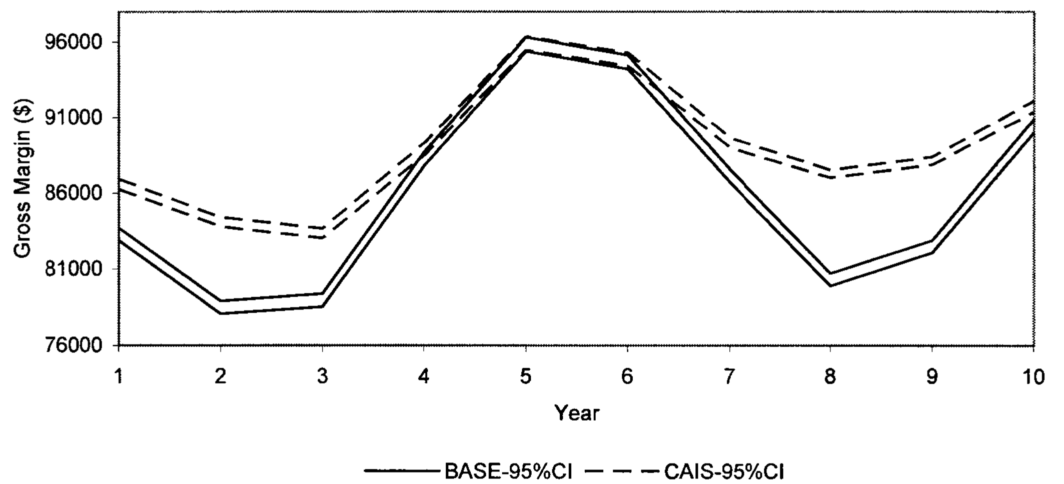


Figure A-2: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Medium Herd Size, Base Scenario and Participation in CAIS (Years 1-10) Southern Alberta

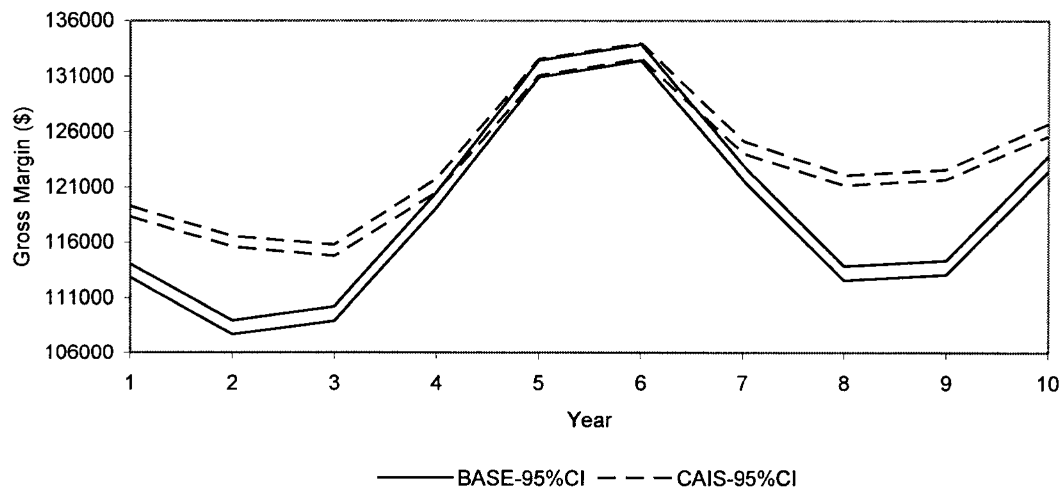


Figure A-3: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Large Herd Size, Base Scenario and Participation in CAIS (Years 1-10) Southern Alberta

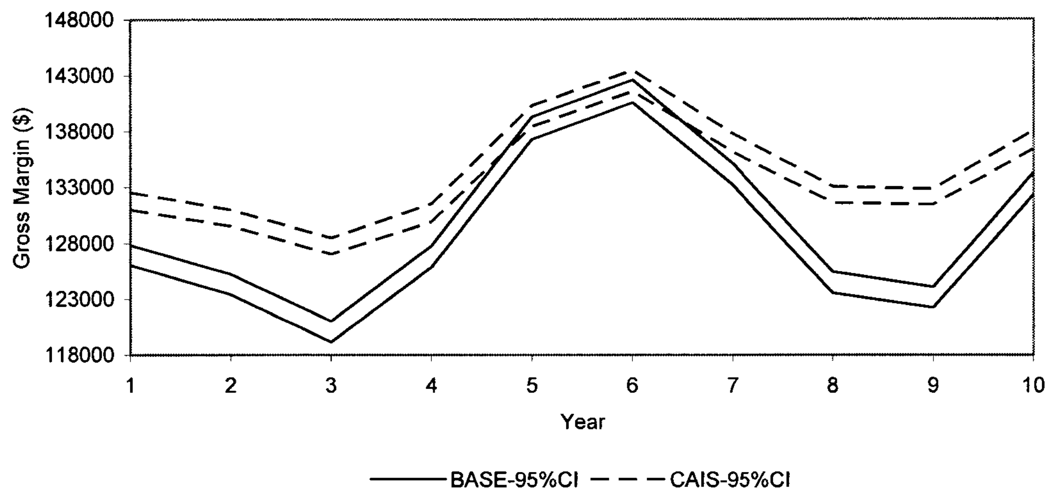


Figure A-4: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Small Herd Size, Base Scenario and Participation in CAIS (Years 1-10) Aspen Parklands

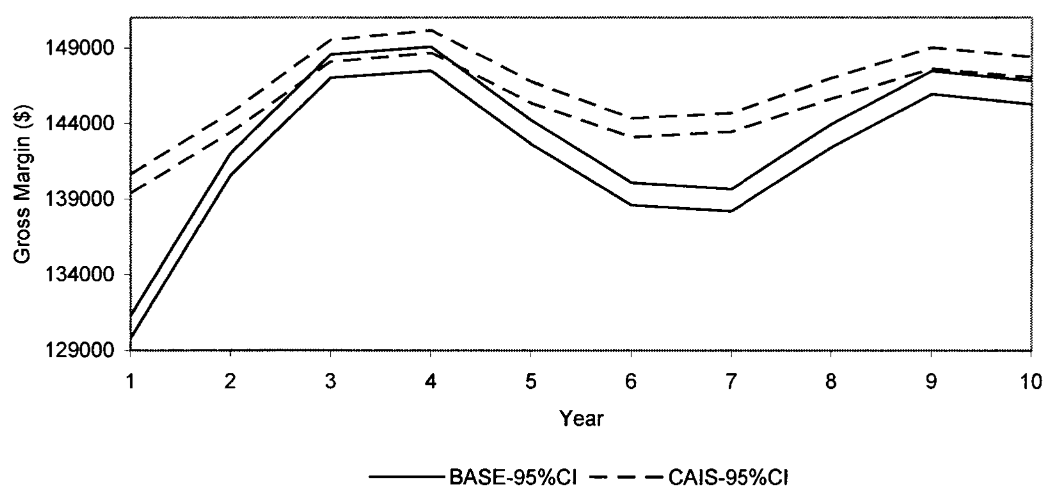


Figure A-5: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Medium Herd Size, Base Scenario and Participation in CAIS (Years 1-10) Aspen Parklands

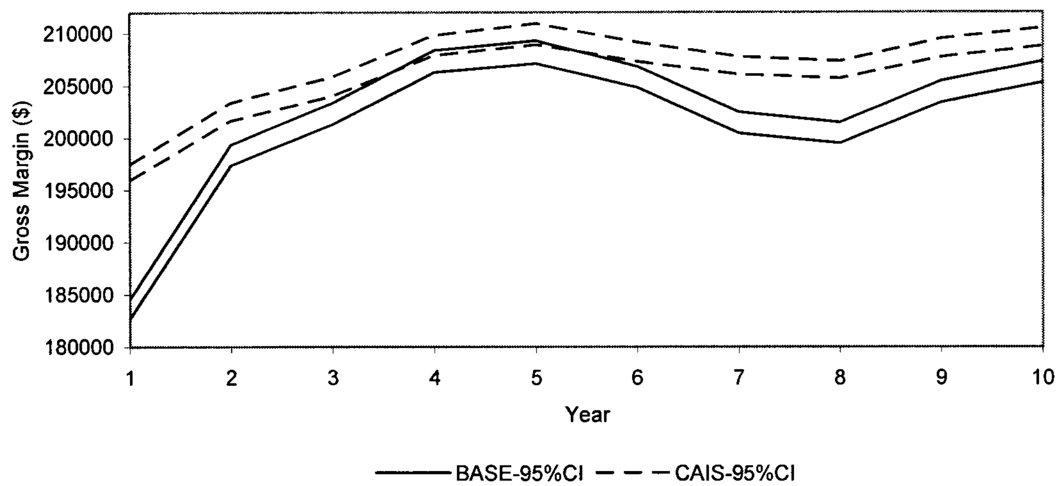


Figure A-6: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Large Herd Size, Base Scenario and Participation in CAIS (Years 1-10) Aspen Parklands

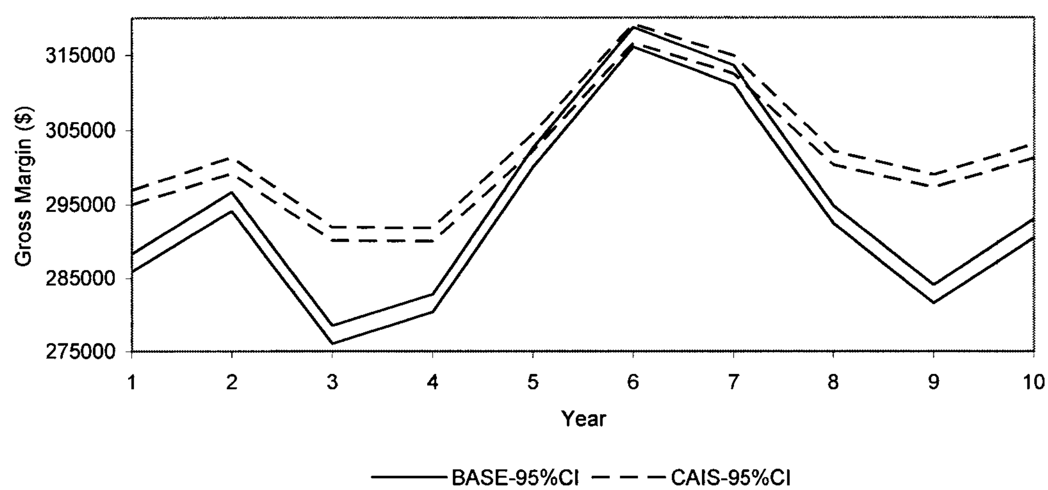


Figure A-7: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Small Herd Size, Base Scenario and Participation in CAIS (Years 1-10) Boreal Peace/Lowlands

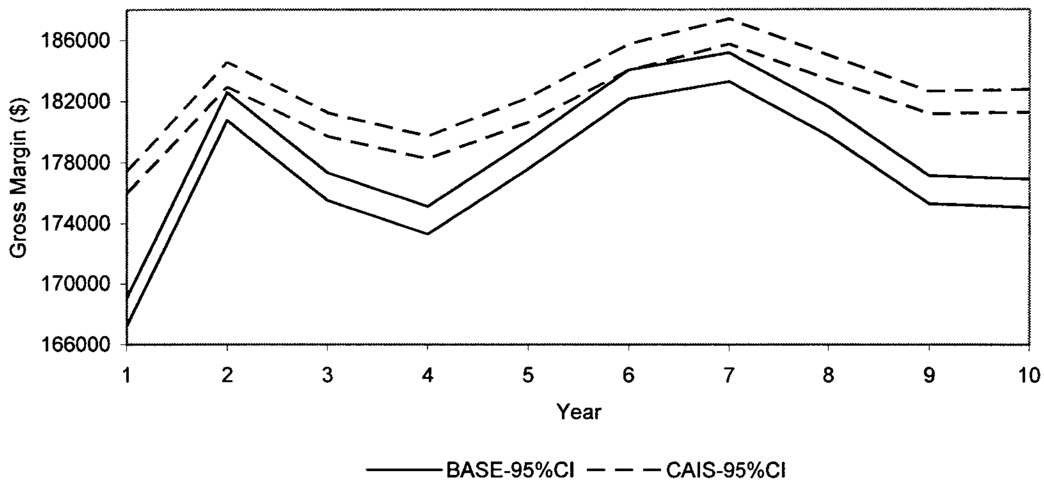


Figure A-8: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Medium Herd Size, Base Scenario and Participation in CAIS (Years 1-10) Boreal Peace/Lowlands

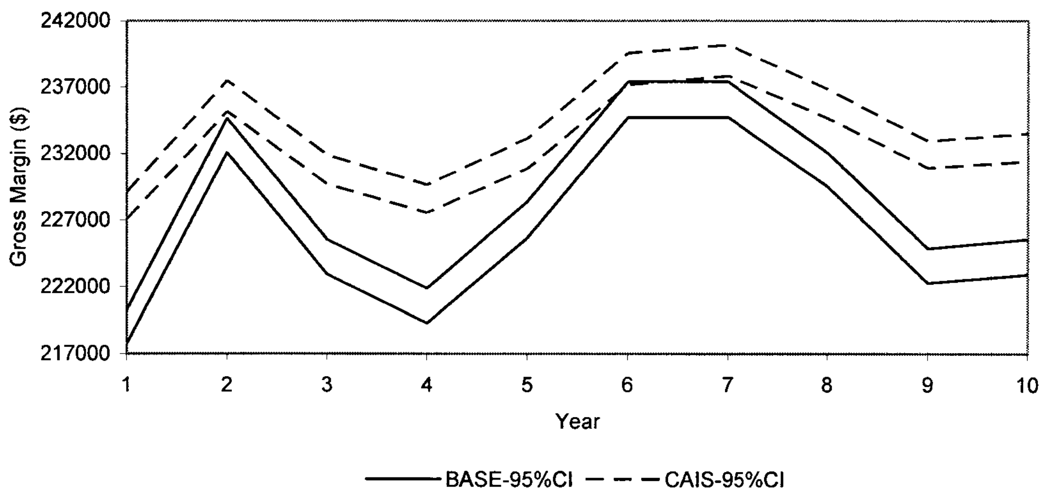
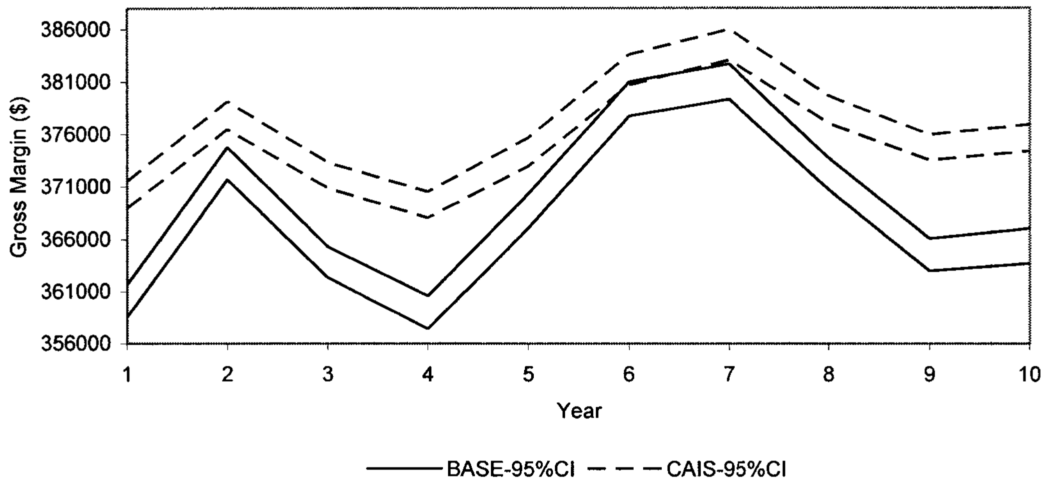


Figure A-9: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Large Herd Size, Base Scenario and Participation in CAIS (Years 1-10) Boreal Peace/Lowlands



APPENDIX B - Variability in Annual Gross Margin for the BASE Scenario versus 100% Feed Storage and No Feed Storage

Figure B-1: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Small Herd Size, Base Scenario, 100% Feed Storage and No Feed Storage (Years 1-10) Southern Alberta

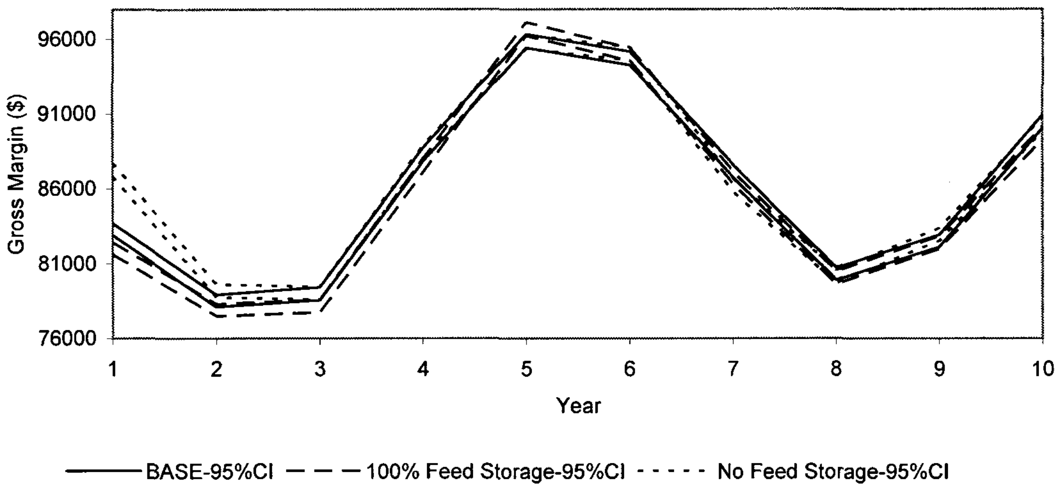


Figure B-2: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Medium Herd Size, Base Scenario, 100% Feed Storage and No Feed Storage (Years 1-10) Southern Alberta

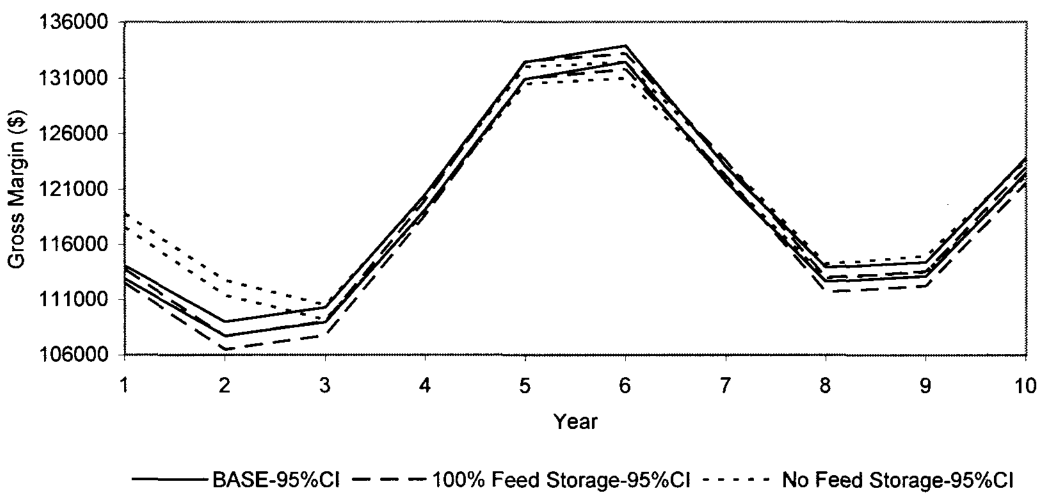


Figure B-3: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Large Herd Size, Base Scenario, 100% Feed Storage and No Feed Storage (Years 1-10) Southern Alberta

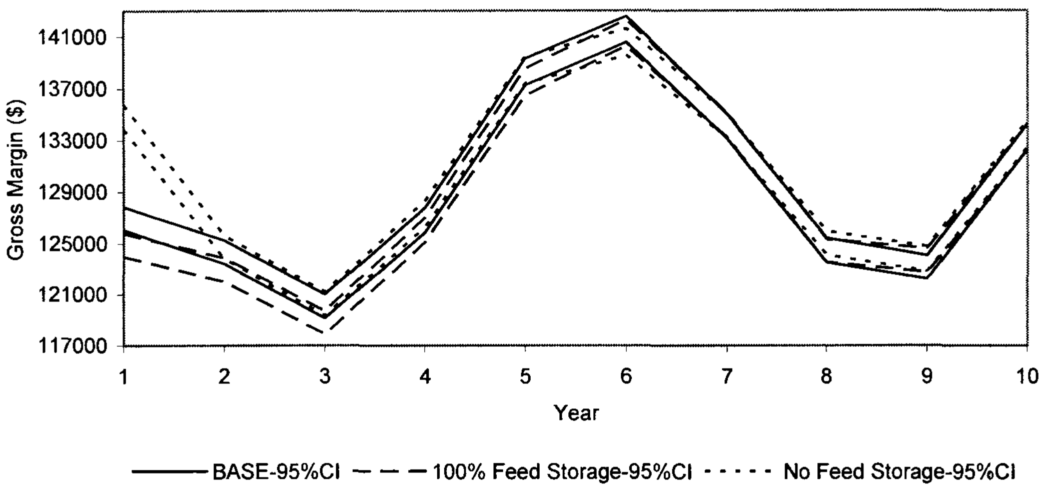


Figure B-4: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Small Herd Size, Base Scenario, 100% Feed Storage and No Feed Storage (Years 1-10) Aspen Parklands

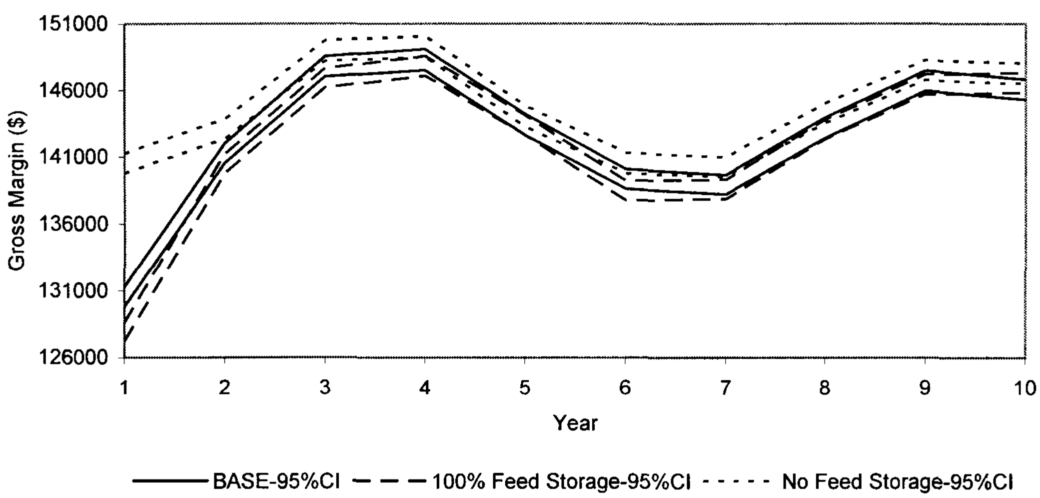


Figure B-5: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Medium Herd Size, Base Scenario, 100% Feed Storage and No Feed Storage (Years 1-10) Aspen Parklands

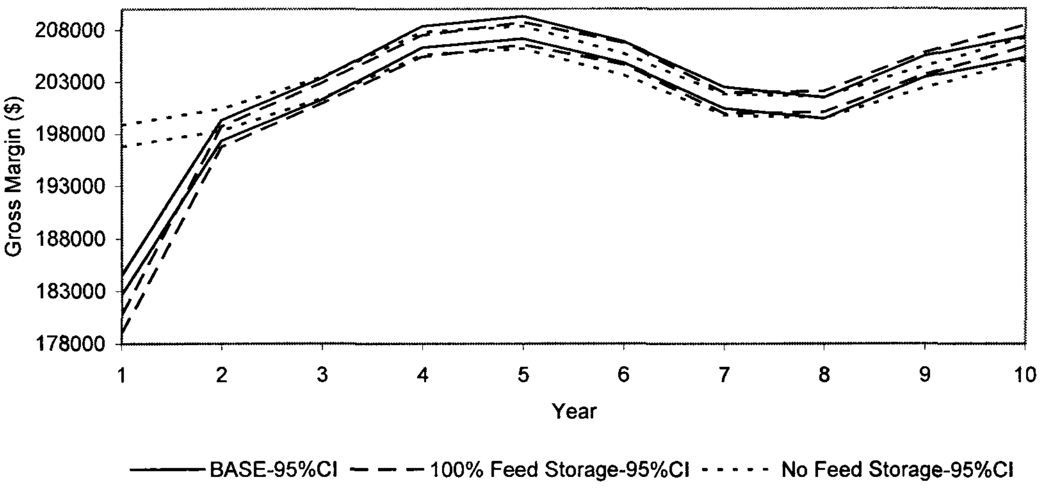


Figure B-6: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Large Herd Size, Base Scenario, 100% Feed Storage and No Feed Storage (Years 1-10) Aspen Parklands

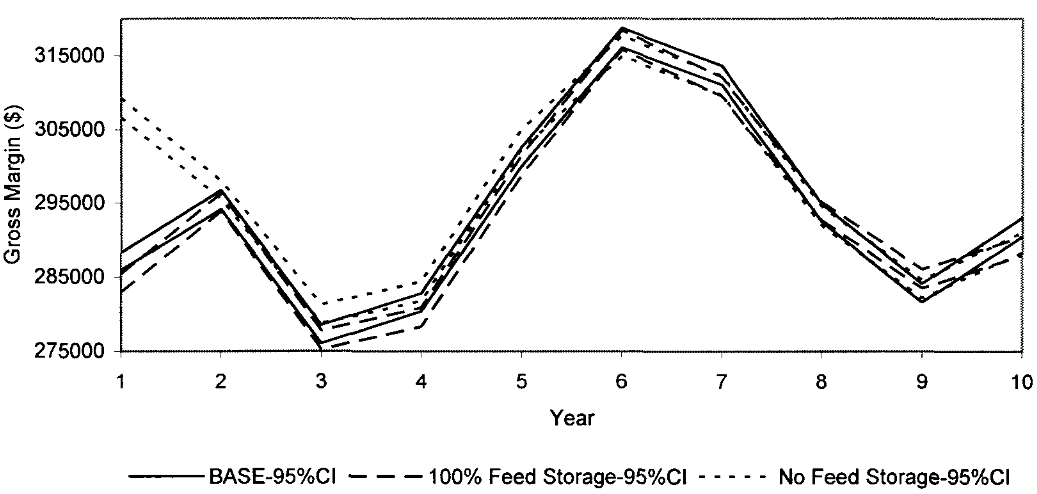


Figure B-7: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Small Herd Size, Base Scenario, 100% Feed Storage and No Feed Storage (Years 1-10) Boreal Peace/Lowlands

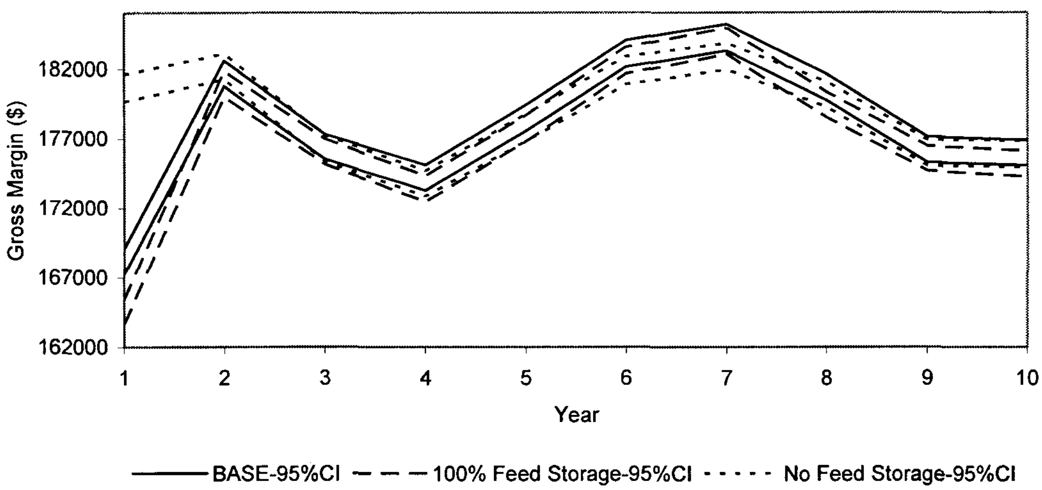


Figure B-8: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Medium Herd Size, Base Scenario, 100% Feed Storage and No Feed Storage (Years 1-10) Boreal Peace/Lowlands

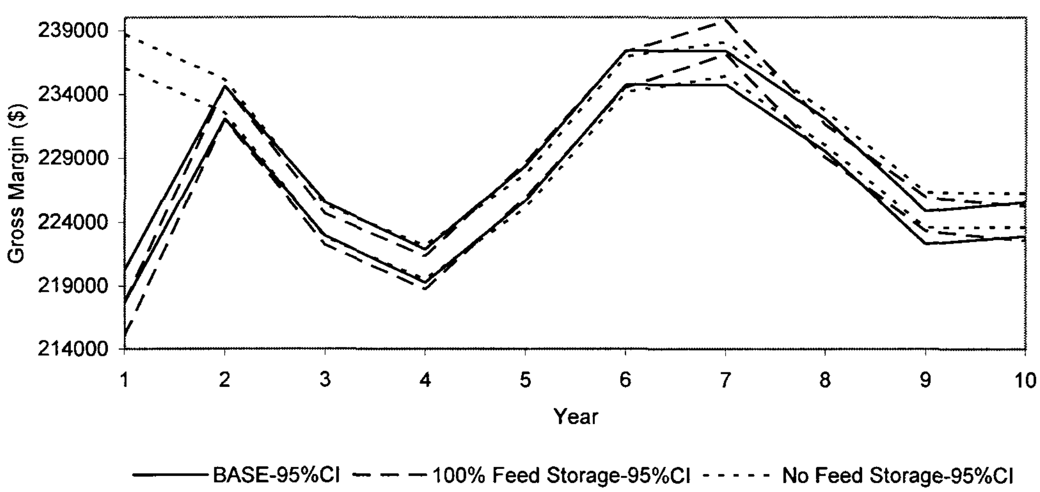
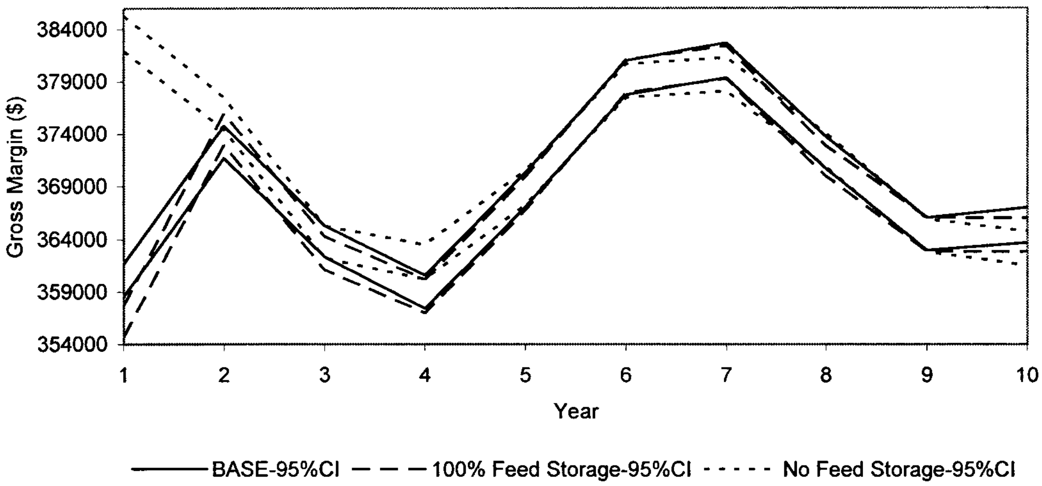


Figure B-9: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Large Herd Size, Base Scenario, 100% Feed Storage and No Feed Storage (Years 1-10) Boreal Peace/Lowlands



APPENDIX C - Variability in Annual Gross Margin for the BASE Scenario versus the No Heifer Retention Scenario

Figure C-1: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Small Herd Size, Base Scenario and No Heifer Retention (Years 1-10) Southern Alberta

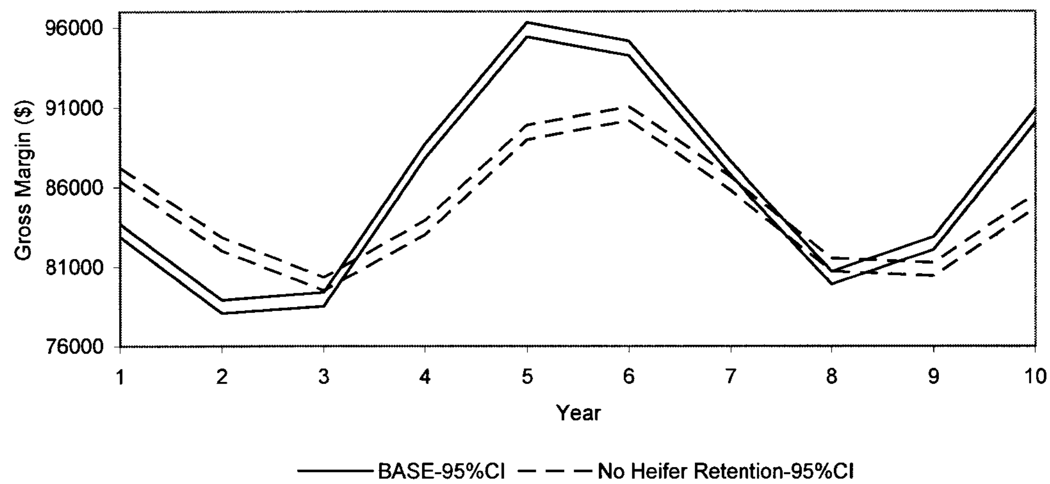


Figure C-2: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Medium Herd Size, Base Scenario and No Heifer Retention (Years 1-10) Southern Alberta

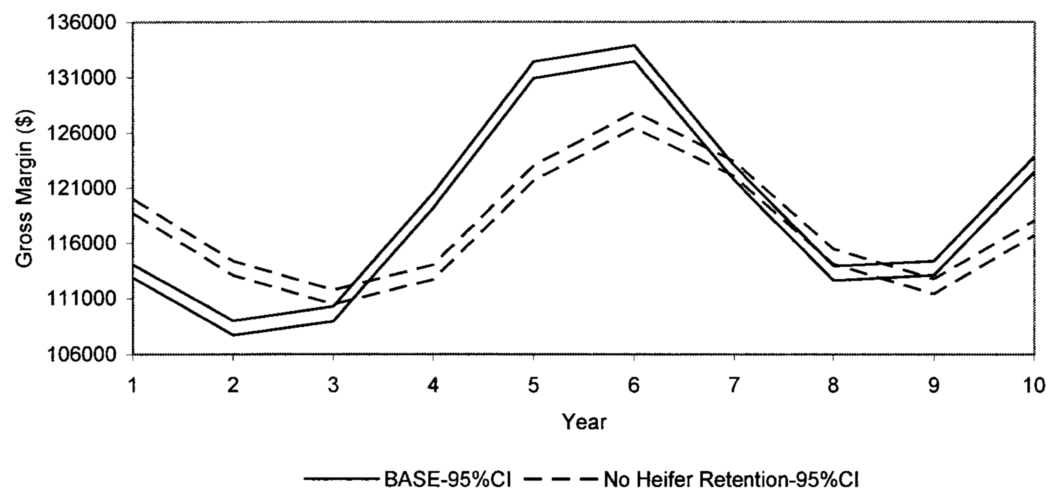


Figure C-3: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Large Herd Size, Base Scenario and No Heifer Retention (Years 1-10) Southern Alberta

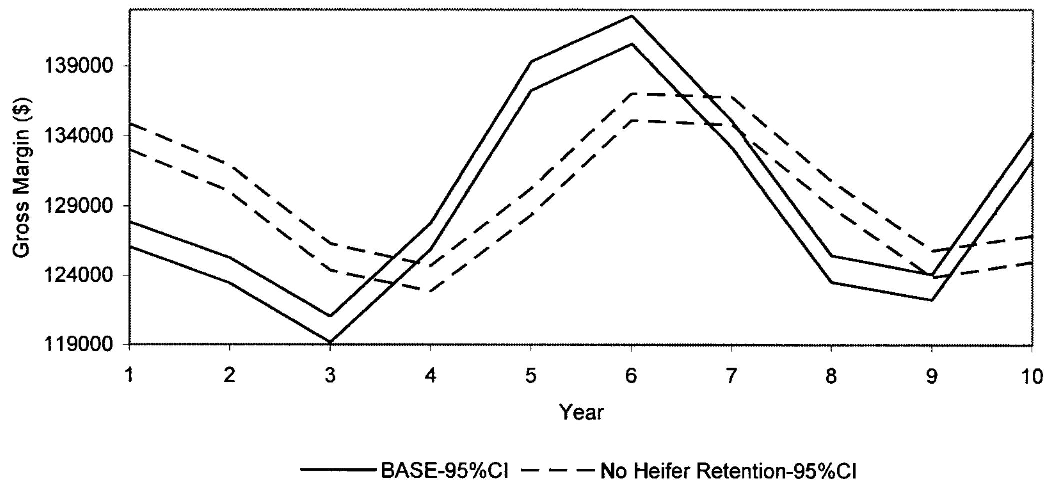


Figure C-4: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Small Herd Size, Base Scenario and No Heifer Retention (Years 1-10) Aspen Parklands

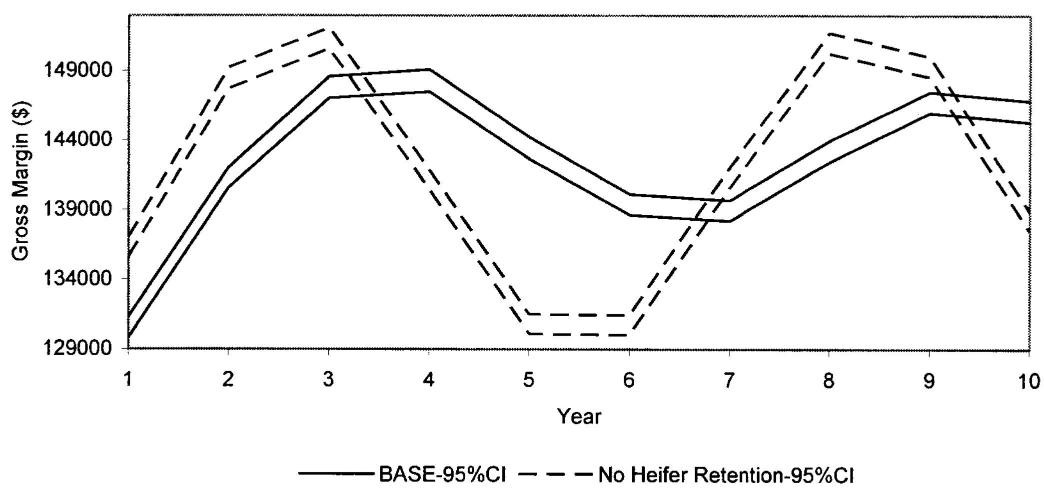


Figure C-5: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Medium Herd Size, Base Scenario and No Heifer Retention (Years 1-10) Aspen Parklands

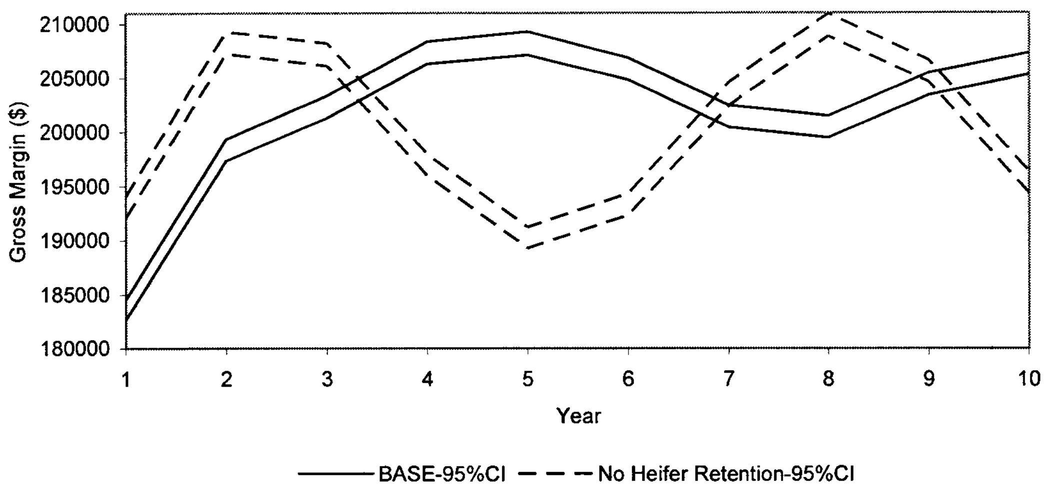


Figure C-6: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Large Herd Size, Base Scenario and No Heifer Retention (Years 1-10) Aspen Parklands

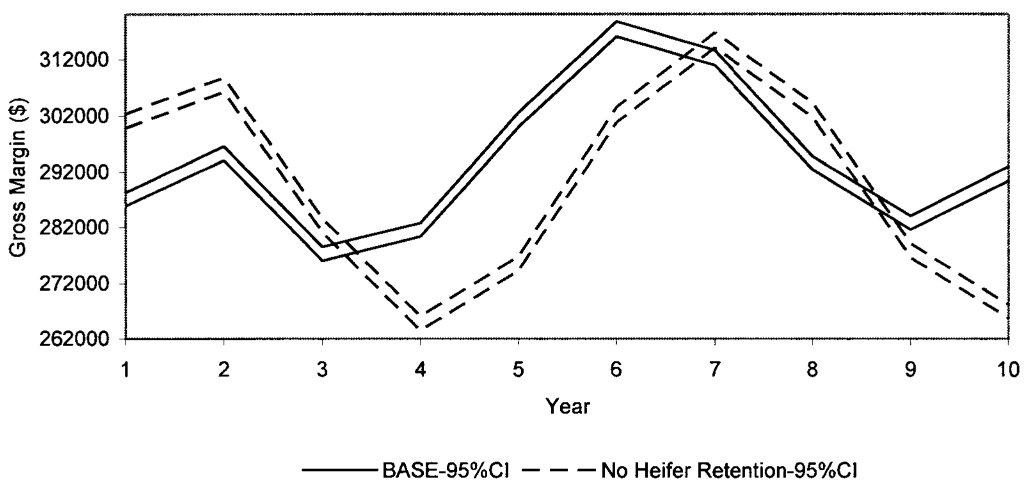


Figure C-7: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Small Herd Size, Base Scenario and No Heifer Retention (Years 1-10) Boreal Peace/Lowlands

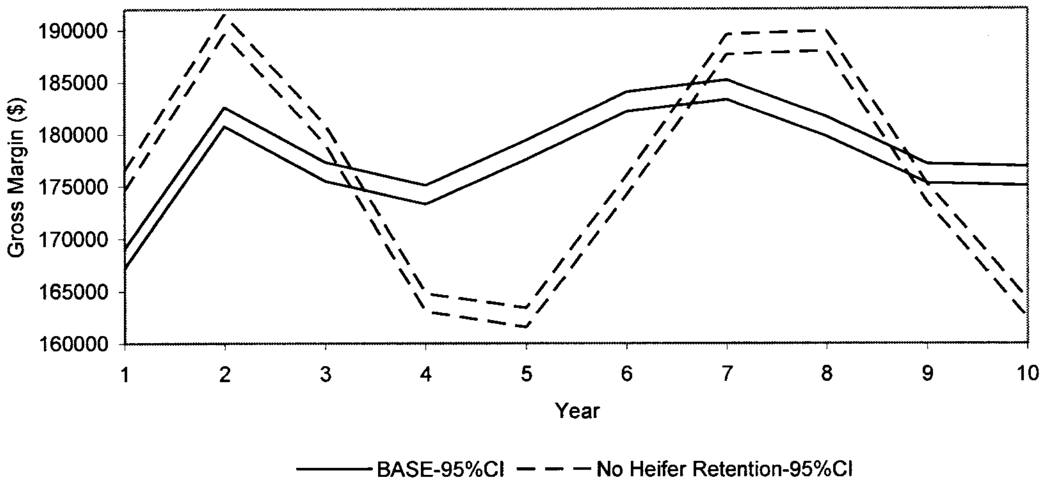


Figure C-8: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Medium Herd Size, Base Scenario and No Heifer Retention (Years 1-10) Boreal Peace/Lowlands

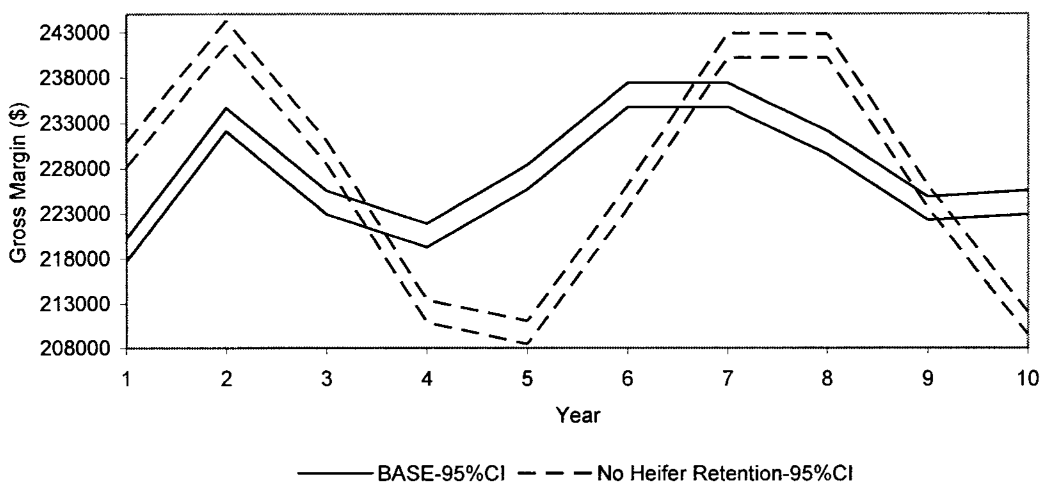
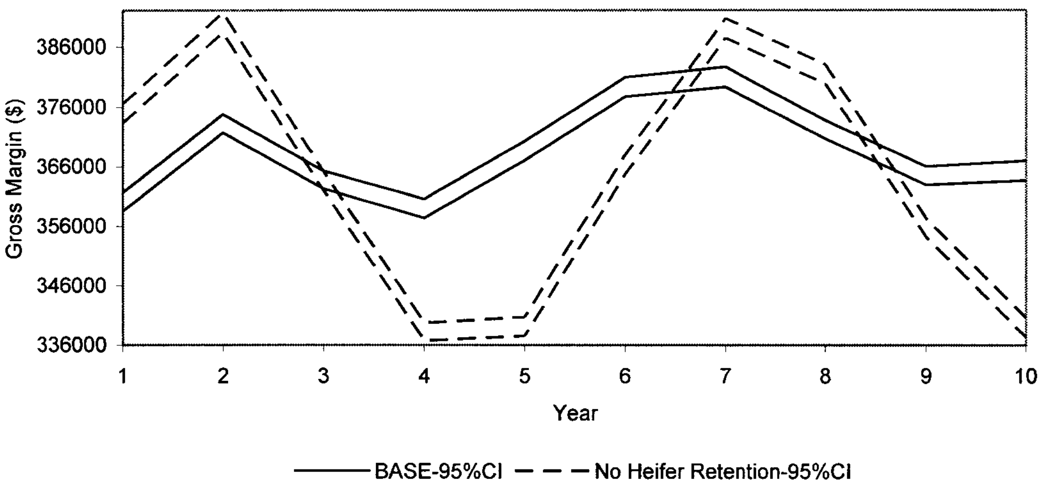


Figure C-9: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Large Herd Size, Base Scenario and No Heifer Retention (Years 1-10) Boreal Peace/Lowlands



APPENDIX D - Variability in Annual Gross Margin for the Combination of CAIS plus no Feed Storage and CAIS for the Nine Representative Farms

Figure D-1: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Small Herd Size, CAIS + No Feed Storage and CAIS (Years 1-10) Southern Alberta

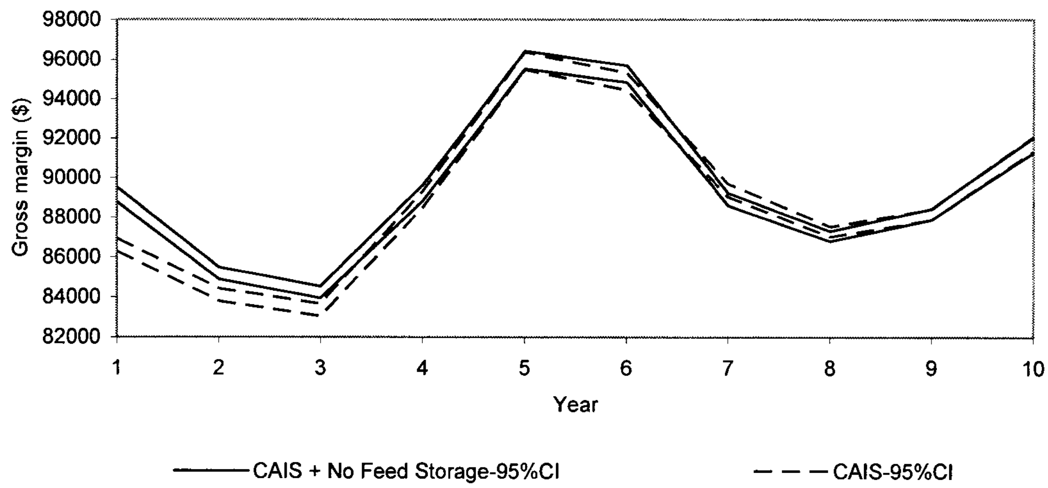


Figure D-2: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Medium Herd Size, CAIS + No Feed Storage and CAIS (Years 1-10) Southern Alberta

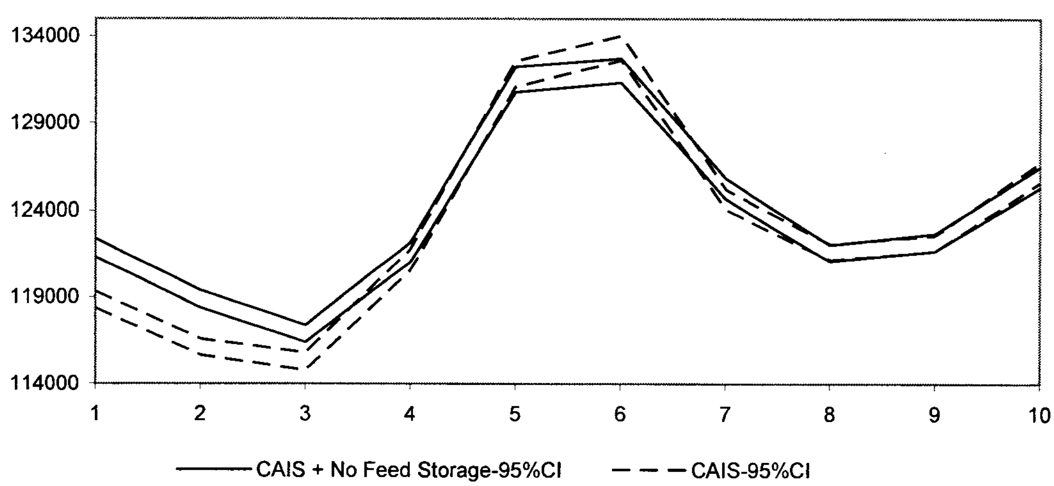


Figure D-3: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Large Herd Size, CAIS + No Feed Storage and CAIS (Years 1-10) Southern Alberta

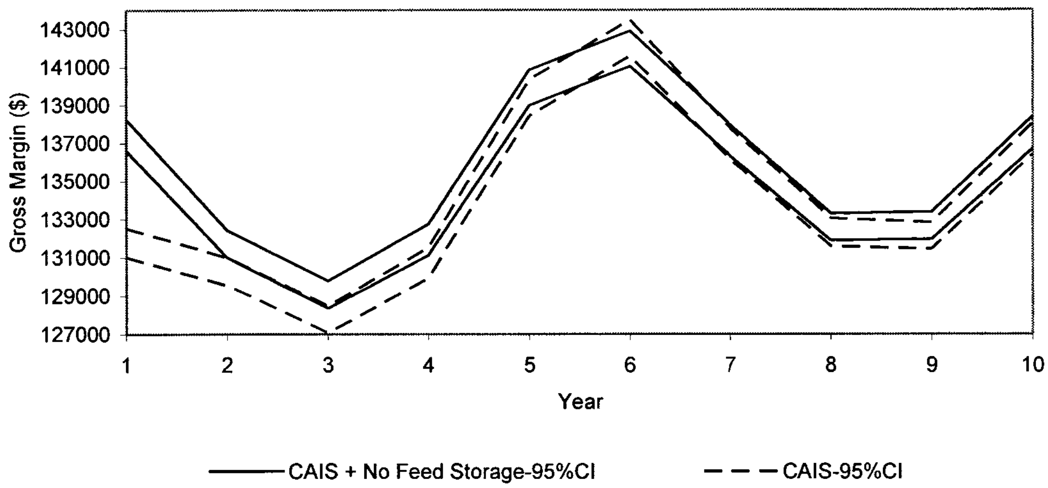


Figure D-4: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Small Herd Size, CAIS + No Feed Storage and CAIS (Years 1-10) Aspen Parklands

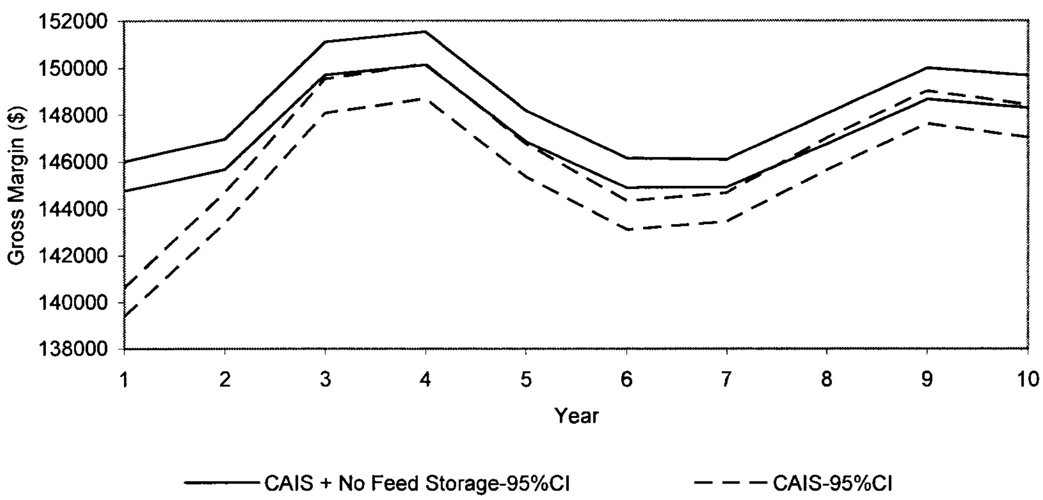


Figure D-5: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Medium Herd Size, CAIS + No Feed Storage and CAIS (Years 1-10) Aspen Parklands

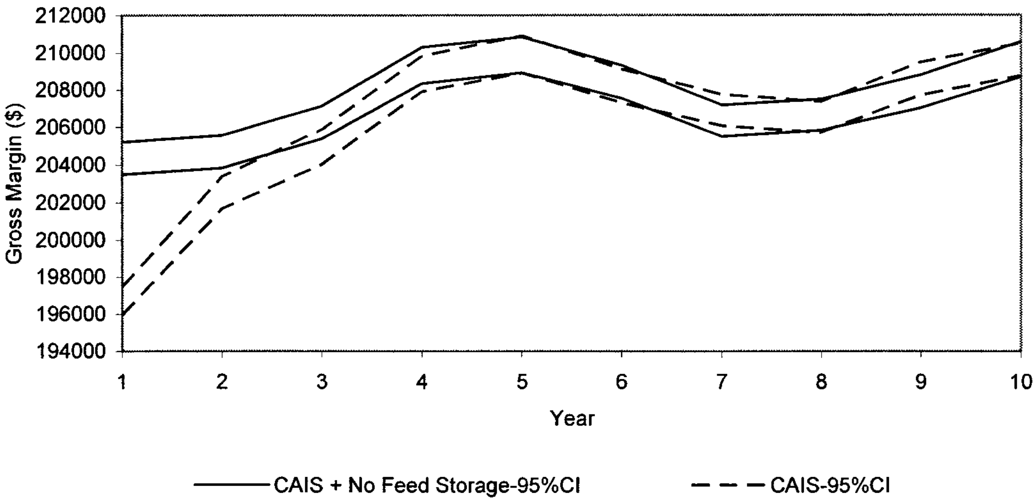


Figure D-6: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Large Herd Size, CAIS + No Feed Storage and CAIS (Years 1-10) Aspen Parklands

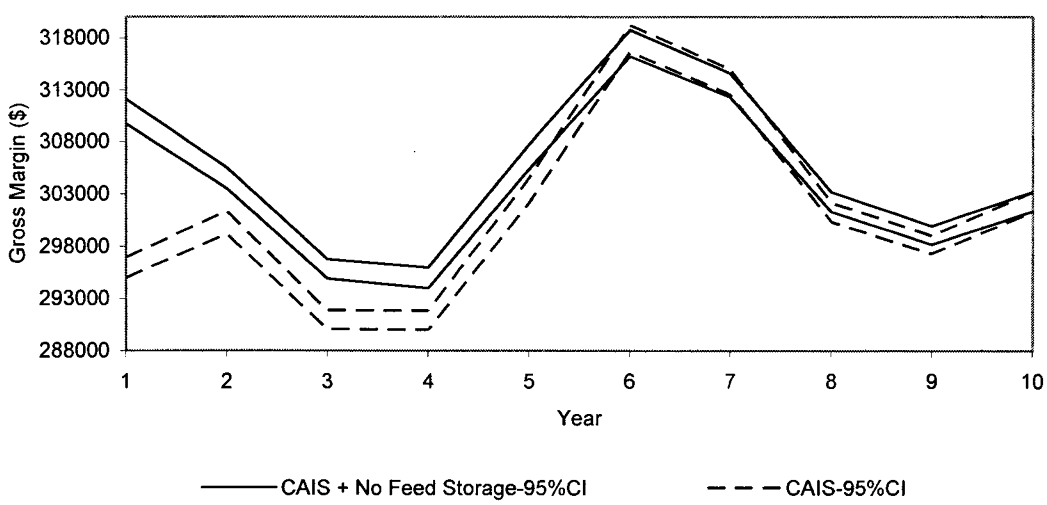


Figure D-7: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Small Herd Size, CAIS + No Feed Storage and CAIS (Years 1-10) Boreal Peace/Lowlands

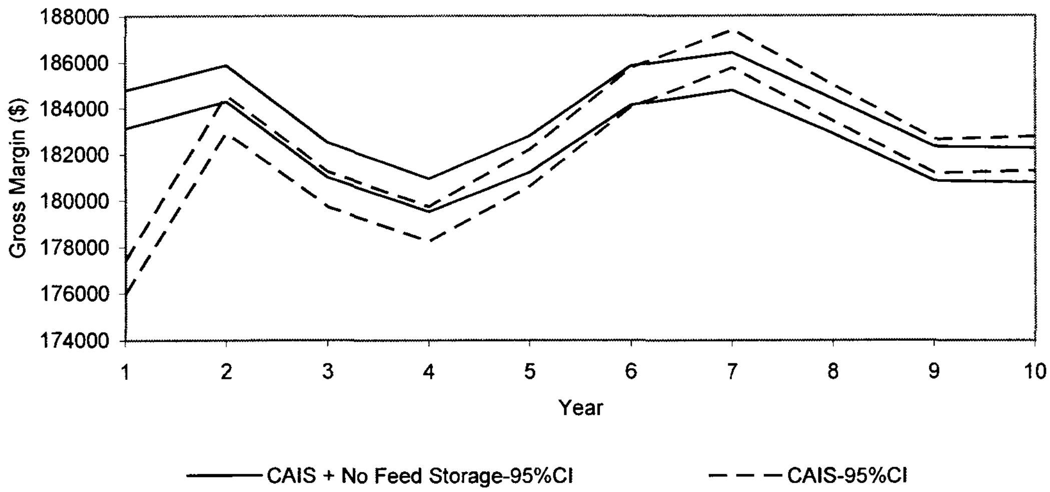


Figure D-8: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Medium Herd Size, CAIS + No Feed Storage and CAIS (Years 1-10) Boreal Peace/Lowlands

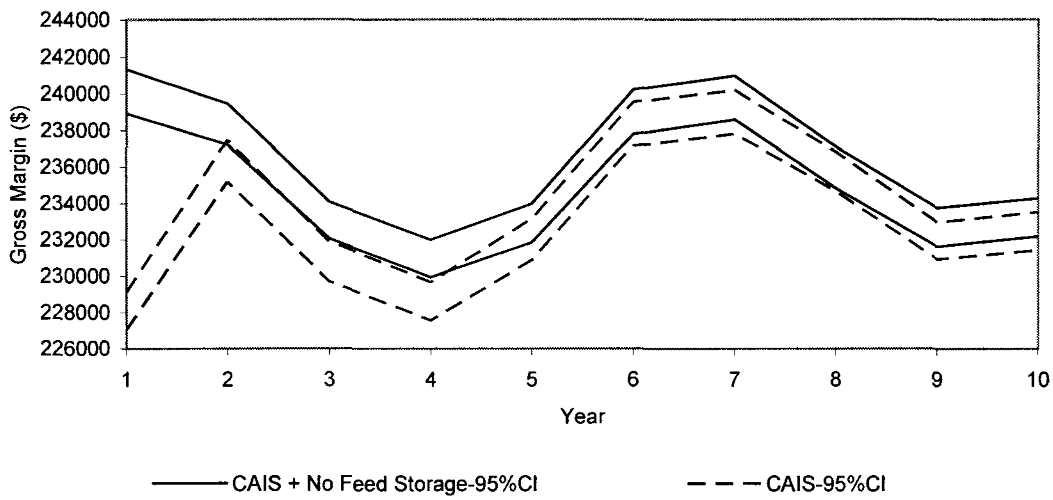
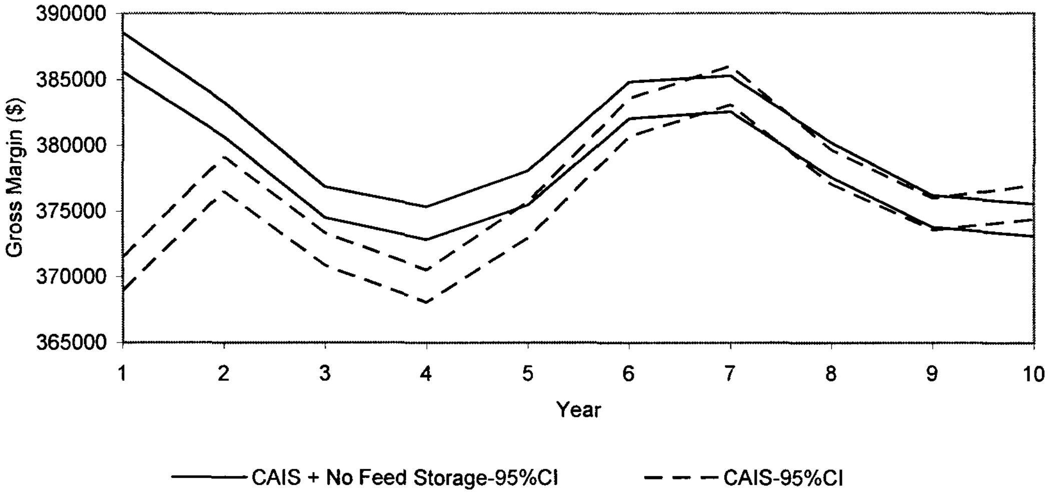


Figure D-9: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Large Herd Size, CAIS + No Feed Storage and CAIS (Years 1-10) Boreal Peace/Lowlands



APPENDIX E - Variability in Annual Gross Margin for the Combination of CAIS plus no Heifer Retention and CAIS for the Nine Representative Farms

Figure E-1: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Small Herd Size, CAIS + No Heifer Retention and CAIS (Years 1-10) Southern Alberta

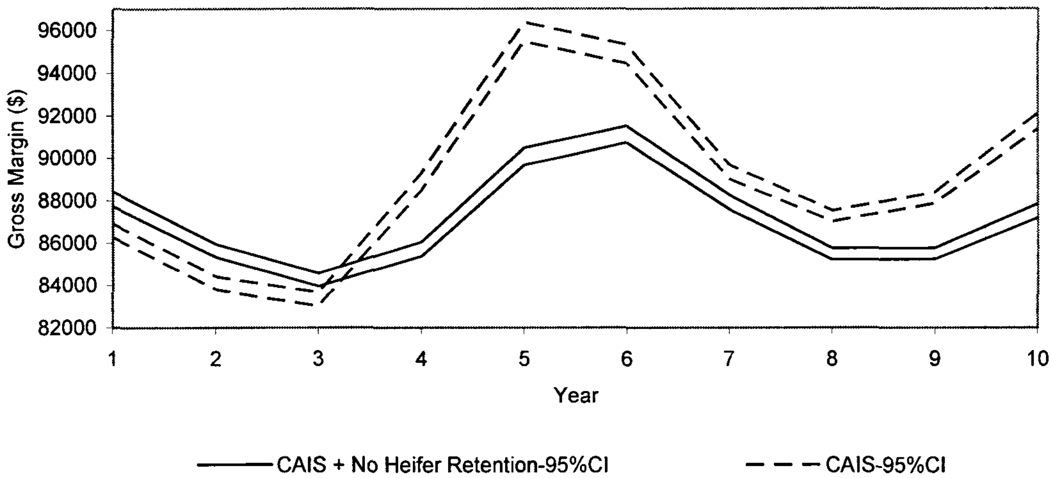


Figure E-2: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Medium Herd Size, CAIS + No Heifer Retention and CAIS (Years 1-10) Southern Alberta

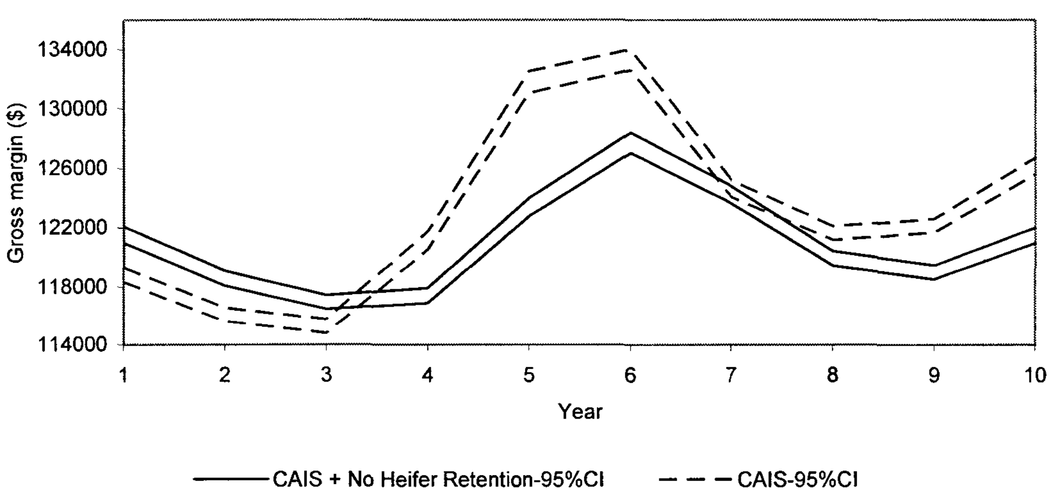


Figure E-3: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Large Herd Size, CAIS + No Heifer Retention and CAIS (Years 1-10) Southern Alberta

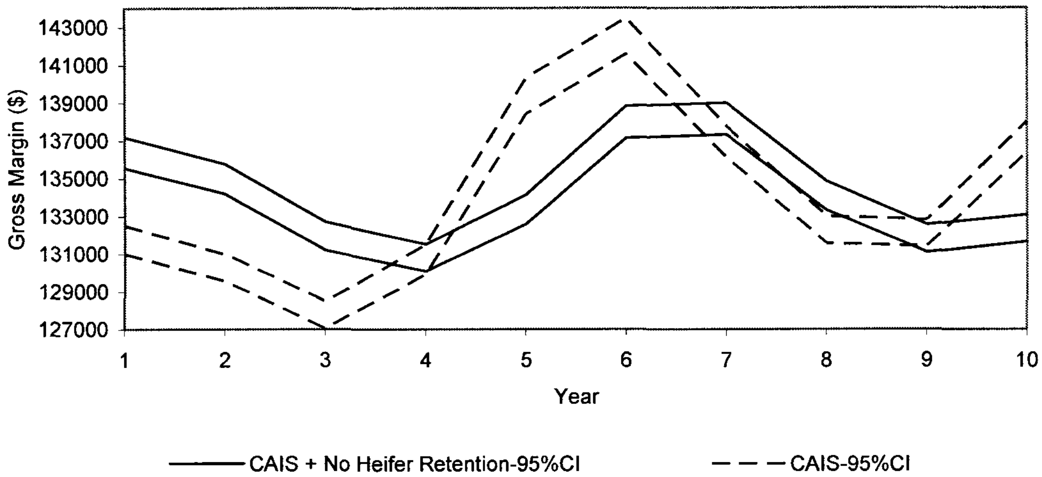


Figure E-4: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Small Herd Size, CAIS + No Heifer Retention and CAIS (Years 1-10) Aspen Parklands

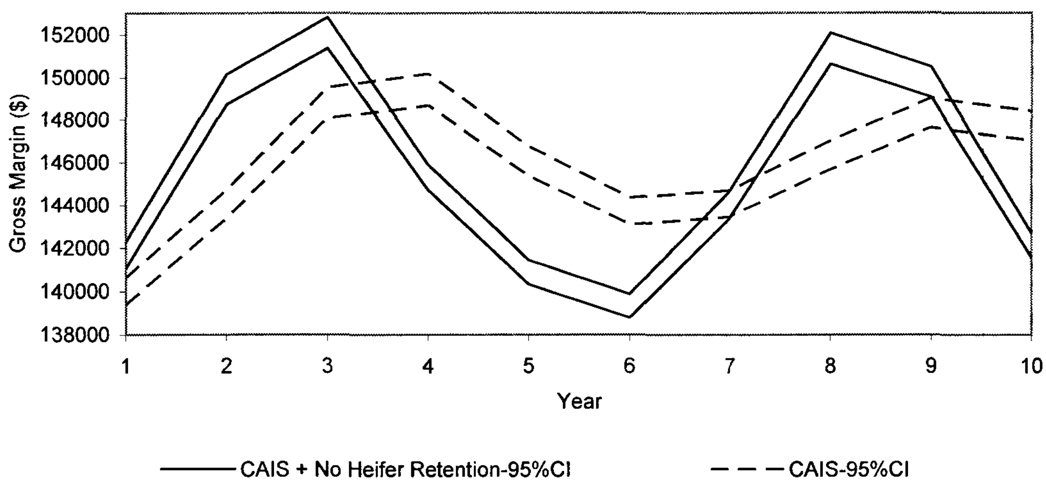


Figure E-5: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Medium Herd Size, CAIS + No Heifer Retention and CAIS (Years 1-10) Aspen Parklands

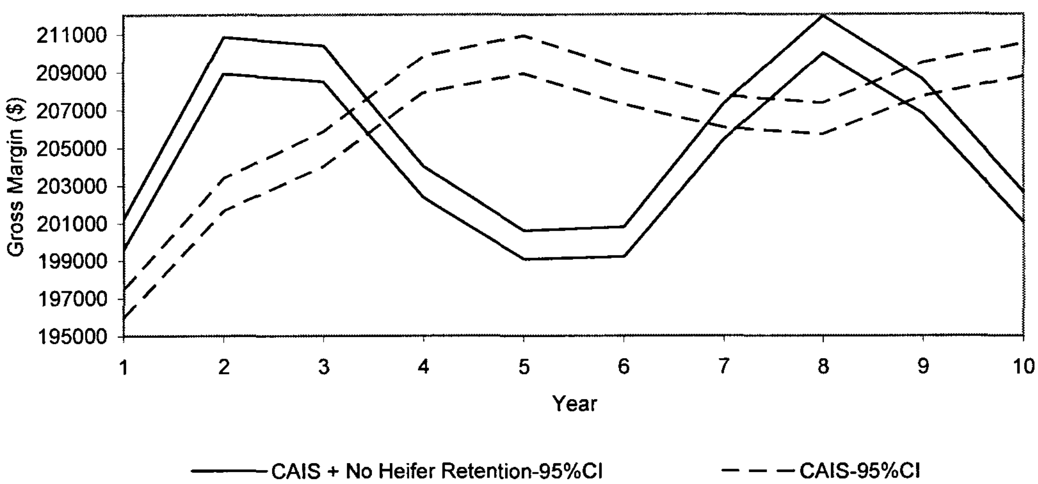


Figure E-6: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Large Herd Size, CAIS + No Heifer and CAIS Retention (Years 1-10) Aspen Parklands

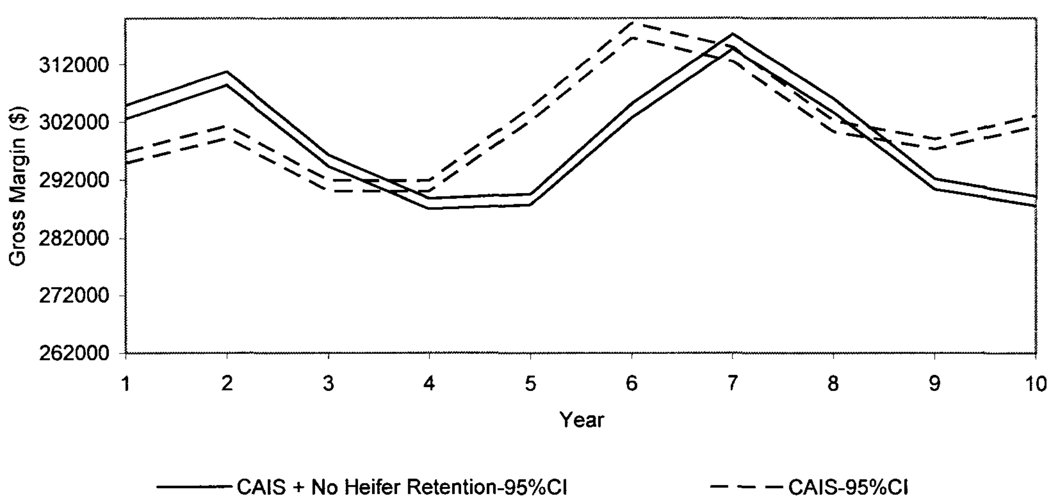


Figure E-7: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Small Herd Size, CAIS + No Heifer Retention and CAIS (Years 1-10) Boreal Peace/Lowlands

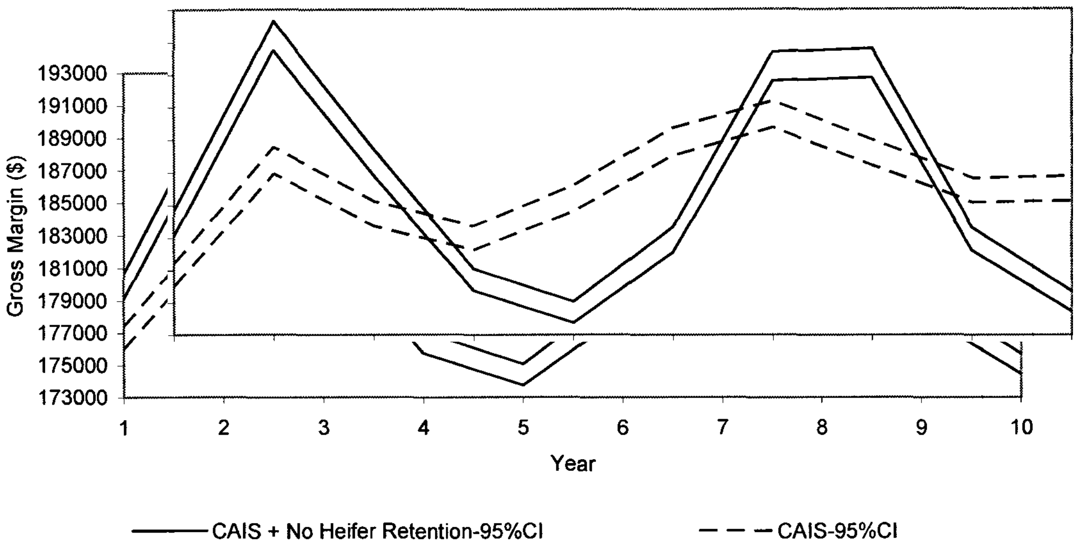


Figure E-8: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Medium Herd Size, CAIS + No Heifer Retention and CAIS (Years 1-10) Boreal Peace/Lowlands

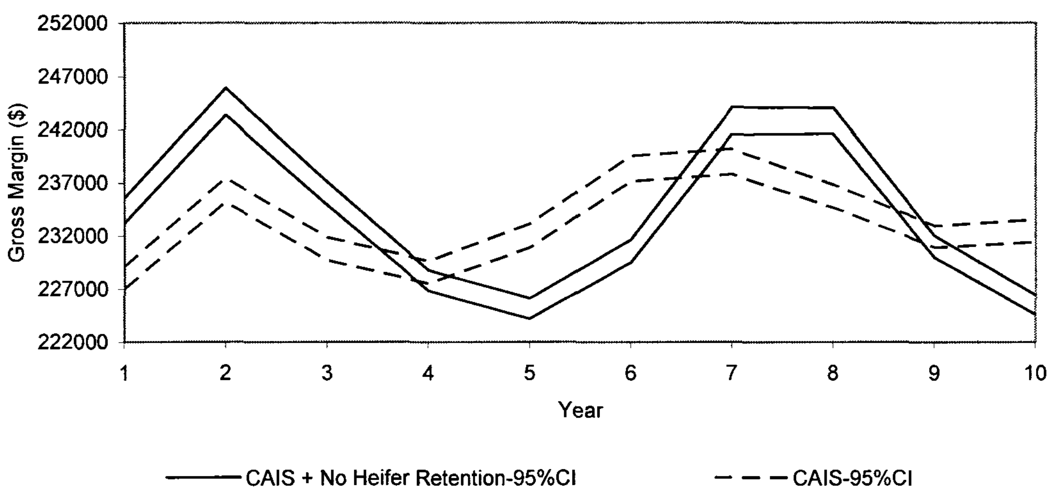


Figure E-9: Variability (95% Confidence Interval) in Annual Gross Margin ($) for the Large Herd Size, CAIS + No Heifer Retention (Years 1-10) Boreal Peace/Lowlands