The Effect of Calving Season on Economic Risk and Return in Cow-calf operations in Western Canada

by

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ABSTRACT

Cow-calf producers in western Canada are faced with many decisions throughout the production cycle. The choice of calving time impacts production rate, marketability of calves, income and expenses and net revenue. The purpose of this study was to determine whether June calving could increase net revenues and be a preferred choice across different risk aversion levels over March calving in western Canada. Data for this study were taken from a study carried out by Iwaasa et al. (2009), who collected information from three sites; Brandon, MB, Lanigan, SK and Swift Current SK. Stochastic budgets and a simulation model were used to study the economic impact of calving time. In Brandon and Lanigan, It was found that June calving increased net income and was the dominant alternative across all levels of risk aversion, and in Swift Current, June dominated at high-risk aversion levels.

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CHAPTER 1: INTRODUCTION

1.1 Problem Statement

The cow-calf producer of western Canada faces serious challenges to the operation of his or her business. Determining what management action to take to overcome these challenges is a common difficulty for producers as they are surrounded with much uncertainty about the potential positive or negative consequences of their actions on the profitability of the operation. The profitability of an operation can be affected by environmental and market factors, as well as management practices, such as feeding strategies. By varying management practices, a producer can have unintended consequences on labour requirements, marketing options and can potentially introduce more risk into the system, which can be a greater concern to some producers than others. Determining the risks and rewards of a specific management practice is the main goal of this thesis.

An animal science study conducted by Iwaasa et al. (2009) observed cattle calving in March and cattle calving in June at three locations across western Canada; Brandon, Manitoba, Swift Current, Saskatchewan and Lanigan, Saskatchewan. The sites had 120, 60 and 100 crossbred cows respectively that were randomly assigned to one of two calving times, March or June, in the fall of 2006. These calving seasons were chosen by the research committee with consultation from industry experts prior to the start of the study. March was chosen to represent the more traditional calving season that many cow-calf operations are currently calving in and June was chosen to represent the season to which producers may wish to learn more about and adopt in the future. The results from this study will be used in this thesis to compare March calving to June calving in terms of financial risks and returns in an expected utility model.

Data collected at each site included performance results such as weight gain/loss for cows and calves, body condition scores throughout the year, and reproductive success for cows and retained heifers. Financial records were kept including the costs to feed the cows and calves throughout the year as well as all herd health requirements. Labour hours, machinery use, and feeding systems costs were also included.

1.2 Objective

The objective of this study was to optimize the expected utility of a cow-calf producer using an alternative June calving season as compared to the traditional March calving season using the results from Iwaasa et al. (2009). More specifically, this study aimed to answer the following questions:

1) Does changing the time of calving increase net returns to producers?
2) What are the tradeoffs to calving later in terms of revenue and cost risk?

Such an analysis may be useful to producers who have been thinking about changing their calving system and who want to have an estimate of the risks and rewards associated with each system.

1.3 Thesis Organization

This study is comprised of seven sections that examine the decisions faced by cow-calf producers when deciding between calving seasons, specifically June or March. Chapter 2 provides background information on the economic uncertainty surrounding the cattle industry, the use of low-cost feeding systems as well as detailed information about each site chosen in the Iwaasa et al. (2009) study from 2007-2009. Chapter 3 reviews the literature on calving times and beef production systems in North America. Chapter 4 explains the theory of decision analysis when facing risk and provides the necessary framework on which this study is based. Chapter 5 continues with the methods used to meet the objectives of the thesis. This includes creating budgets for the time of calving project then applying the results of these budgets to a simulation model. It also looks at previous risk analysis models. Chapter 6 presents the results of the simulation model from each of the three locations and the implications the results may have on producers. Chapter 7 concludes the study with the limitations of the research as well as suggestions for future research.

Chapter 2: Background

2.1 Introduction

This chapter begins by discussing some of the challenges due to uncertainty in the industry faced by cattle producers in western Canada. This is followed by a discussion of cost-reducing feeding strategies producers are using on their operations. The next sections provide details on how changing calving seasons from March to June would impact an operation. This chapter concludes by providing more detail on the locations used for the Iwaasa et al. (2009) study.

2.2 Economic Uncertainty in the Cattle Industry

The cattle industry in Canada has had to deal with a series of unfortunate events in recent years. The discovery of a cow with Bovine Spongiform Encephalopathy (BSE) in 2003 halted live exports to the United States and overseas, reduced consumer confidence in domestic markets, and forced many cattle producers to retain calves and cull cows that otherwise would have been sold. Today, the cattle industry is trying to regain its momentum while adapting to new rules imposed by industry trading partners and adverse changes in currency exchange rates. Individual producers are trying to find ways of coping after years of uncertainty in cattle prices and increasing costs of production.

Given these events, cow-calf producers in western Canada have been hit especially hard. They raise a product that is not ready for market for at least eight to nine months despite incurring high costs of production during that time. In order to raise a calf, they make large investments in facilities, machinery, land and breeding stock. These production decisions are therefore significantly tied to their returns on their investment.

Producing at a low cost is proving difficult according to Manitoba Agriculture, Food and Rural Initiatives (MAFRI). The greatest variable input cost to cow-calf producers in western Canada continues to be the cost to feed their animals. MAFRI estimates that winter-feed costs for cow-calf producers, including grain and stored forage, account for 35% of the total operating cost (not including labour) of the operation. In 2003, MAFRI cost of production guidelines for cow-calf production priced feed barley at $2.50 per bushel, versus $4.00 per bushel in 2008 (MAFRI, 2003, 2008a). Many producers are moving away from these higher-cost feeding systems to alternatives that have been found to be successful in reducing costs (Anderson et al., 2005; Lardner, 2005; Lardner and Froehlich, 2006; McCartney et al., 2004).

2.3 Low Cost Feeding Systems

Examples of low-cow cost feeding systems are: stockpiled forage grazing, where forage growth is allowed to accumulate for later grazing, bale grazing, a system that allows cattle to feed on entire bales in larger paddocks, corn stalk grazing and rations which include straw.[1] These systems are termed ‘low-cost’ as they are generally less expensive on a per head per day basis than feeding in a confined feeding space or

[1] There is a large amount of information on various feeding alternatives within western Canada. Visit the Forage and Beef website at www.foragebeef.ca, Manitoba Agriculture, Food and Rural Initiatives website at www.gov.mb.ca/agriculture or Saskatchewan’s Ministry of Agriculture website at http://www.agriculture.gov.sk.ca/cow-calf.

drylot. Swath grazing is a feeding technique used to extend the grazing season and has been shown to save money through reduced harvesting, handling, feeding and manure removal costs (Alberta Agriculture and Rural Development, 2004; Lardner, 2005; Lardner and Froehlich, 2006; McCartney et al., 2004). Bale grazing is another feeding technique used to extend the grazing season for cows and reduce feeding costs. According to MAFRI (2008b), bale grazing beef cows can save producers' time, effort, money and, with proper management, reduce environmental risk (Lardner, 2005; McCartney et al., 2004; MAFRI, 2008b). The premise behind bale grazing is to set out a large number of bales in the fall and regulate the animal's feed intake using electric fencing.

Implementing these lower cost feeding systems could potentially reduce overall costs and reduce the time spent in a confined feeding space.

2.4 Advantages of a June calving system

A further concept for cost reduction in cow-calf production is that of matching cattle nutrient requirements with forage availability. Shifting calving from late winter to early summer is one method to reach this objective. This shift matches peak nutrient requirements of cattle with abundant availability of low-cost nutrients, such as pasture, in the summer (May et al., 1998). Studies in the United States have suggested that synchronizing calving dates and nutritional requirements with the nutrient availability of standing forage is a method to reduce costs and maintain profitability (Adams et al., 1996; Clark et al., 1997; Grafel, 1996). Clark et al. (1997) estimated that June calving in Nebraska reduced the amount of hay fed during the winter by 1.5 tons per cow per year and resulted in a reduction of $45 per cow in winter-feeding costs. May et al. (1999) found that June calving also had the lowest feed cost, with a reduction of $43 per cow when compared with February calving. They also found that feed costs were very sensitive to the availability of better quality grazeable forage over the winter. When more forage is available to be grazed, cost savings occur as a result of reduced need to bale, haul, store and feed hay (May et al., 1998).

Calving in June also alters the selling point of weaned calves, shifting the sale from October-November to December-January. This can reduce revenue risk by selling at an ‘off-peak’ time – a time with fewer calves in the market – as opposed to selling during the ‘fall rush’ – a time when a high number of calves are in supply. Why are many cow-calf producers hesitant to change their calving season and feeding practices for potential cost savings? Possibly, changing the time of calving would also alter other aspects of the operation such as the kilograms (kg) of weaned calf weight per cow, the time of sale, labour requirements and energy use. Small et al. (1999) found that 70 ± 1.9% of producers in Manitoba had less than 50 cows and managed another enterprise along with their cattle operation. Often a later calving season coincides with seeding in a grain operation. The labour required to seed and calve simultaneously may be a deterrent for producers involved in a mixed farming operation.

Income considerations, combined with risk reduction are important to producers. Profitability of beef production depends not only on production costs, but also on quantity of beef produced and prices received for that product. Market uncertainty and cost variations can make producers consider giving up some profitability to reduce their risk. Taking this into account, producers might consider changing calving time on their operation to June calving if there is less risk and greater reward than the March calving system.

2.5 Site Background

According to the 2006 Census of Agriculture, Manitoba and Saskatchewan combined hold 31% of the total beef cattle ranching and feedlot operations and house 41.3% of the total beef cows in Canada. With these large proportions of cows and producers involved, studying the impacts of production decisions in these two provinces is relevant to the cattle industry.

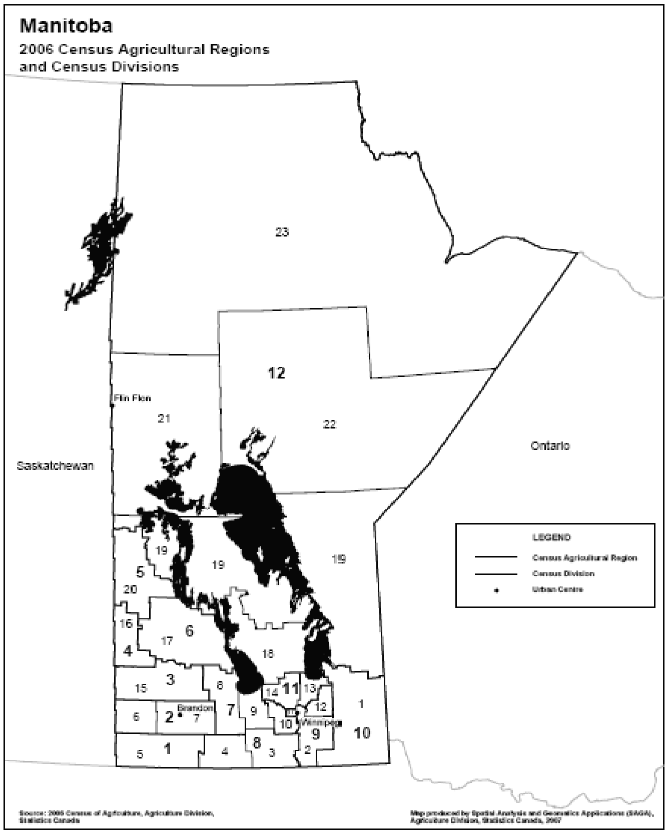
A research study conducted by Iwaasa et al. (2009) collected data over two years on March calving and June calving systems at three locations within Manitoba and Saskatchewan: Brandon, Manitoba (BR), Swift Current, Saskatchewan (SC) and Lanigan, Saskatchewan (LG). The beef herds at the three sites had 120, 60 and 100 crossbred cows, respectively, that were randomly assigned to one of two calving times, March and June, in the fall of 2006. Data collected at each site included performance results such as weight gain/loss for cows and calves, body condition scores throughout the year, and reproductive success for cows and retained heifers. As well, financial records were kept, including the costs to feed the cows and calves throughout the year, labour hours, machinery use, feeding system costs, herd health and breeding costs.

Each site is a research facility; therefore, inherent bias may be present in the data collected. The data obtained from these sites may be different from those obtained from actual producers; under the same operating conditions, it is difficult to assess whether a producer would make the same decisions as the research facility would, or have the same objectives for the operation. Despite these limitations, each facility's objective was to best replicate a typical western Canadian cow-calf production system and reflect the cow-calf producer's decisions.

2.5.1 Brandon, Manitoba

The Brandon portion of the experiment was conducted from 2007-2009 using 120 crossbred cows at Agriculture and Agri-Food Canada's Brandon Research Centre (BRC).   The BRC is located in the Parkland region of Manitoba and is located in the Rural Municipality (RM) of Elton and the Census Agricultural Region (CAR) 2 (Figure 1). According to the Census of Agriculture, the CAR consists of 1,945 farms on 850,156 hectares of land. Of these farms, 768 participated in beef cattle ranching and farming, including feedlots.

Figure 1. Manitoba's Agricultural Census Regions and Divisions



On the day of the 2006 census, 200,931 cattle and calves were reported on farms. Of that number, 81,641 (40.6%) were beef cows, 72,304 (40.0%) were calves under one year of age, 18,378 (9.1%) were steers aged one year and over, and 13,117 (6.5%) were heifers for slaughter or feeding. The high number of young calves demonstrates that cow-calf operations dominate over finishing in this area. The total hectares reported in agricultural production were 794,961, of which 511,551 hectares (64.3%) were used for cropping, 22,386 hectares (2.8%) were summer fallow land, 71,538 hectares (9.0%) were tame or seeded pasture, and 168,729 hectares (33.0%) were unimproved land for pasture. Of the hectares in crop production, 22,976 hectares (4.5%) and 68,797 hectares (13.4%) were seeded into tame hay and fodder crops and alfalfa and alfalfa mixtures, respectively.

From the census, 1,105 farms reported they were sole proprietorships, 252 were family corporations, 450 were partnerships without a written agreement, and the remaining were either partnerships with a written agreement, non-family corporations or other operating arrangements. Gross receipts vary greatly, from under $10,000 to over $2,000,000. Just over 92% of the operations fall beneath $500,000 in gross receipts. Table 1 provides a distribution of gross farm receipts for CAR 2.

Table 1. Distribution of Total Farm Gross Receipts for Census Agricultural Region 2 (surrounds Brandon)

Total Gross Receipts	Number of Farms	Percentage of Total Farms
Under $10,000	262	13.47%
$10,000 to $24,999	257	13.21%
$25,000 to $49,999	296	15.22%
$50,000 to $99,999	311	15.99%
$100,000 to $249,999	468	24.06%
$250,000 to $499,999	204	10.49%
$500,000 to $999,999	82	4.22%
$1,000,000 to $1,999,999	32	1.65%
$2,000,000 and over	33	1.70%

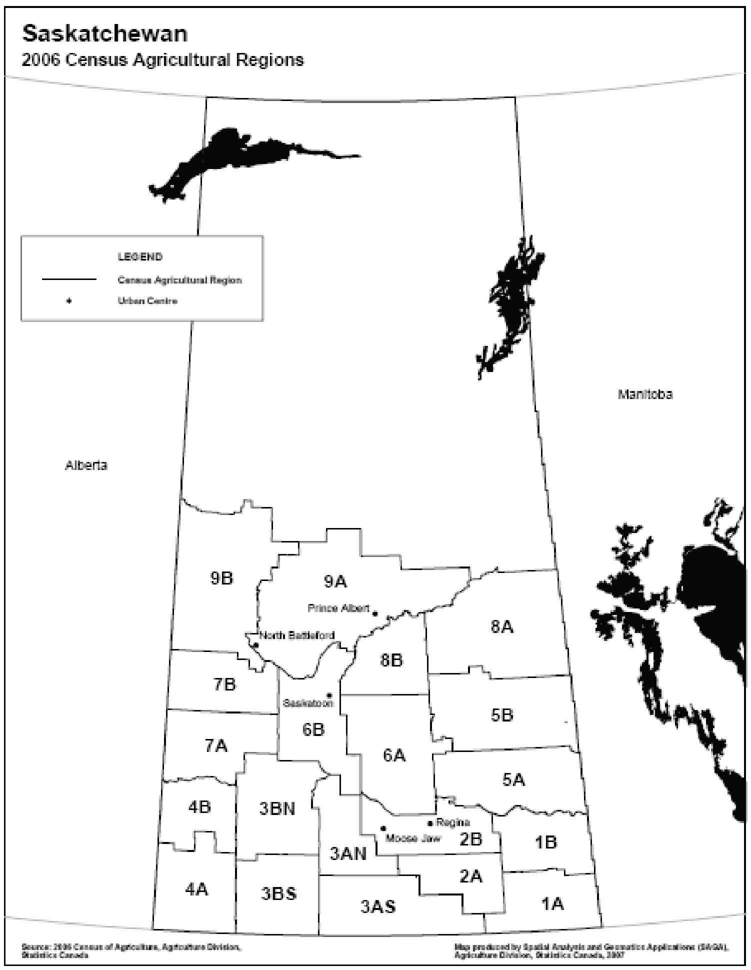
Source: Statistics Canada (2006)

2.5.2 Lanigan, Saskatchewan

The second study site was located near Lanigan, Saskatchewan, at the Western Beef Development Centre (WBDC). Lanigan is located in the RM of Usbourne and in

CAR 6A (Figure 2). According to the Census of Agriculture, the CAR consists of 3,133 farms on 1,777,301 hectares of land. Of these farms, 603 participated in beef cattle ranching and farming, including feedlots.

Figure 2. Saskatchewan's Agricultural Census Regions and Divisions



On the day of the 2006 census 216,959 cattle and calves were reported. Of those, 78,362 (36.1%) were beef cows, 76,215 (35.2%) were calves under one year of age, 32,962 (15.2%) were steers aged one year and over and 13,115 (6.0%) were heifers for slaughter or feeding. This region has a lower total percentage of reproductive animals than Brandon, but a higher percentage of retained calves. The total hectares in agricultural production were reported as 1,706,449, of which 1,230,721 hectares (72.1%) were used for cropping, 139,880 hectares (8.2%) were summer fallow land, 106,740 hectares (6.3%) were tame or seeded pasture, and 196,460 hectares (11.5%) were unimproved land for pasture. Of the hectares in crop production, 33,423 hectares (2.7%) were tame hay and fodder crops and 108,625 hectares (8.8%) were seeded into alfalfa and alfalfa mixtures.

From the census, 2,072 farms reported they were sole proprietorships, 323 were family corporations, 619 were partnerships without a written agreement and the remaining were either partnerships with a written agreement, non-family corporations or other operating arrangements. Gross receipts vary greatly from under $10,000 to over $2,000,000. Just over 95% of the operations fall beneath $500,000 in gross receipts. Table 2 provides a distribution of gross farm receipts for CAR 6A.

Table 2. Distribution of Total Farm Gross Receipts for Census Agricultural Region 6A (near Lanigan)

Total Gross Receipts	Number of Farms	Percentage of Total Farms
Under $10,000	347	11.08%
$10,000 to $24,999	473	15.10%
$25,000 to $49,999	449	14.33%
$50,000 to $99,999	522	16.66%
$100,000 to $249,999	813	25.95%
$250,000 to $499,999	375	11.97%
$500,000 to $999,999	120	3.83%
$1,000,000 to $1,999,999	21	0.67%
$2,000,000 and over	13	0.41%

Source: Statistics Canada (2006)

2.5.3 Swift Current, Saskatchewan

The last study site of the experiment was at Agriculture and Agri-Food Canada's Semiarid Prairie Agricultural Research Centre (SPARC). SPARC is located in the RM of Swift Current and in CAR 3BN (Figure 4). According to the Census of Agriculture, the CAR consists of 2,246 farms on 1,555,069 hectares of land. Of these, 600 farms participated in beef cattle ranching and farming, including feedlots.

On the day of the 2006 census, 168,598 cattle and calves were reported. Of those, 73,496 (43.5%) were beef cows, 67,071 (39.8%) were calves under one year of age, 5,577 (3.3%) were steers aged one year and over and 7,119 (4.2%) were heifers for slaughter or feeding. The total hectares in agricultural production were reported as 1,539,674, of which 840,402 hectares (54.6%) were used for cropping, 197,293 hectares (12.8%) were summer fallow land, 106,106 hectares (6.9%) were tame or seeded pasture, and 375,941 hectares (24.4%) were natural land for pasture. Of the hectares in crop production, 26,588 hectares (3.2%) were tame hay and fodder crops and 69,805 hectares (8.3%) were seeded into alfalfa and alfalfa mixtures.

From the 2006 census, 1,345 farms reported they were sole proprietorships, 395 were family corporations, 401 were partnerships without a written agreement and the remaining were either partnerships with a written agreement, non-family corporations or other operating arrangements. Gross receipts vary greatly, from under $10,000 to over $2,000,000. Of the total number of farms, 95% of the operations fall beneath $500,000 in gross receipts. Table 3 provides a distribution of gross farm receipts for CAR 3BN.

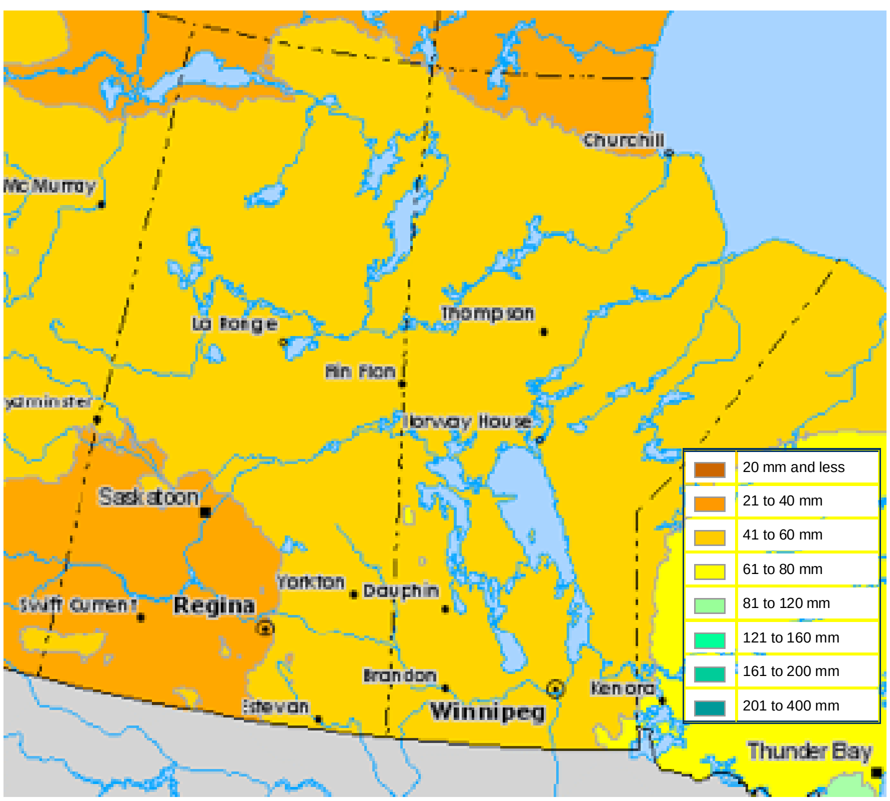
Table 3. Distribution of Total Farm Gross Receipts for Census Agricultural Region 3BN (near Swift Current)

Total Gross Receipts	Number of Farms	Percentage of Total Farms
Under $10,000	192	8.55%
$10,000 to $24,999	288	12.82%
$25,000 to $49,999	355	15.81%
$50,000 to $99,999	469	20.88%
$100,000 to $249,999	599	26.67%
$250,000 to $499,999	231	10.28%
$500,000 to $999,999	86	3.83%
$1,000,000 to $1,999,999	15	0.67%
$2,000,000 and over	11	0.49%

Source: Statistics Canada (2006)

Both Brandon and Lanigan receive, on average, similar precipitation amounts throughout the year (41 to 60 millimeters per year). Swift Current receives less moisture (21 to 40 millimeters per year) on an annual basis. Figure 3 shows annual mean precipitation amounts for both Manitoba and Saskatchewan for the years 1971-2000. This difference in moisture may result in reduced grazing days on pasture in Swift Current versus Brandon and Lanigan, as forage growth and health is dependent on moisture levels (Conrad and Youngman, 1965; Agriculture and Rural Development, 2007).

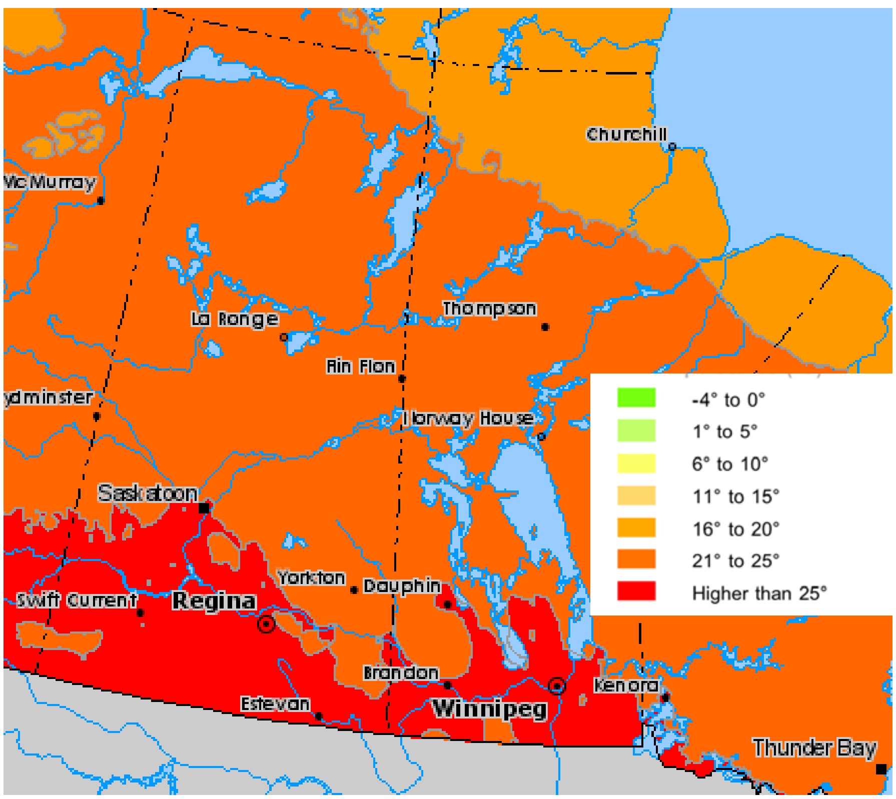
Figure 3. Annual Mean Total Precipitation in Manitoba and Saskatchewan, 1971-2000



Source: Natural Resources Canada (2009)

Average temperatures across the three sites also vary. Figure 4 depicts the mean daily maximum temperature for July across Manitoba and Saskatchewan. Swift Current lies in an area which can experience higher temperatures over other areas of the province. Brandon also lies in this zone of higher temperatures, but on the fringe. Lanigan has a lower July mean daily temperature than both Brandon and Swift Current.

Figure 4. July Mean Daily Maximum Temperatures for Manitoba and Saskatchewan, 1971-2000



Source: Natural Resources Canada (2009)

Chapter 3: Literature Review

3.1 Introduction

This chapter provides an overview of physical science literature relating to this research. The first section reviews studies that have been completed looking at different times of calving in the United States and Canada. The second section of this chapter reviews studies in beef production systems and the various modeling techniques that have been used to simulate these systems.

3.2 Calving Seasons

While much research on the effects of calving season on production and economics has already been done, they have been heavily concentrated in the United States. Even though there are similarities in environmental and land conditions between western Canada and parts of the United States, there are differences that could affect the returns to production systems based on different calving seasons. Moisture conditions, average daily temperatures and available forage resources are some variables that could differ. Perhaps more importantly, market conditions could create the largest gap between the two areas. Using western Canadian production data and western Canadian market conditions are necessary to better reflect the conditions that face western Canadian cow-calf producers.

Stonehouse et al. (1998) carried out the first economic comparison of calving seasons in Canada. They compared a traditional winter (February – March) calving with summer (June – July) calving based on data collected over a 5-year period from 1993 to 1997 at the New Liskeard Research Station in Ontario. They found only small differences in the estimated overall expenses between the two calving groups. Overall expenses for summer calving averaged $481.74 per cow, versus $533.75 per cow for winter calving. In this study, both the summer and winter calving groups were fed in confinement from October to May, therefore there was no difference in confined feeding time between the two groups. In western Canada, confined feeding for such a long period of time is less common and expensive, therefore, a large cost difference may result between the two systems in western Canadian versus Ontario.

Pang et al. (1999a) described a dynamic deterministic model, the Alberta Beef Production Simulation System (ABPSS), for testing the effects of production traits and management strategies on the bioeconomic efficiency of beef production systems. This model used the dynamic program STELLA and was composed of four major submodels: herd inventory, nutrient requirements, forage production and economics. They measured the bioeconomic efficiency by calculating the net return per cow, which was obtained by subtracting total cost from total return. In a subsequent publication, Pang et al. (1999b) then applied the ABPSS model to determine the effects of spring and fall calving seasons and weaning age on the bioeconomic efficiency in cow-calf production systems. It was found that in both spring and fall calving seasons, calf-weaning weight increased as weaning age increased. Fall calving exposed the calf to colder weather therefore, this system required more feed than the spring calving herd to maintain nutrition and body condition. This increased the cost of fall born calves compared to that of spring born calves.

Using the Montana State University model, Reisenauer et al. (2007) evaluated alternate calving seasons in combination with different calf marketing strategies for their effects on profitability under range conditions representative of the Northern Great Plains in the United States. This model simulated profitability based on a fixed forage base with all groups of cattle grazing native range from May 1 to January 1, with supplementation as required thereafter. Calving seasons studied were spring (starting on March 15), summer (starting on May 15), and fall (starting on August 15). This study found that the summer calving feed costs increased 40% and fall calving feed costs increased 80% over spring calving feed costs. Results demonstrated that spring calving was more profitable than summer calving, which are not analogous to other studies. Possible reasons for this difference are embedded in the feeding assumptions in the model. The focus of this study was specifically on changing calving dates without changes to grazing strategies or calf marketing. The results may have been different if grazing and marketing strategies were altered between the three treatments.

A more recent study by Payne et al. (2009) used STELLA to compare the predicted profitability of spring calving, fall calving and dual calving (i.e., calving in both the spring and fall) seasons for a cow-calf operation in South Texas over a 10-year period. The spring and fall calving herds were based on 1,000 head each and the dual calving herd was based on 500 spring calving cows and 500 fall calving cows. They found that dual calving was predicted to be the most attractive investment and management strategy when compared with the individual calving seasons. This system would have less invested in its breeding stock and a greater return on breeding livestock because bulls could be used in both the fall and spring breeding seasons. Dual calving also presents a second chance for cows that fail to get pregnant for spring calving to get pregnant in the fall. This opportunity, combined with cows calving in two separate seasons, may be a risk management strategy, since a producer would be able to take advantage of seasonal highs in the cattle market and spread his or her marketing opportunities out throughout the year. This suggests that dual calving seasons may be the most efficient use of a cow-calf operation's assets. However, dual calving seasons might not be the best strategy for some producers, as it would involve an increase in labour to support two calving times and possibly create conflict with other farming commitments or enterprises.

3.3 Beef Production Systems

Beef production systems include factors of production throughout the entire production cycle. This includes factors such as weather and moisture conditions, forage and feed supplies, land and labour constraints and calf weaning weights, cattle condition and death loss. A systems approach to studying cow-calf production is therefore warranted.

Anderson et al. (2005) analyzed the economic data for two production systems in Nebraska using SAS; cows grazing pasture and fed hay during the winter versus cows grazing pasture and crop residue and fed hay during the winter. Variables included in this analysis included the annual inputs of feed, supplement, breeding, health costs and revenues from sales. Keeping summer grazing management constant, this model found that when cows grazed pasture and were fed hay in the winter, the cost per weaned calf was $455.12 versus a cost of $421.43 when cows grazed pasture and crop residue and were fed hay during the winter. This translates into a savings of almost $0.15 per kg of calf weaned between the two systems ($2.00 per kg of calf weaned versus $1.86 per kg of calf weaned). The difference in feed costs resulted in a different cost per weaned calf and weaning breakeven, which demonstrated the effects of harvested forage costs on the cost per unit of production.

Stockton and Wilson (2007) compared five production systems and the financial implications of each system using twelve years of data from the University of Nebraska, Gudmundsen Agricultural Laboratory. The production systems were simulated using Microsoft Excel® over a 20-year horizon. The ranch scenarios for the five systems had cows allocated to three calving seasons, March, June and August, then divided into two groups based on the source of winter forage, either rangeland or cornstalks. The impact of drought was introduced using historical precipitation data from Nebraska. To compare scenarios, they calculated the average 20-year accumulated earned net worth (AENW), which provided an indication of the financial success of the ranching operation. At the end of the twenty years, June calving with cornstalks as the winter feed source had the highest AENW of $827,469, with March calving and range as the winter feed stock with the lowest AENW of -$125,532. This research showed that systems that relied only on rangeland as their source of grazing were affected most by drought. While this study assumed that all hay fed is purchased, rather than produced on farm or a combination of both, it demonstrated that an alternative system to calving in March and feeding hay in the winter could increase profitability in the system.

Tess and Kolstad (2000a) studied responses of beef production systems to changes in breeding strategies and management using a mathematical model developed at Montana State University. This bioeconomic model was designed to simulate the dynamic relationships among cattle genotype and physiological state, and forage quality and management in range environments. The economic component included measures of system performance such as ratios of inputs to outputs, breakeven prices and annual gross margin per cow or ranch. In a companion study, Tess and Kolstad (2000b) evaluated the model's response to changes in key variables and measured four outcomes: calf weight weaned per cow exposed, net income per cow exposed, cow productivity and profitability and lastly, profit per unit of land or per ranch unit. They found that net income per cow exposed was closely related to the weaned weight per cow exposed, but a more practical measure of profit was found through the profit per unit of land, which reflected the fact that there were constraints on some resources.

Chapter 4: Theory and Previous Work Related to Risk

4.1 Introduction

In economic theory, it is assumed that individuals maximize utility. If risks are not considered, an individual farmer will maximize profits, but if the utility of the individual farmer is affected by risk, changes in the farm that increase risk but also increase profitability may not be utility maximizing, therefore models addressing risk and return are required. The purpose of this chapter is to provide previously developed frameworks for decision making under risk. The first section of this chapter defines risk and provides examples as to the sources of risk. The second section describes probability theory and its use in measuring uncertainty. The third section provides detail on the Expected Utility Theory, the theory that provides the means for ranking risky alternatives. The fourth section addresses the theory behind the risk ranking method stochastic dominance. Finally, recent applications of models addressing risky choices in agriculture are presented.

4.2 Defining Risk

The book *Risk, Uncertainty and Profit* by Knight (1921), can be seen as the initial work defining risk and balancing it with returns. Knight connects the term *risk* with measurable *probabilities* and a known *distribution of the outcomes*. Alternatively, *uncertainty,* according to Knight, arises when the probabilities of possible outcomes are unknown. These formal definitions have allowed others to expand these terms such as Anderson et al. (1977) who state that a decision-maker faces risk when there is uncertainty about the consequences of the decision. More recently, Hardaker et al. (2004a) defines risk as having uncertain consequences and uncertainty as having imperfect knowledge.

To understand risk as a whole and to complete a successful analysis, one must first understand the components of risk. Anderson et al. (1977) defines these necessary components. They state that a decision-maker has a choice among *acts* or actions that will affect the range of outcomes. Further, each action is surrounded by *events* or future states of nature, which are the components that create risk. The decision-maker has no control over an event, nor does he or she know which of several outcomes from an event will occur. An example of an event may be fluctuations in commodity prices or the occurrence of hail during the growing season. In the case of an event such as hail, a decision-maker will have a choice between two actions: seeking to purchase insurance to protect against yield loss or declining to purchase insurance against yield loss. The decision between purchasing insurance or not will not have an impact on the event of hail occurring, but will impact the outcome. This decision will be based on *prior probabilities* or a degree of belief about the chance of hail occurring, which is a reflection of the decision-makers' information and own judgment. Depending on whether hail actually occurs and on the decision made to purchase insurance or not, *consequences* or payoffs occur, which are generally measured in wealth or profit. Both wealth and profit increase utility. In the case of hail, the decision-maker would be left with four possible outcomes, 1) do not purchase insurance and hail does not occur, 2) do not purchase insurance and hail does occur, 3) purchase insurance and hail does not occur, and 4) purchase insurance and hail does occur. If hail does not occur and insurance is purchased, the decision maker will see a loss of utility. This loss in utility may be considerably greater if insurance was not purchased and hail does occur.

There are several categories of risk present in agriculture. Hardaker et al. (1997) describe five types of risk with respect to agricultural production; yield, market, personal, institutional and financial. Together these risks are termed business risk. Yield risks encompass the variability in production due to biological and weather factors. Market risk includes the variability in price levels of inputs and outputs as well as currency values. The third, personal risk, involves risks to the person or persons involved in the production including work-place safety. Institutional risk includes any change or complication of industrial organization such as government intervention. The last risk, financial risk, includes changes in interest rate or available credit.

In agriculture, the decision-maker cannot use a simple rule like highest average payoff because rather than a single value for the economic return, there is a distribution of returns (Ribera, 2004). Decisions should be made after first considering and defining the risks involved in the choices. Accounting for risk gives the decision-maker the ability to determine which strategy is best (Richardson, 2003). The decision-maker faces choice among alternatives or a choice among risky prospects in which the probabilities of possible outcomes is either known or estimated. The decision-maker’s goal is then to maximize his or her utility based on the probabilities of risky prospects occurring and on his or her set of preferences.

4.3 Probability Theory

Probability theory provides the tools to measure uncertainty. An uncertain outcome is one where a particular action can lead to a number of different possible outcomes. Assigning a relative probability or likelihood to each outcome can provide a method for analyzing decisions when uncertain outcomes are present.

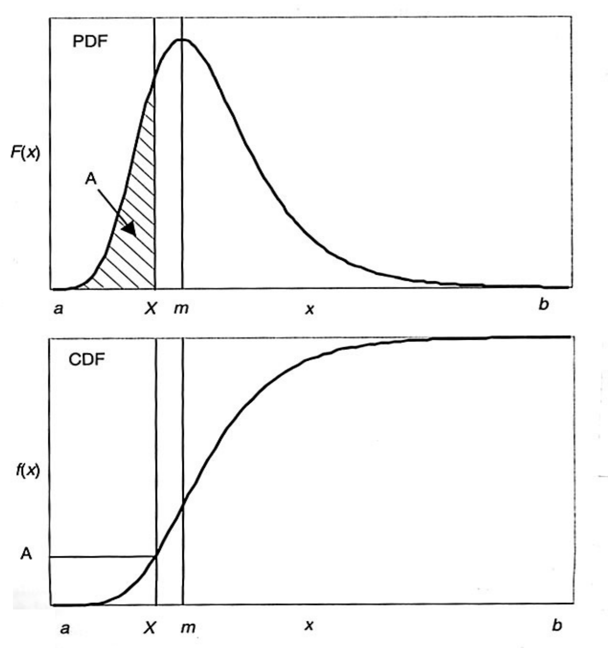
There are different views of probability - an *objective view* and a *subjective view*. Binger and Hoffman (1988) provide a clear discussion of these views. The objective view is based on observed experimentation that creates a probability distribution that is defined regardless of the decision maker. An example of this would be the toss of a coin. The probability of a coin landing on heads is ½ and the probability of landing on tails is also ½. This does not change with a change in the decision-maker. On the other hand, the subjective view is based on the decision-maker's own belief, research, experience or educated guess in regards to a particular situation, and is more often used in decision making. For example, a farmer deciding what crop to grow may base his or her decision on subjective probabilities as he or she will be uncertain as to the exact probabilities of potential outcomes, especially if one year is particularly different than previous years. Another farmer may have an alternative set of subjective probability estimates as he or she would have different information and experiences when faced with the same situation.

Binger and Hoffman (1988) also describe the formal properties of probabilities. The first property is that all probabilities of possible outcomes must sum to 1, since only one event will actually occur and probabilities represent relative likelihoods. For example, in the coin toss, there are two possible outcomes, heads or tails. The probability of heads is ½ and the probability of tails is also ½; the sum of all the probabilities therefore equals to 1. The second property is that of *independence*. Two risky prospects are independent of one another if the occurrence of one event has no effect on the probability that the other event will occur. For example, when tossing a coin several times, the outcomes are independent since every time the coin is tossed, the probability that heads will appear will be the same no matter how many tails have come before. However, in the example of the farmer deciding what crop to grow, the outcomes of yields and prices may not be independent because prairie-wide droughts that lower yields will likely also increase prices. The drought links the distribution of prices and yields.

Multiplying each outcome by its probability and then summing the products can calculate the average value of the possible outcomes. This average is called the *expected value* of the risky prospect. Different risky prospects with the same expected value may display different dispersion patterns around the expected value; this is termed the *variance*. It is measured as the sum of the squared differences between the possible outcomes in a risky prospect and the expected value of the prospect, each multiplied by its respective probability.

The distribution of probabilities can be graphed in two ways, as either as a *probability density function* (PDF) or as a *cumulative distribution function* (CDF). Hardaker et al. (2004a) provide a thorough explanation of the relationship between these two graphical representations (Figure 1). A PDF will often be bell-shaped with a central peak indicating the most likely value, or mode of the uncertain quality. When this is the case, a characteristic ‘tails’ on either side of the peak of the PDF represent the low-probability values that stretch out to the lower and upper extremes. The PDF for an uncertain quantity *x* is denoted by *f(x)*; values range from a minimum value of *a* to a maximum value of *b* with a mode of *m*. The area under the curve (AUC) between the two points, *a* and *X*, on the horizontal axis measures the probability that the value of the uncertain quantity *x* will be found within this range. While fairly straightforward to understand, PDFs are difficult to estimate and it can be difficult to ensure that the AUC equals 1 and adheres to the probability property stated above. The CDF is drawn from observed frequencies of distributions and points on the CDF can be calculated as the cumulative probability to a particular value. In Figure 5, the CDF for an uncertain quantity *x* is defined as *F(x).*

Figure 5. The Relationship Between a Probability Density Function (PDF) and a Cumulative Distribution Function (CDF)



Source: Hardaker et al.

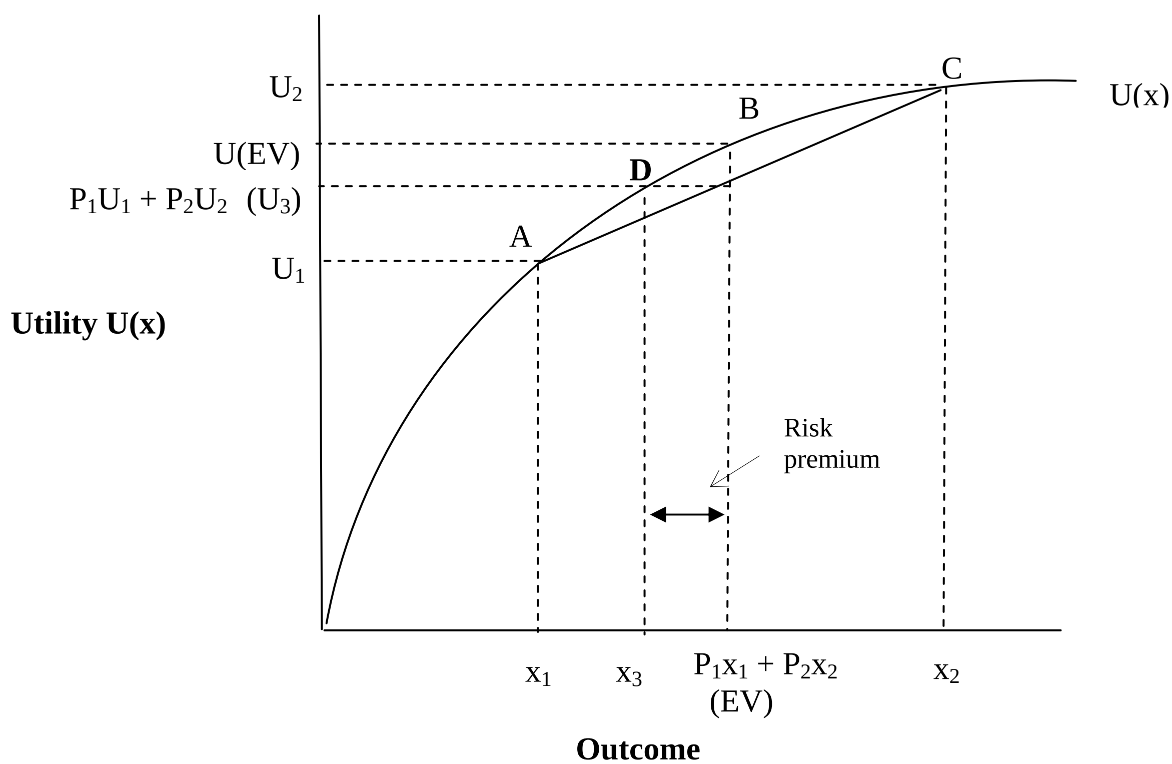
4.4 Expected Utility Theory

It is often assumed that the farm decision-maker will attempt to maximize profit, or expected profit, but this would ignore risky events that affect utility. An alternate theoretical framework was proposed by Bernoulli in 1738 and described by Anderson et al. in 1977. Bernoulli proposed that rather than maximize profit, decision-makers assign a numerical utility to all uncertain outcomes from a decision. In other words, Bernoulli's Principle assigns numerical utility values to consequences so that a decision-maker can act to maximise *subjective expected utility* or SEU if he or she were to be consistent with his or her expressed preferences. In dealing with risky alternatives, utility analysis provides a means for ranking risky prospects in order of preference, with the most preferred being the one with the highest utility.

In 1947 Von Neumann and Morgenstern further expanded Bernoulli's theory of utility through their concept called expected utility. The *Expected Utility Model* (EUM) is a representation of preferences under uncertainty in terms of the expected value of a set of utilities over possible outcomes. From this, it has been shown that Bernoulli's initial work is a logical inference from the six axioms by which decision-makers must abide by for any risky prospect. The first states that preferences of possible outcomes must be *complete*, *reflexive* and *transitive*. Preferences are complete when comparisons of outcomes can be made for all possible pairs of outcome bundles. If two outcomes exist, x and y, a decision-maker prefers one of the outcomes to the other, or is indifferent between them. Preferences are reflexive in that if a decision-maker is faced with two identical outcomes, the decision-maker will prefer them the same or be indifferent to one over another. Transitivity implies that if a decision maker prefers *x* to *y*, and *y* to *z*, then the decision maker will also prefer *x* to *z*. The second axiom states that compound lotteries can be reduced to simple lotteries. An example of simple lottery is flipping a coin or placing a bet on a roulette table. A compound lottery is a two-stage lottery or a lottery over a lottery. An example of this is winning a lottery ticket as an outcome of purchasing a lottery ticket. A compound lottery can be reduced to probabilities over the outcomes in the same manner as the simple lotteries. If the probabilities are the same, a decision-maker has to be indifferent between the two. The third axiom, *continuity*, suggests that for each outcome x_i, between x_1 and x_n, a decision-maker can designate a probability, ρ_{iI} that would make him or her indifferent to getting outcome x_i with certainty and taking the gamble with an uncertain outcome. The concept of *certainty equivalence* stems from this axiom and will be explained in further detail in this section. The fourth axiom is *substitutability*; a decision-maker is indifferent between the gamble and its certainty equivalence and can be substituted. Preferences over gambles are transitive, and stated by the fifth axiom of *transitivity*. The sixth and final axiom is *monotonicity*. This suggests that if two gambles with the same outcome are only different in their associated probabilities, then the gamble that gives higher probability to the most-preferred outcome is preferred to the other gamble. If a decision-maker accepts these axioms, this implies two things: 1) the rank by which expected utilities are ordered is a reflection of the order of rank for the preferences of consequences and 2) the decision-maker should choose among risky prospects to maximize his or her expected utility.

Certainty equivalence (CE), as defined by Anderson et al. (1977) is the amount a decision-maker will exchange to have an outcome with certainty and be indifferent between this exchange and an outcome with risk. Figure 6 provides a graphical example of determining the CE value where x_1 and x_2 are two equally probable outcomes of choice x and $U(x)$ is the utility function. The utility of outcome x_1 with certainty is U_1, while the utility of outcome x_2 with certainty is U_2. The

Figure 6. Graphical Example of Risk Premium and Certainty Equivalence (CE) for a Risk-Averse Decision-Maker



Source: Adapted from Anderson et al. (1977) and Robison et al. (1984)

mid-point between x_1 and x_2 with equal probability of either one occurring is the *expected value* (*EV)* with associated utility *U(EV).* As described earlier, multiplying the probabilities by each outcome and then summing the products calculate the EV. The U(EV) of a risky prospect or gamble, U_3, is calculated in the same manner or $U_3 = P_1(U_1) + P_2(U_2)$ and the level of utility is found at point D. The CE of the risky prospect is x_3. This is the point where the probability of the outcome x_3 is 1, or certain with utility U_3 or any possible outcome, x_i such that $U(x_i) – P_1U(x_1) + P_2U(x_2)$. At this point, the decision-maker is willing to forego an amount of wealth, and therefore utility, to have this amount with certainty, rather than face an outcome with risk. The difference between the EV of the risky prospect and the CE is called the *risk premium.* It measures the willingness to pay to avoid the risky prospect. The magnitude of the CE is dependent on the risk attitude of the decision-maker.

Binger and Hoffman (1988) explain that expected utility functions are usually placed into one of three categories, or attitudes, towards risk. These categories are based on the convexity of the utility function that reflects the preferences of the decision maker. Consequently, it is the value of the second derivatives of the utility function for wealth that ultimately characterizes the perceived attitude towards risk. If the second derivative is negative, this implies *risk aversion*. If it is positive, than this implies *risk preferring* and if it is zero, this implies *risk indifference* or *risk neutral*. However, while the sign of the second derivative tells us a decision-maker's attitude towards risk, the magnitude is random, since for any given preference, utility functions are subject to linear transformation. Any magnitude of derivative can be calculated through multiplication by a well-chosen positive constant. Both Pratt

(1964) and Arrow (1970) proposed an alternative method of measuring risk aversion called the *absolute risk aversion function* given as:

$$R_a(w) = \frac{-U''(w)}{U'(w)} \qquad (1)$$

where *U'(w)* and *U''(w)* are the first and second partial derivatives of the utility function, respectively. In general, the absolute risk aversion function will decrease with increases in wealth, *w*, since individuals can better afford to take risks as wealth increases. This is termed *decreasing absolute risk aversion* (DARA). Another category of risk aversion with respect to wealth is *constant absolute risk aversion*, or CARA, where preferences remain unchanged with increasing wealth.

From Robison et al. (1984), "a risk averse decision-maker will prefer an action with a perfectly certain return to another action with an equal, but uncertain, expected return." This preference occurs because a decision-maker will choose to lose utility from a monetary loss with certainty over a gain in utility from a monetary gain with uncertainty when a monetary loss and gain have equal magnitude and probability. Therefore, a risk-averter would have a CE of a risky prospect that is always less than its expected value.

4.5 Stochastic Dominance and Efficiency

When analyzing risk with preferences unknown, a framework must be specified. There exist several *stochastic efficiency* methods that are based firmly on the notion of direct expected utility maximization. These methods are based on pairwise comparisons of risky alternatives and differ with respect to restrictions imposed on either the utility function or the risk aversion function. King and Robison (1984) first separated risky alternatives into an efficient set and an inefficient set based on preferences. Efficient sets dominate inefficient ones. For example if an investor prefers less risk, their efficient set offers higher returns for the same risk or equal returns for less risk. This provides a means to rank choices among alternatives as the optimal decision lies within the efficient set. For this condition to hold, assumptions about the decision-maker's preference must first be made. There are varying strengths in assumptions regarding the risk preferences of a decision maker, and intuitively, the stronger the assumptions, the smaller the size of the efficient set.

From Hardaker et al. (2004b), the method with the least amount of restrictions on the utility function is first-degree stochastic dominance (FSD). The first to introduce this method were Hanoch and Levy in 1969 and Hadar and Russell, also in 1969. The only restriction for FSD is that the decision-maker is required to have positive marginal utility, *i.e.*, the decision-maker needs to prefer more wealth to less. Comparing alternatives when there are many alternatives involved is difficult with such low restrictive power, therefore greater restrictions must be imposed.

Second-degree stochastic dominance (SSD) further restricts the utility function. While maintaining the positive marginal utility restriction as in FSD, SSD states that the decision-maker must be risk-averse for all values of x and therefore have a utility function with a positive but decreasing slope. Under SSD, the distributions of outcomes are compared using the CDFs and the dominant alternative is found if it is everywhere below and to the right of the curves of the other alternatives.

Beyond the restrictions imposed by FSD and SSD, there are other forms of stochastic dominance analysis. These forms result in much smaller efficient sets and consider a wide range of risk preferences as they introduce stronger discriminatory power. Through his work, Meyer (1977) introduced *generalized stochastic dominance analysis* or *stochastic dominance with respect to a function* (SDRF). The new restriction introduces bounds on the absolute risk aversion function so that $r_1 \le r_a \le r_2$ where $r_1$and r_2 are usually positive coefficient of relative risk aversion levels (Hardaker et al, 2004a). This method applies to a decision-maker who has a degree of risk aversion that falls within the bounds. Assumptions regarding the shape of the utility function also need to be made.

However, a simpler and improved method of stochastic dominance analysis exists which was first demonstrated by Richardson et al. (2001) and then expanded by Hardaker et al. (2004b). This technique ranks risky alternatives in terms of certainty equivalents (CEs). This has been found to be an improved method over comparing the range of risk aversion, as a smaller set of preferred outcomes can be found compared with using stochastic dominance. This method is termed *stochastic efficiency with respect to a function*, or SERF. In this case, the same bounds on the risk aversion function exist as in SDRF, but for each risky alternative *x*, utility can be calculated depending on the degree of risk aversion *r,* given by:

$$U(w,r_a) = \int U(w,r_a)\, f(w)dw \qquad (2)$$

where w is the initial wealth and ra is the coefficient of relative risk aversion with respect to wealth. The SERF method can be calculated using different types of utility functions, such as the power, negative exponential or logarithmic utility functions. Schumann et al. (2004) demonstrated that applying a different utility function to the SERF method is unlikely to affect the results; however Hardaker et al. (2004b) suggest adopting the constant absolute risk aversion (CARA) function or negative exponential utility function as a good approximation of any unknown utility function.

For one alternative to dominate over another, the CEs must be compared. The CE of a risky alternative (in this study the time of calving) is the amount of money that the decision-maker will accept and be indifferent to the alternative. The alternative with the higher-ranking CE is preferred to the alternative with the lower-ranking CE. To calculate the CE, the inverse of the CARA utility function $U(w, r_a) = 1 - \exp(-r_a w)$ is taken and defined by:

$$CE(w, r_a) = \frac{\ln\left\{-\left(\frac{1}{n}\sum_{i}^{n} 1 - \exp(r_a w_i)\right) - 1\right\}}{-r_a} \qquad (3)$$

where r_a is the absolute risk aversion coefficient, n is a random sample of size n and w_i is the risky alternative.

The absolute risk aversion coefficient is taken from Nelson (2004) and established by Babcock et al. (1993). Nelson demonstrated that using an absolute risk aversion coefficient within the range of .000004 to 0.34 is suitable in the CARA model.

4.6 Risk Analysis Methods

A study done by Harrison et al. (1996) used a stochastic budget simulator to compare risk management properties of grazing contracts to futures and options contracts. Stochastic factors were assumed to be feeder cattle prices and climatic effects on animal performance. Probability distributions for revenues were constructed and the results showed that risk-averse pasture owners preferred grazing contracts to integrated production when hedging is used to manage price risks, demonstrating that alternative production methods available to producers also have differing risk profiles.

Evans et al. (2004) used stochastic budgeting to assess profitability and risk associated with producing pasture-raised beef compared to a traditional feeding system in the Appalachian region of the United States of America. Using the Excel add-in @RISK (Palisade, 2009), this model yielded profit estimations accounting for variation in animal performance, pasture yield, input requirements and revenue levels to calculate final return distributions. Alternatives were ranked using stochastic efficiency analysis with the decision criteria of maximum expected returns. This study found that the requirements of pasture-raised beef production including time, management and money, result in greater returns than that of a traditional feeding system. However, if producers are not sufficiently set up for rotational grazing or stockpiling practices, they will face significant start-up costs. The study also found that producers of pasture-raised beef face more production risk in the form of inputs required than market risk from the output price compared with traditional producers.

A study done by Lien (2001) used stochastic budgeting to simulate the business and financial risk for a Norwegian dairy farm. Five different management and investment strategies were compared for their ability to increase net profit on the farm, including continuing farming, making an investment or quitting the dairy business to become a part-time grain farmer. In using the stochastic budget method over the deterministic budget method, risk and uncertainty were incorporated into the model. This was done by using the distributions of the risky variables and then sampling using the Monte Carlo method. Evaluation of the strategies was carried out using Distribution CDFs and SDRF. This study found that making a major investment would be very risky; the best option for the producer would be to continue producing milk until quota price increased and then become a part-time farmer.

Janzen (2007) used stochastic simulation to measure the impact of Canadian safety net programs on net farm income. The Red River Valley agricultural area in Manitoba was selected as the representative region of western Canada for this study. Enterprise budgets were constructed to represent a model farm growing three crops and risk analysis techniques were used to evaluate the results. The revenue generated from these crops was the price received multiplied by the crop yield. To calculate a per-acre profit or loss from each crop, cost of production, calculated using information provided by MAFRI, was subtracted from the generated revenue. Janzen's model allowed the decision-maker to choose between no safety net programs, insurance only and an option including the Canadian Agricultural Income Stabilization (CAIS) program. Through simulation he found that the CAIS program can provide significant benefits to farm income, but it is dependent on the farm's margin position. Janzen's study is an example of stochastic budgeting in Manitoba and the use of risk analysis tools for decision making under risk.

A recent study carried out by McLellan (2009) follows similar reasoning as that of the study of Janzen to quantify the economic savings engendered by adding a legume crop in a cereal-oilseed crop rotation in Southern Manitoba. Legumes are able to fix nitrogen, a major nutrient required by a crop, therefore bringing about the possibility of reducing the amount of nitrogen applied in the following year. Stochastic budgets were developed for four different crop rotations using cost of production information; net returns from each rotation were evaluated using risk analysis tools. McLellan found that including a legume into a rotation could increase net returns by decreasing the amount of nitrogen required by the following crop in the subsequent growing season and was the preferred choice at all levels of risk aversion.

From the literature discussed, June calving is suitable to western Canada and has the potential to decrease costs to the producer. The use of stochastic simulation models has been established as a method to evaluate production alternatives, especially when risk and uncertainty are present. However, taking into consideration all of the factors involved in a cow-calf production system increases the complexity of any model trying to represent it. Modeling and simulation techniques have weaknesses such as including unnecessary variables or excluding necessary ones to create results that may not represent the actual system. However, simulation models continue to be useful tools as traditional experiments in livestock production are time-consuming and expensive. Tess and Kolstad (2000b) suggest that models should be designed for specific purposes as it is unlikely that one large general model can be developed to study all problems encountered in beef production. It is important that the characteristics of the model be flexible enough to illustrate different management strategies (Romera et al. 2002) and to represent the assumptions of the model clearly to the users.

Given the background information in cattle production and calving seasons and the previous work in risk theory, the objectives of understanding whether changing the time of calving increases net returns to producers and identifying the tradeoffs to calving in a later season in terms of risk are reasonable and attainable. This information will be useful to producers who have been thinking about changing their calving season and for those wanting to have an estimate of the risks and rewards associated with each season.

Chapter 5: Methodology

5.1 Introduction

The first section of this chapter describes the premise behind budgeting and its usefulness in farm management. The second section in this chapter focuses on the use and application of stochastic budgets followed by a section on simulation. The fourth and fifth sections explain how the revenue and cost variables were calculated for the Iwaasa et al. (2009) study. This includes how the data were collected and the sources of data used that were not collected directly from the study. The sixth section discusses a specific variable called "Days in Each Feeding System". The last section provides a description of the simulation model.

5.2 Budgets

A budget can be considered a management tool for developing and analyzing alternatives when faced with decisions (Doye, 2008). Normally costs and benefits are compared; if an option does not meet an objective on paper, then it most likely won't meet it in practice. Budgeting can address resource allocation, labour requirements, capital requirements, return on equity and costs of production based on the goals and objectives of a farm; alternatives can be ranked based on the results of the budget for each alternative.

Doye (2008) provides an overview of the three basic types of budgets commonly used in farm management; whole farm, enterprise and partial. The whole farm budget is a detailed summary of the entire farm business. Individual components of the total farm are identified and relationships are scrutinized as they interact within the business. Solid goals, clear objectives, and detailed information are required when developing whole farm budgets, as this method is very holistic in nature. An enterprise budget includes statements of revenues from and expenses incurred by either a specific production practice or product. An enterprise budget is often used when less information is available than the information required to complete a whole farm budget, for example production conditions or production amounts. Both variable and fixed costs are included in an enterprise budget. Partial budgets analyze the effects of a change from an existing procedure and only the revenue and expense items that will change are considered. An enterprise budget was selected for this time of calving model because it was more general than a whole farm budget and more complete than a partial budget.

5.3 Stochastic Budgeting

Variables included in enterprise budgets may have levels of uncertainty or risk associated with them that a fixed-point estimate could not describe. Rather than having these variables remain as fixed-point estimates, another form of budgeting is used. Stochastic budgeting uses probability distribution functions to include the uncertainty regarding certain budgeted variables. This form of budgeting can account for some of the main uncertainties within a model and provide an estimated return.

Building a stochastic budget involves some key steps. The approach is similar to building a deterministic budget except that some key variables are flagged as uncertain. Stochastic budgets use iterations of deterministic budgets, where values for the uncertain variables are drawn from a distribution or simulated. This procedure continues until the distribution of key output variables become stable. The key variable for this model was the net revenue generated from each calving season at each site. Since the distribution was needed for our assessment of risks based on the theory presented in Chapter 4, distributions of the net revenue were also estimated.

5.4 Simulation

Hardaker et al. (2004a) define simulation as "the use of an analogue in order to study the properties of the real system". Further, they explain that simulation models are often used to examine the 'what-if' questions of a real system and models typically represent the relationships between the inputs and outputs of the real system. Stochastic budgeting is a form of simulation model. It is just like ordinary budgeting, except that uncertainty in some variables is taken into account (Hardaker et al., 1997). A software program called @RISK, developed by Palisade Corporation and available as an add-in for Microsoft Excel simulated net returns for the two calving seasons. Iterations were run to produce values for all output variables and to provide all possible outcomes including the best and worst case scenarios. The distribution of incomes was ranked, depending on the level of risk aversion assuming a utility function including risk.

A stochastic simulation model was used to estimate the net returns (NR) distributions for the two calving seasons. The simulation model was represented by:

$$NR_i = \sum n \{W_i \times P_i \times Y_i - Y_i \times VC_i - FC_i\} \qquad (4)$$

where W_i is the stochastic weight of a calf, P_i is stochastic price for a calf, Y_i is the number of calves sold, VC_i *is* the per-unit variable cost for raising a calf, and FC_i is the fixed cost.

With computer programs such as @Risk, simulation has become much easier. The simulation calculates a budget or situation over and over again, with each new calculation recorded as an iteration. Each iteration calculates and records a new net revenue as generated from values drawn from distributions for each uncertain variable in Equation (1). In the model proposed here, each iteration is a representation of the net revenue generated from a cow-calf operation calving in March and calving in June.

In simulation models, Monte Carlo sampling and Latin Hypercube sampling are two common sampling techniques. Monte Carlo sampling techniques are completely random and any sample may fall within the distribution range; the Latin Hypercube is a stratified technique that samples without replacement within a divided distribution. Both sampling methods recreate a distribution; however, the Latin Hyercube may provide a more precise estimate as it increases sampling efficiency and forces low probability events to be included within the outcomes. Once a segment has been sampled using this method, it cannot be sampled again as they are already represented in the sampled set. On the other hand, the Monte Carlo method is a simpler technique that the program @Risk is able to perform. If enough iterations are run, samples of x are more likely to fall within the areas of higher probability of occurrence. This technique will also include any areas of the distributions with lower probability of occurrence.

Using the variable information presented in this chapter, simulation was used to generate a distribution of key variables. The study ran 10,000 iterations of the model using the Monte Carlo sampling technique.

5.5 Revenue Budgets

For each site, the stochastic revenue variables include: steer weaning weight, heifer weaning weight, steer price, heifer price and cull cow price. To calculate the calf revenue associated with each calving time, the number of steers and heifers sold was multiplied by their weight then multiplied by the price per unit weight. Cull cow revenue was added to the calf revenue and was calculated by multiplying the number of culled cows by their weight then by the price per unit weight. Each site had a different number of cows, and different calf and culled cow numbers (Table 4), therefore, consistent assumptions had to be made for each of the herds.

Table 4. Number of Cows at each Location and Calving Time

	March Calving	June Calving
Brandon, MB	66	66
Lanigan, SK	50	50
Swift Current, S	30	30

The following assumptions were taken from the Iwaasa et al. (2009) study as they were the targeted levels for the herds. Based on MAFRI production averages (2008a), it was assumed that there would be a 98% calf crop or a 98% weaning rate.

This meant that not all of the cows were successful in producing a calf or that all calves survived throughout the season. Only 98% of the calves were expected to be sold and contribute to revenue. A further assumption about the herd was made with respect to the cows. It was assumed that 10% of the cows would be removed from the herd, sold and replaced by heifer calves within the herd. In other words, 10% of the heifer calves would not be sold but rather kept in the herd as replacement heifers to maintain a constant herd size. For example, in Lanigan, the March calving herd consisted of 50 cows. With a 2% calf death loss, 49 calves remain in the herd; of those 49 calves, 10%, or 2 of the heifers are retained. This leaves 25 steers and 22 heifers for sale. It was also assumed that for the March calving system all calves (minus the replacement heifers) and culled cows were sold in the October market and all calves from the June calving system (minus the replacement heifers) and culled cows were sold in the January market. After the number of calves and cows sold at each site was determined, values for the weight and price per unit weight of the calves and cows were required.

5.5.1 Steer and Heifer Weaning Weights

Using the fit distribution function from @Risk, distributions were selected for the stochastic input variables. The distribution used for weaning weights for all three sites was either a normal distribution or lognormal distribution, based on data from the study of Iwaasa et al. (2009). Normal distributions were used where the data were symmetrical and lognormal distributions were used where the data were asymmetric or skewed to one side. A correlation matrix was used to define the relationship between steer and heifer weaning weights at each location. This was done to increase the chance that under the exact same conditions, a high steer weaning weight would also mean a high heifer weaning weight. The coefficient was calculated from the Iwaasa et al. (2009) study by determining the correlation of each set of steer and heifer weights from each calving time from each site.

5.5.2 Steer, Heifer and Cow Prices

The distributions for steer and heifer prices were considered to be normal distributions based on historical prices from 2000-2009 for Manitoba and Saskatchewan (Canfax, 2009). These reports provide prices for both Manitoba and Saskatchewan feeder steer and heifer hundred weight (cwt) prices for several different weight categories. Alberta D1, D2 cull cow prices were used to simulate cull cow prices for Manitoba and Saskatchewan. Prices for October and January sale dates were used as they reflect the time at which the weaned calf would be ready for market. Prices were sampled from a normal distribution in the model. For steers and heifers, multiple weight classes exist; therefore when a weaning weight was chosen by the model, the price variable was conditioned to correspond to the appropriate weight category into which the weaning weight fell. A normal distribution was chosen for January cull cow prices while a lognormal distribution was used to describe October cull cow prices since the October cull cow price was an asymmetric distribution.

Given the yield and price data, the revenue received for each calving system was calculated. For each calving system, the cost of production was subtracted from the calculated revenues, to determine the net revenue for each calving system.

5.6 Cost Budgets

Another component of the simulation model was the costs associated with each calving system. Financial cost budgets were compiled for each calving time for each location from the start of calving through to the beginning of the next calf crop. Budgets were based on the resources used during the two production years (2007-2008 and 2008-2009) to produce and wean a calf at each site. These costs were used to determine the total costs for each calving time and did not change from one iteration to the next.

Each calving system was divided into four feeding phases: confined feeding, bale grazing, swath grazing and pasture. The costs for each feeding phase were multiplied by the number of days in each system and then divided by the number of cows being fed. Other costs such as veterinary and medicine, marketing, trucking, salt and mineral, breeding, taxes and water were calculated separately from feed costs. The following describes both the real or actual costs as well as the assumed or average costs incurred at each site throughout the production cycle.

The production cycle was divided into four phases which were classified by the dominating feeding form. These four phases comprised confined feeding, bale grazing, pasture and swath grazing phases; they are explained in further detail below.

Confined Feeding

The confined feeding period was defined as the time cows, and at times calves, spent in a smaller fenced-in area or in pens, eating non-grazed forages, where feed and water were easily accessible. Shelter was provided to protect the animals from the wind and manure that accumulated was removed annually.

A combination of actual costs and assumed costs was used to determine the total cost per head per day incurred during the confined feeding period. Recorded data for feed, grain and straw bale use, as well as actual equipment use hours and labour hours for feeding, checking and treating were used to calculate the costs. Each site used different feeds at different costs, depending on what was available. Assumed costs were used for building repairs, utilities, manure removal, salt and mineral, breeding, taxes and water.

Pasture

During the pasture period, cows and calves spent time grazing either tame or native pasture. A pasture rental rate of $0.80 per head per day was used to account for the forage resources, fencing, water, and land, not including labour. Labour costs were determined using the labour rate multiplied by the actual labour use recorded for each calving system. This included checking cows and calves, assisting with calving when necessary, as well as treating and moving cattle. When either quality or quantity of pasture forage decreased, supplementation in the form of harvested hay was required. This increased the assumed pasture rental rate by the amount of feed required and the equipment and fuel required to feed it to the cattle.

Swath Grazing

Swath grazing is a feeding technique used to extend the grazing season; it has been shown to save money through reduced harvesting, handling, feeding and manure removal costs (Alberta Agriculture and Rural Development, 2004; Lardner, 2005; Lardner and Froehlich, 2006; McCartney et al., 2004). Annual crops were swathed to provide additional grazing into the fall.

The costs incurred by swath grazing included seed, fertilizer and chemical costs to grow the crop, labour, machinery and fuel use throughout the growing season and harvest, land rent and cross fencing to allocate the swaths. The cost of swath grazing was split into a fixed cost and a variable cost. Regardless of the number of days or number of animals, the cost to establish the grazing stand remains the same, therefore this was included in the fixed cost portion. The variable cost portion included labour to check cattle and move fences, any additional equipment use and supplemental feed or straw.

Bale Grazing

Bale grazing is another feeding technique used to extend the grazing season for cows and reduce feeding costs. According to MAFRI (2008b), bale grazing beef cows can save producers' time, effort, money and, with proper management, reduce environmental risk (Lardner, 2005; McCartney et al., 2004; MAFRI, 2008b). The premise behind bale grazing is to set out a large number of bales in the fall and regulate the cow's feed intake using electric fencing. The costs incurred by bale grazing included those for feed, land rent, machinery and fuel use, labour for site set-up and feeding, cross-fencing for allocating bales and straw for bedding.

In addition to being a feeding technique, bale grazing also imports nutrients into the field in which the bales are placed and fed. A discount of $10 per metric tonne of feed was used to value the nutrients being placed on the bale grazing site (Saskatchewan Ministry of Agriculture, 2008b).

5.6.1 Actual Costs

The prices paid for each feed differed from location to location. The differences can be attributed to the supply and demand for each feed source, including weather, proximity to other cattle operations, availability of previous year's crop, and, in the case of barley, the world market. The study collected actual prices paid at each site for hay, silage, grain, greenfeed, and straw (Table 5). These prices were multiplied by the amount used to feed and bed the cow herd during the four phases, including on pasture if required.

Table 5. Price per Tonne for Forage and Grain in Brandon, Lanigan and Swift Current for 2007 and 2008 ($)

	Brandon, MB		Lanigan, SK		Swift Current, SK	
	2007	2008	2007	2008	2007	2008
Hay	77.16	88	56.38	75.32	70	70
Greenfeed		50	50	50		
Silage	49.5	53.86				
Barley Grain			194.38	236.54	180.14	207.7
Straw Bales	35.27	35.27	37.51	32.16	35.2	35.2

Equipment operating rates and fuel use were based on Saskatchewan's Ministry of Agriculture (2008a) *Farm Machinery Custom and Rental Guide.* The variable cost for each piece of equipment employed throughout the study was multiplied by the number of hours of actual use time as recorded for each site. The cost for both gasoline and diesel fuel for each location (Table 6) was calculated by using the average amount of fuel per piece of equipment used per hour multiplied by the average yearly price of the fuel as reported by Statistics Canada (2009). A labour rate of $15.00 per hour was used and multiplied by the number of actual hours recoded at each site for each treatment.

Table 6. Average Gasoline and Diesel Fuel Price per Litre for Brandon, Lanigan and Swift Current in 2007 and 2008 ($)

	Brandon, MB[1]		Lanigan, SK[2]		Swift Current, SK[3]	
	2007	2008	2007	2008	2007	2008
Gasoline	1.02	1.16	1.05	1.17	1.05	1.17
Diesel	0.96	1.21	0.95	1.22	0.97	1.23

[1]Based on retail pump prices for Winnipeg, MB (Statistics Canada, 2009)
[2]Based on retail pump prices for Saskatoon, SK (Statistics Canada, 2009)
[3]Based on retail pump prices for Regina, SK (Statistics Canada, 2009)

The cost to market or sell a calf at an auction mart was different in Manitoba compared to Saskatchewan (Table 7). These costs include sales commissions and check-offs; the check-offs are deducted from the sale of every head of cattle sold and are used to fund the activities of each province's production association, as well as investment into research and market development at the national level (Manitoba Cattle Producers Association, 2009).

Table 7. Marketing Costs for Manitoba and Saskatchewan ($)

	Manitoba	Saskatchewan
Sales Commission	16.50	17.50
Check off	6.65	3.65

Veterinary and medicine cost differed at each location. A standardised vaccination protocol was delivered at each site to ensure the health of cows and calves throughout the year. However, at Lanigan, an additional vaccination was given to cows and calves to protect them against anthrax. All cows were checked for pregnancy by a veterinarian. Treatment costs included any necessary medication or veterinary services required by a cow or a calf throughout the year outside of the vaccination protocol.

5.6.2 Assumed Costs

When factors that contribute to the costs of cow-calf production were not measured or recorded in the study, they were taken from government publications or the literature (Table 8). Each cost was held consistent for all three sites for both calving times.

Table 8. Assumed Costs for March and June Calving Times

Cost Detail	Cost per Unit ($)	Reference
Land Rent ($/hectare)	20.85	Sasktachewan Ministry of Agriculture, 2007
Labour ($/hour)	15.00	Industry Experts - 2009[a]
Pasture Rate ($/cow/day)	0.80	Industry Experts - 2009[a]
Fencing ($/cow/day)	0.10	Sasktachewan Ministry of Agriculture, 2008
Manure Removal ($/cow/day)	0.11	Manitoba Agriculture, Food and Rural Initiavies, 2008
Building Repair ($/cow/day)	0.03	Manitoba Agriculture, Food and Rural Initiavies, 2008
Utilities ($/cow/day)	0.10	Manitoba Agriculture, Food and Rural Initiavies, 2008
Mineral ($/kg)	0.84	Manitoba Agriculture, Food and Rural Initiavies, 2008
Salt ($/kg)	0.20	Manitoba Agriculture, Food and Rural Initiavies, 2008
Breeding Costs ($/cow/day)	0.10	Manitoba Agriculture, Food and Rural Initiavies, 2008
Taxes & Water ($/cow/day)	0.03	Manitoba Agriculture, Food and Rural Initiavies, 2008
Freight ($/cwt)	1.60	Manitoba Agriculture, Food and Rural Initiavies, 2008

[a]Clayton Robins, Technician, Agriculture and Agri-Food Canada, Brandon, Manitoba

A rental rate of $51.52 per acre ($20.85 per hectare) for swath grazing was used (Saskatchewan Ministry of Agriculture, 2007). A charge of $0.80 per cow per day on pasture was used as the pasture rental rate, which includes water, fencing and land rent costs (Robins, personnel communication, 2009). A cross-fencing cost of $0.10 per head per day was added to the swath grazing and bale grazing costs (Saskatchewan Ministry of Agriculture, 2008b). MAFRI's *Cost of Production Budget for Beef Cows* (2008a) was used to estimate the costs for manure removal, building repair, utilities, breeding costs, taxes and water, insurance and freight of calves to market. Mineral and salt consumption was based on average values from this budget, but were multiplied by the actual cost of the supplement incurred at each location.

The calculated cost per head per day for each feeding system is shown in Table 9. These costs were inputted into the stochastic model as deterministic variables for each calving time. A brief explanation of the costs follows.

Table 9. Average Costs for Brandon, Swift Current and Lanigan over 2 years, 2007-2009

	Brandon			Lanigan			Swift Current		
	March	June	% Change[a]	March	June	% Change[a]	March	June	% Change[a]
Confined Feeding ($/head/day)	2.74	2.70	-1.46%	2.25	1.96	-12.88%	2.62	1.80	-31.30%
Bale Grazing ($/head/day)	2.18[b]	2.18	0.00%	1.70	1.86	9.41%	1.64	1.73	5.49%
Swath Grazing - Fixed ($/hectare)	248.88	248.88	0.00%	257.15	257.15	0.00%	274.46	274.46	0.00%
Swath Grazing - Variable ($/head/day)	0.29	0.29	0.00%	0.40	0.40	0.00%	0.29	0.29	0.00%
Pasture ($/head/day)	1.08	1.19	10.19%	0.99	1.05	6.06%	1.16	1.22	5.17%
Other Costs[c] ($/head/day)	0.33	0.32	-3.03%	0.33	0.32	-3.03%	0.32	0.31	-3.13%

[a] Percent change going from March to June

[b] No bale grazing was done for Brandon's Early-calving group, therefore the Late-calving bale grazing rate was used

[c] Includes mineral, salt, vet & med,breeding, taxes, water, trucking, marketing costs, and operating interest.

At all three locations, the cost per cow per day in the confined feeding system was lower for June calving cows than for March calving cows. The largest decrease was recorded in Swift Current, where confined feeding cost went down by 31.3% for the June calving system over the March calving system. While both calving systems spent time in the confined feeding system prior to calving, the difference in climate and weather conditions between the two calving times resulted in an increase in feed, straw, equipment and labour use to maintain a cow's condition. In Lanigan, for the March calving group, a similar situation accounted for a 12.88% decrease in costs from June calving to March calving cows. Increased feed costs to maintain the cow and increased straw use for bedding were the main factors for the cost difference. In Brandon a 1.46% decrease was recorded, from $2.74 per cow per day for March calving cows to $2.70 per cow per day for June calving cows. This difference is not as large as the other sites because severe weather conditions were present throughout the winter and spring. This forced the June calving cows to spend more time in the confined feeding system than originally anticipated.

Confined feeding costs were not the only costs to differ between the two calving times. The cost to bale graze increased for the June calving group in Lanigan and Swift Current by 9.41% and 5.49% respectively. The June calving cows required more feed to meet their nutritional needs over the time they spent bale grazing, which increased the labour hours required and machinery use to feed. In Brandon, bale grazing was not included as a feeding system for the March calving group, therefore the same cost that was calculated for the June calving group was also used for the March calving group. A rate for the March calving system is required because, even though bale grazing was not used, it was included as a feeding option in the simulation model.

The cost for swath grazing did not change from one calving system to the next at any of the three locations. This is because the greatest portion of the cost for swath grazing is fixed and does not change according to the calving season, *i.e.*, no matter which calving time is implemented, the input costs (seed, fertilizer, pesticides, machinery, fencing) remain the same.

Pasture costs increased for the June calving system compared to the March calving system at all three locations. Two factors contributed to this increase; an increase in labour and an increase in truck use. With calving on pasture, the cows and calves were not kept in a confined space as with the March calving system; therefore, more time was required to locate the animals and treat if needed. Another factor in the increased cost for the June calving system was that the cows required more supplemental feed on pasture than did the March calving cows. This feed was often required at the end of August and early September as pasture quality and quantity was declining. The other costs in Table 9 include those for salt and mineral, veterinary and medicine, breeding, water, taxes, trucking and marketing.

Based on the percent changes, costs rose in Brandon and Lanigan by 5.7% and 0.4%, respectively, for the June calving cows, making the March calving system the least costly of the two options. Swift Current showed a 23.8% decrease in cost in favour of June calving. Climate conditions in Swift Current may favour a June calving system more so than other locations such as Brandon and Lanigan, but it is important to keep in mind that these costs are based on a two year study. While they do represent the production costs incurred at each site, it is expected that these costs would differ from year to year depending on weather conditions, feed costs and availability. The simulation model will address the variability of other stochastic variables such as the number of days in each system; however, the above costs will remain the same.

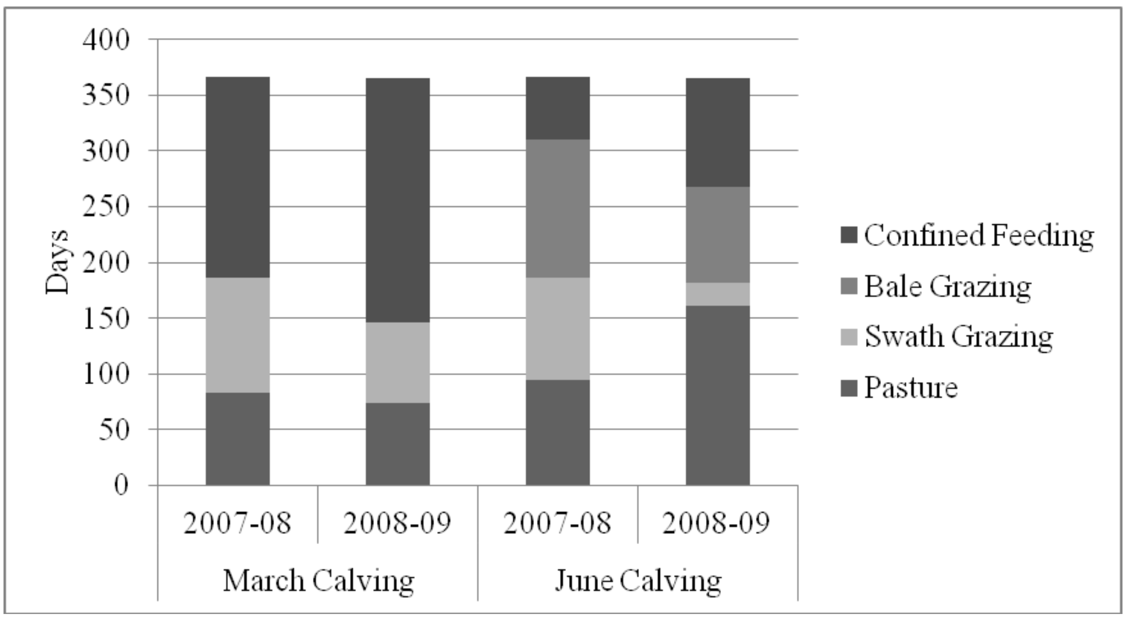
The next step in the model equation is to determine the number of days in each feeding system. This is used as the multiplier for the costs determined above. The feeding system cost is multiplied by the number of days the cattle spend in the system. Then the four feeding system costs are added together to calculate the total cost for each calving system.

5.7 Days in Each Feeding System

While the cost per cow per day of each feeding system is important, it is not the only variable that determines total cost. The number of days a cow spends in each system greatly affects the total cost of the overall system. For example, if a producer maximizes the time the cattle spend in a lower cost feeding system, *e.g.*, pasture, and minimize the time spent in a higher cost feeding system, *e.g.*, confined feeding, this will result in a lower total cost. If the same feeding costs are used but pasture days are limited and confined feeding days are increased, this will result in a higher total cost. It is an essential assumption that June calving cows will spend more time in lower cost feeding systems and less time in higher cost feeding systems than March calving cows.

A standardised protocol guided the daily operations of the animal trial at each location, however the exact number of days spent in each system at each location was influenced by climatic factors, feed quantities and qualities, cow and calf condition and the opinion and experience of the research station crew. Over the two year period, there was a reduction in the number of days spent in confined feeding for June calving compared with March calving. As Figure 7 shows, in Brandon, June calving

Figure 7. Days in each Feeding System in Brandon, 2007-2009



reduced the number of days in the confined feeding system in both years and likewise increased the pasture days. Similar graphs for Lanigan and Swift Current can be found in Appendix A.

While this dataset accurately represents the number of days in each feeding system over the two years of the study, the data do not accurately represent long-term conditions. In order to better predict the number of days in each system, it was decided to use industry knowledge and experience from each of the locations through conversations with production staff from each of the sites (personal communications: Robins and Block, 2009; Pearce, 2009; Birkedal, 2009). Given the knowledge and understanding of each area, including land capabilities and weather factors, each industry expert provided a worst case, best case and most likely case for the number of days the cow herd would spend in each feeding system for a total of 365 days. The best case implied that resources were used optimally, that pasture and swath grazing provide sufficient yield and quality to extend the cow's time spent in these systems and that confined feeding time is reduced, for an overall potential cost reduction. The worst case implied that weather and/or moisture limitations reduced the number of days in a pasture or swath grazing system, thus forcing the cattle to spend more days in a confined or bale grazing feeding system. For the purposes of this simulation model, the number of days spent in a particular feeding system was treated as a stochastic variable and the worst case, most likely case and best case data were placed in a triangle distribution. The triangle distribution can be used as a subjective description of a population when only limited data is known. It is often used in business decision making and in simulation. Table 10 delineates the parameters used for simulating each location's feeding system distribution.

For all three sites, the model holds pasture and swath grazing days the same in March calving and June calving scenarios due to the assumption that weather and

Table 10. Number of Days in Each Feeding System in Worst Case, Most Likely Case and Best Case Scenarios

	March Calving			June Calving		
Brandon	Worst Case	Most Likely Case	Best Case	Worst Case	Most Likely Case	Best Case
Pasture	60	110	125	60	110	125
Swath Grazing	45	75	90	45	75	90
Bale Grazing	110	60	60	200	150	150
Confined Feeding	150	120	90	60	30	0
Lanigan	Worst Case	Most Likely Case	Best Case	Worst Case	Most Likely Case	Best Case
Pasture	75	107	190	75	107	190
Swath Grazing	25	70	93	25	70	93
Bale Grazing	145	100	22	188	158	82
Confined Feeding	120	88	60	77	30	0
Swift Current	Worst Case	Most Likely Case	Best Case	Worst Case	Most Likely Case	Best Case
Pasture	92	138	167	92	138	167
Swath Grazing	0	15	30	0	15	30
Bale Grazing	142	96	81	231	190	158
Confined Feeding	131	116	87	42	22	10

moisture limitations would be the same in a given year regardless of the time a calf is born and that calves would eat an insignificant amount of forage provided. For example in Swift Current, the best possible number of days cattle could spend out on pasture is 167, with environment being the limiting factor in pasture production. This number would not change if calving time is changed in an operation. If environmental conditions are not favourable to forage production, the least number of grazing days would be 92. From past experience, the Swift Current area can expect 138 days of grazing on pasture on average.

What would change between the two calving systems is the number of days in the bale grazing system and the confined feeding system. Environment continued to play a large role in determining the number of days in each feeding system; however, the days spent in confined feeding are assumed to be needed only during extreme weather, during calf weaning or prior to calf selling, and before being released to pasture.

To determine the allotment of days each herd would spend in each feeding system, pasture days, swath grazing days and bale grazing days were deemed stochastic variables. While pasture days remain the same for March and June calving systems, the days change with each iteration of the model. Confined feeding days were calculated by subtracting the sum of the other feeding systems from 365. The days in the confined feeding system serve a ‘need only’ role in that the other less expensive feeding systems are utilized first.

In the case of pasture and swath grazing days, correlation coefficients were entered into a correlation matrix. This took moisture and weather conditions into account and held these factors consistent from the time the cattle were swath grazing to the time they were on pasture or vice versa. For example, if the number of pasture days is high, it was assumed that the number of swath grazing days would also be high. Conversely, if the number of pasture days was low, so was the number of days swath grazing. This comparison among days was an attempt to compare pasture yields to swath grazing yields so that if conditions were suitable for high pasture yields and therefore high grazing days, then the conditions were also suitable for high swath grazing yield and days. What this did not take into account was any short term changes in environmental conditions that could influence the difference between pasture and swath grazing days, but rather simulated a more consistent productivity level between the two.

5.8 Chapter Summary

This chapter described the methodology of using partial budgeting and stochastic budgeting in simulation modelling. This chapter also went into detail about the variables required for the model. Data from the Iwaasa et al. (2009) study and data from industry sources were explained and calculated. Based on the raw data from the study, several inferences can be made. Overall costs for June calving in Brandon and Lanigan were higher than for the March calving system but lower in Swift Current. Calving in June was found to decrease the number of days in confined feeding across all three locations, however the days often shifted into the other high cost feeding system, bale grazing, rather than into pasture or swath grazing. The next chapter will discuss the results of inputting this variable information into the simulation model.

Chapter 6: Results

6.1 Introduction

This chapter describes the results from the stochastic simulation model developed in Chapter 5. This model used Monte Carlo simulation techniques to run 10,000 iterations of revenue, cost and net returns for the model farms. This iteration number was chosen over a lower number of iterations, because a lower number of iterations did not bring the site results to a satisfactory convergence level. Both statistical analysis and stochastic efficiency analysis from Chapter 4 were used to analyze the results. Statistical analysis provided an explanation of the distributions of net income under each calving system while the stochastic efficiency analysis evaluated the calving time preferences of a cow-calf producer.

For all three sites and both calving times, negative net returns dominated over positive net returns indicating that neither March calving or June calving could consistently turn a profit. Overall, June calving had slightly higher (less negative) net returns in Brandon and Lanigan, whereas in Swift Current, June calving also had higher net returns except not consistently through the distribution of results.

Recall that the stochastic variables in Brandon, Lanigan and Swift Current included steer and heifer weaning rate, steer and heifer prices, cull cow price and days in each feeding system. Net revenue was calculated using these stochastic variables along with non-stochastic feeding system costs discussed in Chapter 5. Following the results of Janzen’s (2007), this chapter presents the individual results from each site comparing March and June calving times.

6.2 Model Budget

The budget used to calculate the costs for each calving period incorporated all of the costs described in Chapter 5. An example of these costs is found in Table 11 and an example of the model is found in Appendix E.

Table 11. Cost per Cow per Day Budget for Swift Current, SK

	March Calving	June Calving
Pasture	1.16	1.22
Swath Grazing	3.11	1.32
Bale Grazing	1.64	1.73
Drylot	2.62	1.80
Mineral	0.03	0.03
Salt	0.01	0.01
Cow - Vaccination	0.03	0.03
Cow - Treatment	0.02	0.03
Repl. Heifer -Vaccination	0.00	0.00
Calf - Vaccination	0.02	0.02
Calf - Treatment	0.00	0.00
Breeding	0.10	0.10
Taxes/Water	0.03	0.03
Freight/Trucking	0.02	0.02
Marketing	0.05	0.04

6.3 Brandon Results

The Brandon results are organized into two parts. First is a discussion of the simulation results from each calving time and second is a discussion of the key output results.

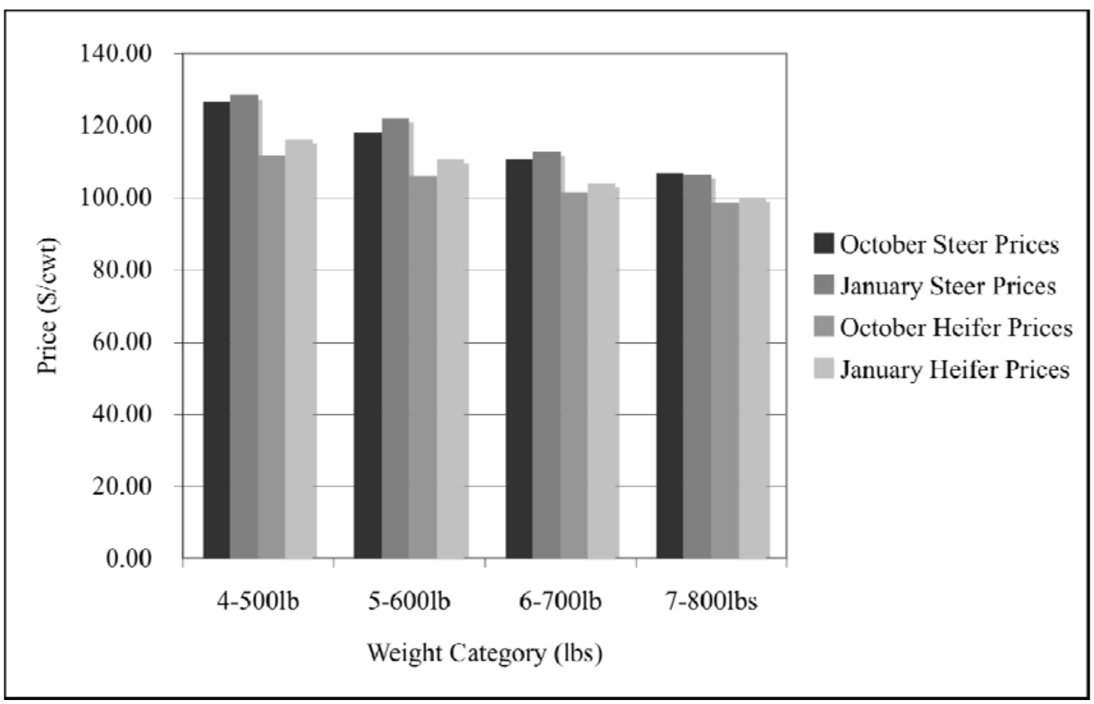
6.3.1 Simulation Results of Stochastic Variables

The stochastic variables in Brandon included steer and heifer weaning rate, steer and heifer prices, cull cow price and days in each feeding system. The means of the simulated weaning weights and prices were found to have less than a 1% difference compared to the historical data. This indicates that the simulated values were valid and appropriate for the model. The summary statistics for all these variables are found in Appendix B and the following section describes the comparison of results between the two calving systems.

The first difference was in the weaning weights of the calves. The stochastic means for March-born steers and heifers were greater than their June counterparts by 25.4 and 11.8 kilograms, respectively. This indicates that March calving could produce heavier calves or more yield than June calving. This could translate into more revenue in March over June calving, depending on the market price. The weights for March were also less variable than those for June, as indicated by the lower variance for March calving. Cow-calf producers who are aiming for a consistent calf crop may continue to calve in March to reduce the variability in weaning weights.

As mentioned previously, the calves born in March were sold in October and the calves born in June were sold in January. When the prices were simulated in the model, the results indicate that January steer and heifer prices were higher than October steer and heifer prices. This means that the calves from the June calving system sold at higher prices than those born in the March calving system. Figure 8 compares the two selling times for steers and heifers. October prices have a lower variance, therefore, less movement from the mean, than January prices. This means that even though the June calving system has the potential for greater prices, there is more volatility or risk than selling in October.

Figure 8. Simulation Results for October and January Steer and Heifer Prices in Manitoba



The last output variable was the number of days in each feeding system. Recall that in the model, pasture and swath grazing days remained the same between the two calving groups; therefore, the bale grazing and confined feeding system days were the only ones to change. Since confined feeding days were calculated by subtracting the total days in the other three systems from 365, it is a stochastic variable, not an output variable and no statistics were calculated. After the simulation was completed, the mean number of days in confined feeding was 120 days for March calving and 30 days for June calving. This suggests that the cows in a June calving system spent less time in confined feeding than those in the March calving system. While the simulated results showed that June calving can reduce the number of days in a confined feeding system, the days are simply a shifted to the bale grazing system, rather than into one of the lower cost feeding systems (pasture or swath grazing).

6.3.2 Results of Key Output Variables for Brandon

The key output variables were the net revenues for each calving time. When net revenue was calculated for each of the systems in Brandon, the June calving system had higher mean net revenue as compared to the March calving system, however both mean net revenues were negative. It was not surprising to see negative returns for both systems, as historical prices included depressed prices during the BSE crisis. Changing the calving time did not change the negative returns, but it did reduce the amount lost. The June calving system had higher variances indicating a greater level of risk involved with this system. The following describes these results in further detail.

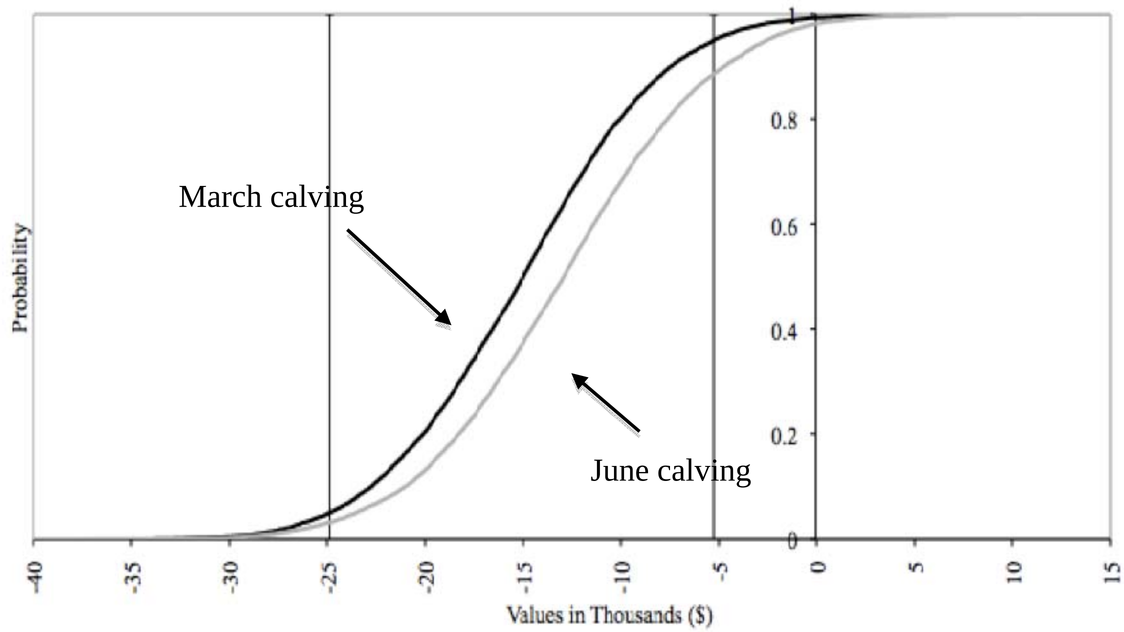
Table 12 shows the total cost and net revenue for both March and June calving. The mean total cost for March calving was $56,632.93 or $858.07 per cow. This was higher than the MAFRI (2008a) cost of production calculation of $801.02 per cow. One factor contributing to this difference may be the fact that feed sources used in the government publication include hay and grain, as opposed to the silage and hay used at the Brandon site. Another possible reason is that the government costs are based on industry and producer averages, which can disguise the highs and lows of actual production costs. For the March calving system, mean net revenue was –$15,053.81 or –$0.20 per kg of beef produced. This means that for each kilogram of calf produced, a loss of $0.20 was incurred. For the June calving system, the mean total cost for this calving time was $53,582.82 or $811.86 per cow. June calving saved $3,050.11 in total costs or $46.21 per cow. Mean net revenue per kg of beef produced was higher than March calving by $0.01 or –$0.18 per kg produced.

Table 12. Total Cost, Total Revenue and Net Revenues for March and June calving in Brandon ($)

	March Calving		
	Total Costs	Total Revenue	Net Revenue
Mean	56,632.93	41,579.11	(15,053.81)
Std Deviation	3,068.08	5,141.35	5,961.78
Variance	9413089	26433460	35542800
Skewness	0.3498076	0.08759657	0.02314103
Kurtosis	2.389151	3.080173	2.970011
	June Calving		
	Total Costs	Total Revenue	Net Revenue
Mean	53,582.82	40,615.38	(12,967.44)
Std Deviation	2,849.50	5,622.96	6,317.05
Variance	8119673	31617660	39905150
Skewness	0.4155028	0.01097468	-0.02226357
Kurtosis	2.366079	3.003785	2.946254

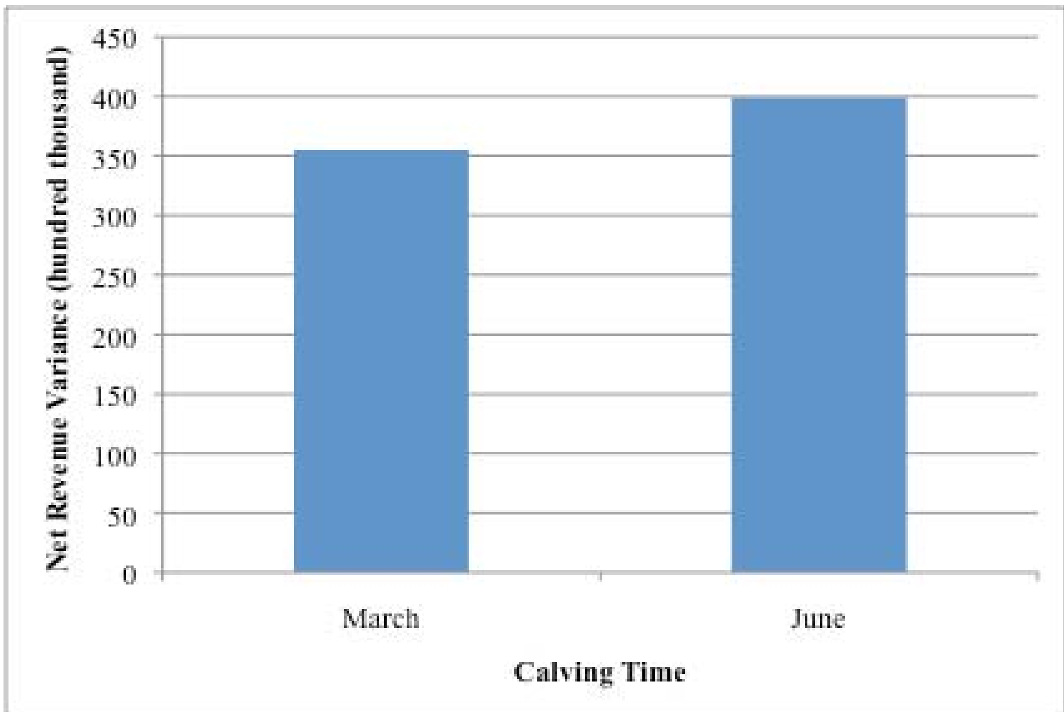
These results show a difference in total cost and net revenue between the March and June calving systems in Brandon. The CDF curve (Figure 9) shows the probability of net returns on the Y-axis and the net return on the X-axis. From the theory presented in Chapter 4, June calving displayed second-degree stochastic domination over March calving since it was below and to the right of the alternate. This curve showed that June calving consistently generated more net revenue than March calving. For example, there was an 80 percent probability that June calving would result in net revenue of –$7,598.80 or higher. For March calving that level is net revenue of –$10,032.18, equaling a difference of $2,433.88. A student t-test revealed that was a significant difference in the means at the 95% level.

Figure 9. Cumulative Distribution Function (CDF) for Brandon



An increase in net revenue is not the only factor to consider when comparing the two systems. The variance of each system can be taken as a measure of the risk involved (Figure 10). June calving had a higher variance than March calving, so while June calving may be the system with greater profit potential, it is also the system with greater risk potential. The risk in the June calving system derived mainly from total revenue. As previously mentioned, calf prices for June-born calves were higher but more volatile than March-born calves. This revenue risk caused the June calving system to hold more risk than the March calving system. On the other hand, cost risk, or the variance derived from total cost, created more risk in the March calving system. This dynamic caused a trade-off between revenue risk and cost risk between the two calving times. The reduced cost risk (Figure 10), does not make up for the higher revenue risk in the March system, so the March system was the less risky alternative of the two. An F -test revealed that there was a significant difference in variances at the 95% level.

Figure 10. Variance of Net Revenue for March and June Calving Times in Brandon



6.4 Lanigan and Swift Current Results

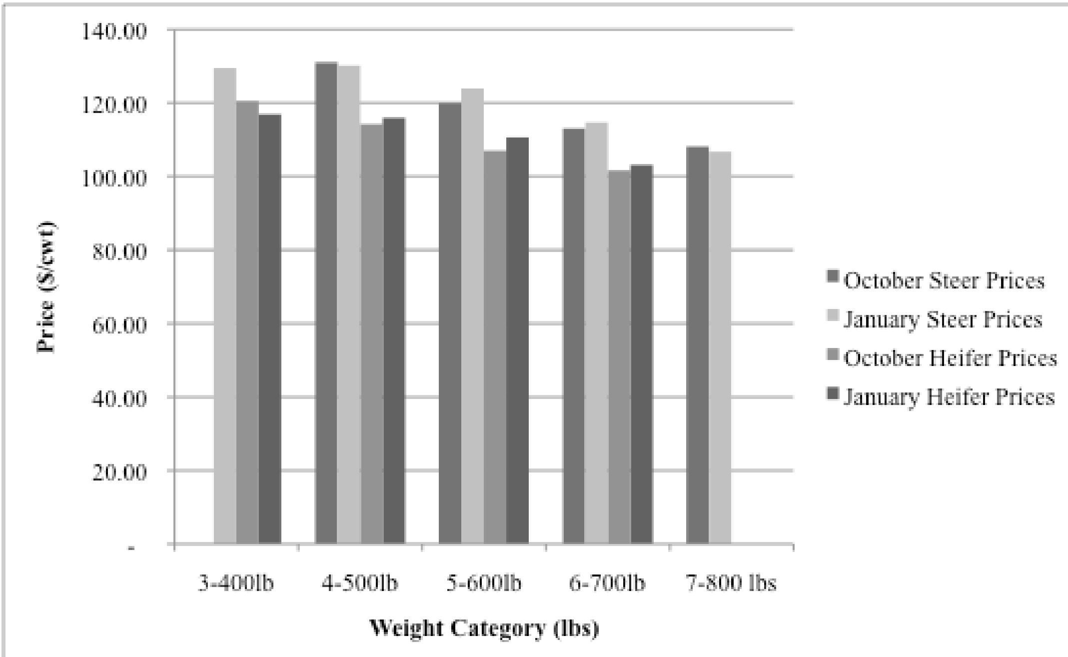
The results for Lanigan and Swift Current are presented in this section. These two sites were modeled separately but shared the steer and heifer price variable. Therefore the price results will be presented first followed by each site's results.

6.4.1 Simulation Results of Steer and Heifer Prices

The simulation results for steer and heifer prices for both Lanigan and Swift Current are found in Appendix C. These prices were used to calculate revenue generated from each calving time at each location. Mirroring the Brandon location, October prices were used for March born calves and January prices were used for June born calves. The simulated prices play a large part in the model; therefore they must be valid in order for the results to also be valid. The means of the simulated weaning weights and prices were compared to the historical data and were all found to have a less than 1% difference. This indicates that the simulated values were indeed valid and appropriate for the model.

The comparison of prices simulated in Saskatchewan was similar to that in Manitoba (Figure 11). January steer prices were higher than October prices in the 226.8-272.2 kg (500-600 lb) and 317.5-362.9 kg (700-800 lb) weight categories, but in the 181.4-226.8 kg (400-500 lb) and 317.5-362.9 kg (700-800 lb) categories, October prices were slightly higher. This suggests there was no price advantage to selling steers in the January market over the October market. However, for heifers, January prices were higher in all weight categories except for the 136.1-181.4 kg (300-400 lb) weight range, suggesting a price premium for heavier heifer calves in the January market.

Figure 11. Simulation Results for Saskatchewan October and January Steer and Heifer Prices



6.4.2 Simulation Results of Stochastic Variables for Lanigan, SK

Focusing now on the Lanigan, SK site, the stochastic variables used in the Lanigan model included steer and heifer weaning weight, days in each feeding system and cull cow price. The summary statistics results for these variables can be found in Appendix D. Overall, March calving systems produced a heavier calf, regardless of sex over June calving and the variance for weight was lower in March. This indicates that June weaning weights were more variable than those for March. Producers wanting to sell a more consistent calf crop might consider calving in March to reduce the variability of weaning weights.

Another output variable was the number of days in each feeding system. In line with the results for the Brandon site, the number of days in a confined feeding system decreased from 90 days for the March calving group to 36 days for the June calving group. This reduction of days in the higher-cost feeding system could result in significant cost savings to producers.

The means of the simulated weaning weights and prices were compared to the historical data and were all found to have a less than 1% difference. This indicates that the simulated values were indeed valid and appropriate for the model.

6.4.3 Results of Key Output Variables for Lanigan

The key output variables were the net revenues for each calving time. When net revenue was calculated for each of the systems in Lanigan, the June calving system had higher mean net revenue as compared to the March calving system; however, both mean net revenues were negative. It was not surprising to see negative returns for both systems, as historical prices included depressed prices during the BSE crisis. Changing the calving time did not change the negative returns, but it did reduce the amount lost. The June calving system had higher variances, indicating a greater level of risk involved with this system. The following describes these results in further detail.

Table 13 displays the total costs and total revenues for March and June calving in Lanigan. The mean total cost for this calving system was $33,589.63 or $671.79 per cow. Mean net revenue was –$4,692.43 or –$0.05 per kg of beef produced. This means that for each kilogram of calf produced, a loss of $0.05 was incurred.

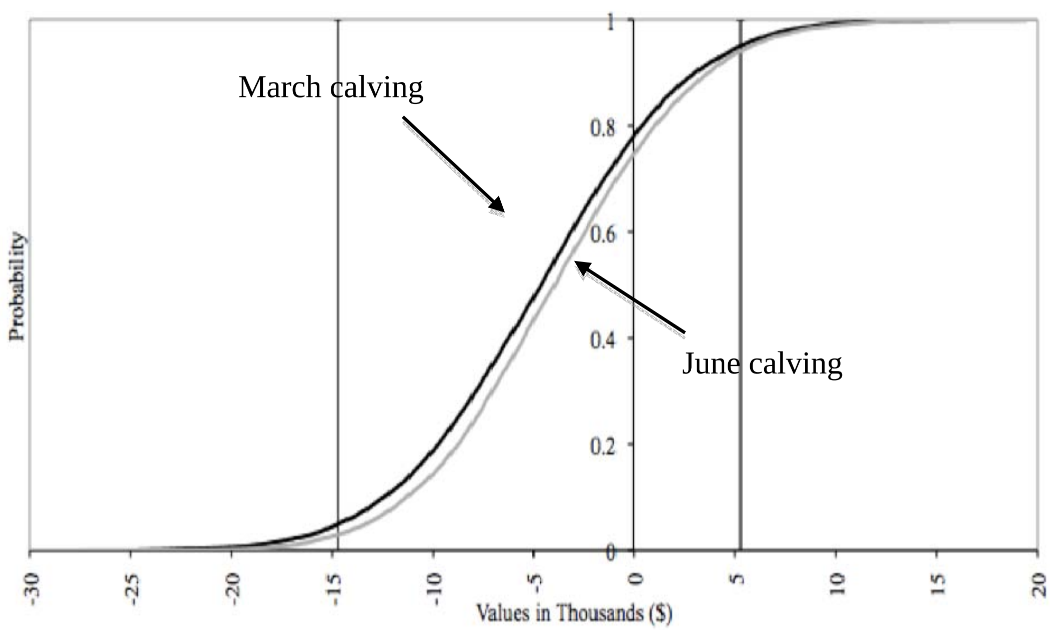
Table 13. Total Cost, Total Revenues Net Revenues for March and June calving in Lanigan ($)

	March Calving		
	Total Costs	Total Revenue	Net Revenue
Mean	33,589.63	28,897.21	(4,692.43)
Std Deviation	2,916.56	5,314.11	6,046.85
Variance	8506331	28239760	36564440
Skewness	-0.0726926	-0.02100935	-0.02570124
Kurtosis	2.380559	3.110034	3.05854
	June Calving		
	Total Costs	Total Revenue	Net Revenue
Mean	32,758.20	28,873.84	(3,884.37)
Std Deviation	2,165.34	5,412.76	5,826.96
Variance	4688689	29297980	33953430
Skewness	-0.00544637	0.0889549	0.07875087
Kurtosis	2.278354	3.059554	2.997975

The mean total cost for June calving, also found in Table 13, was $32,758.20 or $655.16 per cow. A switch to June calving saved $831.43 in total costs or $16.63 per cow. The total revenue from calf and cull cow sales generated an average of $28,897.21 for March calving and $28,873.84 for June calving. Therefore, it was the costs of each system that had the larger impact on net revenue. Looking at mean net revenue per kilogram of beef produced, the June calving system was greater by $0.01 over the March calving system, for a loss of $0.08. Overall, negative returns prevailed in both systems, but the net revenue gap between March and June calving was narrower in Lanigan as compared to Brandon. When graphed on a CDF curve (Figure 12), June calving is clearly displayed second-degree stochastic dominance over March calving since it was below and to the right of the alternate.

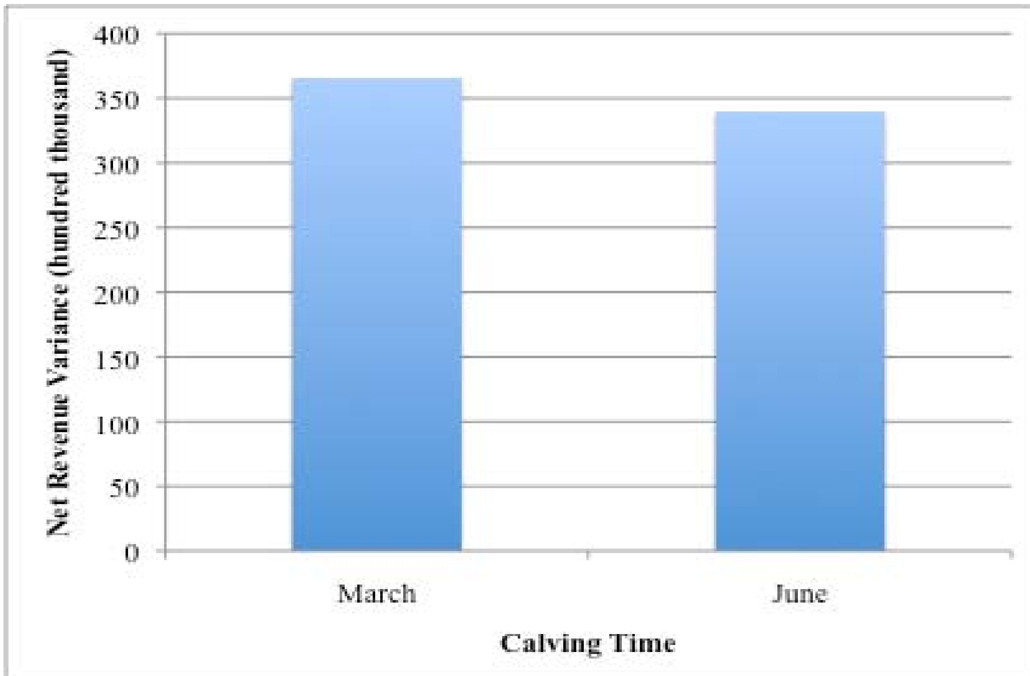
When graphed on a CDF curve, June calving is the dominating alternative by a small margin (Figure 12). From the theory, June calving is displaying second-degree stochastic domination over March calving since it is below and to the right of the alternate. This curve shows that June calving generates more net revenue than March calving. A student t-test revealed that was a significant difference in the means at the 95% level.

Figure 12. Cumulative Distribution Function (CDF) for Lanigan



An increase in net revenue is not the only factor to consider when comparing the two systems. The variance of the two systems must also be compared as a measure of the risk involved (Figure 13). March calving has a slightly higher variance than June calving, making June not only the system with greater profit potential but also the system with lower risk potential. June calving had lower risk because of the higher risk derived from total costs or cost risk in the March calving system. This suggests that the cost risk was higher in March. Revenue risk was greater for June calving, but only slightly. The lowered cost risk was not of sufficient magnitude to compensate for the higher revenue risk, therefore the variance of net returns was higher for June calving as compared to March calving (Figure 13). Environment and weather factors may have had a predominant influence on the costs for the feeding systems in Lanigan, therefore leading to a small difference in net revenue between March and June calving and likewise a small difference in the variance. A student t-test revealed that there was a significant difference in variances at the 95% level.

Figure 13. Variance of Net Revenue for March and June Calving Times in Lanigan



6.4.4 Simulation Results of Stochastic Variables for Swift Current, SK

The results for Swift Current indicate a further advantage of June calving over March calving. The summary statistics for weaning weights and days in each feeding system are found in Appendix E. Similar to both Brandon and Lanigan, March calves were weaned at heavier weights compared to those born in June; variance of June-born calves was much smaller, indicating there was less risk around the weaning weights in March. The means of the simulated weaning weights and prices were compared to the historical data and were all found to have a less than 1% difference. This indicated that the simulated values were indeed valid and appropriate for the model.

The same simulation to determine the number of days in each feeding system in Brandon and Lanigan was also carried out for Swift Current. After the simulation was completed, the mean number of days in confined feeding was 111 days for March calving and 24 days for June calving. This suggested that the cows in a June calving system spent less time in confined feeding than if they were to calve in March.

6.4.5 Results of Key Output Variables for Swift Current

The key output variables are the net revenues for each calving time. When net revenue was calculated for each of the systems in Swift Current, the June calving system had higher mean net revenue as compared with the March calving system, however, both mean net revenues were negative. As explained for both Brandon and Lanigan, it was not surprising to see negative returns for both systems. Changing the calving time did not change the negative returns, but it did reduce the amount lost. The variance of the returns for the June calving system were greater, indicating a greater level of risk involved with this system. The following describes these results in further detail.

Net revenue was calculated by subtracting total costs from total revenue. Table 14 displays the total costs, total revenues and net revenues for March and June calving in Swift Current. The mean total costs for March calving was $24,453.43 or $815.11 per cow. Mean net revenue was a loss of $6,048.17 or a loss of $0.18 per kg of beef produced. This means that for each kilogram of calf produced, a loss of $0.18 was incurred. Table 14 also shows the total costs and net revenues for June calving. The mean total costs for this calving time was $21,946.66 or $731.56 per cow. June calving saved $2,506.77 in total costs or $83.56 per cow. Similar to the results from Brandon and Lanigan, mean net revenue per kg of beef produced was higher for June than March calving by $0.02, making it the system that lost the least.

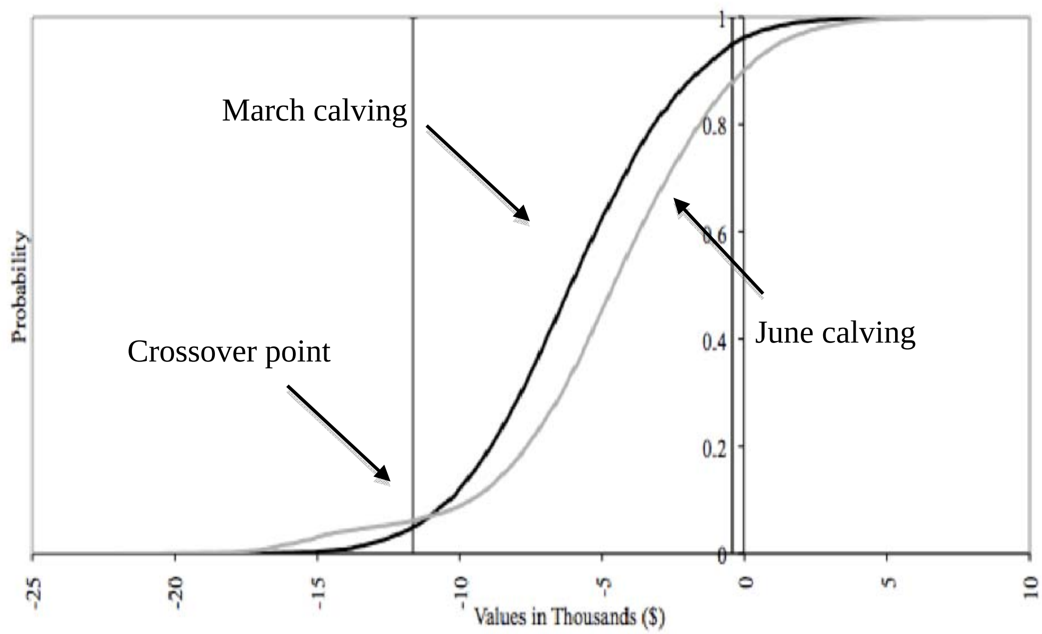
Table 14. Total Costs, Total Revenues and Net Revenues for March and June calving in Swift Current ($)

	March Calving		
	Total Costs	Total Revenue	Net Revenue
Mean	24,453.43	18,405.26	(6,048.17)
Std Deviation	1,161.33	3,196.67	3,410.51
Variance	1348693	10218710	11631600
Skewness	0.09979282	0.04215979	0.03613302
Kurtosis	2.494347	2.956516	2.965954
	June Calving		
	Total Costs	Total Revenue	Net Revenue
Mean	21,946.66	17,090.94	(4,855.71)
Std Deviation	539.26	4,056.61	4,084.68
Variance	290805.8	16456050	16684630
Skewness	0.1558832	-0.6485567	-0.6353233
Kurtosis	2.392689	4.022411	4.005674

The net revenue gap between March and June calving was larger in Swift Current as compared to that of Brandon and Lanigan (Figure 14). A student t-test revealed that was a significant difference in the means at the 95% level. There was a point on the curve where March calving was more profitable than June calving at periods of very low returns. Similar prices in the January and October markets combined with lower weaning weights for June calves created a income region where

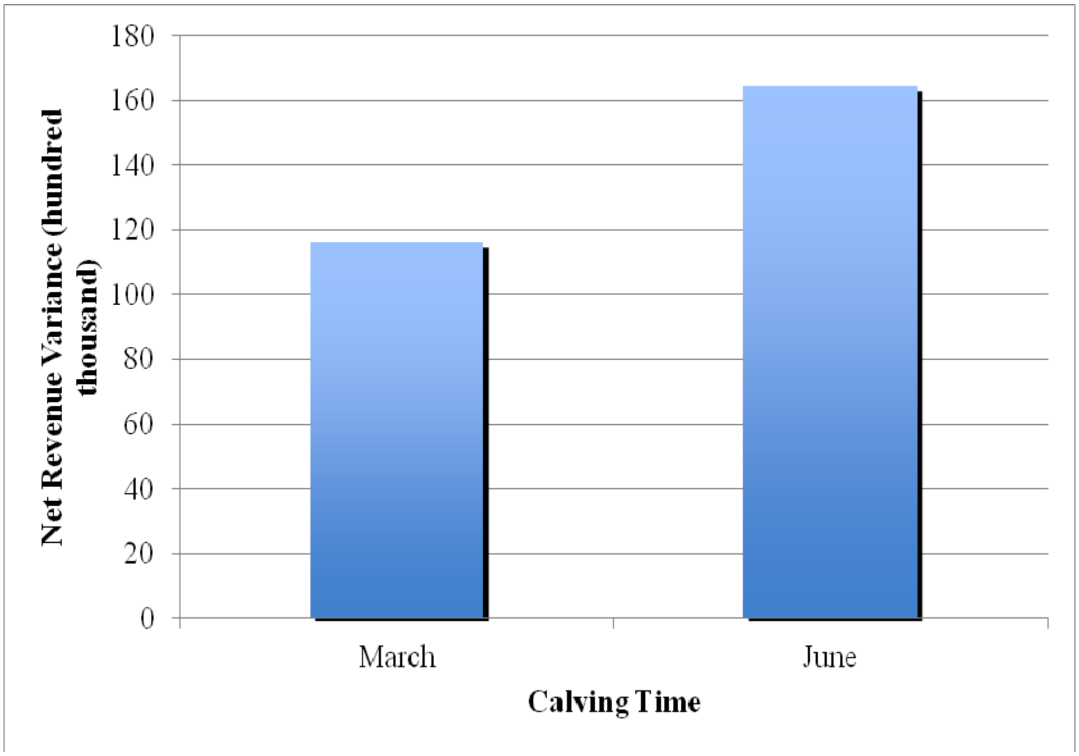
March calving becomes more profitable. As the model revenues increased, June calving became the dominant calving time.

Figure 14. Cumulative Distribution Function (CDF) for Swift Current



The simulated results indicate that June calving had higher average net returns than March calving and like Brandon; the variance in June calving was higher than the March system. Figure 15 displays the variances of the two systems. Referring back to Table 14, it can be seen that while cost risk was lower for June calving than March calving, revenue risk was much higher. This results in an overall variance for net revenue variance that was higher for June calving. An F-test revealed that there was a significant difference in variances at the 95% level.

Figure 15. Variance of Net Revenue for March and June Calving Times in Swift Current



6.5 Stochastic Dominance Results

Combining the above results for individual locations, some trends can be seen. Table 15 summarizes the key output variable results from each location and the difference in mean net revenue is shown in Figure 16. In general, June calving showed greater returns than March calving. Lanigan showed the lowest difference between the two systems, while Brandon showed the greatest difference. Because each site used different feeding protocols, and separate markets were used in Saskatchewan versus Manitoba, it is difficult to draw any firm comparisons between the sites.

Table 15. Mean Net Revenues and Variances per Location

	March Calving			June Calving		
	Brandon, MB	Lanigan, SK	Swift Current, SK	Brandon, MB	Lanigan, SK	Swift Current, SK
Mean Net Return ($)	(15,053.81)	(4,692.43)	(6,048.17)	(12,967.44)	(3,884.37)	(4,855.71)
Variance	35542800	36564440	11631600	39905150	33953430	16684630

Figure 16. Mean Net Revenue Differences per Location

Turning now to the variance of the systems, all three sites had greater total cost, or production variance, with March calving and greater total revenue or revenue risk with June calving. Table 16 shows each site with a description of the variance around cost, market and total risk. In other words, the cost risk in Lanigan is higher for March calving, but revenue risk is higher for June calving. Thus, total risk is higher for March calving in Lanigan than for June calving.

Table 16. Description and Rank of Risk per Location

	Brandon, MB		Lanigan, SK		Swift Current, SK	
	March	June	March	June	March	June
Cost Risk	Higher	Lower	Higher	Lower	Higher	Lower
Revenue Risk	Lower	Higher	Lower	Higher	Lower	Higher
Total Risk	Lower	Higher	Higher	Lower	Lower	Higher

Several conclusions can be drawn from these results. First, while each site was inherently different, it can be concluded that June calving was more profitable than March calving at all three sites, with the exception of extremely low revenues (and probabilities) in Swift Current. This conclusion can be drawn based on the summary statistics and the CDF curves presented above. In Brandon and Lanigan the return per kg of beef produced was $0.01 higher for June calving than March calving and in Swift Current the difference was $0.02 higher for June calving. June calving reduced total costs at all three sites, but by varying degrees. Another conclusion can be made about the variances of total cost and total revenue at each site. For each location, total cost variance, or cost risk, was higher for March calving than for June calving. The opposite was true for revenue risk. There was greater market variance, or risk, in the June calving system than in the March calving system. The total risk for each calving system was site dependent.

6.6 Stochastic Efficiency Results

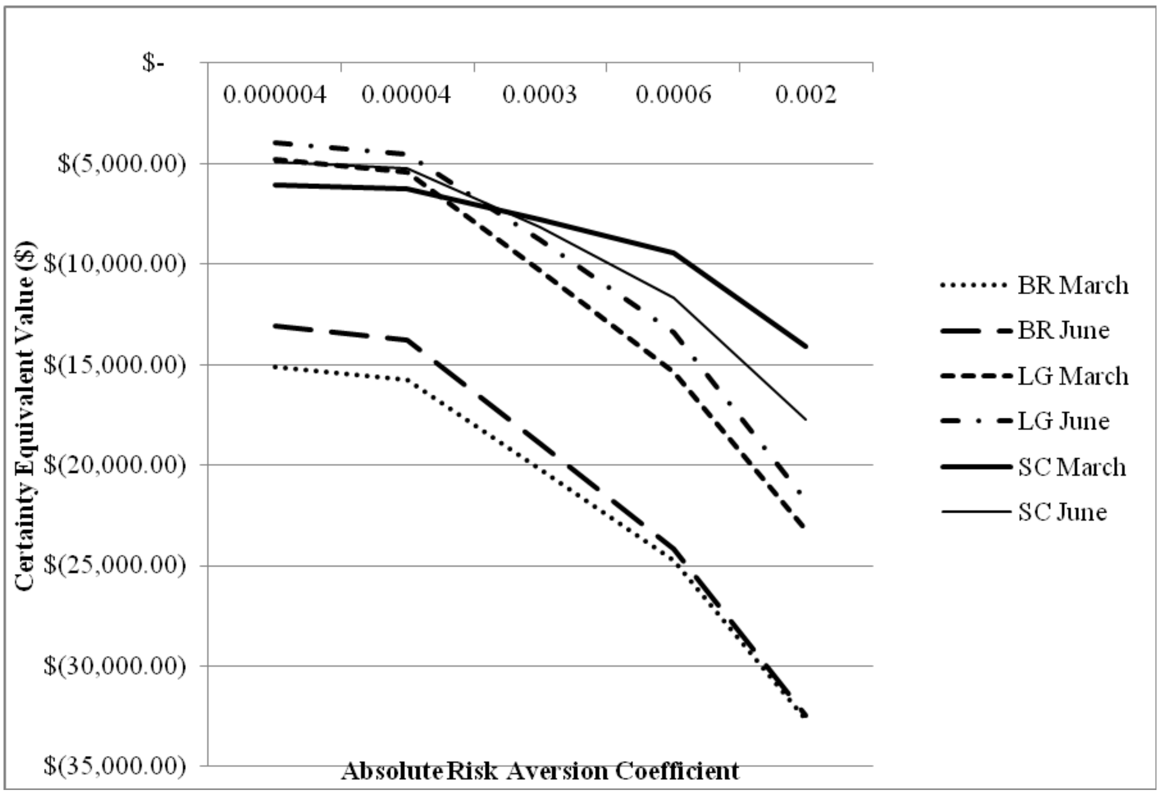
In order to rank the alternatives under stochastic efficiency theory, the CE must be calculated. As discussed in Chapter 4, the inverse of the CARA utility function was assumed in model and absolute risk aversion coefficients within the range of 0.000004 (less risk averse) to 0.34 (more risk averse) were used. At the 0.34 risk aversion level the model was not able to calculate a corresponding CE, therefore 0.002 was the upper limit. Table 17 shows the results of the SERF calculation.

Table 17. Stochastic Efficiency with Respect to a Function (SERF) Results

Level of Risk Aversion	BR March	BR June	LG March	LG June	SC March	SC June
0.000004	$ (15,124.88)	$ (13,047.26)	$ (4,765.56)	$ (3,952.22)	$ (6,071.43)	$ (4,889.20)
0.00004	$ (15,763.17)	$ (13,766.73)	$ (5,425.37)	$ (4,559.22)	$ (6,280.39)	$ (5,201.66)
0.0003	$ (20,227.68)	$ (18,926.35)	$ (10,317.34)	$ (8,776.41)	$ (7,767.86)	$ (8,163.96)
0.0006	$ (24,716.16)	$ (24,178.86)	$ (15,394.04)	$ (13,362.22)	$ (9,412.69)	$ (11,688.95)
0.002	$ (32,669.28)	$ (32,462.87)	$ (23,185.16)	$ (21,717.63)	$ (14,106.81)	$ (17,717.51)

For Brandon and Lanigan, June dominates March calving for all levels of risk aversion, as the SERF results are more for the June calving season then for the March calving season (Table 17). This corresponds with the results from the CDF curves using the stochastic dominance method for Brandon and Lanigan. Therefore, at these sites, at all levels of risk aversion, a producer should rationally choose June calving over March calving. In Swift Current, the CDF curve showed that March calving might dominate June calving at low levels of revenue. If a producer were extremely risk averse or at high levels of risk aversion, he or she would choose June calving over March calving but at low levels of risk aversion or if a producer were less risk averse, he or she would choose March calving. Reasons for this may be because of similarities of the feeding system costs between the two calving seasons and the increased revenue risk from June calving. Figure 17 shows the graphical version of Table 17.

Figure 17. Stochastic Efficiency with Respect to a Function Chart



From this chart, it can be said that June calving is preferred over March calving in Brandon and Lanigan, as the CE line for June calving is above the CE line for March calving at all levels of risk aversion. As for Swift Current, March calving is dominated by June calving at risk aversion levels above 0.0003. At lower levels of risk aversion June calving is preferred even in Swift Current.

Chapter 7: Discussion and Conclusions

7.1 Introduction

The objective of this study was to measure the impact that calving has on net revenue and risk in cow-calf production in western Canada. Low calf prices along with high operating costs have focused producers on searching for low-cost production options. Chapter 2 provided background information on the economic uncertainty in the cattle industry as well as advantages of low-cost feeding systems and particularly to later calving systems. Chapter 3 discussed the literature on calving seasons, beef production systems and methods to analyze risk. In Chapter 4 a theoretical framework was presented for the study. Chapter 5 used the theoretical framework to create a stochastic simulation model based on data collected at three site locations. The results in Chapter 6 presented evidence that June calving provides greater average net return over March calving, but it holds greater risk depending on the site. In this concluding section, the results of this study are compared to that of previous studies. The limitations of this study are also discussed and followed by a discussion on the opportunities for further research and then a final summary.

7.2 Conclusions

Cow-calf producers in western Canada are faced with many decisions throughout the production cycle. The choice of calving season impacts many factors including the production rate, marketability of calves, net income and expenses and a producer’s overall bottom line. Little research has been conducted on how time of calving impacts a producer’s net revenue or it impacts risk. Both income and risk were expected to be important to producers. Therefore, the basis of this study was to provide producers and researchers with information on how calving time could impact farm revenues and risks. Two calving times, March and June, were chosen as a proxies for a traditional winter/early spring calving time to versus an alternative summer calving time. Data for this study was taken from research done by Iwaasa et al. (2009), who collected information from three sites; Brandon, MB, Lanigan, SK and Swift Current SK. The purpose of this research was to determine whether June calving could increase net revenues and be a preferred choice across different risk aversion levels over March calving in western Canada.

Costs were collected to represent the feeding systems used in the study and days in each feeding systems were simulated using a triangle distribution. Revenues were simulated using the distribution of the sample weaning weights and historical price data.

A stochastic simulation model was chosen to study the economic impact of calving time. This is a popular method of analysis in agricultural production as it takes into consideration the variability in net returns and allows for risk to be included in the decision model. Alternatives were ranked using a utility based ranking procedure.

The results presented in Chapter 6 compare net revenue of June calving to that of March calving in western Canada and address the first objective set by this study. It was found that June calving increased average net income across all three locations. By keeping the lower cost pasture and swath grazing days the same for both March and June calving, the factor greatly contributing to total cost was the difference in bale grazing days and confined feeding days. If another option were brought into the model that could influence the feeding costs, June calving could further increase net revenue.

The difference in total costs from March to June calving was found to be $46.21 per cow in Brandon, MB, $16.63 per cow in Lanigan SK, and $83.56 per cow in Swift Current, SK for an average of $48.80 per cow. These results can be compared with those discussed in Chapter 2 and 3. Clark et al. (1997) found that June calving reduced winter feeding costs by $45 per cow. May et al. (1999) suggested that June compared to February calving reduced costs by $43 per cow. These results also agree with Stockton and Wilson (2007) as they found that March calving and feeding hay was the least profitable system in their study.

The second objective set by this study was to compare the trade-offs in revenue and cost risks between the March and June calving systems. As presented in Chapter 6, June calving was the dominant alternative across all levels of risk aversion in Brandon, MB and Lanigan SK, and at high levels of risk aversion in Swift Current, SK. Revenue risk was higher at all three sites for June calving, indicating that it was less risky to sell into the October market than into the January market. Cost risk was higher at all three sites for March calving. This differs from the results found by Evans et al. (2007) who suggested that pasture-raised beef face more production risk in the form of inputs and less market risk. This is understandable as the June calving system in this study was not a complete pasture-raised beef system so the potential cost effects would be different than those studied by Evans at al. (2007).

With these results, it can be said that cost savings can be realized by moving from a March to a June calving system, however several considerations should be measured prior to a farmer making his or her final decision. The first consideration is that of weather. Weather will determine how many low-cost grazing days or how much high-quality feed will be available so that feed supplementation on pasture or in a drylot can be managed. Weather will also determine the number of days that cattle require shelter from the elements and this can be a factor in herd health, weaning weights, cattle condition, and death loss. The second key consideration is a comprehensive understanding of each producer's own costs, all of the expenses incurred in raising his or her herd. This includes labour costs and constraints. Calving in June may increase the amount of labour hours required to check cows on pasture and may conflict with other operations on a mixed farm. This is a real cost that needs to be included at fair market wages and it is often overlooked or ignored by producers. The third key consideration is the amount of risk a producer is willing to take on. Each producer will have his or her own level of risk aversion, which will determine their willingness to expose themselves to higher amounts of risk for the potential of higher rewards. The June calving system was found to have higher revenue risk at all three locations and a higher total risk in Brandon, MB and Swift Current, SK. While a producer may save on total costs by calving in June, he or she may be exposed to more market risk and total risk in the system. Individual and specific costs and revenues, levels of risk aversion and impacts of local weather, all need to be carefully considered before a producer decides which calving season best fits their preferences regarding profit and risk.

7.3 Limitations of the Study

The limitations of this study begin first with the assumptions in the model. In order to capture all of the necessary income and expenses incurred in a cow-calf production system, several assumptions were made. Referring specifically to those described in Chapter 5, the assumed costs including that for land rent, labour, marketing, utilities, building repair, fencing and manure removal may not be an accurate representation of the true costs for these items. Further assumptions were made regarding the equipment and vehicles used at each research site. While the costs used in the model were the documented costs to operate, maintain and fuel the machinery used by the research sites, they may not be a true depiction of the machinery used on a typical cow-calf operation. Without undertaking a survey to determine the average make, model, year and use of the machinery used by cattle producers, the values used were deemed acceptable. The same logic can be applied to all the assumptions made regarding the costs. Costs of production vary from one producer to the next and there may be wide range from the most profitable to the least profitable producer. This makes choosing the appropriate values for these variables difficult. As well, some of the measured costs such as feed costs had assumptions within them. Some feeding protocols differed site to site and in Brandon, differed from each calving time. Without a standard feeding protocol, it was difficult to remove site effects from model.

A further limitation exists in the sites and the cattle herds within these sites. It is difficult to say whether a government funded research facility would make the same decisions and have the same constraints as those faced by a cow-calf producer.

It is also difficult to see how the costs for herd of 50 cows would translate to a herd of 150 cows. There may have been efficiencies missed by having a larger herd to which the model does not address. However, by choosing to collect data at research sites, there existed a consistent level of support to collect the required data. It would be difficult to collect and measure all the data points required for this study in a true cow-calf production setting.

In determining the feed costs and weaning weights in the model a limiting factor lies in the low number of years over which the data was collected. Two years of data is deemed a low sample number for statistical analysis, but since the production cycle lasts an entire year, two years is a considerable amount of time for such a large study. Regardless, the two years of data meant that environmental factors played a large role in determining the feed costs and gain of the calves over the two years.

A limitation in the revenue portion of the model is the prices used to calculate net revenue. This study used only prices recorded from auction marts in Manitoba and Saskatchewan. Choosing auction marts was done as it continues to be a popular method of selling calves and cull cows, and a large database of historical prices was available. There exist other methods to market calves and cull cows including internet sales, direct or private sales and herd dispersals that are not considered in the price data of this study.

Further to the sale of calves, the assumption was made that all calves (minus replacement heifers) would be sold at time of weaning. The option to retain calves for further feeding and growth is not allowed in this model. This would be a more likely option to consider in the June calving situation to add value to the calf, however since the March born calves were sold at weaning time, it only seemed appropriate to hold the June born calves to the same condition.

Each producer and each operation is unique. The level of capital, access to capital, herd size, limitations and opportunities are likewise unique to each producer and to each operation. Considering this, the key limitations are simply limits in describing the range in many important variables.

7.4 Opportunities for Further Research

Given the limitations discussed above, there exists many opportunities for further research. Reducing the number of assumptions through detailed surveys or further cost of production analysis will more accurately represent the average cow-calf producer. Furthermore, finding appropriate multipliers or scales of efficiencies to use this study to represent a larger cow herd would increase the usefulness of the data. Another opportunity lies in including other forms of income into the model, including other farm enterprises such as grain, government assistance, off-farm income or calf retention to better depict a realistic operation.

7.5 Final Summary

The impact of calving time is evident but not easily explained. Cow-calf modeling is complex. Building better models to represent the complex interactions and relationships in cow-calf operations should increase understanding and improve examination of production changes in relation to profitability. While this study addressed some of the fundamental elements involved in the choice between calving times, future work should examine the complex relationships between income and risk in cow-calf production.

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Appendix A: Days in Each Feeding System

Figure A.1 Days in Each Feeding System for Lanigan, 2007-2009

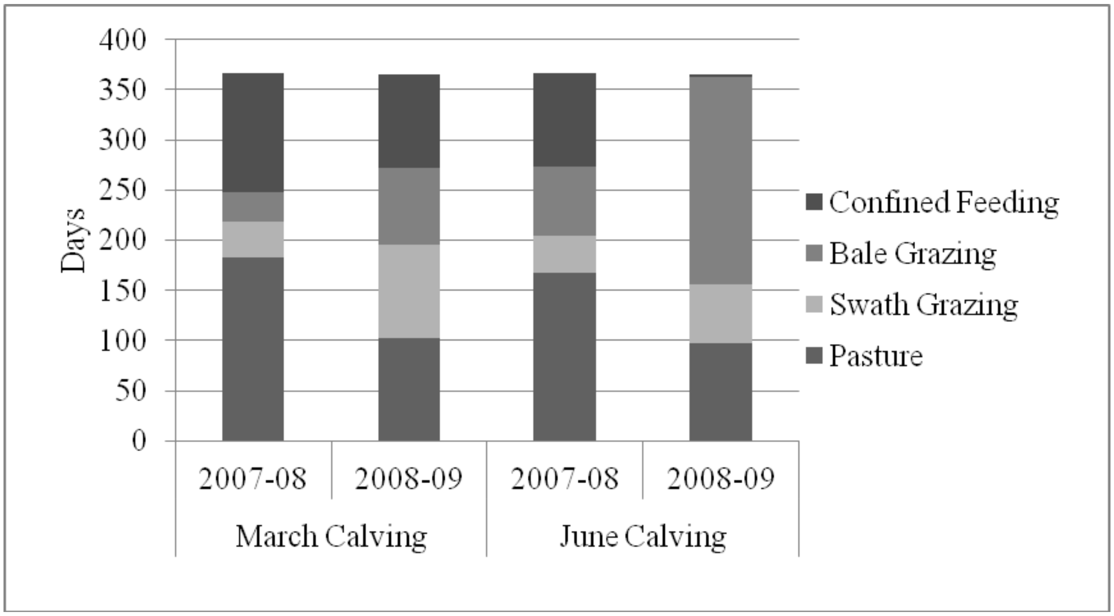
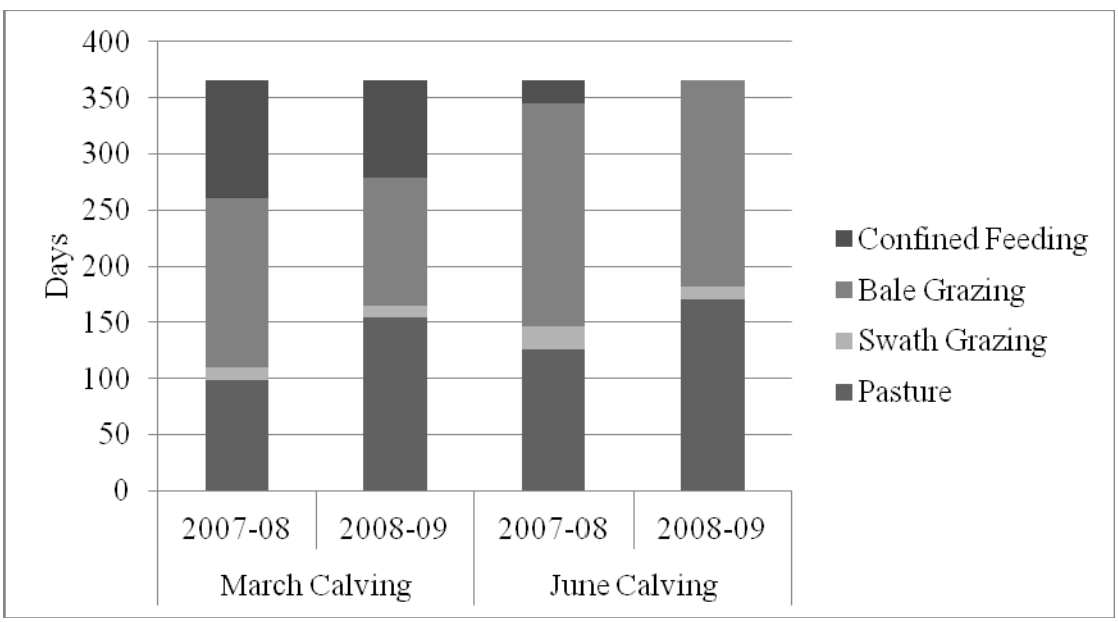


Figure A.2 Days in Each Feeding System for Swift Current, 2007-2009



Appendix B: Summary Statistics for Brandon, MB

Table B.1 Summary Statistics for Calf Weaning Weights

	Steer Weaning weight (lbs)		Heifer Weaning weight (lbs)	
	March	June	March	June
Minimum	359	292	395	293
Maximum	905	898	813	819
Mean	635	579	585	559
Std Deviation	68	77	56	67
Variance	4685.071	5992.157	3145.564	4494.522
Skewness	-0.03428782	0.02443073	0.03739329	-0.01603444
Kurtosis	3.030643	3.017713	2.9487	2.937954

Table B.2 Summary Statistics for October Steer Prices ($/cwt)

	4-500lb	5-600lb	6-700lb	7-800lbs	8-900lb
Minimum	51.74	48.24	38.65	53.60	45.57
Maximum	208.39	185.68	176.14	170.38	173.84
Mean	126.65	118.10	110.76	107.04	103.63
Std Deviation	21.75	18.48	17.42	16.50	15.06
Variance	473.2377	341.5306	303.3496	272.3484	226.9105
Skewness	0.0111834	0.00063619	-0.0033035	-0.0073648	0.00796945
Kurtosis	2.962989	2.976821	2.955169	2.975952	3.057237

Table B.2 Summary Statistics for October Heifer Prices ($/cwt)

	3-400lb	4-500lb	5-600lb	6-700lb	7-800lb
Minimum	8.28	21.98	21.34	35.84	25.30
Maximum	251.86	199.86	176.66	166.27	165.08
Mean	122.19	111.39	106.25	101.63	98.88
Std Deviation	30.98	22.31	19.38	18.51	17.31
Variance	960.0374	497.8803	375.4205	342.6807	299.5688
Skewness	0.02759966	0.00578878	-0.0217584	0.0191559	-0.0146707
Kurtosis	2.961537	3.049032	3.018353	3.040599	3.042546

Table B.3 Summary Statistics for January Steers Prices ($/cwt)

	3-400lb	4-500lb	5-600lb	6-700lbs	7-800lb
Minimum	34.47	38.95	46.35	38.67	42.38
Maximum	248.22	227.84	202.66	170.39	184.24
Mean	138.73	128.67	122.28	112.92	106.54
Std Deviation	28.94	23.42	20.17	17.48	16.91
Variance	837.291	548.5903	406.7427	305.4212	285.8697
Skewness	0.03449248	-0.0028638	-0.0002296	-0.0700083	0.00780978
Kurtosis	3.031349	3.009284	3.030296	3.0692	2.996302

Table B.4 Summary Statistics for January Heifer Prices ($/cwt)

	3-400lb	4-500lb	5-600lb	6-700lb	7-800lb
Minimum	15.73	25.10	28.22	31.68	20.01
Maximum	241.39	200.73	191.50	175.26	164.89
Mean	127.75	116.34	110.79	104.19	100.10
Std Deviation	30.49	24.60	21.84	20.09	18.54
Variance	929.7757	605.2505	477.0418	403.7373	343.5625
Skewness	0.00839702	0.01084691	-0.006314708	-0.01929052	-0.01471952
Kurtosis	2.989522	3.003985	3.013407	3.002885	2.996883

Table B.5 Summary Statistics for the Days in each Feeding System, March calving

	Days in Feeding System		
	Pasure	Swath grazing	Bale Grazing
Minimum	60.84	45.66	60.00
Maximum	124.46	89.72	109.49
Mean	98.13	69.98	76.55
Std Deviation	13.95	9.34	11.75
Variance	194.7232	87.2001	138.0979
Skewness	-0.4319458	-0.2949587	0.5893586
Kurtosis	2.355647	2.380784	2.439183

Table B.6 Summary Statistics for the Days in each Feeding System, June Calving

	Days in Feeding System		
	Pasure	Swath grazing	Bale Grazing
Minimum	60.84	45.66	150.00
Maximum	124.46	89.72	199.56
Mean	98.13	69.98	166.46
Std Deviation	13.95	9.34	11.79
Variance	194.7232	87.2001	138.9035
Skewness	-0.4319458	-0.2949587	0.5718744
Kurtosis	2.355647	2.380784	2.39473

Appendix C: Summary Statistics for Saskatchewan Prices

Table C.1 Summary Statistics for October Steer Prices ($/cwt)

	4-500lb	5-600lb	6-700lb	7-800lbs
Minimum	37.60	46.47	44.50	46.54
Maximum	232.20	202.39	189.41	164.48
Mean	131.02	119.93	113.03	108.14
Std Deviation	25.00	20.87	18.16	15.62
Variance	625.048	435.5099	329.7986	244.0265
Skewness	-0.02427417	-0.00314919	3.69648E-05	-0.00885124
Kurtosis	2.969042	2.967023	3.025958	2.963324

Table C.2 Summary Statistics for October Heifer Prices ($/cwt)

	3-400lb	4-500lb	5-600lb	6-700lb
Minimum	22.38	16.93	11.55	32.75
Maximum	229.55	216.47	187.43	189.40
Mean	120.48	114.23	106.99	101.64
Std Deviation	28.35	25.64	22.05	19.19
Variance	803.8517	657.5087	486.1968	368.2746
Skewness	-0.03145093	0.0429152	-0.01277125	0.008896565
Kurtosis	2.937628	3.054973	3.016815	2.997937

Table C.3 Summary Statistics for January Steer Prices ($/cwt)

	3-400lb	4-500lb	5-600lb	6-700lbs	7-800lb	8-900lb
Minimum	37.67	43.90	39.54	47.37	34.17	42.62
Maximum	245.14	217.18	210.37	189.34	165.26	161.28
Mean	129.52	130.24	124.01	114.71	106.68	101.90
Std Deviation	26.58	24.61	22.11	18.49	16.14	15.27
Variance	706.5259	605.7895	488.9083	341.8381	260.5685	233.2607
Skewness	-0.01069318	-0.01058748	0.0406441	0.01370404	0.01730627	-0.0271014
Kurtosis	2.959049	2.968967	3.037509	3.023965	3.122327	2.983707

Table C.4 Summary Statistics for January Heifer Prices ($/cwt)

	3-400lb	4-500lb	5-600lb	6-700lb
Minimum	23.84	15.42	22.66	36.96
Maximum	210.84	199.13	191.18	178.53
Mean	116.97	115.98	110.69	103.19
Std Deviation	25.40	24.40	23.00	19.53
Variance	645.3757	595.5767	528.7853	381.4354
Skewness	-0.03018713	0.02547922	-0.01125562	0.01334179
Kurtosis	2.997328	2.978012	2.981296	2.988438

Appendix D: Summary Statistics for Lanigan, SK

Table D.1 Summary Statistics for Calf Weaning Weights

	Steer Weaning weight (lbs)		Heifer Weaning weight (lbs)	
	March	June	March	June
Minimum	334	262	266	232
Maximum	762	760	724	752
Mean	535	521	499	486
Std Deviation	52	64	56	67
Variance	2672.331	4125.924	3132.079	4554.831
Skewness	0.03672688	-0.002246894	-0.003501658	0.01821207
Kurtosis	2.981379	3.074392	3.015985	2.992212

Table D.2 Summary Statistics for Days in each Feeding System, March calving

	Days in Feeding System		
	Pasure	Swath grazing	Bale Grazing
Minimum	75.98	25.57	22.36
Maximum	189.40	92.88	144.70
Mean	123.99	62.60	88.84
Std Deviation	24.41	14.14	25.34
Variance	595.7374	200.0482	641.872
Skewness	0.3992855	-0.2916439	-0.2707839
Kurtosis	2.420535	2.37457	2.427983

Table D.3 Summary Statistics for Days in each Feeding System, June calving

	Days in Feeding System		
	Pasure	Swath grazing	Bale Grazing
Minimum	75.98	25.57	83.02
Maximum	189.40	92.88	187.60
Mean	123.99	62.60	142.54
Std Deviation	24.41	14.14	22.39
Variance	595.7374	200.0482	501.5138
Skewness	0.3992855	-0.2916439	-0.3877134
Kurtosis	2.420535	2.37457	2.406168

Appendix E: Summary Statistics for Swift Current, SK

Table E.1 Summary Statistics for Calf Weaning Weights

	Steer Weaning weight (lbs)		Heifer Weaning weight (lbs)	
	March	June	March	June
Minimum	440	209	325	205
Maximum	895	902	776	796
Mean	641	552	546	518
Std Deviation	56	92	53	74
Variance	3169.057	8411.69	2841.907	5477.676
Skewness	0.02569413	-0.006134937	-0.02629126	0.002605433
Kurtosis	3.049558	2.948987	3.04289	3.015926

Table E.2 Summary Statistics for Days in each Feeding System, March calving

	Days in Feeding System		
	Pasure	Swath grazing	Bale Grazing
Minimum	92.64	0.14	81.25
Maximum	166.78	29.95	141.67
Mean	132.73	15.05	106.21
Std Deviation	15.40	6.11	12.89
Variance	237.0781	37.35479	166.0348
Skewness	-0.2241442	-0.01331979	0.4338534
Kurtosis	2.41354	2.399461	2.428597

Table E.3 Summary Statistics for Days in each Feeding System, June calving

	Days in Feeding System		
	Pasure	Swath grazing	Bale Grazing
Minimum	92.64	0.14	158.23
Maximum	166.78	29.95	230.57
Mean	132.73	15.05	192.91
Std Deviation	15.40	6.11	14.85
Variance	237.0781	37.35479	220.5527
Skewness	-0.2241442	-0.01331979	0.1192523
Kurtosis	2.41354	2.399461	2.400857

Appendix F: Example of Model Iteration

Production

Number of cows	66	Number of Steers Sold	32
Weaning rate	98%	Number of Heifers Sold	28
Cull rate	10%	Number of Cows Sold	6
Replacement rate	10%		

MARCH CALVING			JUNE CALVING		
		1			1
Costs			**Costs**		
Feeding System			Feeding System		
Pasture	$	4,775.76	Pasture	$	5,262.18
Swath Grazing	$	8,672.50	Swath Grazing	$	8,672.50
Bale Grazing	$	16,977.84	Bale Grazing	$	28,632.12
Drylot	$	20,073.24	Drylot	$	5,346.00
Other	$	8,017.44	Other	$	7,630.30
TOTAL COSTS	$	58,516.78	**TOTAL COSTS**	$	55,543.10
TOTAL COSTS/CO\	$	886.62	TOTAL COSTS/COW	$	841.56
Revenue			**Revenue**		
Steer Revenue	$	17,661.48	Steer Revenue	$	20,774.09
Heifer Revenue	$	20,472.59	Heifer Revenue	$	21,797.01
Cull Cow Revenue	$	2,285.55	Cull Cow Revenue	$	1,341.69
TOTAL REVENUI	$	40,419.62	**TOTAL REVENUE**	$	43,912.78
NET REVENUE	**$**	**(18,097.15)**	**NET REVENUE**	**$**	**(11,630.31)**

June - March		
Total Cost Difference	$	(2,973.68)
Total Revenue Difference	$	3,493.16
Total Net Revenue Difference		

Feeding Systems

	MARCH	JUNE
SWATH GRAZING Hectares	29.54	29.54
PER hectare FIXED COST	$ 248.88	$ 248.88
TOTAL FIXED COST	$ 7,351.84	$ 7,351.84

		MARCH		JUNE	
		$/head/day	Total Days	$/head/day	Total Days
Pasture	$ 4,775.76	$ 1.08	67	$ 1.19	67
Swath Grazing	$ 8,672.50	$ 0.29	69	$ 0.29	69
Bale Grazing	$ 16,977.84	$ 2.18	118	$ 2.18	199
Dylot	$ 20,073.24	$ 2.74	111	$ 2.70	30
TOTAL DAYS			365		365

Other Costs	$/head/year	$/head/year
Mineral	$ 12.28	$ 12.28
Salt	$ 2.92	$ 2.92
Vet - Vaccination	$ 25.63	$ 22.02
Vet - Treatment	$ 6.04	$ 4.38
Breeding	$ 36.55	$ 36.55
Taxes/Water	$ 10.97	$ 10.97
Freight/Trucking	$ 8.04	$ 7.99
Marketing	$ 19.04	$ 18.51

Weaning Weights

	OCTOBER	JANUARY
Steer Wean Weight	712	617
Heifer Wean Weight	615	458
Cull Cow Weight	1448	1426

Prices

	OCTOBER	JANUARY
	$/cwt	$/cwt
Steer	$ 77.56	$ 105.22
Heifer	$ 114.75	$ 164.15
Cull cow	$ 52.61	$ 31.36