KEEPING DAIRY PRODUCERS IN BUSINESS: THE EFFICACY OF RISK MANAGEMENT PORTFOLIO'S ABILITY TO PROVIDE FINANCIAL STABILITY

A Thesis

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By

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AUTHORIZATION TO SUBMIT

THESIS

This thesis of Dustin Winston, submitted for the degree of Master of Science with a major in Agricultural Economics and titled "Keeping Dairy Producers in Business: Efficacy of Risk Management Portfolio's Ability to Provide Financial Stability," has been reviewed in final form. Permission, as indicated by the signatures and dates given below, is now granted to submit final copies to the College of Graduate Studies for approval.

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Abstract

Dairy production is one of the most significant segments of the agricultural industry in the United States providing for jobs, value added processing, and nutritious products to countless consumers. In Idaho, the dairy industry is equally impactful to the state's agricultural industry. In a state where every dairy is family owned and agriculture is a lifestyle. Tragically, dairy farms in Idaho and nationwide are going out of business due to increasing pressures on profit margins on dairy farms, leading to consolidation in dairy farms. It is important to provide this industry the tools so that dairy operations have a greater ability to stay profitable and in business.

Marketing risk (the risk of changing prices for a commodity) is one of the greatest factors influencing the dairy industry consolidation. Risk management tools are available for dairy farms of all sizes to use allowing for the offsetting of marketing risk; yet they are used at a rate fractional to that of other agricultural industries such as grains and livestock.

This thesis details the current risk management tools and strategies available to the dairy industry. A panel of dairy risk management experts provided risk management potential strategies for dairy producers to be able to reduce margin risk. The efficacy of different risk management strategies was analyzed for potential use in production by applying each treatment to historical data. These treatments are compared to the control of no risk management practices. Performance was compared using stochastic dominance. The results of this work will benefit dairy farms of all sizes, especially smaller farms who might not have the time or resources to determine an optimal risk management strategy.

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Chapter 1 – Overview

The dairy industry is extremely important to American agriculture, and it provides substantial impact to gross domestic production (GDP) for both the country and specifically the state of Idaho. Idaho is known across the country for its potato reputation; however, dairy is the largest sector of the state's vast agricultural industry. Dairies are a foundational piece of the Idaho agricultural industry, providing substantial impact to their local communities. With the dairy industry being such an important piece of the agricultural economy and rural infrastructure, it would be devastating if the industry became negatively impacted. Therefore, it is very important that dairy farmers utilize risk management tools to protect their profits and thus the viability of the industry.

The viability of many dairies in the industry is waning evidenced by consolidation across the country. Volatility of the milk price being offered to dairy farmers is one of the biggest factors contributing to the growing consolidation in the dairy industry. There are powerful incentives behind consolidation as larger farms are more capable of absorbing short-term, rapid changes in price due to their ability to spread costs across a larger production volume (MacDonald, Law, and Mosheim, 2020). Idaho is not exempt from this trend, experiencing a significant reduction in the number of operational dairies, and thus a significant impact to the rural communities that make up the core of the state.

Consolidation itself is not a bad thing if producers are choosing to exit. However, if dairy producers are being pushed out as a result of market volatility that is outside of their control, then it is important to evaluate the situation. Risk management tools and their ability to assist dairy producers have been studied, but we have yet to find any research that compares current risk management tools to provide insight on the best ones available, and current literature calls for further research to be conducted on the industry's behalf (Wolf, 2012).

Background

While dairy products have been consumed for centuries, modern dairy farming did not begin until the late 1800s following the development of pasteurization and other inventions (Moyer, 2019). Moyer (2019) noted that the progression of the dairy industry has brought with it technological advancement, jobs, and contribution to state and national GDPs. In 2019 that contribution was significant, according to the Economic Research Service (2020), U.S. revenue from milk and milk products was over $40.4 billion, accounting for 10.8 percent of total agricultural cash receipts, trailing only cattle and calves ($68 billion) and corn ($48.8 billion).

In 1924, Idaho dairymen decided to come together to form the Idaho Dairymen's Association (IDA) in an effort to develop and sustain an economically viable dairy industry in the Gem State (Dairy West and Idaho Dairymen's Association, 2018). Currently in Idaho, every dairy is family owned and as an industry has a major impact on the state – contributing to local communities, providing jobs and revenue, and giving back in the form of scholarships and school funding (Dairy West and Idaho Dairymen's Association, 2018). The financial impact of Idaho's dairy industry in 2018 was $2.4 billion dollars in farm cash receipts and 47,000 jobs (Ellis, 2019).

The dairy industry is pivotal to the agricultural economy and rural communities that they reside in, but the number of dairies able to contribute at the local level. In 2017, the Agricultural Census counted 54,599 farms with milk cows, of those farms 30,373 had less than 200 cows. The number of small commercial dairy farms (<200 cows) has fallen substantially over time from 47,873 in 2007 (a 36.55 percent decline from 2007 to 2017) and 146,685 three decades earlier in 1987 (a 79.29 percent decline from 1987 to 2017). Dairy farms in the U.S. are declining at an average annual rate of 4 percent from 2002 to 2017. Since 2017 that rate has accelerated to nearly 8 percent. While the number of dairy farms is declining the level of production in the US continues to grow as a result of greater herd size average (Figure 1.1) and greater yield per cow (Figure 1.2).

Figure 1.1 – Number of Dairy Farms Over Time

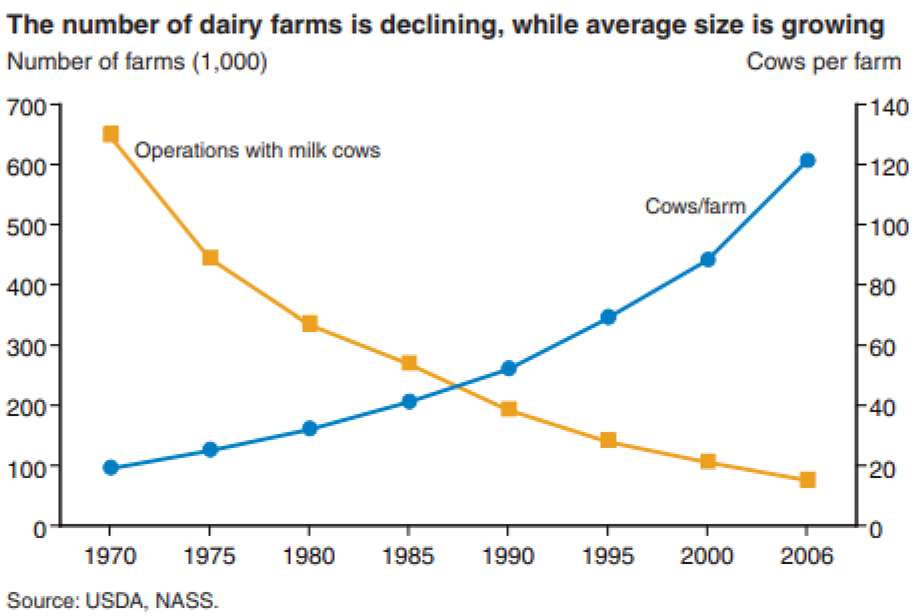
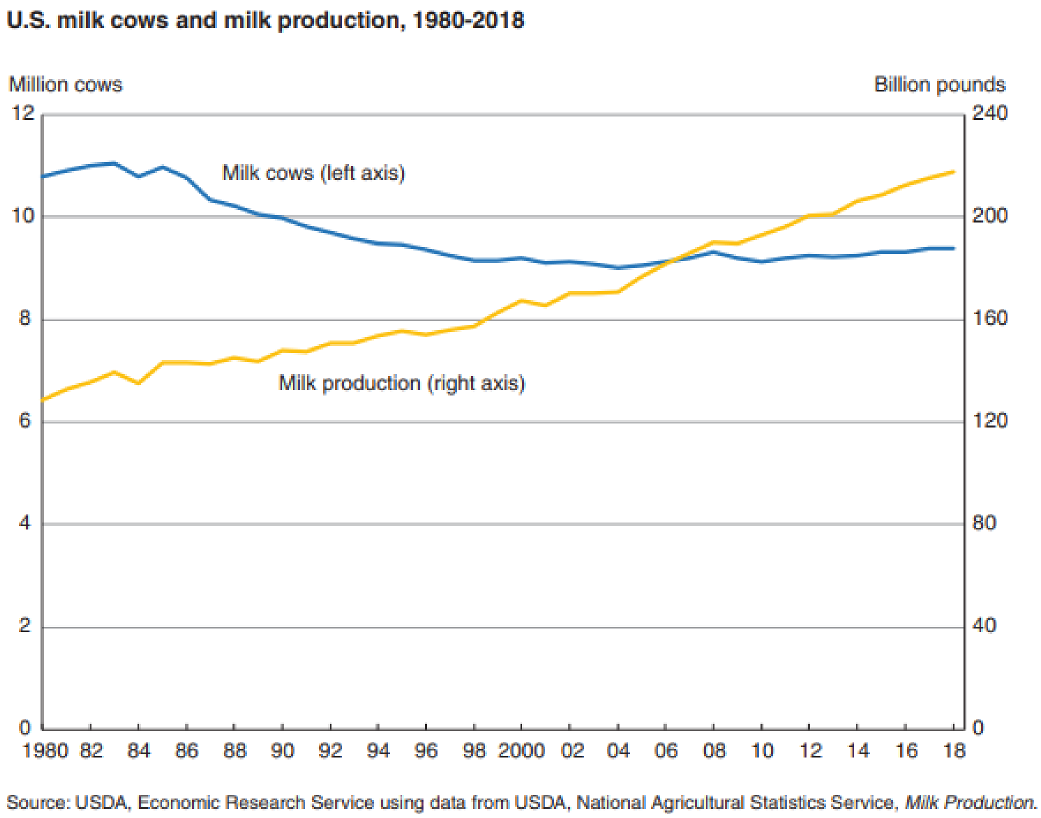


Figure 1.2 – Milk Cows Versus Production Over Time



Unfortunately, like dairymen across the country, Idaho dairymen are facing consolidation as family farms are forced to close their doors due to an inability to manage the growing risks in the present-day market (Nepveux, 2021). In 2014 Idaho had a total of 526 dairy operations. In 2019 this number fell to 437 with 91 of those operations accounting for 85 percent of the state production (Naerabout, 2020). This decline represented a reduction of 17 percent in number of dairy facilities, yet over that same time period Idaho moved from 4th to 3rd in the national milk production rankings.

A key characteristic of agriculture is the high level of production, financial, and marketing/price risks, which influence farmers profit margins (Velandia et al. 2009). These are just some of the many risks that businesses face on a daily basis, but in agriculture these three risks hold a heavy influence on the success of a producer to operate their business. Production risk, for dairy, impacts a dairy farmer's ability to get the most yield possible from their milk cow due to things such as disease. Financial risk is experienced by dairy farmers when they are working to get or pay off a loan because of the leverage on their balance sheet. Price risk, resulting from market volatility, impacts the price that dairy farmers are able to receive for their milk and therefore their ability to establish stable profit margin (Dohlman, 2020).

Production, financial, and price risks are managed in separate ways. Production and financial risks are able to be managed with tools that all business professionals would likely consider to be a requirement to operate. Things like medicine for sick cows or working with a loan agent are just two of the many ways that an efficient producer should already be working to inherently manage these risks. So how does a producer manage price risk when they have no control over the volatility in the market?

There are many reasons why managing price risks can be a major challenge for dairy farmers, but the volatile nature of commodity markets presents opportunities for profits and losses when milk prices change (Shields, 2011). Volatility, which leads to price uncertainty, is experienced as a result of demand fluctuations in international and domestic markets, production uncertainty, and agricultural market infrastructure such as homogeneous output and many competitors (Moschini, G., and D.A. Hennessy, 2001). In recent years volatility has seen a significant increase, driven by lower buffer stocks, weather events reducing production, strong growth in global demand, and lower government support prices (International Dairy Foods Association, 2010).

This volatility in output (milk) price presents the reason why risk management tools are so necessary for dairy producers. In fact, farmgate milk prices (prices received for milk by a dairy farmer) are the most volatile of any price in the supply chain (Novakovic, 2009). Novakovic (2009) showed that from the beginning of the 1900s to the 1990s the average annual fluctuation of farm gate milk prices was never more than $2/hundred-weight (cwt). Over the last 20 years we have seen the annual fluctuation in farmgate milk price reach, at times, more than $10 from the yearly high to the yearly low (CME Group, 2018). Novakovic (2009) also showed that since the severe reduction in the government support price, the value of milk has become increasingly erratic with each passing year.

Risk management tools, as explained by Shields (2011), provide an opportunity for dairy farmers to transfer the price risk they experience to either the private sector or the government through programs that support the producer as milk prices decline. Risk management began to be studied after World War II where the origin of the practice is considered to be between 1955-1964 (Dionne, 2013). Risk management, at it's core, encompasses many facets of a business operation. Over time the application of risk management has evolved to protect against many forms of risk. Dionne (2013) determined that initially risk management was associated with operational risk - the use of insurance to protect individuals and companies against loss due to accidents. As time progressed through the 1960s, new forms of risk management, such as contingency planning, personal protection activities, and coverage for work-related incidents, were implemented. In the 1970s, the use of derivatives[1] for financial products as instruments to manage risk were created and

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[1] Derivatives are defined as an arrangement or instrument (such as a future, option, or warrant) whose value derives from and is dependent on the value of an underlying asset. (CME Education, 2021)

adoption developed very quickly in the 1980s. The use of derivatives assisted a myriad of business types in their ability to manage financial risk, operational risk, and liquidity risk (Dionne, 2013).

While financial derivatives and modern risk management has only been around for the last 60 years, the agricultural industry has been using derivatives to manage risk since the mid-1800s (CME Education, 2021). As a result of primitive storage facilities and seasonal supply fluctuations, agriculture had an inherent price risk that was experienced by farmers. Futures[2] were created by the Chicago Board of Trade in order to offer farmers the opportunity to offset that risk. The CME Education group (2021) explains that as markets open, technology evolves, and risks facing the supply chain continue to be identified, the derivative products that are available to producers to offset risk continue to adapt.

Since the initial futures contracts used in the grain industry, the use of derivatives to reduce the risks facing an agricultural producer have compounded. To see this one simply needs to look at CME Corn Futures. In the last full week of June 2021, the front month (July 2021) corn contract traded enough futures to represent two thirds of the expected total harvest in 2021. Initially the only tool to manage marketing risk in the agricultural industry

[2] A form of derivative, a Futures contract is a standardized legal agreement to buy or sell something at a predetermined price at a specified time in the future, between parties not known to each other. The asset transacted is usually a commodity or financial instrument. (CME Education, 2021)

was futures. Today products include not only futures, but options[3], swaps[4], over-the-counter[5] (OTC) and insurance products[6] across many agricultural commodities including dairy. Risk management is not about gaining the highest price possible but rather ensuring that an operation will be able to receive a profitable margin month-to-month in order to keep their business sustainable. As the tools available to dairy producers has evolved, so has the knowledge needed to effectively use these tools creating the need for research on their utilization.

Currently, the literature is limited with regards to studies about risk management in the agricultural and dairy industry. Many of the studies in the current literature do not fully analyze the use of risk management tools, are out of date, are from other countries, or too often do not evaluate all aspects of the practice. Pennings and Meulenberg (1997) found that many research efforts do not include cost of using risk management tools. Asravor (2019) and Wolf (2011) evaluate usage of risk management tools, but not effectiveness. Tudor et al. (2014) and Velandia et al. (2009) evaluate adoption factors of risk management, but not usage or viability. Schaper et al (2009) evaluated risk management in the dairy industry, but in the EU where risk management tools function slightly differently. Kuethe and Morehart

[3] A form of derivative, an Option contract or simply option, is defined as "a promise which meets the requirements for the formation of a contract and limits the promisor's power to revoke an offer". An option contract is a type of contract that protects an offeree from an offeror's ability to revoke their offer to engage in a contract. (CME Education, 2021)

[4] A form of derivative, a swap is an agreement between two counterparties to exchange financial instruments or cashflows or payments for a certain time. The instruments can be almost anything but most swaps involve cash based on a notional principal amount. (CME Education, 2021)

[5] A form of derivative, an Over-The-Counter (OTC) contract is a financial contract that is arranged between two counterparties but with minimal intermediation or regulation. OTC derivatives do not have standardized terms and they are not listed on an asset exchange. (CME Education, 2021)

[6] Insurance products as they relate to the dairy industry come in many forms; current insurance offerings used in risk management provide a myriad of coverage subsidized by the government. (CME Education, 2021)

(2012) and Neyhard et al. (2013) evaluate dairy risk management tools but limited their studies to one or two tools and over a limited period of time. These studies highlight that the study of dairy risk management is only a fragment of the current research and it is significantly lacking a present-day comprehensive understanding.

Objectives

The goal of this work was to empirically test tangible solutions to minimizing the detrimental effects of increasing volatility to help stem the rapid consolidation of dairy farms. The objectives of this study were as follows:

1. Utilize industry expert perspective to gauge the most successful financial tools available to dairy producers to protect against market risk;
2. Build a portfolio of risk management strategies designed to manage risks associated with dairy industry markets; and,
3. Test by producer type (based on production) the efficacy of risk management strategies towards protecting profitability.

Research Overview

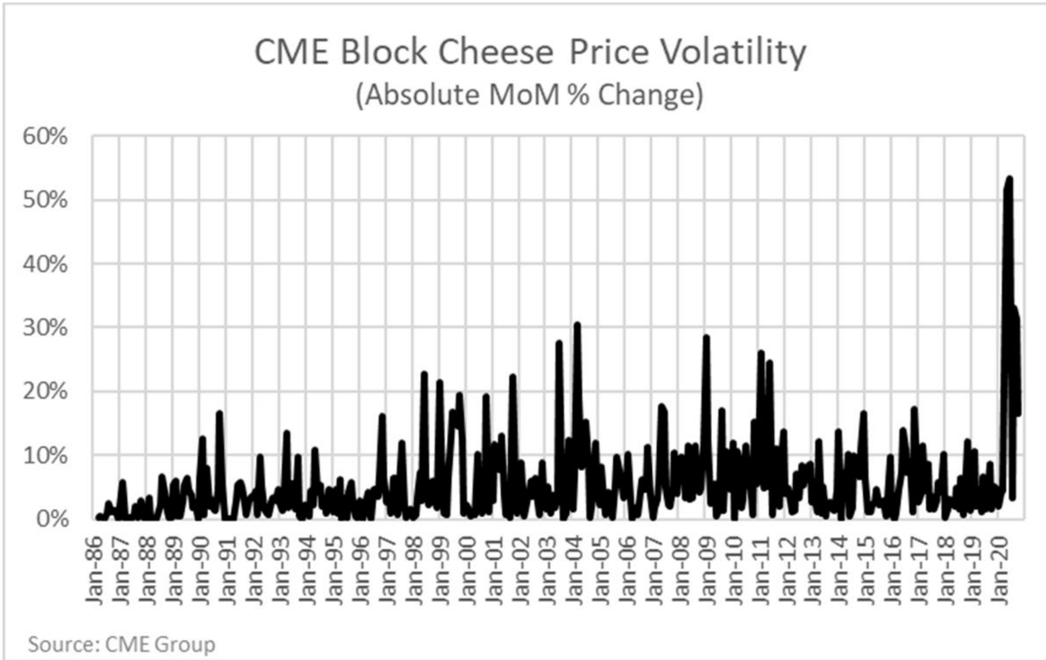
The remainder of this paper discusses in detail the four research objectives. Chapter 2 describes the dairy industry perspective of the risk management industry as well as the perspectives relating to the practices of this analysis. Chapter 3 details the steps of this research and the data used in order to meet our research goal. The results of the analysis are presented and discussed in Chapter 4. Finally, the conclusions and impacts of this study, its contribution to the industry, and what future work could be done are presented in Chapter 5.

Chapter 2 – Review of Literature Related to Risk Management Practices on Price Risk in Agriculture

2.1 – Introduction

The dairy market has evolved a lot over the last 150 years, and it is important for those interested in using risk management tools to understand the current landscape of the market (CME Education, 2021). A major change in the dairy market is the impact of volatility that milk prices have experienced over the last 40 years, in large part due to the reduction in government support (Nicholson and Fiddamon, 2003). Nicholson and Fiddamon (2003) showed in a study of milk prices from 1980 to 2002 that milk price variation was nearly double from 1980-1988 to 1988-2002. Stewart et al. (2016) showed that in the last decade prices received by dairy farmers have had more than a $10/cwt price range whereas retail prices hold far more steady and are not as exposed to volatility. Comparing milk price volatility to wholesale cheese prices, which are a good representation of volatility's impact on Idaho dairy farmers as that is how a majority of Idaho milk is priced, we can see that cheese price variation was about double as well. Figure 2.1 shows the growth of volatility in block cheese prices on the spot market over time. From 1886-1995 volatility had an annual average of 8 percent, from 1996-2005 it more than doubled to over 16 percent.

Figure 2.1 – CME Block Cheese Price Month-to-Month Price Change



Current prices for milk and dairy products on the world dairy market challenge dairy farmers, increasing the need for risk management systems (Schaper, Lassen, and Theuvsen, 2010). Schaper et al. (2010) found that price and liquidity risks will become increasingly important in dairy farming due to the ebb and flow of government support and growing dependance on global trade income. These factors contribute to the requirement of careful identification and assessment of changing market conditions, as well as improved risk management at the farm level. Interest in understanding risk behavior and management of risk by dairy producers can be traced back to the late 1980s. Studies on dairy markets recognize a large number of risk management strategies for managing marketing risk such as forward contracting, cooperative membership, hedging, insurance, and the use of consultants or brokers (Wilson, Luginsland and Armstrong 1988; Bosch and Johnson 1992; Neyhard, Tauer and Gloy 2013).

Risk management tools have been around for some time, but usage in the dairy industry continues to be very low, especially compared to other industries. In 2011 a survey of Northeast dairy farmers found that only 22 percent of farmers had utilized tools to manage their milk margins via their output sales and 39 percent to manage margins through input purchases. These numbers are up from 6 percent and 32 percent respectively in 1999 (Wolf, 2012). In comparison, Midwest grain farmers were surveyed in 2017 to find that some risk management tools were used by nearly 70 percent of respondents, while futures, the least used risk management tool, was still used by 25 percent of respondents (Coffey and Schroeder, 2019). That means Midwest farmers utilized one risk management tool more than the collective risk management tools available to dairy producers. It is highly unlikely that time and location accounts for that much difference.

2.2 – Dairy Market Constructs

A primary structure of the U.S. dairy market is the Federal Milk Marketing Order (FMMO). FMMO's were originally created in the 1930s under the Agricultural Adjustment Act of 1933 however current FMMO's have been adapted and are now based on the Agricultural Marketing Agreement Act of 1937 (International Dairy Foods Association, 2010). FMMO's are a market construct created by the United States Department of Agriculture (USDA) to insure that all dairy farmers receive a fair price for their milk. FMMO's are not meant to be a source of risk management or eliminate risk for a farmer, but rather are meant to insure a stable supply of quality production to the marketplace, and because they impact price anyone using risk management tools should be aware of them. With the recent entrance of California into the Federal Milk Marketing Orders (FMMOs), more than 80 percent of the U.S. milk supply is sold under FMMOs (USDA-NASS 2019;

Natzke 2018; Cavanaugh 2018). The eleven FMMOs across the United States partition the country into geographical regions where producers have elected to be governed by a federal order. The objective of FMMOs is to match the market power of sellers to that of buyers of raw milk to provide market stability. The essence of these orders is to regulate a minimum price paid by milk processors to the milk producers. The minimum price paid depends on the classification of the raw milk purchased (CME Education, 2018).

There are four different milk classes defined by the federal government, which are a function of the final use of the raw milk purchased. Class I milk is used as fluid milk products. Class II milk is used for soft manufactured products such as ice cream, yogurt, and condensed milk. Class III milk is used for cheese and whey. Class IV milk is used to make butter and dry milk products. Class I milk commands the highest price. FMMO prices are based on current wholesale dairy product prices (e.g., for cheese, butter, nonfat dry milk, whey), which are reported by the USDA through the National Dairy Product Sales Report (NDPSR). Final prices received by producers result from a weighted average of pooling together the different class prices obtained from the total volume of milk sold.

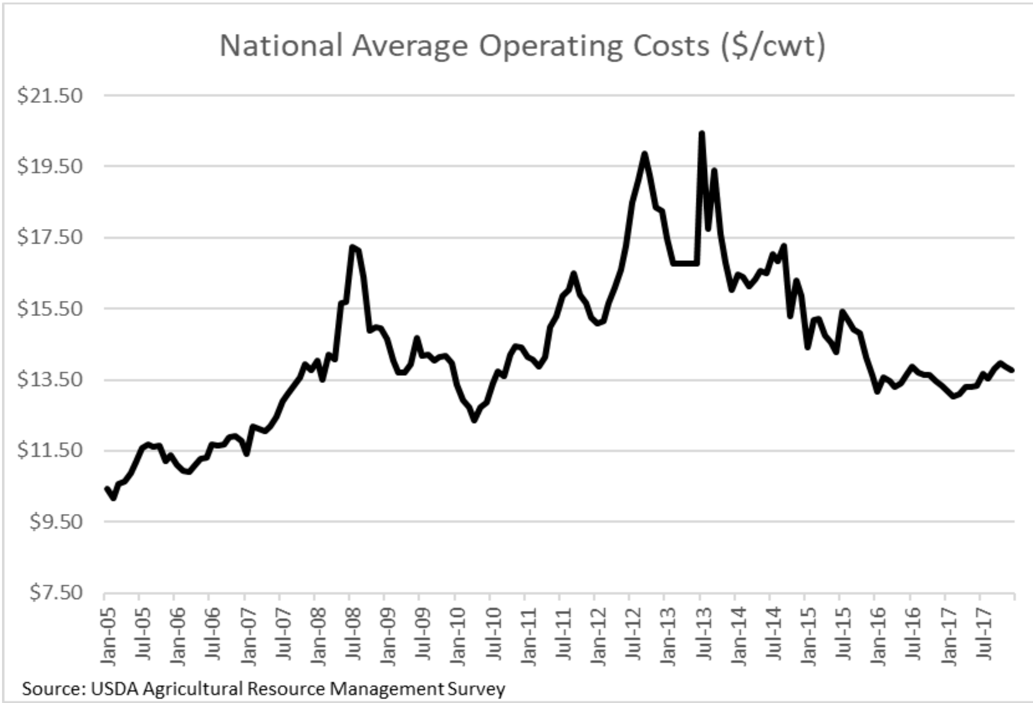
FMMO total objectives are listed as: (1) promote orderly marketing conditions in fluid milk markets, (2) improve the income situation of dairy farmers, (3) supervise the terms of trade in milk markets in such a manner as to achieve more equality of bargaining between milk producers and milk processors, and (4) assure consumers of adequate supplies of good quality milk at reasonable prices (Greene, 2017).

2.3 – Impact of Volatility

As government price control was reduced to nearly non-existent levels 40 years ago, volatility has continued to grow leading to an ever-growing need for the utilization of risk management tools (International Dairy Foods Association, 2010). Unforeseen events such as COVID-19 lead to unexpected market volatility provide another layer of risk that is extremely hard to endure and prepare for without risk management tools.

Operation costs contribute to the risk of every industry, the dairy industry is no different as many costs are variable and volatile month-to-month. In terms of operating cost, dairy inputs have also experienced similar volatility to milk prices, due in part to global markets expanding over recent decades (International Dairy Foods Association, 2010). Since 2005, the cost of production nationwide for a per hundredweight of milk has increased 25 percent (Figure 2.2). The cause of this volatility in output prices is market fundamentals (homogeneous product, continuous production, etc.) affecting supply and demand along with varying macro-economic factors (Madre and Devuyst 2016). Commodity price volatility is a major factor of the risk experienced by dairy producers, and it creates unreliable prices for business planning and causes minimal, even negative, profit margins. The more unpredictable prices are, the harder it becomes for producers to plan for their business and thus they incur more financial risk. Greater production often leads to a greater success of long-term viability for any operation, while smaller dairy producers have less opportunity to overcome a greater change in income due to fixed costs being spread over a smaller amount of production and creating a smaller total profit margin.

Figure 2.2 – National Average Operating Cost



2.4 – Risk Management Tools and Practices

Usage of risk management tools by farmers varies for many reasons, be it age, farm size, off-farm income, or education (Velandia, M., Rejesus, R. M., Knight, T. O., & Sherrick, B. J., 2009). Greater farm size often leads to the increased usage of risk management tools for many reasons including capital and ability to sustain potential short-term losses such as margin calls and transaction costs (Coffey and Schroeder, 2019). In a study completed by Coffey and Schroeder (2019) of Midwest grain farmers, they observed a positive relationship between farm size and probability of hedging with futures as well as a positive impact from using hedges. Likewise, Tudor et al. (2019) showed a tendency to utilize more risk management tools increases as gross farm income increases.

The approach to risk management in the dairy industry has generally been determined by policies and tools that address or assist in improving the profitability of the dairy producer (Price, 2004; Newton, Thraen and Bozic, 2016; Novakovic and Wolf, 2016). There are support programs provided by the federal government, as well as instruments offered by private industry, for dairy producers to weather adverse market conditions. The recent 2018 Farm Bill amended the 2014 Farm Bill's Margin Protection Program (MPP), which provides payout relief when income minus feed reaches certain pre-selected low levels. The federal government further assists private industry in offering insurance contracts for dairy producers. These contracts are (i) the Livestock Gross Margin – Dairy (LGM-Dairy) protection, which uses futures market data (from CME) to ensure a dairy producer's margin (income over feed costs) of operation; and (ii) the recent Dairy Revenue Protection (DRP) program, which also uses CME futures market data to ensure a dairy producer's revenue offered through private insurers assisted by the USDA's Risk Management Agency (RMA). The CME provides futures and options contracts for daily trade of Class III and Class IV milk, which are cash settled (i.e., cash is traded in place of physical milk). These products are available by trading through a broker. Brokers often offer additional opportunities such as Over-The-Counter (OTC) products and forward contracting. Further risk management can be achieved through membership in a cooperative which often offers forward contracting or basis pricing[7] as a result of the cooperative managing risk with a broker on their end (Wolf, 2012).

[7] Basis pricing, offered by some cooperatives, is a price structure in which farmers receive a milk check payout structured around a pre-determined basis to a Class of milk or other dairy product.

According to Coffey and Schroeder (2019), the risk management choices of agricultural producers are influenced by individual goals, risk preferences, farm characteristics, and financial profiles of farms. On top of those factors, there is an array of available risk management tools to choose from, which make this choice complex (Pennings et al. 2008). The risk management tools most commonly used in the agricultural sector include crop insurance, futures and options hedging, forward contracting, diversification, and risk balancing (Kuethe and Morehart 2012).

2.5 – Gaps in Literature

Risk management strategies in dairy have typically been evaluated individually (Shields, 2011; Pennings, 1997). In our framework, we will evaluate tools perform individually, and how they can be combined into a portfolio of strategies. As identified by Velandia et al. (2009), grain producers often use a combination of tools rather than a single one, thus supporting the relevance of evaluating choices as a portfolio (Pennings et al. 2008; van Winsen et al. 2016).

In the grain markets, Coffey and Schroeder (2019) evaluated the potential combined choice of forward pricing (futures, options, and forwards) and revenue protection insurance as a function of farm traits, farmer characteristics, and farmer risk attitudes. Their findings suggest that the portfolio choice is strongly influenced by farmer characteristics.

Similarly, Velandia et al. (2009) analyzed corn and soybean producers in the Midwest, evaluating the joint choice of crop insurance, forward contracting, and spread sales. They found that the decision to adopt one tool positively influenced the decision to adopt other tools. In addition, specific profiles of farms and farmers tend to influence the type of risk management choice including level of education and age. To the best of our knowledge no study has tackled the portfolio choice of risk management tools in the dairy industry, which is a necessary step to analyze optimal margin management choices for producers. This use of multiple strategies within the constraints of our dairy farm will serve as the basis for our study, what tools and opportunities provides a dairy producer the greatest opportunity for success on average.

As previous research has shown, volatility is a problem, and in the current marketplace dairy farmers are facing a greater challenge in predicting the price that their milk will garner. Risk management tools are needed to manage the growing price risk that volatility exposes producers too. There are many studies of different methods and reasons for adoption, but they are seldomly compared and analyzed as to their effect that diary producers receive using them. This research will extend previous research and provide tangible evidence to dairy producers as to the success that they might have in using these tools.

Chapter 3 – Determining Risk Strategies based on Expert Opinion

3.1 – Introduction

With the changing landscape of dairy risk management and the limited adoption of risk management tools by dairy producers, it is important to frame this study on state-of-the-art information in dairy risk management practices. To that end, we recruited a panel of experts and obtained their opinion on the most impactful risk management practices. In an effort to gather the insights of experts in the dairy risk management industry, we chose to utilize the Delphi Method. The Delphi technique was originally developed and used by the Rand Corporation (Hasson, et al., 2008) as a consensus forecasting technique. Using a found consensus on risk management strategies from our experts, risk management strategies were established and information on current risk management observations from our panel were recorded. These steps are meant to ensure that our research analyzes the best possible strategies for use in dairy risk management.

3.2 – Delphi Method

The Delphi Method was meant to provide a consensus forecasting technique. An early use was for refining military defense systems (Rasp, 1973). The Delphi Method has been used in the dairy industry to evaluate topics such as curriculum (Joyner and Smith, 2015) and food security (Lamm, Randall, and Fluharty, 2021). In the risk management industry, the use of the Delphi Method is relatively minimal. One of the few studies involving the Delphi Method used an adapted version, the Fuzzy Delphi Method and centered around Risk Culture and how it effects risk management (Faghihi et al., 2019). A combination of the traditional Delphi Method with Fuzzy Set Theory is often used in order to address some of the ambiguity of the Delphi panel consensus allows for elimination of some of the oversight of the common Delphi Method (Ishikawa et al., 1993). The extra effort of the Fuzzy Set Theory was determined to be superfluous for our study and the common Delphi Method was utilized.

In order to determine the risk management strategies that we would utilize in our study along with supplemental information about the current dairy industry a Delphi Method was used. This iterative process began with interviewing everyone in the panel. A summary of the findings were then presented to each individual. The individuals were invited to revise the summary via email, after seeing the group response. Unlike many group consensus methods, the Delphi technique is able to achieve a group consensus while ensuring groupthink does not occur; since all respondents are able to offer input independent and anonymously (Rasp, 1973). The iteration of updating the experts and soliciting additional feedback continued until disagreement was minimized or consensus is reached among the experts.

Interviews

The first stage of the Delphi process was to conduct personal interviews with industry experts to establish an industry expert baseline. We identified and contacted eight established risk management or financial experts within companies providing financial and risk management services to the dairy industry. These selected companies represented the four largest dairy risk management firms (based on volume traded) in the country, as well as multiple agricultural lenders that work with dairy farmers on the financial level. Of these selected experts, five agreed to participate, yielding a 63 percent response rate. Three of the participating experts work with risk management tools and dairy producers on a daily basis, while the other two represent the agricultural lending perspective as it relates to using these risk management tools. Thirty-minute interviews were conducted by members of the research team from January to February 2021 over a Zoom call. Researchers specifically probed when risk management tools were most beneficial to a producer in the eyes of the risk management professional, what tools are currently most used by producers actively managing risk, the challenges that these producers faced, and how to compile these components to create a baseline risk management strategy. The full list of questions are presented in Figure 3.1. When discussing risk management strategies, information regarding dairy size, risk management attitude, financial exposure, and geographic exposure were mentioned frequently. Based on the responses from our interviews a list of Best Management Practices (BMP's) was established for dairy risk management practices and confirmed over two rounds of email communication.

Figure 3.1 – Questionnaire for Interviews with Expert Panel

Interview Questions:

1. What type of dairy producers, in terms of size, market focus, etc., do you work with primarily?
2. For each of the groups you described in the previous question, what have you experienced as the average producer's attitudes and perceptions about risk management?
3. What about their attitudes and perceptions about margin management?
4. Do you find producers have a defined risk management strategy? If so, how would you describe the different strategies you have observed?
5. Along the lines of types of dairy producers, that you described in the first question, do you find any differences in the way each approaches margin management?
6. What are the most common tools you see used in margin management for dairy producers (inputs and outputs)?
7. What are the most optimal tools in your opinion to most successfully manage dairy margin (input and outputs)?
8. Do they (risk management tools) vary in their effectiveness by producer type? If so, how?
9. Outside of seasonality what factors most impact a dairy producer's ability to successfully manage margin with risk management tools? This could be an effect on market price or the producer's ability to use certain tools.
10. In determining an optimal hedging strategy what suggestions do you have?
11. Would you offer any additional ideas or thoughts with respect to margin management and margin management strategies in the dairy industry?
12. Do you have any questions for us at this time?

BMP – Scenario Development

Based on the collective expertise presented in the interviews, a list of BMPs was developed for risk management tools that are available to dairy farmers. When asked about risk management tools our experts cited several reasons why a dairy farmer may or may not use a particular strategy. While our experts acknowledged size plays a factor, capital was highlighted as a more impactful measure of a producer's limitation to usage of different risk management tools. This finding led us to evaluate if size of an operation is truly impactful to a dairy farmer's ability to utilize risk management effectively. Our experts highlighted that the normal correlation between a farmer having the available capital to use all risk management tools and their dairy farm size being 500 cows or more. Other notable factors included FMMO regions, risk attitude, and milk destination for processing. Following producer information, details about risk management tools that are available and which tools are most widely adopted were discussed.

While milk under Federal Milk Marketing Order (FMMO) regions now represents nearly 80 percent of the national milk production (USDA-NASS, 2019), the majority of Idaho milk production is not under a FMMO. While important, FMMO locations were not factored into the BMPs due to their minimal impact on Idaho farm-gate milk prices. Since dairy producers were not polled about this information, and a wide array of risk attitudes exist among farmers, risk attitudes based on complexity and data availability were not able to be analyzed in conjunction with our BMPs. Milk destination is an important factor in a producers' specific risk management strategy as highlighted by our experts, but this information is factored into a producer's normal operation. Therefore, we considered it to only be impactful on an individual farmer basis. Given adequate regard to each of the factors mentioned by our expert panel, we developed two tiers of dairy risk management strategies that could be analyzed on their efficacy to manage the risk that a dairy might face as a result of volatility on milk price and the corresponding impact on operating margin/cwt.

3.3 – Results

We gleaned a myriad of information from the interviews with the members of the expert panel. Major topics were highlighted by our panel as pertinent information to the use of risk management tools in the current marketplace.

- Break-Even
    - A frequent observation from our interviews was the need for a break-even to be understood and known (calculated) in order to formulate a risk management strategy and optimize a producer's ability to manage their margin. If margin management is a race, the break-even is the starting line for dairy farmers. Essentially, the experts all echoed the necessity of knowing the current financial situation by a dairy producer in order to establish an effective risk management strategy for that person.
- Individuality
    - The risk management strategy of choice is dependent on extrinsic and intrinsic traits of the dairyperson. Specifically, the best practices to manage risk is dependent on:
        - Milk use or market destination (Class/component)
        - Inclusion in FMMO region or not
        - Risk attitude (aggressive/conservative)

        - Free cash flow
        - Capital availability
    - Thus, each producer will start with a similar baseline strategy, but based on these factors they will adjust it according to their individual needs and preferences.
- Strategy
    - Our experts noted every producer has the opportunity, though not always financial capability to utilize all risk management tools. It was mentioned that tools like DRP and DMC are available to all producers while others like futures, options, and other derivatives are only available to those producers with flexible capital. The point our experts identified as the delineation between producers having the capability to use products with a need for greater capital was at roughly 500 cows (1 million pounds of milk production per month).
- Challenges to usage
    - The biggest challenges facing dairy producer's ability to manage risk include the following
        - Education – formal (post-secondary institution) and informal (self-researched)
            - Understanding of risk management tools
            - Understanding of the goal of risk management (not about getting the highest profit)
        - Experiences using derivative products
        - Capital/Cash Flow – availability to utilize upside risk management tools available

        - Market volatility – certain tools provide protection in different volatility environments
- Opportunities for greater risk management outside of derivatives and insurance
    - Opportunities in margin management for dairy farmers of all sizes can be maximized using other tools such as:
        - Co-op affiliation
        - Forward contracting for both inputs and outputs
        - Financial management (Greater clarity in accounting management)
        - Brokerage relationship for access to greater margin management specialization
    - These factors are noteworthy but were not considered in our modeling of risk management practices for simplicity reasons as they vary significantly based on region, processor shipment, and ownership among other reasons.

The above comments focused on utilization and knowledge of producers on risk management tools. In addition, the experts specifically noted a set of risk management strategies that fell into two tiers which are delineated by the cash flow or available capital.

Tier 1 Risk Management Tools – These tools are available to all farmers, regardless of their ability to pay. These tools were selected as the default base for any dairy producer adopting risk management practices.

- Utilize minimum coverage through Dairy Margin Coverage (DMC) at administrative fee.
- Long-term coverage through Dairy Revenue Protection (DRP).

  - Cash flow benefits from making payments after the quarter ends, payment is only necessary when a producer receives prices above coverage level

Tier 2 Risk Management Tools – Tools in this tier are available to farmers with access to capital or greater cash flow availability The capital level that was determined by our expert panel was a farmer with more than >$25,000 which works out to the operating margin being ten percent of working capital per 200,000 pounds of production (one futures contract). A moderating force on the utilization of Tier 2 risk management tools is leverage exposure. The practice of managing debt and optimizing working capital will, in large part dictate the ability of producers to utilize risk management tools that benefit from the upside potential.

Tier 2 risk management tools should be considered following the implementation of Tier 1 tools.

- Futures position
  - Futures add additional costs (commissions and margin) but allows a producer to take advantage of selling at higher price levels if the market moves higher.
- Collars to mitigate risk but capture higher profit potential.
  - Collars (buying Put / selling Call) allows you to create a floor but still allows limited participation to the upside. Experts usually suggest the use of collars when the market is in that middle value range

Information was also gathered on the individual extrinsic and intrinsic traits of dairy farmers based on the experience of our experts. While the risk management tiers established for analysis were unable to take into consideration all of the individual aspects of dairy producers, we were able to find an agreement among our experts as to the different focuses that a producer might have and use the 'Contribution to Margin' mindset to build our strategies around.

- Break Even (focus on profitability)
    - Producers would focus on insurance and/or long put options to ensure a break-even. Risk management tools would be more consistently employed here to allow farmers to consistently employ break-even levels.
- Contribution to Margin (Marginal Revenue-Marginal Cost: focus on margin principle)
    - Producers who manage a margin would focus on using futures/options to fix both inputs/outputs simultaneously. They are not worried about getting the top price, rather a target margin. Risk management tools would likely be used here only when prices are in-line with the prices desired to fix the specified margin.
- Leverage (focus on debt service)
    - If producers are above their "burn rate," they are more likely to minimize unknown costs, relying on insurance and options to protect against costs.
- Cash flow (focused on debt service, among other things)
    - Same reaction to risk as the Leverage focused individuals.
- Marketing (focus on revenue)

- Likely to employ risk management tools only sometimes as their focus is to insure maximum revenue. These producers would likely start with insurance and add option strategies as the market moves in their direction, adding on futures when price reaches the top 10 percent of the price decile.

Delphi Survey

Following our initial interviews two follow-up email rounds were utilized to draw agreeable conclusions from the entirety of our panel. Due to the fact that the majority of the responses in the interviews were qualitative, the agreement was largely based on a thought process rather than numerical values. In each email round all participants continued to respond.

In these follow up emails, clarification was sought in order to become familiar with what level of milk production allowed for the use of particular tools. It was determined that dairies producing under 1 million pounds (approximately 500 cows) of milk per month had better experience using tools such as DMC and DRP where dairies producing more milk than that had opportunities to use futures and other tools to capture potential favorable prices when available.

3.4 – Summary

The development of risk management tiers and responses from the Delphi Method revealed many impactful findings for the dairy industry. One of the findings that could inform future research is the specific focus for varying farmer’s perspectives as it relates to risk management. The best practices and development of risk management tiers allowed for clarification on risk management strategies and made sure that the research would be in-line with current industry practices.

The risk management tiers provide opportunities for dairy producers at any production level to engage in risk management. The first tier of risk management strategies is available to all producers while the second tier of strategies is available to farmers with larger production levels that provide greater levels of cash availability.

Chapter 4 – Determining the Efficacy of Risk Management Strategies to Manage Price Risk Impact on Dairy Producer Margins

4.1 – Introduction

Risk management has increasingly become a necessary factor for the success of a dairy producer in the current marketplace. The literature is filled with studies about risk management in the agricultural and dairy industry, but many of these studies do not fully analyze the use of risk management tools, are out of date, are from other countries, or often do not evaluate all aspects of the practice. These showed our research group that there is a significant need for risk management. Of the research presented in Chapter 2, dairy risk management research is only a fragment. Additionally, the literature is significantly lacking a present-day comprehensive understanding. The empirical analysis presented in this chapter will serve to partially fill that gap.

Data for the empirical analysis was gathered from sources within the dairy and risk management industry. This data was used to construct the operating margin that Idaho dairy farmers face without risk management usage. To accomplish this task, the data was compiled into a monthly historical timeline from 2005 to the first quarter of 2021. Operating margins were calculated for an average dairy farm using no risk management practices (the control group) and alternative risk management strategies (the proposed treatments). The results of implementing our risk management strategies were calculated to determine the impact on operating margin.

Jones et al, (2017) shows that there are two broad categories that motivate agricultural model development: scientific understanding, and decision/policy support. At the basic level, models used to increase understanding are used as tools to address research questions about control of processes, magnitudes of responses, and interactions. Outputs modeled in a controlled space such as a lab are compared with observations to test the understanding embedded in the model. Models developed to provide information are meant to support specific public policy processes and decision making. Users of such models may be interested in prediction of responses that help guide decisions. The primary type of model that produces response outputs that are of interest to support decision making is statistical models. Statistical models are developed using historical data sets on system responses. It is assumed that data used to create statistical models are samples of a population and can therefore be used to predict future values. Based on Jones et al. (2017), we used historical data in our research study.

This analysis is built on the historical results of variables affecting the dairy industry over the last 16 years. Veterinary, bedding, marketing, fuel, repair, and other input costs gathered from the USDA Economic Research Service (ERS) served as the foundation to determine the cost of production for our dairy operation and represent the national average cost/cwt experienced by dairy producers. The final input variable used to calculate operating margin was feed costs. This data was supplied by StoneX and represents the average cost/cwt experienced by Idaho dairy producers. The sum of the listed input costs against the monthly average Idaho farm gate milk price/cwt serves as our calculation to determine the monthly operating margin that average Idaho dairy farmer faced over the last 16 years.

Results of the risk management strategies were analyzed in a variety of ways including summary statistics, cumulative distribution functions, and stochastic analysis to determine which strategies were most optimal in managing price risk as it relates to the operating margin/cwt for a dairy farmer. Harrison (1998) and Kauffman and Tauer (1986) analyzed cattle risk management and dairy farm management respectively using first and second order stochastic dominance.

Stochastic dominance with respect to a function (SDRF) has been a study used throughout time to evaluate outcomes with uncertainty involved with it and can be shown visually through a cumulative distribution function (CDF). For first-order stochastic dominance, a CDF curve is further right (representing greater returns) and never crosses the dominated CDF. Second-order stochastic dominance occurs when a CDF curves cross, but the area from zero to any point under the dominant CDF is always larger than that of the dominated curve. This means the curves can cross, but the overall advantage always favors the dominating distribution. First order stochastic dominance is the least discriminating stochastic dominance method for ranking risky alternatives (Richardson, J.W., 2008). If the CDFs for the risky alternatives do not cross, this is the preferred method for ranking alternatives. Second order stochastic dominance assumes the decision maker is risk averse so the risk aversion coefficients (RACs) must be positive (Richardson, J.W., 2008). Stochastic dominance for one method over another in the CDF is determined using Equation 4.1:

Equation 4.1 – Generalized SDRF Equation

$$\int_{r1}^{r2} [G(z) - F(z)]\, u^1(z)dz \ \geq 0$$

Where: G(z) is the CDF of option 1

F(z) is the CDF of option two

u is the upper risk aversion coefficient z is the operating margin attained by the given strategy

While stochastic dominance has been commonly used there is an alternative measure that is becoming popular. Stochastic efficiency with respect to a function (SERF), is becoming adopted as a better risk ranking procedure compared stochastic dominance. Unlike conventional SDRF, SERF involves comparing each alternative with all the other alternatives simultaneously, not pairwise, and hence can produce a smaller efficient set than that found by simple pairwise SDRF over the same range of risk attitudes (Hardaker et al., 2004). Ribera, Hons, and Richardson (2004) used SERF to compare conventional and no-till farming methods in farming systems. SERF is a procedure of ranking risk alternatives based on their certainty equivalents (CEs) for alternative absolute risk aversion coefficients (ARACs) using an exponential utility function (Richardson, J.W., 2008). Certainty equivalents are dynamic and established by the data set being analyzed using the following calculation in Equation 4.2:

Equation 4.2 – SERF Equation to Determine CEs

$$CE = -\exp(-ARAC*M(x))$$

Where: CE is the certainty equivalent

ARAC is the average risk aversion coefficient

M(x) is the operating margin achieved under a given risk management strategy

The SERF equation was completed under multiple ARAC levels and is provided visually with the results graphs in forms throughout the research. In this analysis results from both SDRF and SERF models are presented.

4.2 – Determining the Model Dairy with Respect to Operating Margin

To gather an accurate representation of the impact of our studied risk management tools, we set out to gather as many input costs relating to operating margin as possible. The USDA Economic Research Service (2021) publishes input costs for differing sizes of dairies. Initially the research team believed that the distribution of input costs would vary greatly based on dairy size. While there is a difference in the total margin between different dairy sizes, we were able to determine that the distribution of returns by operating margin for different dairy sizes varies minimally. Our research was done using input and output data from the USDA Economic Research Service (ERS) (2021) showing that operating margins between small and large dairies are 98.7 percent correlated (Figure 4.1). It is important to note that this is just operating margin (revenue received from milk production – input costs (not including feed)). Total margins do vary due to the larger revenue from production of larger dairies being able to compensate for a large volume of fixed costs. Feed is also a factor that was not evaluated in Figure 4.1 as the national average of feed costs varies due to the geographical weighting of where larger and smaller dairies are located, but on a state-by-state basis feed costs were determined to be relatively similar according to our expert panel.

With the assumption that the distribution of input costs stays steady between dairy size, it was determined that costs for each dairy size could be used to represent the construction of our model; however, the results were computed for each size for the sake of completeness. Given the feedback from our expert panel and breakdown of dairies in Idaho

(Figure 4.2), we identified two dairy sizes, small (200-499 cows) and large (1,000+ cows), to analyze the impact of risk management tools on operating margin. Dairy farmers looking to implement these risk management strategies should use their own input costs to determine the true success of these tools on their own individual operation.

Figure 4.1 – National Average Operating Margin (Less Feed)/CWT by dairy herd size, 2005-2020

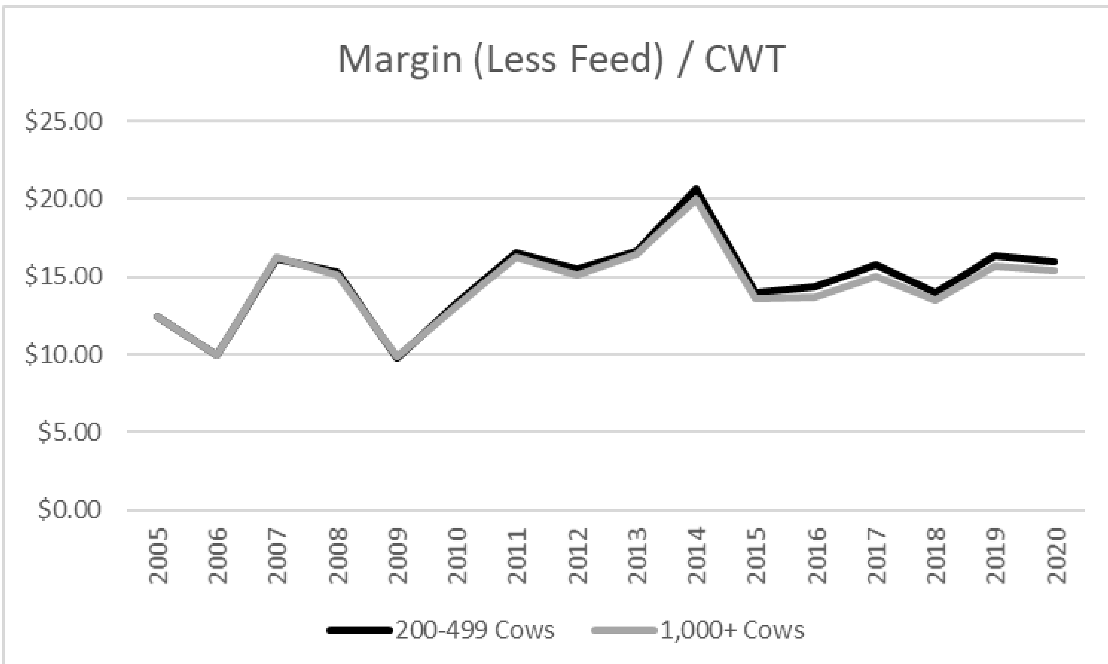
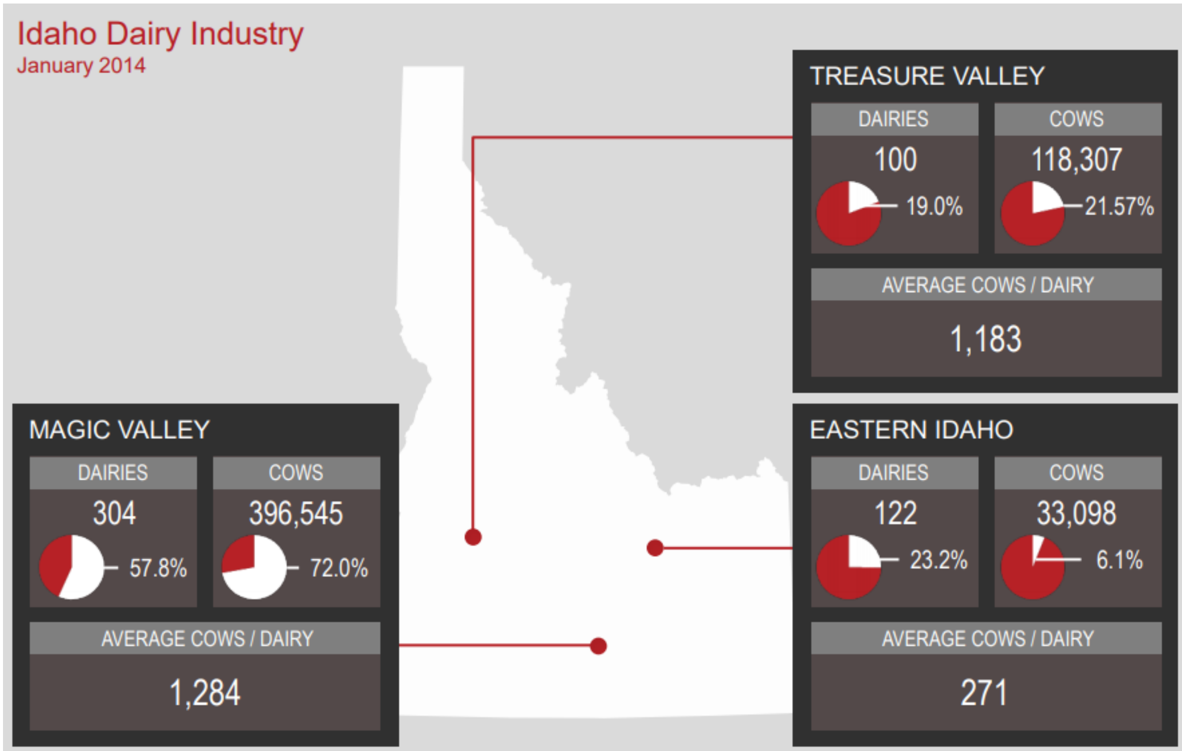


Figure 4.2 – Breakdown of Idaho Dairy Sizes by Region



In our cost of production calculation portion of the operating margin nine, variables were identified as impactful and were included in our dairy farm construction. These variables are feed, veterinary and medicine, bedding and litter, marketing, custom services, energy (fuel, lube, and electricity), repairs, other operating costs, and interest on operating capital. The values for the latter eight variables were gathered from the information published by the USDA ERS, while feed costs values for Idaho were provided by StoneX. Table 4.1 shows the summary statistics for these variables on a 200-499 cow dairy, Table 4.2 shows these variables for a 1000+ cow dairy, and Table 4.3 shows the correlation of these variables between farm size. Only veterinary and bedding costs were found to have a correlation of less than 70 percent. The likely cause for this is that large farms can get better deals with suppliers based on operational scale, and geographical factors can also impact this issue.

Labor costs were sought after, but due to geographical differences and limitation of availability these costs were not included. The omission is expected to have no impact other than a shift in the central tendencies of each result as they have a linear relationship to operating margin.

Table 4.1 – Input Costs for 200-499 Cow Dairy by CWT

Input Variable Costs for 200-499 cow dairy per cwt	Mean	Min	Max	Std Dev
Feed Costs	9.65	5.40	15.55	1.99
Veterinary & Medicine	0.94	0.86	1.08	0.06
Bedding & Litter	0.29	0.25	0.35	0.03
Marketing	0.23	0.15	0.33	0.06
Custom Services	0.67	0.47	0.78	0.12
Fuel, lube, electricity	0.78	0.55	1.00	0.16
Repairs	0.71	0.57	0.85	0.09
Other Op Costs	0.00	0.00	0.00	0.00
Interest on Op Capital	0.09	0.01	0.29	0.10

Table 4.2 – Input Costs for 1,000+ Cow Dairy by CWT

Input Variable Costs for 1,000+ cow dairy per cwt	Mean	Min	Max	Std Dev
Feed Costs	9.65	5.40	15.55	1.99
Veterinary & Medicine	0.70	0.63	0.79	0.04
Bedding & Litter	0.13	0.09	0.18	0.03
Marketing	0.22	0.14	0.32	0.06
Custom Services	0.48	0.35	0.66	0.12
Fuel, lube, electricity	0.52	0.38	0.64	0.09
Repairs	0.45	0.36	0.55	0.06
Other Op Costs	0.00	0.00	0.00	0.00
Interest on Op Capital	0.08	0.00	0.25	0.08

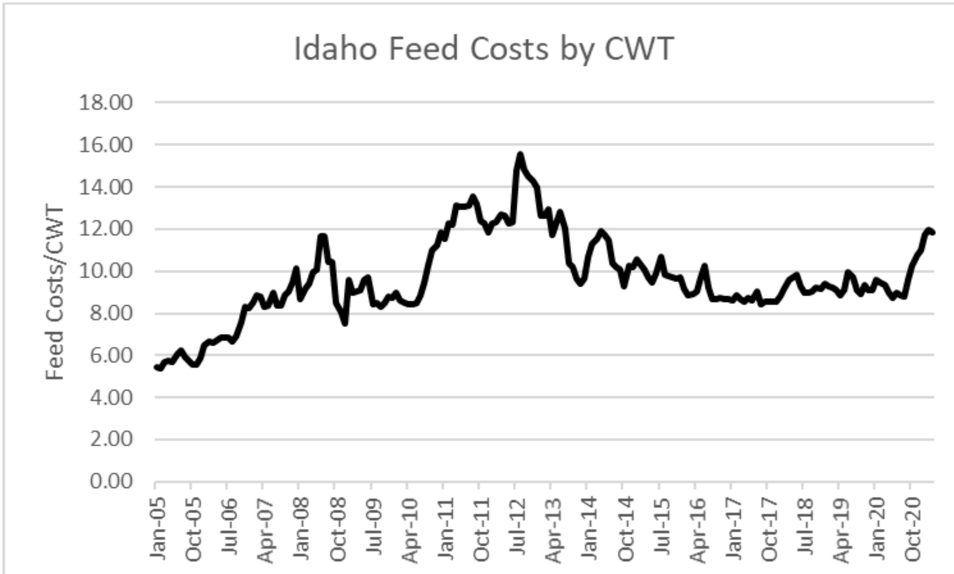
Table 4.3 – Correlation of Input Costs Between Dairy Sizes (200-499 vs 1,000+)

Input Variable	Correlation
Feed Costs	100 percent
Veterinary & Medicine	40.1 percent
Bedding & Litter	-11.8 percent
Marketing	99.5 percent
Custom Services	71.2 percent
Fuel, lube, electricity	82.1 percent
Repairs	98.8 percent
Other Op Costs	100 percent
Interest on Op Capital	99.9 percent

Feed Costs

Feed costs carry the largest share of impact on the operating costs of a dairy operation. StoneX provided their data on Idaho dairy feed costs based on the industry accepted DMC formula. Since the feed costs are determined using the DMC formula the Idaho average price was utilized for both dairy sizes. This is a limitation of the research dictated by unavailability of data for varying dairy sizes. Figure 4.3 shows the historical Idaho feed costs over time. Notably high feed costs can be found during recession-type events or periods of higher-than-normal market volatility.

Figure 4.3 – Idaho Feed Costs/CWT 2005-Present Day



Veterinary & Medicine Costs

Veterinary and medicine costs are essential to keep healthy dairy cows which are responsible for the production of revenue stream for the dairy. Dairy farmers cannot avoid this cost if they want to push production capacity of cows. Veterinary cost data from the ERS also includes artificial insemination costs, which is the primary method of breeding cows in the dairy industry. Veterinary and medicine costs vary from dairy-to-dairy based on various factors such as location, relationship with the veterinarian, if an operation has its own semen production – these variations contribute to the differences in veterinary and medicine costs between dairies of varying sizes and within the same size demographic. Due to the varying costs, average cost data as reported by dairy farmers to the USDA is about the only way to evaluate the impact of veterinary and medicine expense on a dairy operating margin.

Bedding & Litter Costs

Bedding and litter costs are necessary to ensure animal comfort and health. Bedding and litter costs experience a lack of correlation between dairy operations for many of the same reasons as veterinary and medicine costs. The standard deviation of bedding and litter costs in Table 4.1 and 4.2 show just how much costs can vary on average. Despite this variation in price these costs are an important factor in the operating margin of a dairy farm and was included in the calculations.

Marketing Costs

Marketing costs are very similar based on geographic region and size. The correlation in size can be seen in Table 4.3 where small and large marketing costs have a near 100% correlation statistic. Marketing cost have changed very little over time compared to other operating costs experienced by a dairy farmer. In fact the average annual marketing cost over the last five years for both small (200-499 cows) and large (1,000+ cows) has not changed.

Custom Services Costs

Custom services are a normal expectation of a dairy operation. Many dairy farmers hire nutritionists – without them it is extremely difficult for a dairy farmer to gain the best production level possible. Nutritionists provide information to dairy producers on optimal ration mixes depending on season, temperature, and production cycle. While 71 percent correlation of custom service costs amongst dairy operations is not ideal, the slight divergence in values likely comes from different company prices among the participants in the industry.

Energy (Fuel, lube, electricity) Costs

An operation cannot function if the lights are not able to stay on and power is not available for milk machines. While energy costs can vary on usage amount and geographic location the values that the USDA was able to gather from dairy producers remains highly correlated across dairy operations (82 percent).

Repair Costs

Many types of machinery and infrastructures can be found on a dairy operation, all of which need maintenance and upkeep over time to continue to perform. Repair costs across dairy operations are very highly correlated (Table 4.3), but can be impacted by available experts, on-hand staff knowledge, and service providers. Being able to transport feed and house dairy cows is necessary for production and impactful to the operating margin that a dairy farmer receives.

Other Operating Costs

Other operating costs as reported by the USDA ERS include: machinery and equipment, housing, manure handling, feed storage structures, and the dairy breeding herd. While the values of these costs are relatively minimal due to differing operational styles of dairies it is an important factor for each individual dairy producer to consider in the analysis of their own operating margin and break-even price.

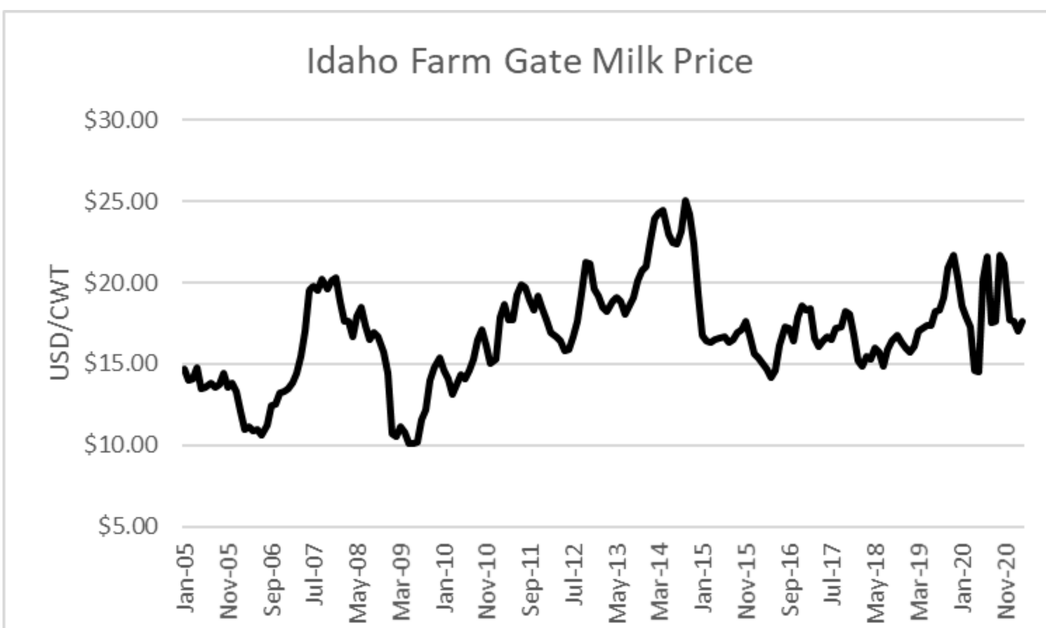
Interest on Operating Capital

Interest on operating capital is a natural occurrence as agricultural costs of operations are high and require loans or other funding to function. The experts on our panel in the lending industry work with many dairy operations with each having different funding needs. The greatest risk to price fluctuations for this input variable is changing interest rates by the Federal Reserve.

Idaho Farm Gate Milk Price

The revenue factor for the operating margin in our model dairy farm is the milk price received per cwt of milk by a producer. This data was provided by StoneX and is specific to the average price that Idaho dairy farmers receive at the production level. Using Idaho specific data, we are more accurately able to model the impact of our strategies on the operating margin for Idaho dairy producers. Figure 4.4 shows the Idaho farm gate milk price over our analysis time frame. Other revenue streams such as culling cattle were not considered as they were not part of the scope of this research. We focus on risk management success in limiting price risk on milk production.

Figure 4.4 – Idaho Farm Gate Milk Price/CWT 2005-Present Day



4.3 – Strategy Construction and Analysis

Based on the results from our expert panel Delphi Method, we developed two tier strategies, one tier for small dairies (using 350 head – the midpoint of the 200-499 range cows[8]) and for large (1,000 head[9]) dairies, and one strictly for large dairies. Strategies possible for both small and large dairies included DMC and DRP, as recommended, while large dairy strategies (Tier 2) included the addition of futures contracts. Due to the relatively new usage of options compared to our historical timeline, data availability prohibited an evaluation of collars in our analysis. The control model using No Risk Management for each dairy herd size was determined using Equation 4.3:

Equation 4.3 – Operating Margin Achieved Using No Risk Management

$$M(x) = FG(x) - COGS(x)$$

Where: FG(x) is the Idaho farm-gate milk price for a given observation

COGS(x) is the total cost of input variables for a given observation

Dairy Margin Coverage (DMC)

Dairy Margin Coverage (DMC), the first of our Tier 1 risk management strategies in accordance with our expert panel opinion, was based on the first tier of DMC coverage by the USDA under the highest margin coverage ($9.50). The operating margin achieved under DMC is calculated using Equation 4.4:

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[8] 350 cows equates to roughly 9.5 M pounds of milk production per year (350*75(lbs/day)*30 days*12 months)

[9] 1,000 cows equates to roughly 27 M pounds of milk production per year (1,000*75(lbs/day)*30 days*12 months)

Equation 4.4 – Operating Margin Equation Using DMC

$$M_{DMC}(x) = 0.185(DMC(x) - (COGS(x) + P(x))) + 0.815M(x) \text{ when } FM < \$9.50$$

and

$$M_{DMC}(x) = M(x) \text{ when } FM > \$9.50$$

Where: DMC(x) is the revenue achieved when using DMC

P(x) is the cost of premium for a given observation

M(x) is the operating margin achieved using No Risk Management

FM is the Feed Margin according to DMC

Costs and protection values can be seen in Figure 4.5. Under DMC Tier 1 coverage of 5 million pounds of milk or less is covered for a cost of $0.15/cwt. For a small dairy, DMC coverage of five million pounds accounts for roughly 55 percent of dairy production per month, while a large dairy DMC covers roughly 19 percent of monthly dairy production.

Figure 4.5 – DMC Premium Schedule by Tier

Coverage Level	Tier 1 Premium per cwt for covered production history of 5 mil lbs. or less	Tier 2 Premium per cwt, all years for covered production history over 5 mil lbs.
$4.00	None	None
$4.50	$0.0025	$0.0025
$5.00	$0.005	$0.005
$5.50	$0.030	$0.100
$6.00	$0.050	$0.310
$6.50	$0.070	$0.650
$7.00	$0.080	$1.107
$7.50	$0.090	$1.413
$8.00	$0.100	$1.813
$8.50	$0.105	N/A
$9.00	$0.110	N/A
$9.50	$0.150	N/A

Operating margins for this strategy were calculated and compared to the operating margins if no risk management was utilized (see Table 4.4). A quick observation of the results finds that for both small and large dairies, DMC yields a larger mean operating margin than not utilizing risk management. For small dairies, the average operating profit per cwt of milk is higher ($6.72/cwt) than the large dairy ($5.49/cwt) due to coverage being spread over a larger percentage of the production for small versus large dairies. For the same reasons, DMC for small dairies leads to a much smaller ability for milk price volatility to impact operating margin. This disparity in percentage of production covered is also reflected in the coefficient of variation for small dairies (18 percent) being more than half of that of the large dairy (39 percent). The strategy of No Risk Management is worse with notably lower average operating margin ($4.61/cwt) and a much higher coefficient of variation (56 percent) for large dairies. Figures 4.6 and 4.7 display the distribution of the operating margin that would have been experienced had a small and large producer used DMC as a risk management strategy.

Table 4.4 – Dairy Margin Coverage (DMC) Summary by Farm Size

	Small Dairy		Large Dairy	
	No Risk Management	DMC	No Risk Management	DMC
Mean ($/CWT)	3.50	6.72	4.61	5.49
StDev	2.61	1.20	2.60	2.15
95 % LCI	3.07	6.53	4.19	5.15
95 % UCI	3.92	6.92	5.03	5.84
Min ($/CWT)	-3.16	3.72	-2.14	-0.01
Median ($/CWT)	3.09	6.53	4.34	5.27
Max ($/CWT)	10.99	10.99	12.53	12.53
Coeff. of Var.	78 %	18 %	56 %	39 %

A *t*-test was performed to test the statistical significance among the means achieved through DMC for the different dairy sizes. Both means for small and large dairies when using DMC were found to be statistically different from the No Risk Management strategy at the 5 percent significance level (Table 4.5).

Table 4.5 – Two Tailed *t*-test Results for Statistical Difference among DMC and no Risk Management means

	Small Dairy DMC to no RM	Large Dairy DMC to no RM
***t*-stat**	31.9038	27.1271
p-value	0.0000	0.0000
***t*-crit**	1.9723	1.9723
H_0: Difference between means = 0; N=195		

A F-test was done to compare the variances of DMC to the practice of using the No Risk Management strategy in both models. This test proves the effect of a risk management strategy to protect against volatility at a statistically significant level from using no risk management. The results of the F-test is presented in Table 4.6, which shows that DMC in both the small and large dairy models have statistically different variances compared to not using risk management.

Table 4.6 - F-test Results for Statistical Difference among DMC and no Risk Management Variances

	Small Dairy DMC to no RM	**Large Dairy DMC to no RM**
f-stat	0.2124	0.6821
p-value	0.0000	0.0000
f-crit	0.7892	0.7892
H_0: Difference between variances = 0; N=195		

Figure 4.6 – Distribution of Operating Margin Received by a Dairy Farmer in a Small Dairy Model under DMC

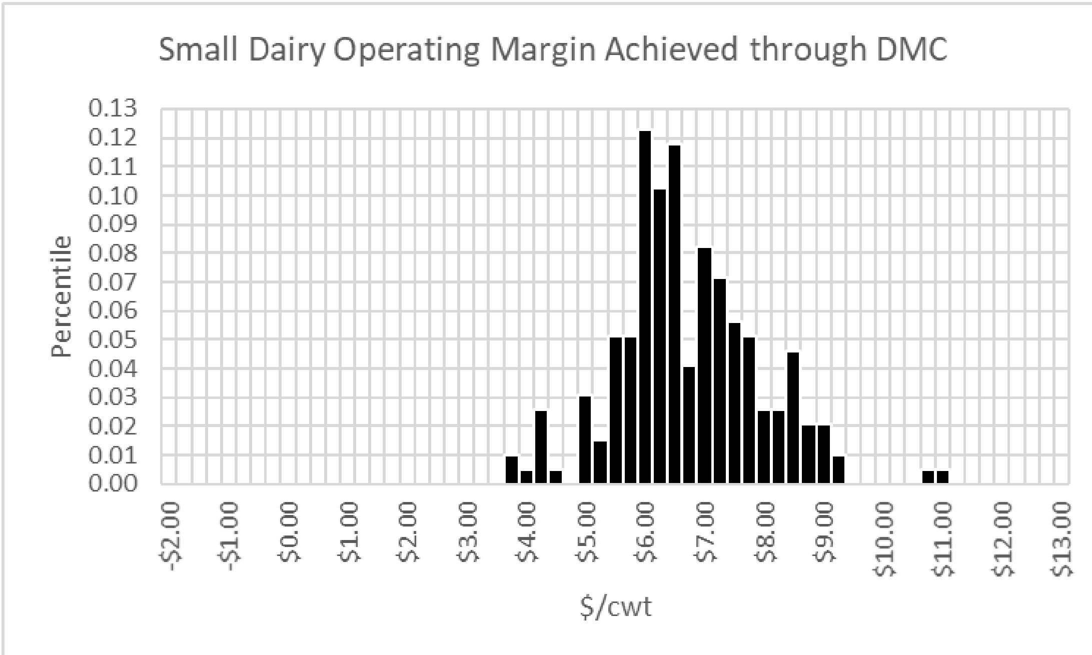
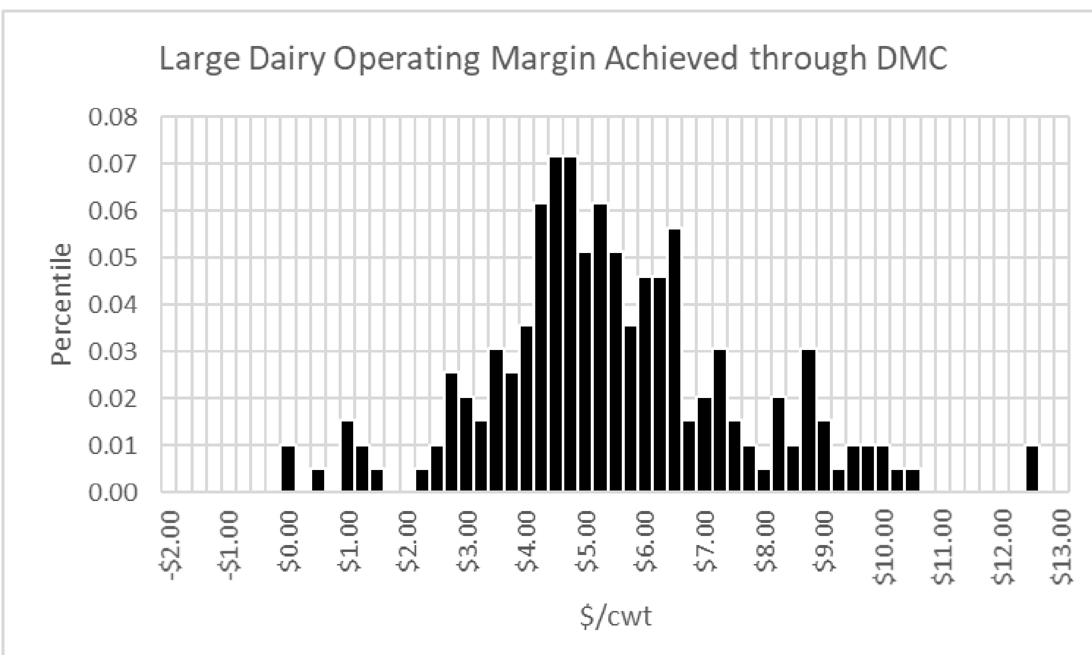


Figure 4.7 – Distribution of Operating Margin Received by a Dairy Farmer in a Large Dairy Model under DMC



Stochastic dominance with respect to a function (SDRF) analysis was performed to determine the relationship of DMC usage for different operating size compared to not using risk management. Using Simetar, an analytic software specialized for evaluating stochastic dominance, we were able to test for first and second order stochastic dominance. Figures 4.8 and 4.9 show the cumulative distribution functions (CDFs) of operating margin achieved by DMC use for each operation size compared to the usage of no risk management.

Upon evaluation of the CDF graphs, we see that DMC usage for our small dairy model first and second order stochastically dominates that of No Risk Management strategy. In the large dairy operation model while the graph does not appear to show the strategies crossing, DMC is only second order dominant. The stochastic dominance table produced by the SIMETAR software can be seen in Tables 6.1 and 6.2 and confirms the visual representation in the CDF figures.

Figure 4.8 – Cumulative Distribution Function Comparing DMC results on Operating Margin to no Risk Management for Small Dairy Model

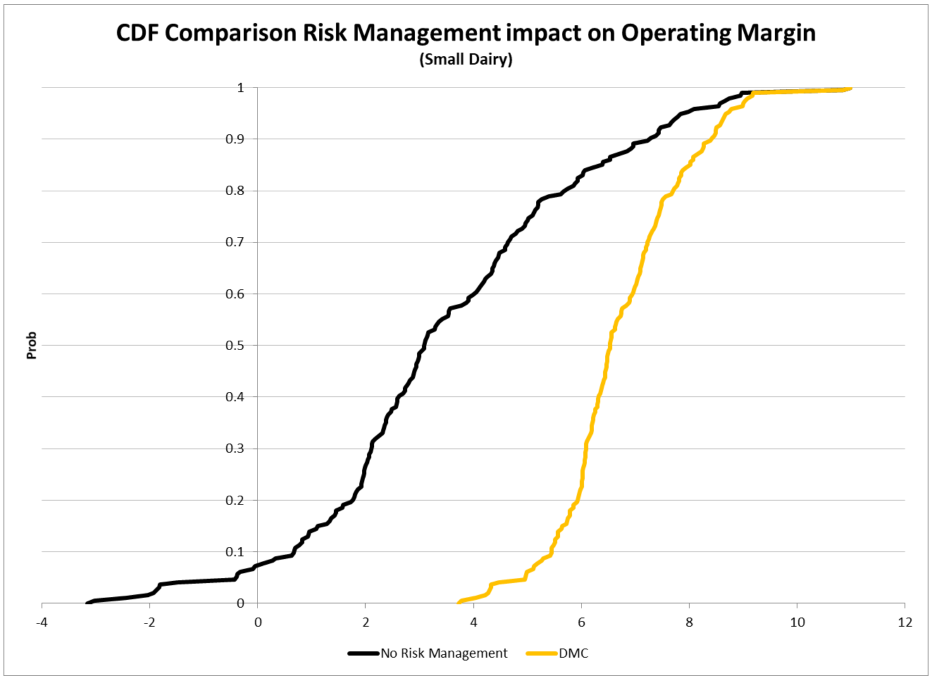
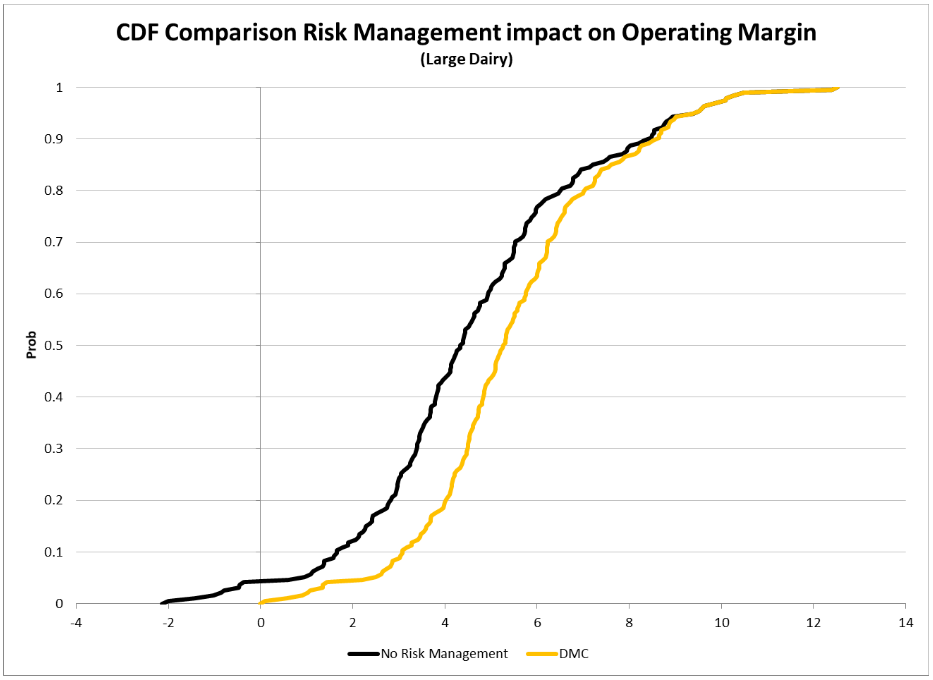


Figure 4.9 – Cumulative Distribution Function Comparing DMC results on Operating Margin to no Risk Management for Large Dairy Model



Using stochastic efficiency with respect to a function (SERF) allows us to look at the success of a strategy with respect to the risk attitude that a dairy farmer might have. In Figures 4.10 and 4.11 we can see that for any level of risk aversion represented by Average Risk Aversion Coefficient (ARAC), DMC is always the more optimal strategy for both model sizes. For the small dairy model, the certainty equivalent (CE) is also shown to be nearly flat, showing that values of operating margins to be expected under DMC in this model are nearly equal for any risk attitude.

Figure 4.10 – Stochastic Efficiency Analysis of DMC versus no Risk Management in the Small Dairy Model

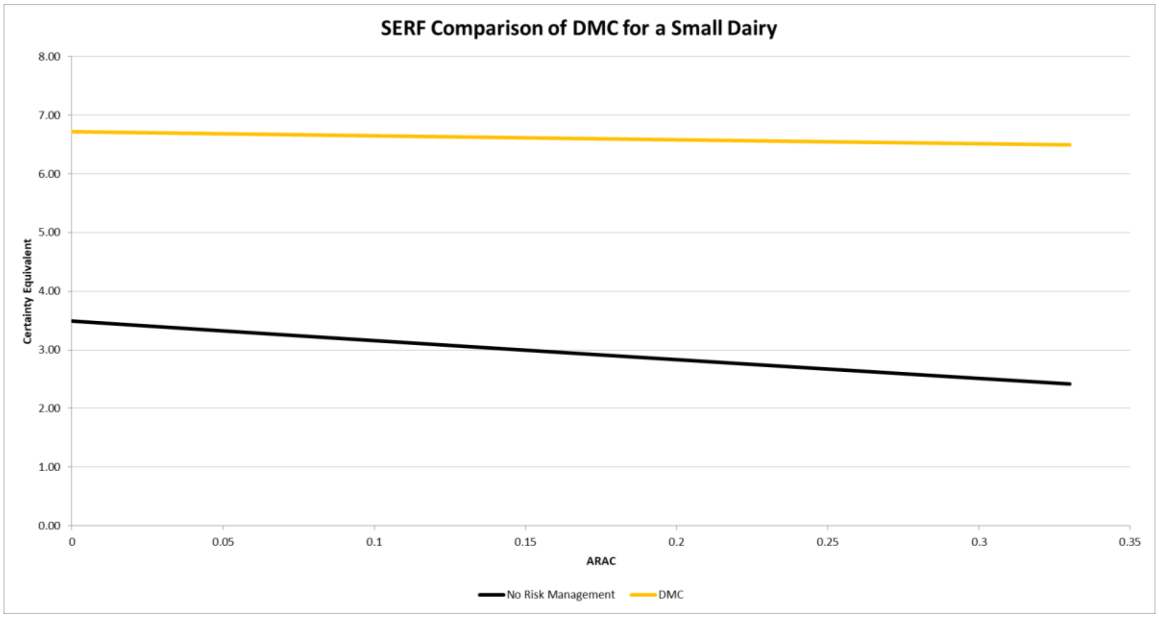
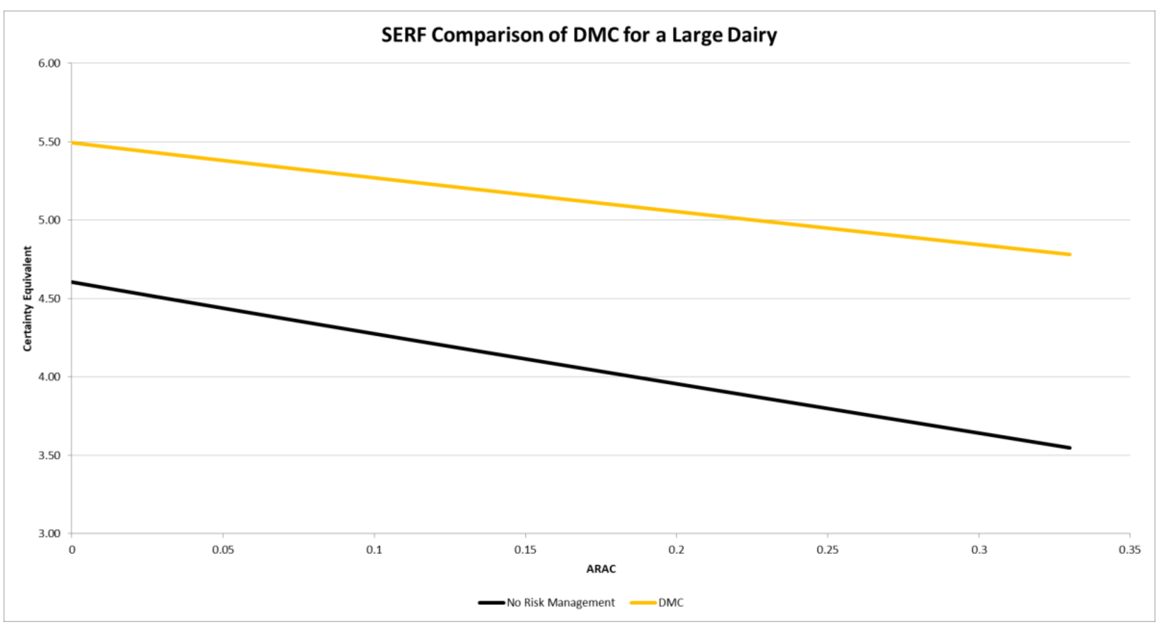


Figure 4.11 – Stochastic Efficiency Analysis of DMC versus no Risk Management in the Large Dairy Model



Dairy Revenue Protection (DRP)

Dairy Revenue Protection is government subsidized insurance package designed to insure against unexpected declines in the quarterly revenue from milk sales relative to a guaranteed coverage level. The expected revenue is based on futures prices for milk and dairy commodities, and the amount of covered milk production elected by the dairy producer. In this study the research utilized the advice of our expert panel and choose to use a 95 percent coverage level. Cost of premiums and resulting payouts over time are included in the calculation to reach the achieved operating margin by dairy size and time of implementation. DMC coverage can be placed anytime up-to 15 months out. A benefit to DRP is that if a producer is not paid an indemnity and a premium payment is required it is due in arears (after the quarter being covered has been completed). This study looked at the success of implementing DRP at intervals of one, three, six, nine, and twelve months away from the quarter being covered on a Class III basis. The operating margin achieved using DRP was calculated using Equation 4.5:

Equation 4.5 – Operating Margin Achieved Using DRP

$$M_{DRP}(x) = DRP(x) - (COGS(x) + P(x))$$

Where: DRP(x) is the revenue achieved using DRP

Reviewing the summary statistics for each DRP model in Tables 4.7 and 4.8 (small and large dairies, respectively) show that the highest average operating margin achieved through DRP is placing coverage nine months out in both the small and large dairy model. Both of our dairy models also experience the lowest amount of variation at the nine-month timeframe. All DRP methods, except for the one-month time frame, provide a higher average operating margin than not using risk management. DRP success is a combination of finding a time in which premium is not too high and when futures prices offer a carry in the market that will provide benefit to the dairy producer's price exposure. Figures 4.12 and 4.13 shows the distribution of operating margin per cwt of milk returned to a dairy producer under our small and large dairy models when placing DRP coverage nine-months.

Table 4.7 – Dairy Revenue Protection (DRP) Summary for the Small Dairy Model

	No RM	DRP 1	DRP 3	DRP 6	DRP 9	DRP 12
Mean ($/CWT)	3.50	3.48	3.64	3.73	3.74	3.73
StDev	2.61	2.53	2.44	2.34	2.26	2.26
95 % LCI	3.07	3.07	3.25	3.35	3.38	3.37
95 % UCI	3.92	3.89	4.04	4.10	4.11	4.10
Min ($/CWT)	-3.16	-2.77	-3.32	-2.19	-2.26	-2.30
Median ($/CWT)	3.09	3.03	3.24	3.66	3.53	3.69
Max ($/CWT)	10.99	10.87	10.79	10.74	10.67	10.63
Coeff. of Var.	78 %	76 %	70 %	65 %	62 %	63 %

Table 4.8 – Dairy Revenue Protection (DRP) Summary for the Large Dairy Model

	No RM	DRP 1	DRP 3	DRP 6	DRP 9	DRP 12
Mean ($/CWT)	4.61	4.59	4.75	4.84	4.85	4.84
StDev	2.60	2.52	2.42	2.31	2.22	2.23
95 % LCI	4.18	4.18	4.36	4.46	4.49	4.48
95 % UCI	5.03	5.00	5.14	5.21	5.21	5.20
Min ($/CWT)	-2.14	-1.75	-2.30	-0.72	-0.79	-0.83
Median ($/CWT)	4.34	4.33	4.44	4.52	4.59	4.62
Max ($/CWT)	12.52	12.40	12.32	12.27	12.20	12.16
Coeff. of Var.	56 %	55 %	51 %	48 %	46 %	46 %

A *t*-test was performed to test the statistical significance of using DRP as a risk management tool (Tables 4.9 and 4.10). Using DRP one month prior to the quarter being insured, the mean is shown to not be statistically significant at the five percent significance level for either the small or large model dairy. Placing coverage at six-, nine-, and twelve-month time frames show the most optimal success according to our summary statistics.

Table 4.9 – Two Tailed *t*-test Results for Statistical Difference among DRP and no Risk Management Means in the Small Dairy Model

DRP models compared to No RM	DRP 1	DRP 3	DRP 6	DRP 9	DRP 12
***t*-stat**	-0.6115	2.7099	2.5805	2.2501	2.1485
p-value	0.2708	0.0037	0.0053	0.0128	0.0165
***t*-crit**	1.9723	1.9723	1.9723	1.9723	1.9723
H_0: Difference between means = 0; N=195					

Table 4.10 – Two Tailed *t*-test Results for Statistical Difference among DRP and no Risk Management Means in the Large Dairy Model

DRP models compared to No RM	DRP 1	DRP 3	DRP 6	DRP 9	DRP 12
***t*-stat**	-0.6115	2.7099	2.5805	2.2501	2.1485
p-value	0.2708	0.0037	0.0053	0.0128	0.0165
***t*-crit**	1.9723	1.9723	1.9723	1.9723	1.9723
H_0: Difference between means = 0; N=195					

Like we did for DMC, an F-test was performed to confirm that the variances of using DRP was statistically different from using No Risk Management (Table 4.11 and 4.12). The test provided further indication of the *t*-test results that DRP at a one-month interval is not statistically significant at a five percent level. Given that DRP at a one-month interval was found to be statistically no different than using No Risk Management and further analysis of this method would be unproductive, thus no SDRF or SERF were conducted for this option. It also showed that DRP at three- and six-month intervals did not reduce the variance to a statistically significant level at a five percent level. DRP used at nine and twelve months was found to limit the variance to a statistically significant level given a 5 percent alpha level. These results hold true for both the small and large dairy models.

Table 4.11 – F-test Results for Statistical Difference among DRP and no Risk Management Variances in the Small Dairy Model

DRP models compared to No RM	DRP 1	DRP 3	DRP 6	DRP 9	DRP 12
F-test	0.9397	0.8723	0.8057	0.7473	0.7497
p-value	0.3326	0.1711	0.0667	0.0216	0.0228
F-crit	0.7892	0.7892	0.7892	0.7892	0.7892
H_0: Difference between variances = 0; N=195					

Table 4.12 – F-test Results for Statistical Difference among DRP and no Risk Management Variances in the Large Dairy Model

DRP models compared to No RM	DRP 1	DRP 3	DRP 6	DRP 9	DRP 12
F-test	0.9351	0.8673	0.7916	0.7302	0.7321
p-value	0.3204	0.1612	0.0522	0.0145	0.0152
F-crit	0.7892	0.7892	0.7892	0.7892	0.7892
H_0: Difference between variances = 0; N=195					

Figure 4.12 – Distribution of Operating Margin Received by a Dairy Farmer in a Small Dairy Model under DRP at 9 Months

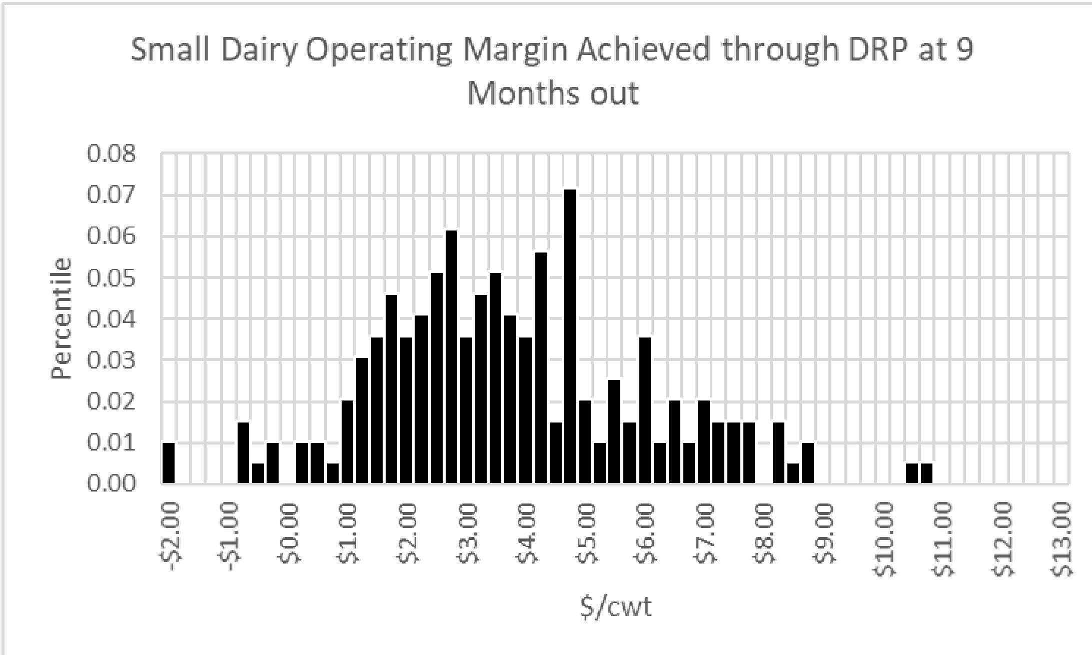
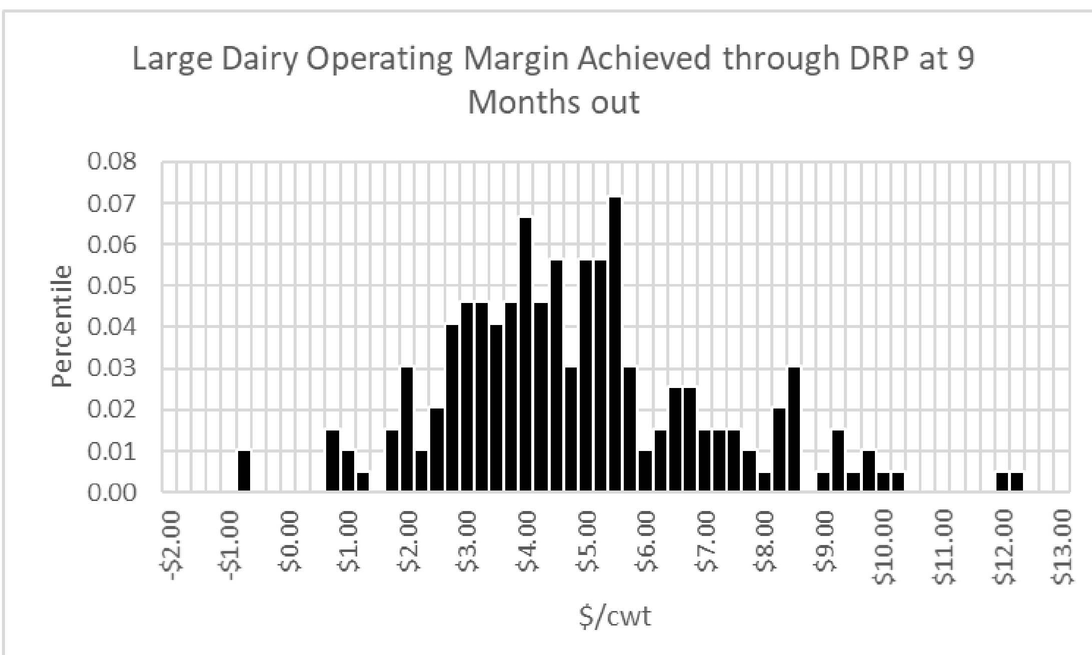


Figure 4.13 – Distribution of Operating Margin Received by a Dairy Farmer in a Large Dairy Model under DRP at 9 Months



Stochastic dominance analysis for DRP results were performed in the same fashion as it was done for DMC. Figure 4.14 and 4.15 show the cumulative distribution functions for both the small and large dairy model as it relates to the use of DRP in our simplified break down at six-, nine-, and twelve-month placements of coverage. We can see that for both models DRP's biggest benefit is protecting against the worst months where operating margin is at its lowest value. No placement period of DRP was found to be stochastically dominant in the first order, but placement at six-, nine-, and twelve-month time periods were found to be stochastically dominant in the second order of using no risk management. Tables 6.1 and 6.2 confirms this.

Figure 4.14 – Cumulative Distribution Function Comparing DRP results on Operating Margin to no Risk Management for Small Dairy Model

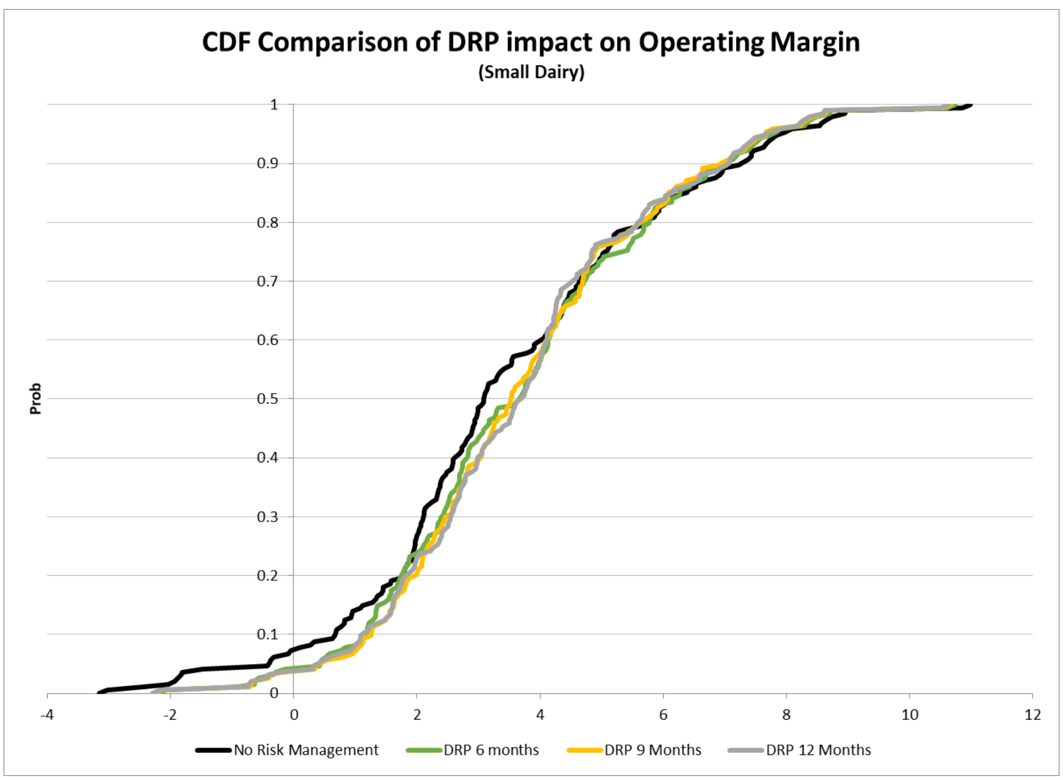
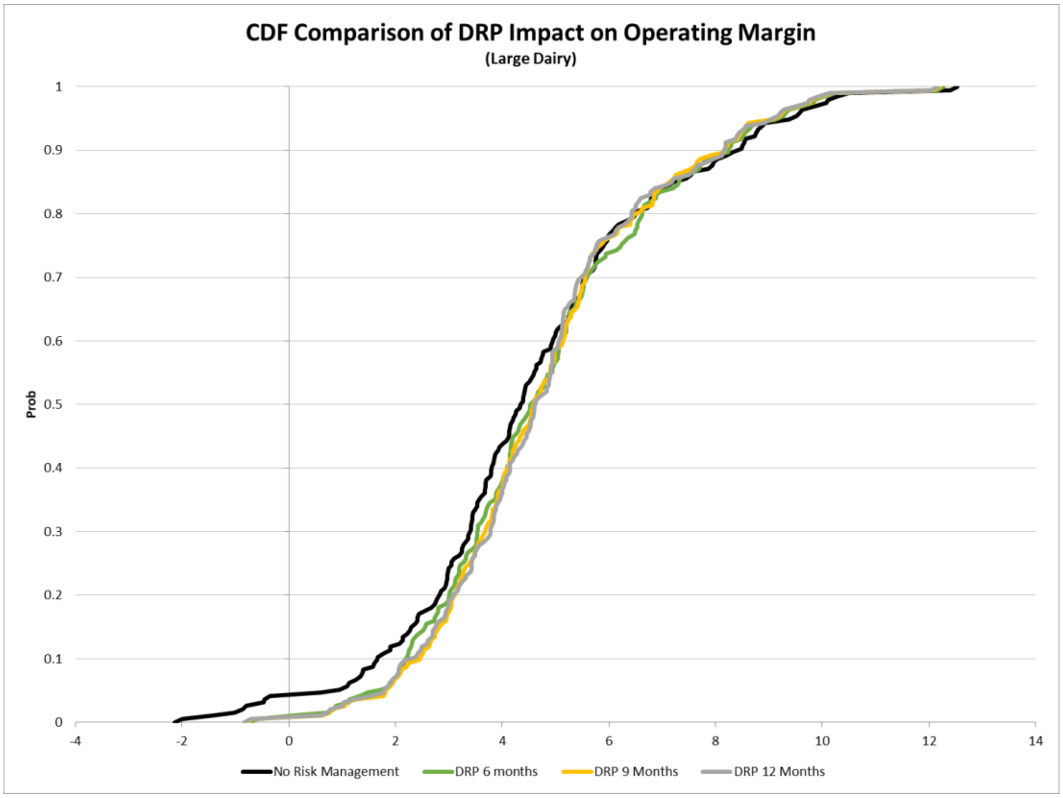


Figure 4.15 – Cumulative Distribution Function Comparing DRP results on Operating Margin to no Risk Management for Large Dairy Model



A SERF test was completed for our DRP options at six-, nine-, and twelve-month intervals (Figures 4.16 and 4.17). These results showed the for both dairy sizes any producer, regardless of risk attitude should expect to gain a higher operating margin when using DRP compared to no risk management. We can also observe that a risk for dairy producers with higher risk tolerance (ie. a lower ARAC), that the DRP options for our three time periods are nearly equal. On the other-hand dairy producers that are more risk averse should utilize DRP at either the nine- or twelve-month interval, with a nine-month interval being slightly higher.

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Figure 4.16 – Stochastic Efficiency Analysis of DRP versus no Risk Management in the Small Dairy Model

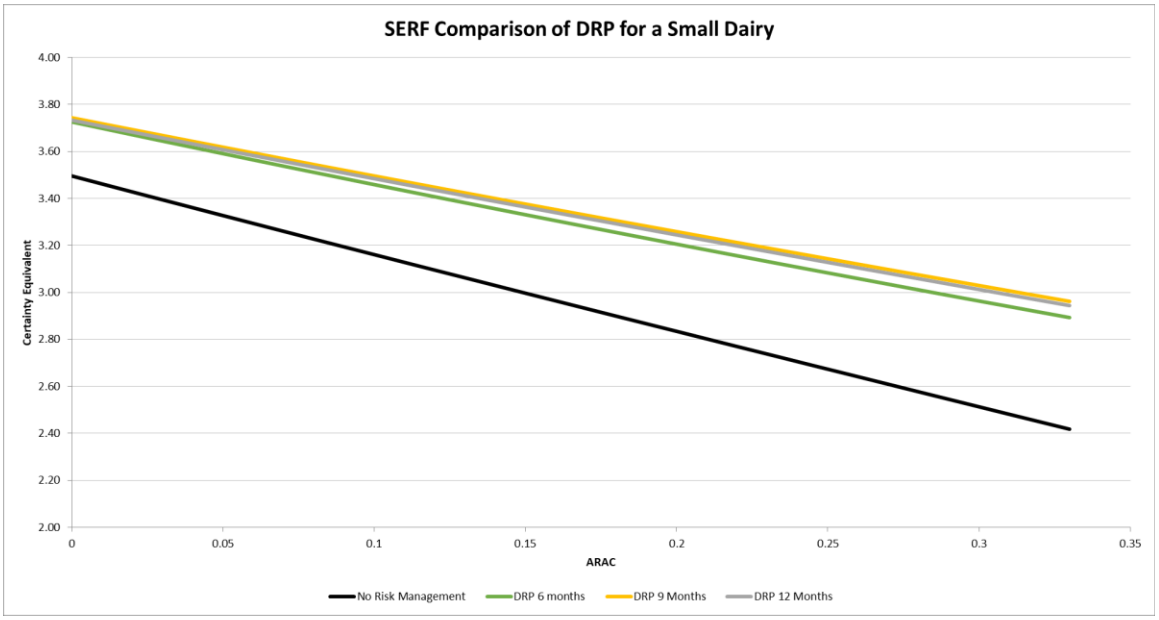
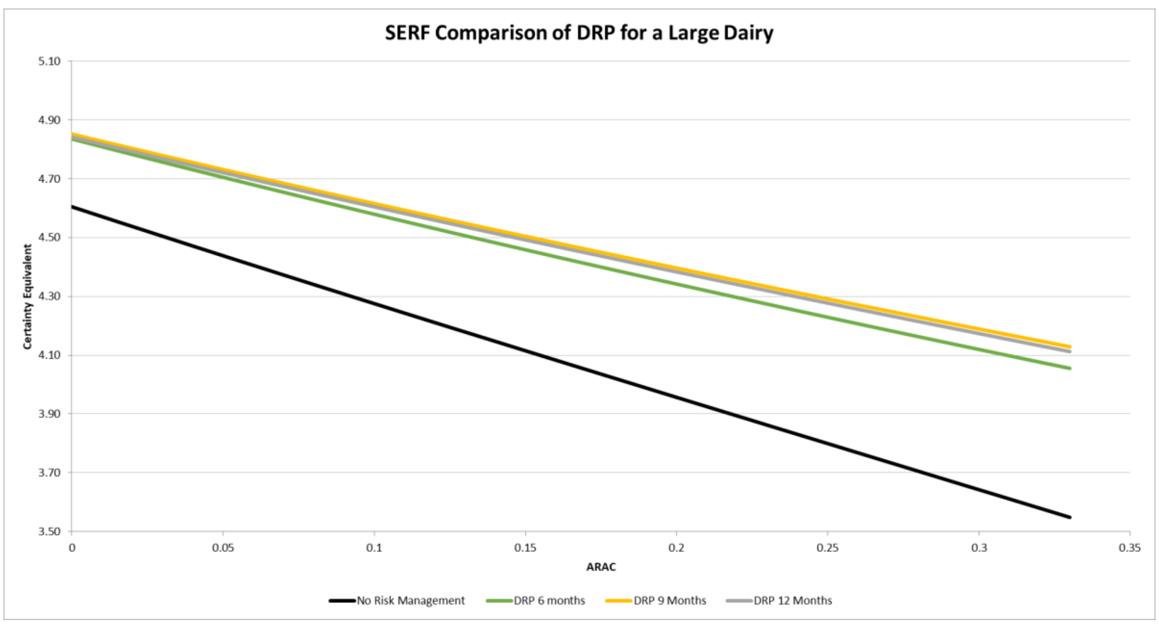


Figure 4.17 – Stochastic Efficiency Analysis of DRP versus no Risk Management in the Large Dairy Model



Futures

As mentioned by our expert panel, futures are not a preferrable tool to utilize for dairy producers if production is not large enough or if there is not enough flexible capital to cover margin and commission costs. For that reason, futures contracts were only analyzed in our large dairy model. Futures contracts represent 200,000 pounds of milk, and we have chosen to evaluate Class III futures as they represent the majority of milk produced in Idaho which is primarily used in cheese production. The costs or commission paid to use a broker service to hedge using futures was derived from our current trading program at the University of Idaho which is $50/contract. Our model assumes all production will be hedged using futures. The goal of futures is to place a trade at a point in which a profit margin is achieved that will keep a farm in business, or to establish a price for the milk that will be sold, where the futures contract will provide value if the price of milk falls below that level.

Common futures strategies as discussed in our expert panel included trading futures at three- or six-month intervals. We evaluated scenarios using Equation 4.6:

Equation 4.6 – Operating Margin Achieved Using Futures

$$M_{FUT}(x) = F(x) - (COGS(x) + C(x))$$

Where: F(x) is the revenue achieved when using futures

C(x) is the commission costs for a given observation

Futures analysis was modeled in three- and six-month timeframes where futures were only traded if the average monthly price received was higher than the 70 percent decile of the five-year historical price series, and if futures were to be traded every month in this timeframe. We see in Table 4.13 there is no futures strategy under our model that returns a higher average operating margin than our control model of no risk management usage. A conclusion from these results is futures should not be a stand-alone strategy, supporting our experts' belief that futures needs to be utilized in conjunction with Tier 1 risk management strategies as a flexible strategy to capture incremental moments of higher prices. Futures do provide a lower standard deviation and coefficient of variation at a statistically significant level of 0.05 compared to not using risk management, which does speak to their ability to protect against the volatility of milk price. Given futures were designed to shift risk, this result is in line with.

Table 4.13 – Futures Summary for Large Dairy Model

	No RM	Futures 3 Month	Futures 6 Month	Futures Trade Every Month (3 Months)	Futures Trade Every Month (6 Months)
Mean ($/CWT)	4.61	4.20	4.16	3.75	3.77
StDev	2.60	2.08	2.18	1.78	1.37
95% LCI	4.18	3.86	3.81	3.47	3.55
95% UCI	5.03	4.54	4.51	4.04	3.99
Min ($/CWT)	-2.14	-2.14	-2.14	-1.47	0.55
Median ($/CWT)	4.34	4.24	4.20	3.63	3.83
Max ($/CWT)	12.52	12.40	12.52	8.38	7.45
Coeff. of Var.	56 %	50 %	52 %	48 %	36 %

Like our other strategies a *t*-test was completed in order to test the statistical significance of using futures as a risk management strategy compared to no risk management.

While the means of all futures strategies were found to be statistically significant the *t*-statistic shows that futures tend to be a poor stand-alone strategy in managing risk (Table 4.14).

Table 4.14 – Two Tailed *t*-test Results for Futures and no Risk Management Means in the Large Dairy Model

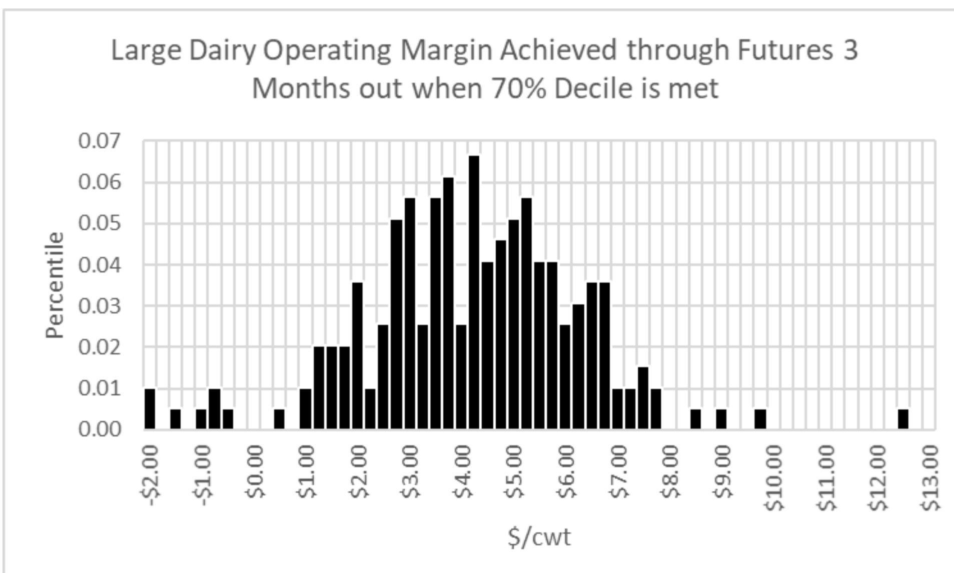
Futures compared to No RM	Futures 3 Month	Futures 6 Month	Futures Trade Every Month (3 Months)	Futures Trade Every Month (6 Months)
***t*-stat**	-4.4823	-4.4752	-7.1496	-5.6367
p-value	0.0000	0.0000	0.0000	0.0000
***t*-crit**	1.9723	1.9723	1.9723	1.9723
H_0: Difference between means = 0; N=195				

Using a F-test for futures (Table 4.15), like the other tools analyzed, we were able to conclude that trading futures under both the three- and six-month 70 percent decile strategy provides a statistically significant smaller variance from not using risk management. The F-test did show that trading futures every month at the three and six months out did not limit variance enough to be statistically significant at a five percent level.

Table 4.15 – F-test Results for Statistical Difference among Futures and no Risk Management Variances in the Large Dairy Model

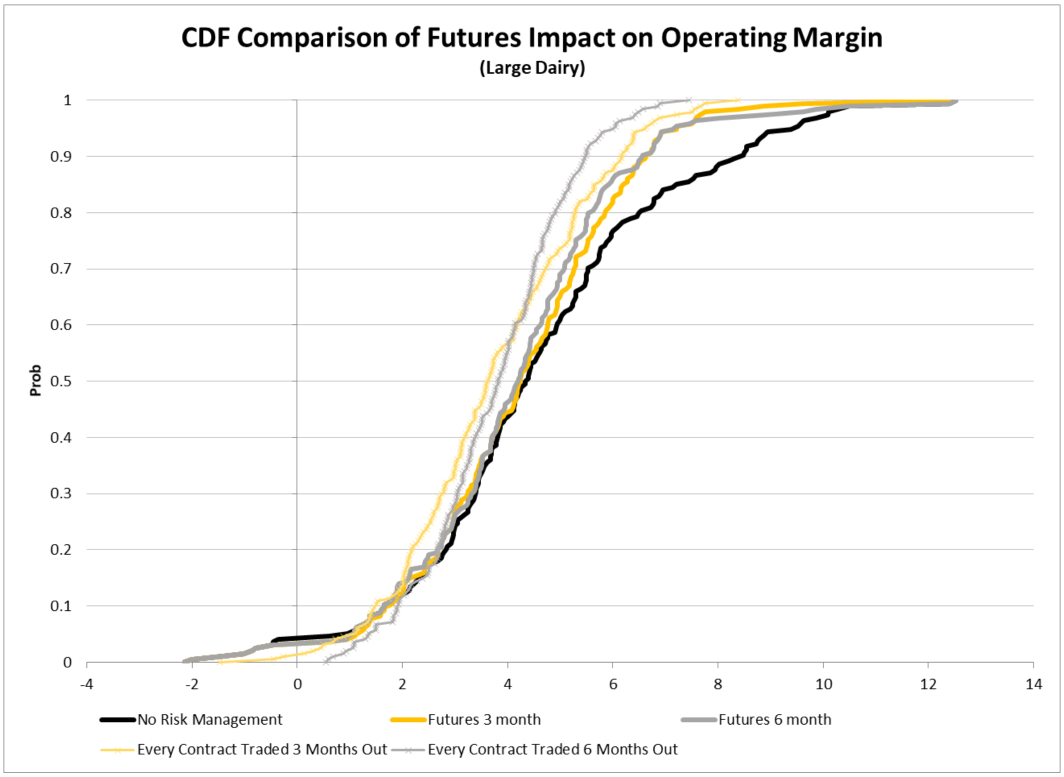
Futures compared to No RM	Futures 3 Month	Futures 6 Month	Futures Trade Every Month (3 Months)	Futures Trade Every Month (6 Months)
F-test	0.6421	0.7036	0.4707	0.2785
p-value	0.0011	0.0074	0.4707	0.2785
f-crit	0.7892	0.7892	0.7892	0.7892
H_0: Difference between variances = 0; N=195				

Figure 4.18 – Distribution of Operating Margin Received by a Dairy Farmer in a Large Dairy under Futures 3-months out when the 70 percent decile is met



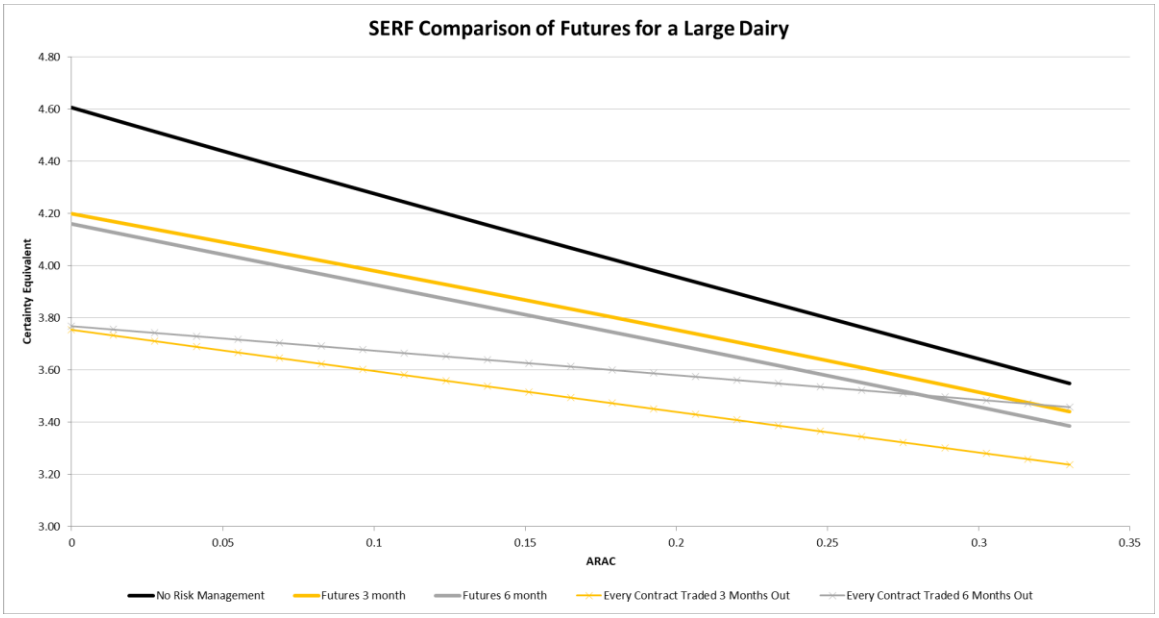
To show the impact of futures as a risk management strategy we have to look no further than Figure 4.19 where the cumulative distribution function shows that no risk management is clearly better than only using futures to manage risk in terms of operating margin payout. Trading futures at a 3-month basis under the 70 percent decile rule was found to have second-order stochastic dominance over the 6-month strategy. Trading futures at a 6-month basis every month was found to have second-order stochastic dominance over the 3-month every month strategy, these results can seen as well in Tables 6.1 and 6.2.

Figure 4.19 – Cumulative Distribution Function Comparing Futures results on Operating Margin to no Risk Management for Large Dairy Model



The SERF comparison of using Futures is depicted in Figure 4.20. The results show that Futures under our model are not favorable when used alone compared to No Risk Management. For the most risk averse dairy farmer trading Futures every month at six-months away from the hedged production was found to be more favorable to the 70 percent decile strategies for both three- and six-month timeframes.

Figure 4.20 – Stochastic Efficiency Analysis of Futures versus no Risk Management in the Large Dairy Model



4.4 – Strategy Combinations

As recommended by our expert panel, diversification among the strategies that a producer uses is important to gain the benefit of each tool available. To that end we have combined the more successful versions from each tool in order to evaluate both the first and second tier risk management tools as a portfolio to protect against milk price volatility. The top three strategy combinations that we analyzed were: DMC + DRP 9 months out (Equation 4.7), DMC + Futures 3 months out (Equation 4.8), and DMC + DRP 9 months out + Futures 3 months out (Equation 4.9).

Equation 4.7 – Operating Margin Achieved Using DMC and DRP

$$M_{DMC/DRP}(x) = M_{DRP}(x)*0.815 + 0.185(M_{DMC}(x) – (COGS(x) + P(x)))$$

Equation 4.8 – Operating Margin Achieved Using DMC and Futures

$$M_{DMC/FUT}(x) = M_{FUT}(x)*0.815 + 0.185(M_{DMC}(x) – (COGS(x) + P(x) + C(x)))$$

Equation 4.9 – Operating Margin Achieved Using DMC, DRP, and Futures

$$M_{DMC/DRP/FUT}(x) = M_{DRP}(x)*0.565 + M_{FUT}(x)*0.25 + 0.185(M_{DMC}(x) – (COGS(x) + P(x) + C(x)))$$

Because some of these strategies included futures contracts they were only analyzed in the large dairy model for comparison. The summary statistics in Table 4.16 show that all three of these strategy combinations provide a far higher average operating margin to dairy farmers than any single strategy. The highest average payout of $5.71/cwt is achieved through the combination of DMC and DRP. While DMC/DRP offers the highest average payout, adding futures to that portfolio provides a lower standard deviation and coefficient of variation, showing that utilizing all three techniques of risk management creates the best protection against the volatility of milk price, both at the mean and variance of results. Figure 4.21 shows the distribution of operating margins achieved by a large dairy producer using the entire grouping of our strategies (DMC+DRP+Futures).

Table 4.16 – Strategy Combination Summary for the Large Dairy Model

	No RM	DMC	DRP 9	DMC + DRP	DMC + Futures	DMC + DRP + Futures
Mean ($/CWT)	4.61	5.49	4.85	5.71	5.29	5.53
StDev	2.60	2.15	2.22	1.88	1.97	1.66
95 % LCI	4.18	5.15	4.49	5.41	4.97	5.26
95 % UCI	5.03	5.84	5.21	6.01	5.61	5.80
Min ($/CWT)	-2.14	-0.01	-0.79	1.08	-0.01	1.60
Median ($/CWT)	4.34	5.27	4.59	5.47	5.19	5.39
Max ($/CWT)	12.52	12.52	12.20	12.52	12.52	12.16
Coeff. of Var.	56 %	39 %	46 %	33 %	37 %	30 %

A *t*-test was completed to test the statistical significance of using portfolios of risk management strategies compared to no risk management. The results of the *t*-test (Table 4.17) show that all of the means are statistically different from the No Risk Management control strategy.

Table 4.17 – Two Tailed *t*-test Results for Combined Strategy Means in the Large Dairy Model

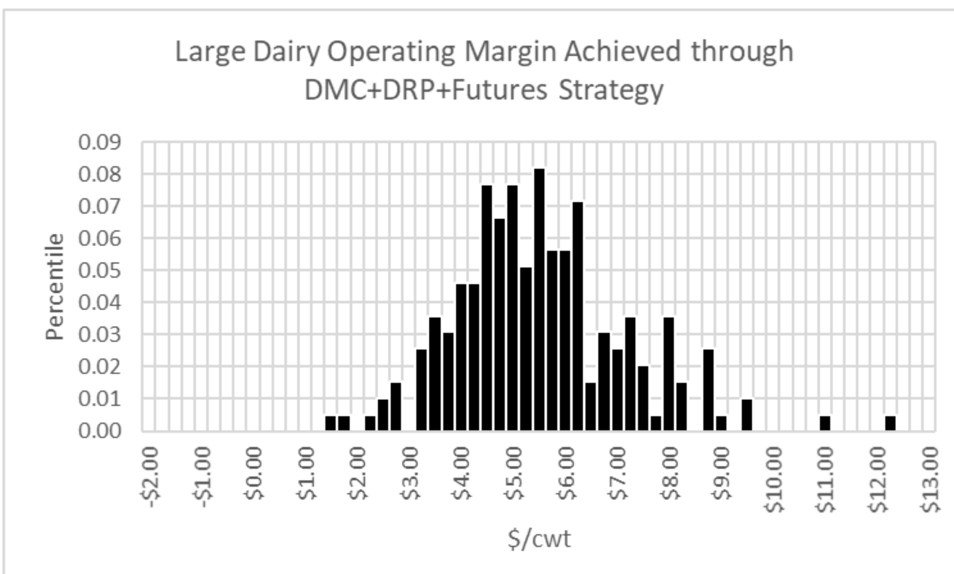
	DMC + DRP	DMC + Futures	DMC + DRP + Futures
***t*-stat**	10.0259	8.5503	9.7737
p-value	0.0000	0.0000	0.0000
***t*-crit**	1.9723	1.9723	1.9723
H_0: Difference between means = 0; N=195			

Using an F-test for our combined strategies, we were able to show that these tools have statistically significant effect on limiting the variance of operating margin for a dairy producer (Table 4.18). All three combined strategies were found to be statistically significant at a 5 percent alpha level.

Table 4.18 – F-test Results for Combined Strategies Variances in the Large Dairy Model

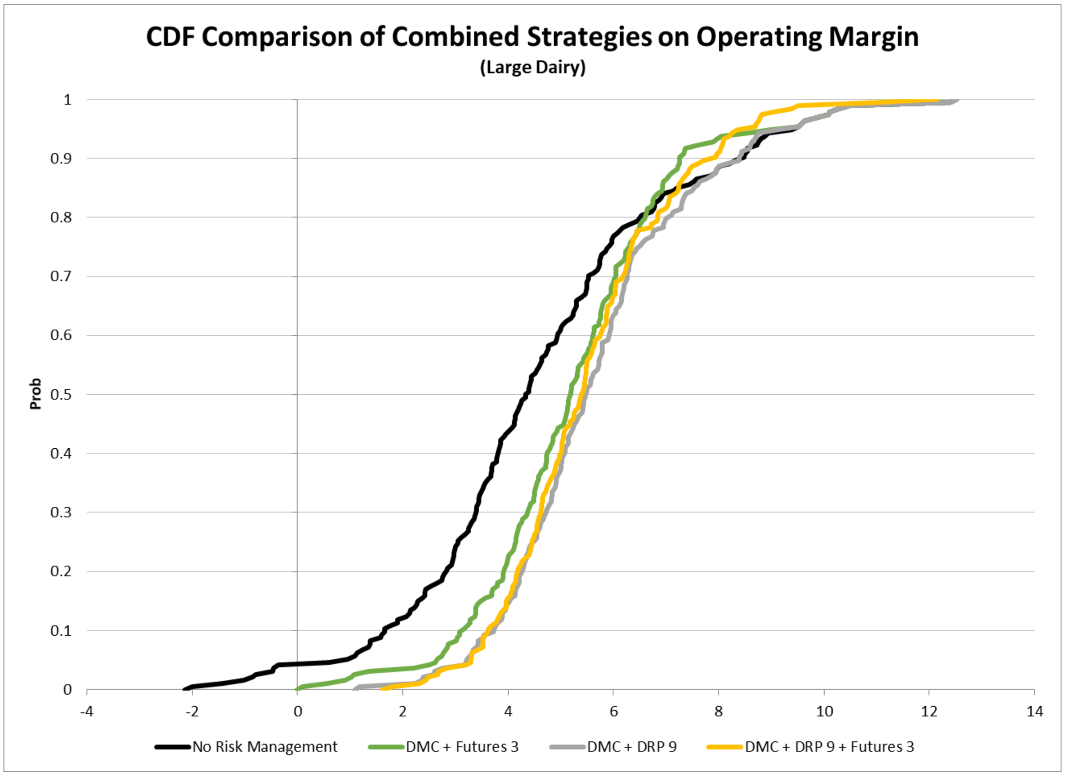
	DMC + DRP	DMC + Futures	DMC + DRP + Futures
F-test	0.5197	0.5731	0.4051
p-value	0.0000	0.0001	0.0000
F-crit	0.7892	0.7892	0.7892
H_0: Difference between variances = 0; N=195			

Figure 4.21 – Distribution of Operating Margin Received by a Dairy Farmer in a Large Dairy using DMC+DRP+Futures Strategy



To determine the stochastic dominance of our combined risk management strategies a cumulative distribution function was graphed (Figure 4.22). The CDFs shows that all three of the combined strategy options provide significant protection for dairy farmers against the worst months where operating margin is at its lowest. While none of the combined strategies were stochastically dominant to the first order, all of them were dominant to the second order, showing that over time they would be preferred. Of the three strategies DMC+DRP is shown to be the best strategy for total returns on operating margin. Tables 6.1 and 6.2 show these results in-line with the CDF functions.

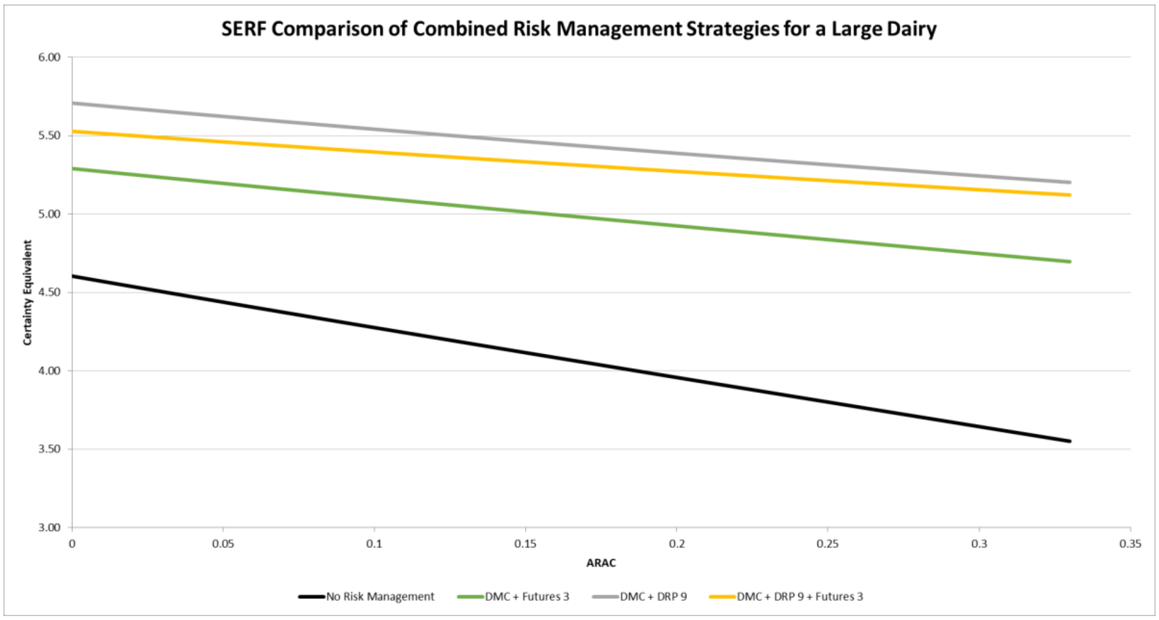
Figure 4.22 – Cumulative Distribution Function Comparing Combined Risk Management Strategies impact on Operating Margin to no Risk Management for Large Dairy Model



Similar to the individual strategies we have compared the combined risk management strategy options using SERF (Figure 4.23). This graph indicated that all of the combined risk management graphs return a much higher operating margin certainty than not using risk management. One notable factor is the convergence of the DMC+DRP strategy towards the

DMC+DRP+Futures strategy showing that the more risk averse a dairy producer might be, the less likely they can be certain that the DMC+DRP option will be more favorable in comparison.

Figure 4.23 – Stochastic Efficiency Analysis of Combined Risk Management Strategies versus no Risk Management in the Large Dairy Model



4.5 – Discussion

This study has provided many important findings for the use of dairy risk management practices in Idaho. The first major finding is that there is significant benefit to dairy producers who engage in risk management. While costs are incurred by participating in any risk management strategy, the only strategy that does not overcome those costs is solely using futures to hedge against price risk. The costs of risk management vary from strategy to strategy but are relatively minimal in relation to the benefit received by their use.

A second major finding is that a combination of risk management strategies is proven to be the most beneficial option for dairy producers. The use of multiple strategies is particularly impactful to continued conversation in the industry about risk attitudes as even risk averse participants in the market can benefit from a combination of risk management tools that holds relatively little risk compared to other risk management tools. DMC and DRP provide the highest average return while a combination of DMC, DRP and Futures provides the best protection against volatility.

The third important finding of this research, while not analyzed, was the feedback from our experts on the way in which producers with different goals engage with risk management tools. While this data was unable to be structured into the static models that the research analyzed there is an opportunity to enhance the model to evaluate these goals within the risk management space.

Limitations of Study

While this research resulted in many impactful findings for the dairy industry there were limitations to the study that provide room for further research. Due to limited data not all of the input costs evaluated were able to be based on exposure that Idaho dairy farmers face. If Idaho dairy input prices were able to be found for all input categories discussed in this research this could provide a clearer picture into the true operating margin the producers face.

Aside from input costs, the data available to the research group constricted this research to only be applicable to Idaho dairy farmers. Idaho is one of the major dairy producing states, but if farm gate milk prices were able to be identified for other states along with input costs such as feed this model could be applied to every state that has a large dairy industry.

The output of this analysis included details on many risk management strategies, but the dairy risk management industry provides many tools that could be analyzed in order to provide dairy farmers the most optimal risk management strategy available. Other risk management strategies that could be included in future research include options, input hedging, forward contracting, OTC products, swaps, and even vertical integration advantages if the data is available. Furthermore, this research focused exclusively on the dairy producer, but manufacturers of dairy products can also benefit significantly from the use of risk management tools.

Chapter 5 – Conclusion

The practice of managing risks that agricultural producers are exposed to is becoming increasingly important as industry's such as dairy face increasing volatility and ever-changing market spaces. The benefits of risk management on the financial viability of dairy producers is endless for those with the willingness to understand and use the products available. As the dairy market evolves new risk management tools are becoming available to dairy producers. We hope that this study encourages dairy producers to begin, or continue to engage in risk management practices so that they might become more financially secure.

5.1 – Important Findings

Findings of this research offer important implications to the Idaho dairy industry and in particular to dairy farmers. The first important finding of this study is the impact of volatility in the dairy market. Prices experienced in the market are ever-changing leading to potential financial insecurity of dairy producers. Utilizing risk management tools allows dairy farmers to protect themselves against some of this financial insecurity and provides a more stable balance sheet and business model.

Another important finding of this research was the gathering of industry expert opinions on many aspects of the risk management industry and how it relates to the dairy market. The contributions of the industry expert panel used in this research not only influenced our model through the construction of the risk management tiers and best practices, but also provides quality perspective as to the current marketplace that dairy farmers are facing today. The relationship between dairy producers and industry experts is imperative to the success of a risk management strategy as most dairy farmers are not familiar with every tool that is available to them.

The final conclusion of this research is that a package of risk management strategies utilized by a dairy producer provides the best opportunity to limit the prices risks that they face and insure the best operating margin available for their business. By using production budgets and Simetar software we were able to determine that using DRP, DMC, and Futures provided a structure that protects against the worst prices dairy farmers might face. Often time these moments of hardship are extremely impactful to a business's constitution and contributes to the growing rate of consolidation in the dairy industry.

5.2 – Future Research

While this study provides an extensive look into the impacts of risk management on managing the effects of volatility on milk price, there are further areas that could be of interest to research further. As more information becomes available similar studies could be done to provide more geographical impact.

An enhancement on this study could be performed with the addition of other risk management strategies. With the addition of data on other risk management strategies the analysis of their impact on operating margin and other budgetary benchmarks could be achieved. Studying these tools impacts could provide further clarity on the most optimal risk management package available to dairy producers.

A change in the model to a more dynamic format could provide a greater impact on the risk management research currently in place. The use of a dynamic model would serve to provide dairy producers an outlook of when to use certain tools and when not to, leading to variable use risk management portfolios rather than constant use. Research done in this area could serve to provide dairy farmers risk management tools that showcase greater impact on profit during seasonal timeframes. A dynamic model approach could also serve the industry by accounting for risk attitude of the dairy farmer, and what tools best fit their comfort level.

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Chapter 6 – Appendix

Figure 6.1 – StopLight Chart of Risk Management Strategies

StopLight Analysis Results
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Lower Cut-Off Value		**2.00**	Upper Cut-Off Value	**7.21**			
	No RM	DMC	DRP 9 Months	Futures 3	DMC + Futures 3	DMC + DRP 9	DMC+DRP+Futures
Prob(Unfavorable	**0.12**	**0.05**	**0.07**	**0.12**	**0.04**	**0.01**	**0.01**
Prob(Cautionary)	**0.72**	**0.76**	**0.78**	**0.82**	**0.84**	**0.80**	**0.83**
Prob(Favorable)	**0.15**	**0.19**	**0.15**	**0.06**	**0.12**	**0.19**	**0.16**

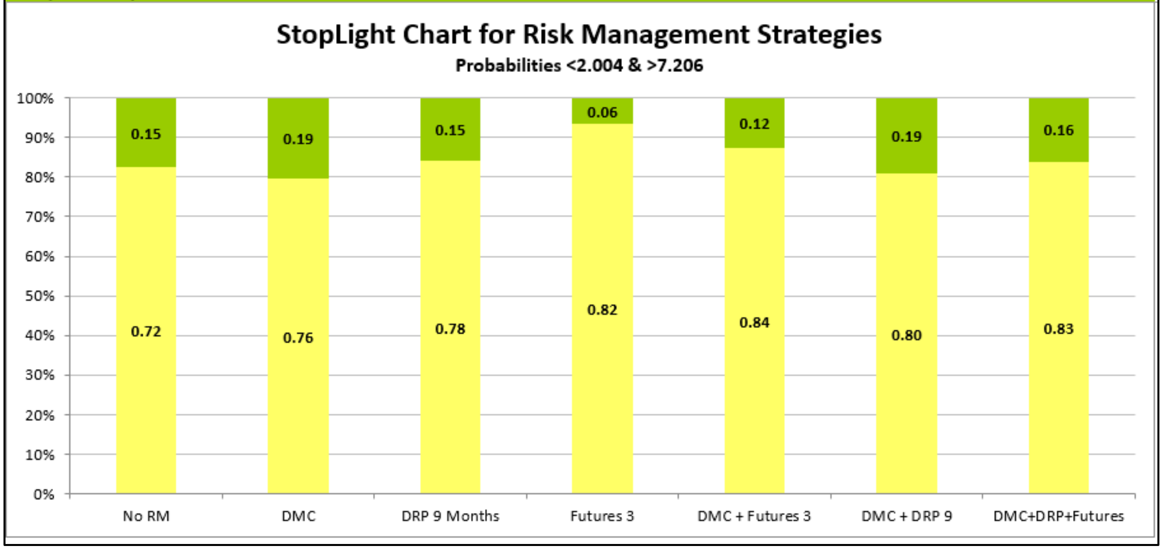

Table 6.1 – Large Dairy First and Second Degree Stochastic Dominance Table

Large Dairy First and Second Degree Stochastic Dominance

First Degree Dominance Table

	No Risk Management	DMC	DRP 9	DRP 12	Futures 3	Futures 6	DMC + Futures 3	DMC + DRP 9	DMC + DRP 9 + Futures 3
No Risk Management					Futures 3	Futures 6			
DMC									
DRP 9									
DRP 12									
Futures 3									
Futures 6					Futures 3	Futures 6			
DMC + Futures 3									
DMC + DRP 9			DRP 9		Futures 3	Futures 6	DMC + Futures 3		
DMC + DRP 9 + Futures 3									

Second Degree Dominance Table

	No Risk Management	DMC	DRP 9	DRP 12	Futures 3	Futures 6	DMC + Futures 3	DMC + DRP 9	DMC + DRP 9 + Futures 3
No Risk Management									
DMC	No Risk Management		DRP 9	DRP 12	Futures 3	Futures 6			
DRP 9	No Risk Management				Futures 3	Futures 6			
DRP 12	No Risk Management				Futures 3	Futures 6			
Futures 3						Futures 6			
Futures 6									
DMC + Futures 3	No Risk Management		DRP 9	DRP 12	Futures 3	Futures 6			
DMC + DRP 9	No Risk Management	DMC	DRP 9	DRP 12	Futures 3	Futures 6	DMC + Futures 3		
DMC + DRP 9 + Futures 3	No Risk Management	DMC	DRP 9	DRP 12	Futures 3	Futures 6	DMC + Futures 3		

Table 6.2 – Small Dairy First and Second Degree Stochastic Dominance Table

Estimates of First and Second Degree Stochastic Dominance

First Degree Dominance Table

	No Risk Management	DMC	DRP 9	DRP 12
No Risk Management				
DMC	No Risk Management	DMC	DRP 9	DRP 12
DRP 9				
DRP 12				

Second Degree Dominance Table

	No Risk Management	DMC	DRP 9	DRP 12
No Risk Management				
DMC	No Risk Management	DMC	DRP 9	DRP 12
DRP 9	No Risk Management			
DRP 12	No Risk Management			