USE OF LGM-DAIRY FOR REVENUE RISK MANAGEMENT

by

Mayuri Valvekar

A thesis submitted in partial fulfillment of

the requirements for the degree of

Master of Science

Dairy Science

at the

UNIVERSITY OF WISCONSIN-MADISON

2010

Dedication

I dedicate this thesis to my dear husband, Sachin, for his love and encouragement, which have always inspired me at every juncture and my lovely daughter, Sharvari for being patient with me while I wrote this thesis.

I would also like to dedicate this thesis to my parents, Aai and Pappa, for their love and support. Without them I would not have been what I am today. Their consistent faith in me has always inspired me to do the best. I am also grateful to my parents-in-law for their encouragement and patience. Their presence in my life has been a blessing. To my sister, Aarti for her love and support.

I also dedicate this thesis to my advisor Dr. Victor Cabrera, for guiding me in every step of this journey. He is instrumental in making research in model-based decision support systems in dairy very interesting. His constant encouragement and enthusiasm have inspired me explore the area of dairy management and economics. I am deeply grateful to him for giving me the opportunity to work for him.

Acknowledgements

I would like to thank Dr. Brian Gould for being on my committee and guiding me throughout my MS program. His contribution in the area of dairy marketing and policy needs no mention. His valuable suggestions throughout my study helped me learn and improve my research further.

I would also like to thank Dr. Michel Wattiaux for being on my committee and for his invaluable guidance throughout my MS program. His words “Learning is not acquiring new knowledge but more importantly, it includes the ability to apply and analyze” have always inspired me.

I thank Dr. Jean-Paul Chavas, who has contributed to my education and introduced me to the area of applied risk research.

I also thank my friends in the department, Jose, Gota, Carolina, Leanne and others for their help.

Introduction

With uncertain and volatile milk prices and feed costs, there is a significant need for effective risk management strategies that can enable dairy producers to more effectively manage their revenue risk. Unpredictable markets for inputs and outputs, changes in government policy, changes in laws governing farm production and financial risks are some of the other risks that can have far-reaching implications on farm profitability. It is sometimes difficult eliminating a particular risk or uncertainty completely. However managing the risk is possible by making informed decisions. For informed decisions, farmers first need to determine level of risk they can tolerate in terms of cash flow and second, the risk reduction alternatives available to them and finally costs involved.

Today there exist a variety of price risk management tools available to dairy producers for managing price risk like forward pricing their output and input purchases, use of traditional hedging and options strategy, and starting in 2008, a revenue insurance policy specifically designed for dairy farms (LGM-Dairy). Use of LGM-Dairy creates a risk management strategy similar to the use of a bundled option. It acts as a put option setting a floor on the milk prices and as a call option, setting a ceiling on the feed costs. Thus it ultimately protects against the declines in the income over feed cost (IOFC). When considering the use of LGM-Dairy there are a number of decisions that must be made including but not limited to is the percentage of monthly milk marketings to be insured.

The primary objectives of this thesis are to understand the LGM-Dairy program characteristics and to illustrate how LGM-Dairy can be incorporated into a dairy farms revenue risk management strategy under a number of alternative scenarios.

Under one scenario we demonstrate an algorithm to identify optimal strategies where optimality is defined as the minimum premium cost of insuring a pre-defined target guaranteed IOFC for total milk produced on the farm. The optimization model incorporates all the components of LGM-Dairy. Another objective of this study was to investigate the interplay between producer risk preferences, insurance costs and market conditions that could impact participation in the LGM-Dairy program. We undertook this analysis using the expected utility framework for two different contracts under different market conditions.

TABLE OF CONTENTS

CHAPTER 3. LEAST COST LGM-DAIRY CONTRACT DESIGN FOR A GIVEN TARGET INCOME OVER FEED COST

CHAPTER 4. RISK MANAGEMENT AND LGM-DAIRY INSURANCE: AN EMPIRICAL ANALYSIS

List of Tables and Figures

CHAPTER I

RISK MANAGEMENT IN DAIRY

1.1 INTRODUCTION

The value of milk represents more than 90% of a dairy farm's total agricultural income (ERS, 2009). In addition, feed costs can represent more than 40% of a dairy farm's variable costs (Ishler, 2009). With relatively stable production, uncertainty in milk and feed prices represent a major source of dairy farm business risk. Variability in dairy income over feed costs (IOFC) arises from volatility of milk prices as well as feed costs. There is no doubt that the volatility of milk prices has increased since the mid-1980s (Gould et al., 2008). Given the perishable nature of milk, dairy producers cannot hold milk and wait for a better price. Even temporary low price troughs can create cash flow problems. Therefore milk price swings and volatility at all levels makes it a necessity for dairy producers today to consider various risk management options.

1.2 HISTORICAL PERSPECTIVE ON VARIABILITY IN MILK PRICES AND FEED COSTS

For the first 40 years following its inception in 1949, Federal milk price support program protected the dairy industry from price volatility. The minimum price of milk used for manufacturing purposes has been supported continuously since passage of the Agricultural Act of 1949. This Act required the Secretary of Agriculture to support prices received by dairy farmers for manufacturing use milk at between 75 percent and 90 percent of parity (Bozic and Gould, 2009). Between 1970 and 1980 support price increased from $4.6 per hundredweight to $13.10 per hundredweight. Dairy farmers responded with increased milk production. The parity method of setting the support price was abandoned in 1981. From 1981 to 1990, the support price was reduced eight times to $10.10 per cwt. During the period 1983 – 1995 government held stocks of dairy products were reduced from 24% (cheese), 35% (butter) and 83% (nonfat dry milk) of annual production to less than 1% of annual production for any of these products. Under the 2008 Farm Bill the support program was changed from supporting the milk price to directly supporting the prices of cheddar cheese, nonfat dry milk and butter. The combined effects of (1) lower government price supports, (2) reduced government stocks of dairy products and (3) market fundamentals have increased milk price variability.

Using the National Agricultural Statistics Service (NASS, 2009) 12- month average data for Minnesota-Wisconsin/ Basic Formula Price/ Class III (MW/BFP/Class III)milk prices from 1991 through 2009, the variability in the MW/BFP/Class III milk prices was calculated. It is evident that there has been a significant variation in the MW/BFP/Class III milk prices over a period a time. As presented in Table 1.1, the coefficient of variation in MW/BFP/Class III milk prices was calculated for different time periods, For 1992 to 2000, the coefficient of variation was 0.10. From 2001 through 2009, it was 0.20. Variability in milk prices over the past three years was significant. For the time period, 2007 to 2009, coefficient of variation was 0.24. Figure 1.1 represents the 12-month average MW/BFP/Class III milk prices from 1992 to 2009.The value of R^2; coefficient of determination is 20.4%. This unexplained variation can be a result of a multitude of factors. Some of which are seasonal production, government policies as discussed above, relative supply and demand scenario, stocks held by commercial dairies and government, international trade policies and world economy.

As in the case of milk, the 1980s were a time of heavy government involvement in the US grain sector. Factors like commodity loan programs resulted in large government grain inventories in the mid-1980s, which reduced the potential for upside price swings. With the passing of the 1996 Farm Bill, the federal government moved away from market stabilization policies. For grain commodities, loan rates have been reduced. The result has been lower commodity inventories being carried by the government and more volatile prices. Dramatic growth in the biofuels industry has created a demand-driven boom in corn (and, by extension, other crops) prices. Although this has been a most welcome development for grain producers, it has created a difficult situation for livestock producers (Anderson et al., 2008).

As an example, 12-month average corn and soybean prices are shown in Table 1.1 along with their coefficient of variation. The coefficient of variation of corn price for 1992 to 2000 was 0.21 and for soybeans over the same period was 0.16, whereas for the recent time period 2001 through 2009, coefficient of variation for corn was 0.36 and in soybeans, it was 0.35.

Combining the above trends there has been a significant increase in variability in IOFC in the recent years. Daily per cow IOFC by a cow producing 65 lbs is presented in Table 1.2. On an “as fed basis” this ration used 22.22 pounds of corn grain, 2.52 pounds of 48 percent soybean meal, and 25.5 pounds of alfalfa hay to produce 65 pounds of milk. Chicago prices for corn, soybean meal, and alfalfa hay and US all-milk price were used. The average IOFC was $7.51 per cow per day in 2005 peaked in 2007 at $8.97 per cow per day and again bottomed at $4.83 per cow per day in 2009. The coefficient of variation ranged from 0.05 in 2005 to 0.27 in 2009

1.3 RISK MANAGEMENT TOOLS AVAILABLE FOR DAIRY PRODUCERS

In response to increased volatility, several viable dairy-based futures and options markets have evolved since the mid-1990s. Currently there are futures contracts at the Chicago Mercantile Exchange (CME) for Class III milk, Class IV milk, butter, dry whey, non-fat dry milk and skim milk powder. Starting in July 2010 there will be a new cheddar cheese futures contract. In addition, there are options markets for Class III milk, Class IV milk, butter and non-fat dry milk and soon cheddar cheese. Dairy farmers have the ability to be either directly involved with the above markets or to use forward or minimum price contracts offered by their processing plant to manage their output price risk. With the passage of the Food, Conservation and Energy Act of 2008 (i.e., 2008 Farm Bill) private firms can now offer forward and minimum price contracts to their farm patrons while not being obligated to pay minimum Federal Milk Marketing Order minimum prices. However, advanced or fixed price contracts cannot be used for Class I milk. The objective of implementing price risk management strategies is not to enhance profits, but rather to minimize losses. Next section outlines some of the risk management strategies used by dairy producers.

1.3.1 Overview of Forward Contracts

A forward contract is a private contract between a buyer and a seller in which the buyer agrees to buy and the seller agrees to sell a specific quantity of a certain security or commodity (known as the *underlying instrument*) at the price specified in the contract (Hull, 2000). The difference between a forward contract and most other sales contracts is that with the forward contract, the delivery and payment of the underlying instrument occurs at a specified future date. The party agreeing to buy the underlying asset in the future assumes a long position, and the party agreeing to sell the asset in the future assumes a short position. The price agreed upon is called the delivery (forward) price.

Use of forward contracts by dairy processors has the potential for generating benefits to both the processor and dairy farm operator since they are able to "lock in" prices, thereby reducing risk associated with milk price volatility. For a cheese processor, this can assist in better cash flow planning since 70 to 85% of the costs are milk related.

Signing a cash forward contract is equivalent to hedging because it guarantees the future price of the commodity, regardless of the price movements in the future. Price offered for forward contracts in milk is a base farm price usually for milk with specified butterfat, nonfat solids and quality. Adjustments for milk composition differing from standards are made at the time of delivery of the commodity. Dairy plants offer a variety of cash forward contracts like fixed prices for specific months, single price for several months of production and a minimum price for a single month or several months. There are advantages and disadvantages of forward contracts since the price agreed upon by both parties, while entering into the contract will not vary despite changes in the spot market. If the market price decreases, the seller will benefit because the contracted price has been locked in at a higher level relative to the spot market price. Secondly, there are no regulations on the contract as it is agreed upon by the buyer and seller themselves. Therefore, it is important to ensure that all of the terms and contingencies are clear and that there are no uncertainties or ambiguities at the time of the contract. All contract parameters like delivery terms, location, quality specifications of the underlying instrument, payment and credit terms and cancellation provisions etc should be clearly defined. Another possible disadvantage is that brokerage fees and other hedging expenses are built into the price offers in a cash forward contract.

1.3.2 Overview of Futures Contracts

A futures contract is a standardized contract between two parties to buy or sell a specified asset or commodity of standardized quantity and quality at a specified future date at a price agreed today (the futures price). These contracts are traded on a futures exchange. The party agreeing to buy the underlying asset in the future assumes a long position, and the party agreeing to sell the asset in the future assumes a short position. The future date is called the delivery date or final settlement date. The official price of the futures contract at the end of a day's trading session on the exchange is called the settlement price for that day of business on the exchange. A futures contract gives the holder the *obligation* to make or take delivery under the terms of the contract. The exchange's clearing house acts as counterparty on all contracts, sets margin requirements, and crucially also provides a mechanism for settlement.

Futures contracts are commonly traded for several different delivery months throughout the year. Unlike forward contracts, delivery is not normally specified for a specific date, but rather a delivery period within the delivery month (Hull, 2000). For cash settle contracts, there is no delivery of the underlying commodity. However, there is settlement period. A primary use of futures involves shifting risk from a firm that desires less risk (the hedger) to a party who is willing to accept the risk in exchange for an expected profit (the speculator). Also, hedgers with opposite positions in the market trade with each other. Because futures contracts are commitments to trade in the future, actual delivery and payment are not required until the contract matures. However, both buyers and sellers are required to make margin deposits with their brokers to guarantee their respective commitments. Another advantage of futures contracts is the existence of an organized market and standardized contracting terms that give liquidity and offers to the participants the possibility of closing positions on a date before the expiration. Most traders offset their positions prior to maturity instead of actual delivery of the commodity. Therefore, futures contracts do not lock in an absolute, fixed price. The basis is the difference between the futures market price and the cash price where the physical commodity is actually purchased or sold. Basis risk is usually significantly less than price risk associated with the commodity and therefore, futures markets act as a significant hedging tool. One of the major disadvantages with futures contracts is that producers need to have enough volume of the commodity to enter into a futures contract. For example, the contract size for Class III milk future contract traded on Chicago mercantile exchange (CME) is 200,000 lb. Cash forward contracting is especially useful for producers who do not have enough volume of the commodity.

1.3.3 Review of Options

An option gives its holder the right, but not the obligation, to buy or to sell the underlying asset/commodity on or before the expiration of the option at an agreed price also known as the strike price. A call option gives the buyer of the option the right but not the obligation to buy the underlying asset at the strike price, wheras a put option gives the buyer of the option the right but not the obligation to sell the underlying at the designated strike price. If the buyer or seller chooses to exercise this right, the seller is obliged to sell or buy the asset at the agreed price. The buyer or seller may choose not to exercise the right and let it expire. The theoretical value of an option is evaluated using several methods. The Black Scholes model is one of these methods (Podlozhnyuk., 2005).

Put options increase in value if prices fall and decrease in value if prices rise. The buyer of a put has the right to exercise the option into a short or sell futures position. The buyer of a put option has limited risk and unlimited profit if prices fall. Call options increase in value if prices rise and decrease in value if prices fall. The buyer of a call has the right to exercise the option into a buy futures position. The buyer of a call option has limited risk and unlimited profit if prices rise. A put (call) option is said to be in the money if the strike price is above (below) the underlying futures price. A put (call) option is said to be at the money if the strike price is equal to the underlying futures price. A put (call) option is said to out of the money if the strike price is below (above) the underlying futures price. At any given time, the range of strike prices quoted will cover values in the money, at the money, and out of the money. Thus, a hedger or speculator has the option of purchasing an option at any of these three levels. Typically, options in the money will have the highest premium, followed by options at the money, and options out of the money will have the lowest premiums. There are two components which make up the value of the option, intrinsic and time value. Both of these values are implicit values not observed, but theoretically present. Intrinsic value is the value of the option relative to the underlying futures price. Additionally, there is a time component to the value of an option. The time value reflects the time between the option premium quote and contract expiration. Typically, the larger the time period the greater the implicit time value of the option. That is, the greater number of days until contract expiration, the higher the probability of the futures market changing in value enough to improve the intrinsic value of the option.

Options offer many advantages over futures and forward contracts. Futures and forward contracts represent the obligation to transact on a future date, whereas options provide the right to buy or sell an asset, but do not impose any obligation. There are also no margin calls with options. However, option premiums at appealing price levels can be costly. For example in June 2004, September 2004 put option for Class III, at $12.00 had a $0.09 premium, while an option at $18.00 has a premium of $3.52. Perhaps the best way to envision option contracts is as insurance policies. An investor taking a long position in a put option would be equivalent to the purchaser of the insurance, and the short would essentially be the insurance provider. Futures and options on grains and oilseeds which constitute major feed ingredients in dairy farms are also available on CME. Contracts are available to be traded on corn, soybean and soybean meal among other agricultural commodities. Contract specifications can be obtained at www.cmegroup.com. Jesse and Cropp (2009) provided a detailed overview of the use of dairy-based futures and options.

To educate dairy producers in the use of option contracts as risk management tools and to ascertain the usefulness of options to dairy producers in various regional markets, the Federal Agricultural Improvement and Reform Act of 1996 authorized the Secretary of Agriculture to operate options pilot programs. Accordingly, USDA initiated the Dairy Options Pilot Program (DOPP) in 1999 in an effort to provide dairy producers with real-world experience trading options (Vandeveer et al., 2004). DOPP was designed to teach producers how fluid milk put options can be used to provide price protection. The USDA cost-share arrangement subsidized the purchase of these put options, paying 80% of the put option's price and up to $30 in commission fees (Buschena and McNew, 2005). More than 6,000 dairy producers participated in DOPP, comprising somewhat over 5% of total US dairy farms (Vandeveer et al., 2004).

1.3.4 Livestock insurance policies

In a 1996 an Agricultural Resource Management study conducted by Economic Research Service (ERS), agriculture producers were asked about their adoption of risk management strategies. Results showed that only 15 to 25% of cattle and hog producers adopted futures and options (USGAO, 1999). Increasing livestock producer's usage of various risk management tools was a goal of Risk Management Agency (RMA) (Hart, 2006). Until 1996 the only form of insurance provided by the USDA was traditional crop insurance that protects farmers against yield losses. In recent years, several revenue insurance products like crop revenue coverage (CRC), Adjusted Gross Revenue (AGR), Group Risk Income Protection (GRIP) among others were introduced for the crop sector. These policies provided an additional extension to the risk management tools available to crop producers. Another insurance program based on margin is gaining increased attention lately. National Milk Producers Federation (NMPF) is recommending establishing a new program entitled the Dairy Producer Margin Protection Program (DPMPP) which is intended to support producer *margins*, not prices. DPMPP is a program that is designed to address both catastrophic conditions which can result in the severe loss of equity for dairy farmers such as those witnessed in 2009, as well as long periods of low margins such as those in 2002. Under this program, "margin" is simply defined as the all-milk price minus feed costs. Feed costs are determined using a new feed ration that has been developed to more realistically reflect those costs associated with feeding the entire dairy farm enterprise consisting of milking cows, heifers, etc. The DPMPP operates on the premise of providing a base level of protection (i.e. insurance coverage) for all producers which is fully subsidized by the federal government and a voluntary level of supplemental coverage which is partially subsidized by the government, but in a manner in which the level of subsidization decreases as the level of coverage increases. Since DPMPP is a margin insurance program it is proposed to have no payment limitations based on income or size of herd (NMPF, 2010).

The collapse in livestock prices in the fall of 1998 has spurred interest in expanding coverage to US livestock producers. Since the early 2000's there have existed gross margin insurance programs for swine (LGM-Swine) and feeder cattle (LGM-Cattle). An overview of the current LGM-Cattle and LGM-Swine programs can be found at the USDA's Risk Management Agency's website: http://www.rma.usda.gov/livestock/. These programs have been used to establish a lower bound on gross revenue net of feed costs for finishing hogs and feeder cattle. Under LGM-Cattle adjusted cattle and corn futures prices are used to determine target expected and actual gross income over feed cost. For the LGM-Swine program, adjusted lean hog, corn and soybean meal futures are used to determine target expected and actual gross income over feed cost. In 2002, USDA Risk Management Agency (RMA) introduced Livestock Risk Protection (LRP) to provide another alternative for protecting pricing levels on future sales of hogs and cattle. LRP provides single-peril price risk protection for the future selling price of the insured livestock. An overview of the current Livestock risk protection (LRP) program can be found at the USDA's Risk Management Agency's website: http://www.rma.usda.gov/livestock/.

A natural extension of the LGM-Cattle and LGM-Swine programs is the Livestock Gross Margin for Dairy Cattle (LGM-Dairy) insurance program, which is the focus of this thesis. This program can be used to establish a floor on dairy producer's gross margin defined as milk revenue less *imputed* purchased feed costs. Use of LGM-Dairy can be considered analogous to the use of a bundled option risk management strategy where Class III put options establish a milk revenue floor and feed-based call options are used to establish a feed cost ceiling. Such a strategy reduces the downside IOFC risk but allows for possibly higher values. Figure 1.2 provides a simple representation of this bundling strategy. If the Announced class III milk price increases, then the IOFC also is higher than the IOFC when the put option is exercised. Therefore the producers will not use the put option if the announced class III milk price is announced higher than the put value. Similarly if the feed costs decrease, then IOFC is higher than the IOFC realized if the call options on corn and SBM is exercised. In such a scenario, farmers may opt not to exercise the call option.

This program was approved by USDA's Risk Management Agency in July 2007 with the first policy being offered in August 2008. Starting in July 2010 48 states across US can use this program. A detailed description of an earlier version of the LGM-Dairy policy and how it can be used as a risk management tool has been outlined by Gould, Mitchell and Cabrera (2008). An extensive website devoted to LGM-Dairy can be found at the University of Wisconsin's Understanding Dairy Markets website: http://future.aae.wisc.edu/lgm_dairy.html as well as University of Wisconsin, Dairy management and extension's website http://dairymgt.uwex.edu/lgm.php.

Livestock insurance policies are relatively new compared to the traditional risk management strategies like hedging with futures, options and forward contracts. However livestock policies are gaining increased attention, given the complexity involved in understanding hedging mechanisms. Hart, Babcock and Hayes (2003) provided an overview of some of these insurance programs and compare program performance with that of risk management programs based on the use of futures and options. They found that livestock producers would benefit from such insurance packages and that these insurance products provide more dollar-for-dollar benefits than the use of traditional put and call options. To understand the participation in livestock insurance policies across US, sales of livestock insurance policies including LRP and Livestock Gross Margin (LGM) policies across US were shown in Table 1.3. LGM refers to Livestock Gross Margin insurance policies for cattle, feeder cattle, fed cattle, dairy cattle, swine and lamb. It is obvious that participation in livestock insurance policies is increasing in recent years. Among LGM policies, LGM-Dairy is relatively new insurance policy. In 2009, 45 LGM-Dairy policies were sold, whereas in 2010 as on 22nd June 2010, 148 policies have been sold (ERS, 2010). Out of these, 50 policies have been sold in Wisconsin in 2010 and 12 policies in 2009.

1.4 Conclusion

Due to increased variability in milk prices and feed costs, profitability of dairy farms could be seriously affected. The viability of today's dairy farms depends upon the ability of producers to effectively manage price risk. Many risk management tools are available to dairy producers to manage price risk. This chapter briefly discusses various risk management tools available to dairy producers including futures, forward contracts, options and livestock insurance policies. Producers can opt for a single risk management strategy or a combination of different risk management strategies like LGM-Dairy, futures and options.

Various price risk management tools are available to dairy producers for managing price risk like forward pricing, hedging, options, and livestock insurance policies. Given the complexity in understanding the futures and options markets, more livestock producers might prefer a revenue insurance product to using the futures and options markets. The insurance product can be tailored to the individual producer's needs. The need for specialized knowledge about the futures and options markets would be transferred from the producer to the insurance company, so that the insurance contract would be similar to crop insurance contracts, which many of the producers have entered (Hart et al., 2001). In some cases producers may want to select one method and use this to protect their income or gross margin. In other cases, producers may want to use the LGM-Dairy on a certain percent of their milk supply, then use either forward pricing or hedging or options on another percent. The amount of milk to hedge and the combination of approaches is up to the individual producer (Bailey and Dunn, 2009).

1.5 REFERENCES

Anderson, D.A, J.G. Robb, and J. Mintert. "The Cattle Cycle." *Managing for Today's Cattle Market and Beyond*, http://www.ag.arizona.edu/arec/wemc/cattlemarket /CatlCycl.pdf. Accessed: May, 2009.

Bailey,K and J Dunn.2009." Comparison of the dairy livestock gross margin program and standard risk management approaches", The Pennsylvania State University, Department of agricultural economics and rural sociology Staff paper No. 382, June 2009

Bozic, M. and B.W. Gould. 2009. **"***The Dynamics of the U.S. Milk Supply: Implications for Changes in U.S. Dairy Policy",* University of Wisconsin- Madison, AAE Staff Paper No. 540, July 2009, 40p

Buschena, D and K.McNew. 2008."Subsidized Options in a Thin Market: A Case Study of the Dairy Options Pilot Program Introduction", Applied Economic Perspectives Pol. (2008) 30(1): 103-119.

Commodity Products Homepage, 2010, Chicago Mercentile Exchange (CME), http://www.cmegroup.com/trading/commodities/ Accessed June,2010

Economic Research Service (ERS), United States Department of Agriculture (USDA), http://www.rma.usda.gov. Accessed: June, 2010.

Gould, B.W., P.D. Mitchell and V.E Cabrera.,2008. *"USDA's Gross Margin Insurance Program for Dairy: What is it and Can it be Used for Risk Management*". Marketing and Policy Briefing Paper, Department of Agricultural and Applied Economics, University of Wisconsin-Madison, http://future.aae.wisc.edu/pubs/pubs/show/339.

Hull, John C. *Options Futures, and Other Derivatives*, Upper Saddle River, NJ: Prentice Hall, 2000.

Hart, C. (2006) ‘The current state of U.S. federally supported livestock insurance.’ In The Economics of Livestock Disease Insurance, ed. S. R. Koontz, D. L.Hoag, D. D. Thilmany, J. W. Green, and J. L. Grannis (CABI Publishing, Massachusetts) pp. 164–180

Hart, C.E., B.A Babcock, and D.J. Hayes, 2000. “Livestock Revenue Insurance”. Journal of Futures Markets, 21(2001):553-580.

Hart, C.E., D.J. Hayes, and B.A. Babcock,2003. "Insuring Eggs in Baskets: Should the Government Insure Individual Risks?" Staff General Research Papers 10669, Iowa State University, Department of Economics, Ames.

Ishler, V., E. Cowan, and T. Beck. 2009. Track your income over feed costs. Hoards Magazine, 10August 2009, pg. 490.

Jesse, E. and R. Cropp, 2009. Futures and options trading in milk and dairy products: A guidebook for dairy producers, Publication No. A3732, University of Wisconsin Extension, Madison, WI.

Livestock policies, 2010, USDA’s Risk Management Agency’s website: http://www.rma.usda.gov/livestock/.

Livestock risk protection (LRP) program, 2010, USDA’s Risk Management Agency’s website: http://www.rma.usda.gov/livestock/.

National Milk Producers Federation (NMPF), 2010, Comprehensive Dairy Policy Proposals: Detailed Narrative, http://future.aae.wisc.edu/publications/fftf_narrative_061010.pdf . Accessed June , 2010.

Podlozhnyuk V, Black–Scholes option pricing, part of CUDA SDK documentation, 2007.

University of Wisconsin Understanding Dairy Markets, Livestock Gross Margin-Dairy Website 2009, http://future.aae.wisc.edu/lgm_dairy.html

US General Accounting Office. USGAO (1999). Agriculture in transition: farmer's use of risk management strategies, Report# GAO/RCED-99-90.

Vandeveer, M., D. Blayney, D. Buschena, T. Crawford, R. Heifner, and L. Maynard. *An Evaluation of the Dairy Options Pilot Program: A Report to the Risk Management Agency*, USDA. July, 2004.

Table 1.1 12- Month Average Prices for Minnesota-Wisconsin/Basic Formula Price/ Class III (MW/BFP/Class III) Milk, Corn

and Soybean.

MW/BFP/Class III Milk Prices			
Statistic	1992-2000	2001-2009	2007-2009
Mean ($/cwt)	12.14	13.67	15.61
Standard Deviation ($/cwt)	1.22	2.76	3.69
Coefficient of Variation	0.10	0.20	0.24
Corn Price			
Statistic		1992-2000	2001-2009
Mean ($/bu)		2.40	2.77
Standard Deviation ($/bu)		0.50	0.99
Coefficient of Variation		0.21	0.36
Soybean Price			
Statistic		1992-2000	2001-2009
Mean ($/bu)		5.94	7.07
Standard Deviation ($/bu)		0.96	2.32
Coefficient of Variation		0.16	0.33

Table 1.2 Summary Statistics for 12-Month Average Income over Feed Cost Considering All Milk Price (2005 to 2009)

Income over feed cost (All Milk price)[1]					
Statistic	2005	2006	2007	2008	2009
Mean ($/cow/day)	7.51	5.88	8.98	7.54	4.83
Standard Deviation ($/cow/day)	0.37	0.63	1.81	0.84	1.29
Coefficient of Variation	0.05	0.11	0.20	0.11	0.27

1 On an "as fed basis" this ration used 22.22 pounds of corn grain, 2.52 pounds of 48 percent soybean meal, and 25.5 pounds of alfalfa hay to produce 65 pounds of milk. Chicago prices for corn, soybean meal, and alfalfa hay and US all-milk price were used to calculate the income from milk.

Table 1.3 Number of Livestock Insurance Policies Sold across US from July 2007 to June 2010.

Year	Details	LGM[1]	LGM-Dairy[2]	LRP[3]	Total
2010[4]	Policies sold	474	148	4,145	4,619
	Hundredweights of milk insured	NA	1,710,027	NA	
	Head insured[5]	1,904,404	NA	358,416	2,262,820
2009	Policies sold	430	45	6,084	6,514
	Hundredweights of milk insured	NA	401,680	NA	
	Head insured[5]	532,780	NA	302,418	835,198
2008	Policies sold	349	NA	5,554	5,903
	Hundredweights of milk insured	NA	NA	NA	
	Head insured[5]	436,281	NA	847,002	1,283,283
2007	Policies sold	351	NA	4,558	4,909
	Hundredweights of milk insured	NA	NA	NA	
	Head insured[5]	367,866	NA	148,109	515,975

[1]LGM refers to Livestock Gross Margin insurance policies for cattle, feeder cattle, fed cattle, dairy cattle, swine and lamb.
[2] LGM-Dairy refers to Livestock gross margin insurance for dairy cattle, available since August 2008
[3] LRP refers to Livestock risk protection policy.
[4] Data is presented from USDA's ERS website as on 22nd June, 2010.
[5] Head insured reflects number of animals insured for LGM commodities except LGM-Dairy.

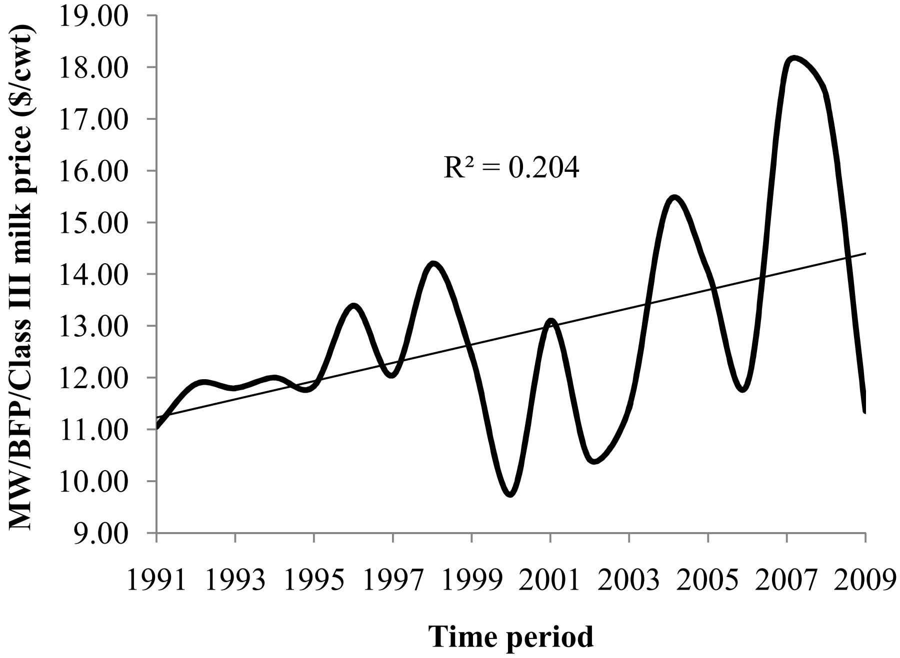

Figure 1.1 12-Month Average Minnesota-Wisconsin / Basic Formula Price / Class III (MW/BFP/Class III) Milk Prices for US, 1991 to 2009 (ERS, 2010)

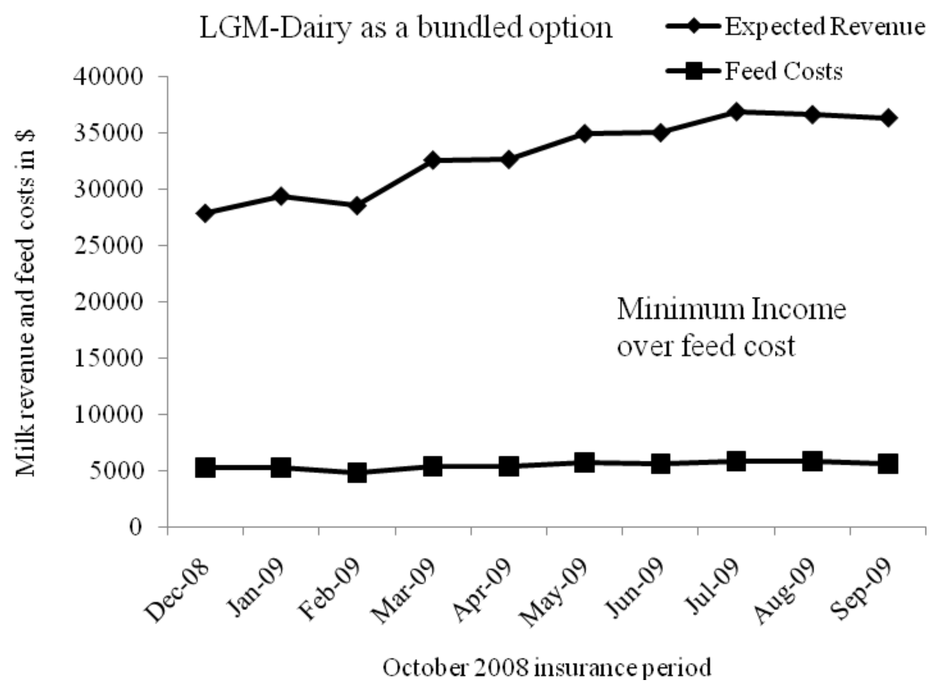

Figure 1.2 Diagrammatic Representation of October 2008 LGM-Dairy Contract as a Bundled Option Strategy

CHAPTER 2

LGM-DAIRY: AN ANALYSIS OF PROGRAM PERFORMANCE AND COST UNDER ALTERNATIVE POLICY CONFIGURATIONS

2.1 INTRODUCTION

LGM-Dairy is a very new livestock insurance policy available to US producers. From a producer's perspective understanding the policy and how it can be used as a risk management tool is important. LGM-Dairy premiums are impacted by the expected prices of Class III milk, corn and SBM, the variability of these prices, the amount of feed used and milk productivity. . Cabrera and Solis (2008) evaluated the usefulness of climate forecasts on managing LGM-Dairy by Wisconsin dairy farms. They found that the seasonal climate variability impacts feed costs, milk production, feed consumption and milk price and that dairy producers could use climate forecasting to decide if it is profitable to purchase LGM-Dairy and the level of protection. Hence, decisions such as when to buy LGM-Dairy and percent of production to be covered are crucial. With these considerations, a detailed understanding of the structure of the policy and relationships between different decision parameters is important.

2.2 GENERAL DESCRIPTION OF LGM-DAIRY

Under the LGM-Dairy program, a dairy farm operator farmer is paid an indemnity if the difference between the contract's imputed guaranteed IOFC (GIOFC) and Actual IOFC (AIOFC) is positive. Coverage begins one full month after the sales closing date. The expected IOFC (EIOFC) is the difference between expected milk revenue and imputed feed costs determined at sign-up. It is important to note that actual farm-specific milk and feed prices are not used in the calculation of the EIOFC, but expected Class III, US average corn and US average soybean meal prices are used. These are obtained from the futures settlement prices in the price discovery period. The price discovery period ends on the last business Friday of each insurance purchase month and starts the previous Wednesday. Expected milk revenue is the product of the producer's target milk marketings (i.e., insurable milk quantity) and the expected Class III price. The feed costs are the product of quantities of corn and soybean meal equivalents used to account for energy and protein consumption and expected corn and US soybean meal prices.

Total program expected income over feed cost is the sum of the monthly EIOFC's over the contracted insurance period which can be anywhere from 1 to 10 months. The dairy farm operator needs to provide proportion of the approved maximum target marketings and estimated feed use to be insured each month of the insurance contract. In any one month the insurance contract can cover between 0% - 100% of expected production. In addition, the farm operator need not insure all of the gross revenue associated with the covered milk. That is, a portion of the EIOFC can be left uninsured. This uninsured portion of the EIOFC, referred to as the program deductible which can range from $0 - $1.50 per cwt.

According to program rules, for a single operation, the EIOFC associated for any amount of milk up to 240,000 cwt per insurance period (or within a single fiscal year) can be insured. The total amount of corn and soybean meal equivalent to be fed need to be within wide pre-defined feeding ranges. For corn equivalents, the feeding rate must be between the range of 0.13 – 1.04 bu per cwt milk (0.00364 and 0.02912 tons per cwt milk) whereas for soybean meal equivalents the allowable feeding range must lie between 1.61-12.85 lbs per cwt milk (0.000805 and 0.006425 tons per cwt milk). The GIOFC for the t^{th} month is calculated as that month's EIOFC minus the level of deductible (DL, $/cwt) chosen times the covered milk marketings (cwt).The indemnity is the difference, if positive, between the GIOFC and AIOFC, where AIOFC is calculated using the actual prices of Class III milk, corn and soybean meal prices. These actual prices are obtained from futures settle prices for each commodity over the last 3 trading days prior to the last trading day of each futures contract.

Unlike some crop insurance products, there are no producer premium subsidies associated with the purchase of LGM-Dairy. However there is an administrative and operating (A&O) subsidy payment made from USDA to the insurance provider where the funds for such payments do not come from producer premiums. By program rule producer premiums are set equal expected indemnities plus a 3% insurance reserve. Expected indemnities are calculated using 5,000 random draws from assumed distributions of Class III, corn and soybean meal expected prices. The premium is then calculated as the expected average indemnity received by the producer in the long-run by simulating 5,000 price scenarios plus 3% insurance reserve. Given the above review of the basic structure of the LGM-Dairy program, it is clear that the insured milk, feed quantities as well as deductible levels are crucial in determining the GIOFC and associated premium. The objectives of this chapter are to examine the sensitivity of gross income over feed cost (GIOFC) and premium to changes in feeding regimes and quantify the impacts of changes in deductible level on important program characteristics.

2.3 MATERIALS AND METHODS

The LGM-Dairy premium depends on the insured milk quantity, insured corn and soybean meal equivalent fed and deductible level. For this analysis, the insured milk quantity for all insurance periods was considered to be at a constant level per month (1,000 cwt). The allowable bounds of corn and soybean meal equivalents were divided into five equivalent ranges to understand the sensitivity of the GIOFC and LGM-Dairy premium to changes in insured feed quantities. Twenty five different combinations of the feed equivalents were obtained and are represented in Table 2.1.

We undertook a series of simulations for a hypothetical Wisconsin dairy farm using the University of Wisconsin's LGM-Dairy premium calculator (http://future.aae.wisc.edu/lgm_dairy.html#2) for four insurance purchase months: February 2000, May 2003, September 2006 and December 2008. However this analysis can be extended to any insurance contract from February 2000 to present. Constant levels of corn and soybean meal equivalents per cwt of milk were considered for every coverage month. The resulting GIOFC and producer premiums were calculated for 25 different feed combinations and 16 deductible levels. Table 2.2 represents an example of the type of results generated under these twenty five feed scenarios and 16 deductible levels. As noted above we used the alternative feeding and deductible scenarios to examine the relationship between GIOFC and premium with insured feed quantity and deductible level. In Table 2.3 estimated correlation coefficients for a number of policy variables are shown. These correlation coefficients were calculated via the 5,000 simulated price scenarios used to determine contract-specific premiums. These correlations were tested for statistical significance at a significance level (α) of 1%.

2.4 FEED CONVERSION RATES

Dairy farms use a wide array of feed stuffs according to availability, nutritional contribution to the desired budget and relative costs. To purchase an LGM-Dairy contract, on-farm or purchased feedstuffs are to be converted to corn and soybean meal equivalents. Any industry accepted conversion system can be used to convert purchased and home-grown feeds to corn and SBM equivalents. For the present analysis, the feed conversion rates as specified by the RMA are based on the Nutrient Requirements of Dairy Cattle (NRC 1989) are used. The factors used to convert the feed to equivalent corn (shelled, grade 2) and soybean meal (44% protein) units are calculated by solving simultaneous equations for energy and protein in terms of the feed stuff in consideration. NRC 1989 Table 7.1 is used to determine the energy and protein amounts. This table gives the composition of commonly used feeds in the dairy cattle diets on a 100% dry matter basis. For the protein, crude protein in % and for the energy, NEL (net energy at lactation) for the lactating cows in Mcal/lb are considered. Net energy at lactation (NEL) is the amount of energy of the feed that will be available to meet cow's requirements for maintenance, lactation and pregnancy. For corn grain, the crude protein is 10% and the NEL is 0.89 Mcal/lb on a 100% dry matter basis. For soybean meal (44% protein), the crude protein is 49.9 % and NEL is 0.88 Mcal/lb on a 100% dry matter basis. So, the equations for protein and energy for corn and soybean meal are:

Protein: $0.10\,x + 0.499y = z_1$ [1]

Energy: $0.89\,x + 0.880\,y = z_2$ [2]

Where x represents corn equivalents and y represents soybean meal equivalents. z_1 and z_2 represent crude protein % and NEL for the feed stuff to be converted. For example, if wheat bran is to be converted in terms of corn and soybean meal equivalents. The crude protein of wheat bran as per the NRC 1989 table 7-1 is 17.1 % and the NEL is 0.73 Mcal/lb on a 100% dry matter basis. In this case $z_1 = 0.171$ and $z_2 = 0.730$. Then, there will be two simultaneous equations with 2 sets of unknowns, which are the conversion factors for corn and soybean meal. Equation for wheat bran can be re-written as:

$$0.10\,x + 0.499\,y = 0.171 \quad [3]$$

$$0.89\,x + 0.880\,y = 0.730 \quad [4]$$

Solving these two equations, $x \approx 0.60$ and $y \approx 0.22$.

Nutrient requirements of dairy cattle (NRC 2001) is the most recent version among all the editions of the NRC. NRC 2001 provides accurate, updated and a greatly expanded set of feed composition tables. It provides a comprehensive list of feedstuffs commonly used in dairy cattle diets and their nutrient breakdown. Table 15-1 from NRC 2001 is used for the energy and protein equations. This table lists the nutrient composition and variability of commonly used feed stuffs for the dairy cattle on a dry basis. NRC 1989 and 2001 differ greatly in the calculation of crude protein and NEL. In the new edition of NRC, the metabolizable energy (ME) is used to calculate the net energy for lactation (NEL). In the NRC 2001, Net energy at 3 times the maintenance level as well as 4 times maintenance level (high producing cows) , NEL 3x and NEL 4x are enlisted in terms of Mcal/kg. Average of these two values was used to estimate of the NEL for most dairy farms today. For corn grain, the crude protein is 9.4 % and the NEL 3x is 2.01 Mcal/kg and NEL 4x is 1.90 Mcal/kg on a dry basis. For the Soybean meal (44% protein), the crude protein is 49.9 % and NEL 3x is 2.13 Mcal/kg and NEL 4x is 2.02 Mcal/kg on a dry basis. So, the equations for protein and energy for corn and soybean meal taking the average values of NEL 3x and 4x are:

$$\text{Protein: } 0.094\,x + 0.499\,y = z_1 \quad [5]$$

$$\text{Energy: } 1.955\,x + 2.075\,y = z_2 \quad [6]$$

For wheat bran, the crude protein is 17.3% and average NEL for 3x and 4x is 1.565 Mcal/kg. Therefore,

$$0.094\ x\ +\ 0.499\ y = 0.173 \quad [7]$$

$$1.955\ x\ +\ 2.075\ y = 1.565 \quad [8]$$

Solving the two equations, the conversion factor for wheat bran to corn equivalents, x is 0.54 and soybean meal equivalents y is 0.25. Thus a whole range of feeds used on farm can be easily converted into corn or soybean meal equivalents using the UW-Feed-Convert software system (Valvekar et al., 2010). To get an estimate on the feed bounds for a typical Wisconsin dairy farm, we analyzed a feed ration for milking cows producing 80 lb per day. With reference to Table 2.1, the corn equivalents for this farm were between Min and Mid-Min and the SBM equivalents were between Mid-Min and Med feed bounds.

2.5 RESULTS AND DISCUSSION

As mentioned above, expected indemnities and premiums are calculated using 5,000 random draws from assumed distributions of Class III, corn and soybean meal expected prices. Not surprisingly, the largest (absolute value) correlation coefficient was obtained between insurance deductible and premium with a range from -0.96 to -0.98 (Table 2.3). The lower the deductible, the higher will be the premium as the probability of payout increases with lower deductible levels as the GIOFC is larger. Similarly, it was found that the GIOFC is highly correlated with the energy diet or the insured corn quantity with a range of correlation coefficients between -0.77 to -0.87. In contrast to these large coefficients, the correlation between GIOFC and energy diets or SBM equivalents are relatively low with a range from -0.31 to -0.39. The correlations between the amount of energy diets and premium also have a relatively low value with a range of 0.07 to 0.23 across feeding scenarios. Protein diets also were found to show a very low correlation coefficient ranging up to 0.02. All the correlation coefficients were statistically significant at 1% level of significance except for the correlation coefficients between premium and feed diets. GIOFC, as mentioned earlier is calculated using the insured quantities of milk and feed and the expected prices. To investigate why the energy diets are highly correlated to GIOFC, correlation coefficients among the expected prices at the time of contract for Class III milk, corn and SBM were calculated (Table 2.4) for all the four insurance periods. The expected prices of Class III milk were highly correlated with corn prices than SBM prices for all the insurance periods except for September 2006 insurance contract. Among these correlation coefficients, only December 2008 contract had statistically significant correlation coefficient and this insurance contract witnessed higher correlation coefficient between expected prices for Class III milk and corn compared to Class III milk and SBM. GIOFC is also conditional upon the insured amounts of feed. Due to higher influence of the energy diets compared to the protein diets as per the bounds mentioned in Table 2.1, energy diets were highly correlated with GIOFC compared to protein diets.

Table 2.5 is used to show the premium as % of GIOFC for all the four insurance contracts for medium bounds of insured feed. With an increase in deductible, the LGM-Dairy premium decreased as it reduced the potential insurance liability given the lower GIOFC as well as decreasing the payout probability. For every cwt of insured milk, if the deductible level is increased by 10 cents, premium decreased by 1 to 5 cents (while GIOFC decreases by exactly 10 cents). Hence, at constant insured milk quantity, the decrease in premium depends on the actual prices, volatility and futures prices for milk and feed. In addition at a deductible level of $1.5 per cwt milk, the premium as a percentage of GIOFC ranged from 0.36% to 2.15%, whereas at $0 per cwt deductible, it was 3.87% to 6.74% for all the insurance periods (Table 2.5). Maximum amounts of feed equivalents corresponded with higher premium levels compared to premiums obtained under the minimum feed equivalent price scenarios. At a deductible of $1.50 per cwt milk, the premium for August 2008 insurance period at the maximum bounds of insured feed equivalents was approximately 43 cents per cwt milk, while at the medium bounds, it was 28 cents per cwt of milk and for minimum bounds was 21 cents per cwt milk.

Table 2.5 shows the percentage premium change as a result of changes in feed equivalents. For example with a decrease in the insured feed equivalents from maximum to medium the premium for February 2000 insurance period decreased by approximately 6% to 29%, whereas if the insured feed equivalents are decreased from medium to minimum, the premium decreased by 3% to 16% across all the deductibles. The sensitivity of GIOFC across deductible levels to different bounds of insured feed quantities for the four insurance periods was also analyzed (Figure 2.1). With a constant deductible level, the GIOFC increases with a decrease in feed bounds. For December 2008, GIOFC at a deductible level of $0.50 per cwt milk using the Min-Min feeding regime is approximately $13.64 per cwt milk. Under the Med-Med feeding scenario, the GIOFC was estimated to be $10.98 per cwt milk and under the Max-Max scenario the GIOFC was $8.31 per cwt milk.

Changes in deductible levels and feeding regimes impact the probability of receiving an indemnity. To simulate these probabilities we used the 5,000 simulations to estimate the percent of observations where a positive indemnity is recorded. We estimated these probabilities under all feed regimes and deductible levels. In Figure 2.2we show the probability of positive indemnities over the 5,000 simulations for September 2006 contract under alternative feeding regimes and minimum and maximum levels of deductible. Figure 2.2 (a) and (c) reflected that at maximum coverage levels ($0 per cwt milk deductible), probability of payouts using the minimum amount of feed was approximately 52% and the indemnities ranged from $0 to $3.3 per cwt milk, while probability of payouts at maximum bounds of insured feed was almost 52% with indemnities ranging from $0 to $3.8 per cwt milk. Figure 2.3(b) and (d) reflected that at maximum levels of deductible ($1.5 per cwt milk), the probability of payouts for the minimum bounds of insured feed was approximately 9% and the indemnities ranged from $0 to $1.8 per cwt milk, while probability of payouts at maximum bounds of insured feed was almost 10% with indemnities ranging from $0 to $2.3 per cwt milk. Similar trend was observed for other insurance periods. From results above, it can be inferred that at maximum bounds of insured feed equivalency, the range of indemnities is larger than at minimum bounds of insured feed. When this analysis was extended to insurance months in 2006 and 2010, similar results were found.

2.6 CONCLUSION

This chapter provided an overview of the basic structure of LGM-Dairy and key relationships between different variables like insured corn quantity, insured soybean meal quantity and deductible levels with premium and GIOFC. Three important insights that are inferred from the correlation coefficients are i) deductible level and premium have a highly negative and strong association; ii) insured corn equivalents and GIOFC have a highly negative and strong association and iii) in comparison to insured corn equivalents, insured soybean meal equivalents do not have a strong association with GIOFC. Results from graphical analysis further corroborate some of these findings. Our results indicated that insurance premium is very sensitive to deductible level and insured feed quantity. With an increase in the deductible level, premium decreases. While at a constant deductible level, as the insured feed quantities are reduced, premium decreases. However the percentage reduction in premium also decreases. GIOFC on the other hand, is very sensitive to changes in the insured feed quantities and insured corn equivalents in particular. With an increase in the insured feed quantities, GIOFC decreases. Further at higher levels of deductibles, there is lesser probability of payouts. While at maximum bounds of insured feed equivalents, the range of indemnities is larger than at minimum bounds of insured feed. This chapter also includes an explanation on feed conversion factors used by RMA.

2.7 REFERENCES

Cabrera, V.E. and D.Solis, 2008. "Managing the Newly Created LGM-Dairy Insurance under Seasonal Climate Variability." Journal of Animal Science,Vol.86, E-Suppl.2/ J.Dairy Sci.Vol.91, E-Suppl.1,654.

National Research Council. 1989. Nutritional Requirements of Dairy Cattle. 6th rev. ed. Natl. Acad. Sci., Washington, DC

National Research Council. 2001. Nutritional Requirements of Dairy Cattle. 7th rev. ed. Natl. Acad. Sci., Washington, DC.

US Department of Agriculture, USDA. 2008. Livestock Gross Margin – Dairy website, http://www.rma.usda.gov/policies/2009/lgm/09lgmdairypolicy.pdf, Accessed June,2009

University of Wisconsin Understanding Dairy Markets, Livestock Gross Margin-Dairy Website 2009, http://future.aae.wisc.edu/lgm_dairy.html, Accessed June, 2009.

Valvekar, M., V.E.Cabrera, M. Wattiaux, B.W. Gould, 2010, LGM-Dairy Feed Equivalent Conversion, http://dairymgt.uwex.edu/lgm/lgmfeeds.php

Table 2.1. Alternative Insured Corn and Soybean Meal Equivalents Used in Simulations

Feed Scenario	Corn Equivalent (bu/cwt)	Soybean Meal Equivalent (lb/cwt)
Minimum Required by LGM-Dairy [Min]	0.13	1.61
Midpoint Between Med and Min [Mid-Min]	0.36	4.42
Average of Minimum and Maximum Allowed [Med]	0.59	7.23
Midpoint Between Med and Max [Mid-Max]	0.81	10.04
Maximum Allowed by LGM-Dairy [Max]	1.04	12.85

Table 2.2. Example GIOFC and Premium Data for February 2000, May 2003, September 2006, and December 2008 Contracts

Feed Equivalent Scenario			Insurance Period							
			February 2000		May 2003		September 2006		December 2008	
Corn	Soybean meal	Deductible ($/cwt)	GIOFC ($/cwt)	Premium ($/cwt)	GIOFC ($/cwt)	Premium ($/cwt)	GIOFC ($/cwt)	Premium ($/cwt)	GIOFC ($/cwt)	Premium ($/cwt)
Min[1]	Min[1]	0	12.52	0.44	12.76	0.58	13.70	0.46	14.14	0.73
Mid-Min[2]	Mid-Min[2]	0.10	11.69	0.40	11.90	0.53	12.80	0.41	12.71	0.69
Med[3]	Med[3]	0.50	10.55	0.24	10.73	0.35	11.58	0.25	10.98	0.53
Min[1]	Max[4]	0.80	10.79	0.14	10.98	0.24	11.97	0.15	11.68	0.39
Mid-Max[5]	Mid-Max[5]	1.00	9.31	0.11	9.47	0.20	10.27	0.12	9.14	0.39
Max[4]	Min [1]	1.20	9.31	0.07	9.49	0.15	10.18	0.09	9.27	0.34
Max[4]	Max[4]	1.50	10.08	0.03	10.27	0.08	11.27	0.04	10.98	0.19

[1] Minimum feed equivalents required by LGM-Dairy
[2] Midpoint between Med and Min feed equivalents
[3] Average of minimum and maximum feed equivalents allowed
[4] Maximum feed equivalents allowed by LGM-Dairy
[5] Midpoint between Med and Max feed equivalents

Table 2.3. Correlation Coefficients among Contract Characteristics, February 2000, May 2003, September 2006, and December 2008 Insurance Periods.

Correlated Variables	Insurance Period			
	February 2000	May 2003	September 2006	December 2008
Deductible level and Premium[1]	-0.97**	-0.98**	-0.97**	-0.96**
Energy diet and GIOFC	-0.77**	-0.79**	-0.82**	-0.87**
Protein diet and GIOFC	-0.31**	-0.37**	-0.33**	-0.39**
Energy diet and Premium	0.07	0.06	0.06	0.23**
Protein diet and Premium	0.02	0.02	0.00	0.00

** p-values are statistically significant at 1% level of significance. This implies that the correlation coefficients for these variables are statistically significant.

Table 2.4 Correlation Coefficients between Expected Prices of Class III milk, Corn and Soybean Meal for February 2000, May 2003, September 2006 and December 2008 Insurance Periods.

Expected prices	February 2000	May 2003	September 2006	December 2008
Class III milk and Corn	0.74	-0.27	0.53	0.97**
Class III milk and Soybean meal	-0.32	0.24	0.72	0.93**
Corn and Soybean meal	-0.12	-0.33	0.92**	0.87**

** p-values are statistically significant at 1% level of significance. This implies that the correlation coefficients for these variables are statistically significant.

Table 2.5 Premium as % of GIOFC for Medium Bounds of Insured Feed across all Deductible Levels.

Deductible ($/cwt)	February 2000	May 2003	September 2006	December 2008
0	4.13%	5.24%	3.87%	6.74%
0.1	3.70%	4.81%	3.48%	6.34%
0.2	3.29%	4.40%	3.11%	5.95%
0.3	2.91%	4.01%	2.77%	5.57%
0.4	2.56%	3.64%	2.44%	5.21%
0.5	2.23%	3.30%	2.15%	4.86%
0.6	1.94%	2.97%	1.87%	4.53%
0.7	1.67%	2.66%	1.62%	4.21%
0.8	1.43%	2.37%	1.39%	3.90%
0.9	1.21%	2.10%	1.18%	3.61%
1.0	1.01%	1.86%	1.00%	3.34%
1.1	0.84%	1.63%	0.84%	3.07%
1.2	0.69%	1.43%	0.70%	2.82%
1.3	0.56%	1.24%	0.57%	2.59%
1.4	0.45%	1.07%	0.47%	2.36%
1.5	0.36%	0.92%	0.38%	2.15%

Table 2.6 Percent Change in Premium under Alternative Feed Equivalents and Deductible Level

	Insurance Period							
	February 2000		May 2003		September 2006		December 2008	
Deductible ($/cwt)	Max[2]→ Med[1] (%)	Med[1] → Min[3] (%)	Max[2]→ Med[1] (%)	Med[1] → Min[3] (%)	Max[2]→ Med[1] (%)	Med[1] → Min[3] (%)	Max[2]→ Med[1] (%)	Med[1] → Min[3] (%)
0	6%	3%	4%	2%	4%	2%	12%	6%
0.1	7%	3%	4%	2%	5%	3%	12%	7%
0.2	7%	4%	5%	2%	5%	3%	13%	7%
0.3	8%	4%	5%	3%	6%	3%	14%	8%
0.4	10%	5%	6%	3%	7%	4%	15%	9%
0.5	11%	6%	6%	3%	8%	4%	16%	10%
0.6	12%	6%	7%	4%	9%	5%	18%	10%
0.7	13%	7%	8%	4%	10%	6%	19%	11%
0.8	14%	8%	9%	4%	11%	6%	20%	12%
0.9	16%	9%	9%	5%	12%	7%	21%	13%
1	18%	10%	10%	5%	13%	8%	22%	14%
1.1	20%	11%	11%	6%	15%	8%	24%	15%
1.2	22%	11%	12%	6%	16%	9%	25%	16%
1.3	24%	13%	13%	7%	18%	9%	27%	18%
1.4	26%	14%	15%	8%	20%	10%	28%	19%
1.5	29%	16%	16%	8%	21%	11%	30%	21%

[1] Average of minimum and maximum feed equivalents allowed.
[2] Maximum feed equivalents allowed by LGM-Dairy.
[3] Minimum feed equivalents allowed by LGM-Dairy.

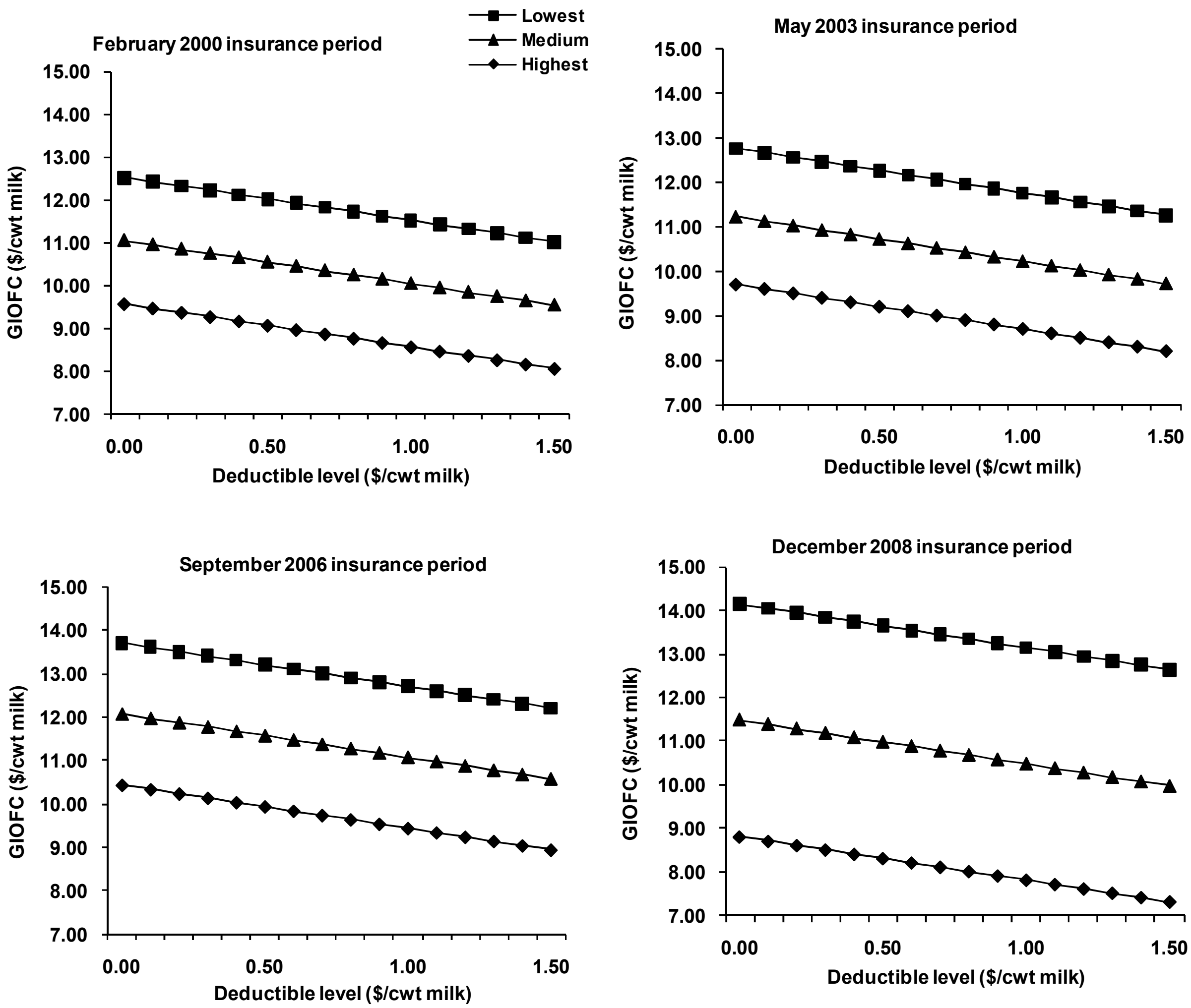

Figure 2.1 Sensitivity of GIOFC to Deductible Levels and Alternative Feed Diets

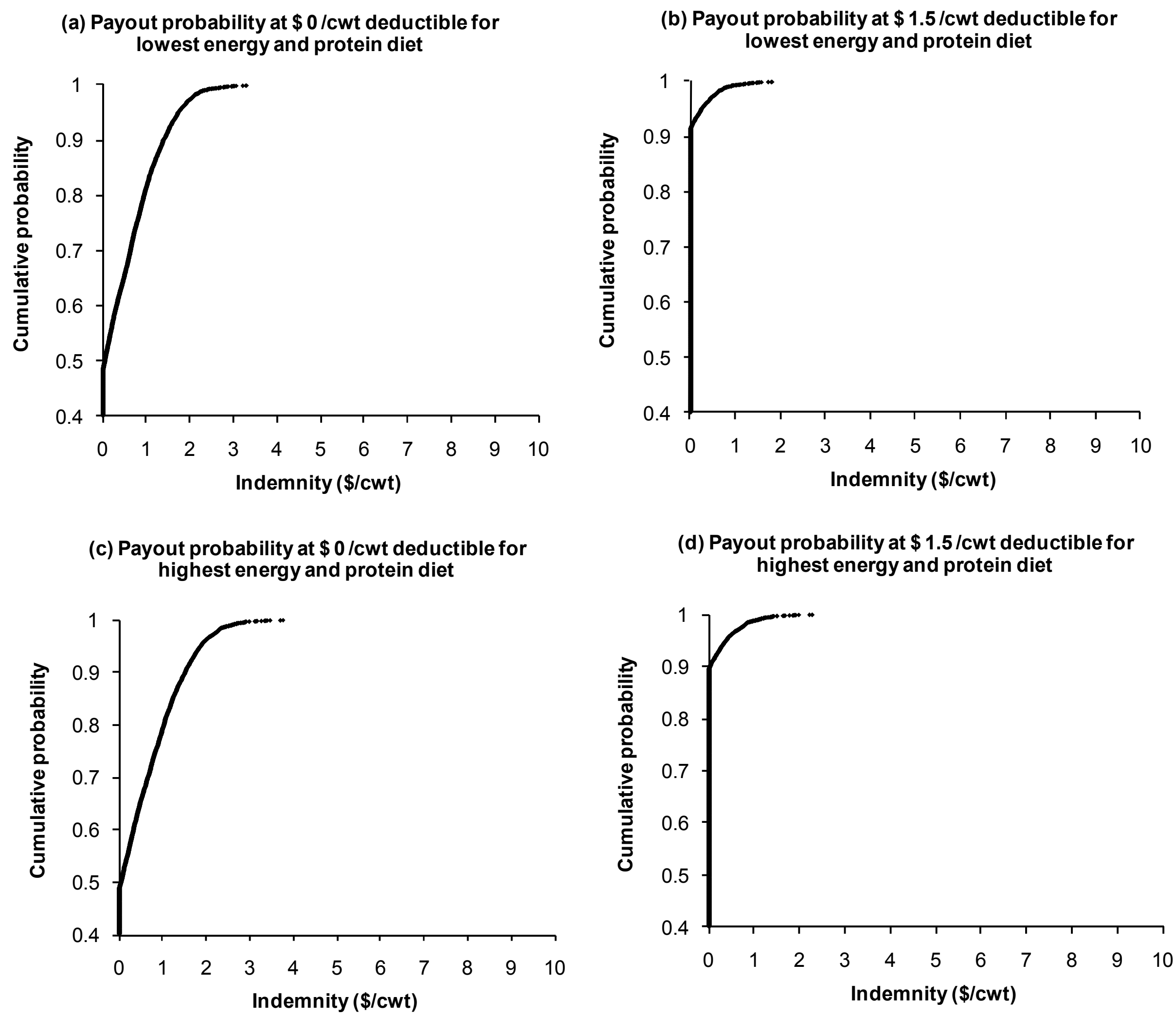

Figure 2.2 Cumulative Probability of Positive Indemnities for September 2006 contract under Alternative Feeding Scenarios and Minimum and Maximum Deductibles.

CHAPTER 3

IDENTIFYING THE OPTIMAL (LEAST COST) LGM-DAIRY CONTRACT DESIGN

3.1 INTRODUCTION

The ability of LGM-Dairy to reduce downside IOFC risk obviously comes at a cost. The degree of desired protection and dairy farmer risk preferences will determine how this program is integrated into a farm's marketing program. Given the program structure there are an infinite number of LGM-Dairy contracts that could be used to obtain a desired level of protection. This section of the thesis is used to describe an economic model that can be used to identify optimal strategies where optimality is defined as that LGM-Dairy contract design that provides a pre-defined target IOFC per cwt of all farm milk at the least cost. In this analysis we differentiate *insured* versus *all farm* milk as the GIOFC of the *insured* milk can be applied to *all farm* milk produced.

3.2 MATERIALS AND METHODS

The following is the mathematical description of the LGM-Dairy insurance and the optimization problem objective of this study. Table 2.1 contains a summary of the variables used in the analyses.

3.2.1 Mathematical Description of LGM-Dairy

LGM-Dairy premiums are set by the USDA, Risk Management Agency (RMA) to be equal to the long-term expected (average) contract-specific indemnity (plus 3%). The expected indemnity is determined via the use of 5,000 simulated price regimes defined by vectors of 30 prices (10 Class III, corn and SBM) for the contract being considered. These random draws are obtained from an assumed lognormal distribution as outlined in the LGM-Dairy program policy (RMA, 2009c). Means of these prices are estimated as the average of the futures settle prices observed over the price discovery period defined as the 3 days ending on the last business Friday of each month. Price standard deviations are computed from the annualized implied volatility from "at-the-money" options over the same price discovery period. The calculation of the LGM-Dairy premium (LGMPREM) can be represented via the following:

$$LGMPREM = \frac{(1.03)*(LGMINDEM)}{TCP} \quad [1]$$

where the premium, is the average of simulated indemnities, LGMINDEM,

$$LGMINDEM = \frac{\sum_{t=1}^{5,000} Max[(GIOFC - SIOFC_t),0]}{5,000} \quad [2]$$

plus a 3% reserve load or reasonable insurance reserve, specific to that particular contract ($ per cwt), TCP is the producer identified total covered milk production in the contract period $SIOFC_t$ is the simulated IOFC determined for the t^{th} price simulation scenario, GIOFC is the guaranteed IOFC determined at contract sign-up.

The GIOFC is calculated using the EIOFC ($/cwt), a deductible level (DL, $/cwt) and covered production ($TCP_m \equiv \%C_m * MQ_m$):

$$GIOFC = \sum_{m=1}^{M} \left[\%C_m * \left(MQ_m * \left(ECL3P_m - DL \right) - CF_m * ECP_m - SBM_m * ESBMP_m \right) \right] \quad [3]$$

where $\%C_m$ is the percent of monthly production elected to be insured (0 to100%) in the m^{th} month, MQ_m is monthly milk production to be insured, $ECL3P_m$ is the expected Class III price obtained from the 3-day price discovery period. CF_m is the total corn equivalent amount expected to be fed to obtain MQ_m, ECP_m is the expected corn price obtained from the price discovery period, SBM_m is the amount of soybean meal (SBM) equivalent expected to be fed to obtain $MQ_{m,}$ $ESBMP_m$ is the expected SBM price obtained from the price discovery period and M is the number of months in the planning period (M = 1,…,10).

Given the above, we define a per cwt Net GIOFC (NGIOFC, $/cwt) by subtracting from the GIOFC guarantee the per cwt contract premium where the above cwt are for covered milk, TCP:

$$NGIOFC = (GIOFC/TCP) - (LGMPREM/TCP). \quad [4]$$

As noted in Chapter 2, the futures and options markets for Class III milk, corn and SBM are used as information sources in the calculation of expected prices. Unlike Class III milk futures which are traded every month, only 5 contracts are traded for corn grain during any year and only 8 for SBM. For insurance months where no corn or SBM futures contracts are traded the associated expected grain price is the weighted average of the daily settlement prices of the surrounding months during the expected price measurement period (RMA, 2009a). The weights are based on the distance between the desired month and futures contract month actually used and proportional to the number of months until the futures contract expires.

Similar to other insurance policies, the dairy farmer identifies the portion of the GIOFC not to be insured. Allowable deductibles range from \$0 to \$1.50 per cwt of milk in \$0.10 per cwt milk increments. Higher deductibles imply lower insurance premiums, as this, by definition, reduces potential insurance liability given lower indemnity probabilities and if there are indemnities, the payout amounts are lower.

At the end of the insurance period, the actual insurance indemnity is the difference, if positive, between the GIOFC and the AIOFC, where the AIOFC is the IOFC estimated at the end of each LGM-Dairy contract. The AIOFC is calculated via the following:

$$AIOFC = \sum_{m=1}^{M}\left[\%C_m * \left(MQ_m * ACL3P_m - CF_m * ACP_m - SBM_m * ASBMP_m\right)\right] \quad [5]$$

where $ACL3P_m$ is the actual Class III milk price calculated as the simple average of the daily settlement prices of the CME Class III milk futures contract during the m^{th} month's actual price measurement period. ACP_m is actual corn price calculated as the simple average of the daily settlement prices for the CME corn futures contract during the actual price measurement period (the last three trading days prior to contract expiration). Similar to expected prices, for months with no corn or SBM futures contracts, the actual price are the weighted average of the immediately surrounding month's daily settlement prices during the actual price measurement period. The indemnity is then calculated as follows:

$$ACTUALINDEM = max\ (GIOFC - AIOFC,\ 0) \quad [6]$$

3.2.2 Formulation of the Optimization Problem

For the present study we assume that a dairy farm operator wants to identify an LGM-Dairy insurance program such that a target farm guaranteed IOFC (TGIOFC, \$/cwt all farm milk) is returned at the least farm premium (FARMPREM, \$/cwt all farm milk) cost (Valvekar et al., 2010). Note that TGIOFC and FARMPREM are evaluated using total farm milk rather than the insured milk for the insurance period. To reduce the degree of nonlinearity of this model we fixed the DL and used program default corn and SBM equivalent feed amounts per unit of milk produced and for the present analysis we assume the only choice variable available to the farm operator is $\%C_m$. Depending on market conditions at sign-up and the desired TGIOFC over the planning period, the target may be obtained by insuring a portion of the planning period's production. As specified in the LGM-Dairy policy, the dairy farmer cannot insure more than 240,000 cwt of milk production during any 10 month coverage period or during a fiscal year.

We can represent the operator's optimization problem via the following:

$$\text{Optimal LGM-Dairy Contract} = \underset{\%C_m}{Min}\ (FARMPREM) \quad [7]$$

$$\text{subject to:} \quad TGIOFC \geq \left(\frac{GIOFC}{\sum_{m=1}^{M} MQ_m} \right) - FARMPREM \quad [8]$$

$$\text{and } TCP \leq 240{,}000 \ \ cwt\ milk \quad [9]$$

$$\text{where} \quad FARMPREM = 1.03 * \left(\frac{LGMINDEM}{\sum_{m=1}^{M} MQ_m} \right) \quad [10]$$

$$GIOFC = \sum_{m=1}^{M}\left[\%C_m * \left(IOFC_m - DL * MQ_m\right)\right] \qquad [11]$$

The model is a nonlinear programming model given that the the actuarially fair premium (FARMPREM in Equations 7, 8, and 10) is conditional on program design as is GIOFC (Cabrera et al., 2009). We used a generalized reduced gradient method to solve this optimization problem. This method of solution allows for nonlinear constraints on the variables in the optimization process (Lasdon et al., 1973). To ensure that we identify a global minimum cost solution, we set every insurance month coverage percentage to non-zero starting values (Ragsdale, 2004). The model was solved using the Premium Solver Software System, V5.0 (Frontline Systems, Incline Village, Nevada) used as an add-in within Excel ®.

3.2.3 Parameters, Assumptions and Scenarios Used in the Optimization Model

For the present analysis we use as our case farm a representative 120 herd size Wisconsin dairy farm producing 19,985 lb per cow per year. We used insurance premium data associated with the October 2008 insurance contract for the analyses. This implies the possible coverage months are from December 2008 to September 2009. Month-specific milk production per cow was considered using Wisconsin State summary data for 2008 and 2009 (NASS, 2009). Thus, the total milk available for coverage for the 10 month period was taken as 20,016 cwt.

We used default corn and SBM equivalent feed rates per unit of milk produced according to the program policy (28 lb corn equivalents and 4 lb SBM equivalents per cwt of milk produced). Milk sales, corn equivalents to be fed and SBM equivalents to be fed for the October 2008 contract are shown in Table 3.2. Previous analyses indicate that under normal market conditions, premiums are substantially reduced with higher deductible with relatively smaller gross income impacts (Cabrera et al., 2009). The model however can be extended for any level of deductible between $0 per cwt and $1.5 per cwt. For these analyses however we assumed no deductible ($0 per cwt) in the insurance contract.

Analyses were also done for a range of possible TGIOFC scenarios believed to be feasible between $1 per cwt milk to $12.21 per cwt. As a reference, we examined a range of IOFC for a sample of 500 similar sized Wisconsin dairy farms participating in the Agriculture Financial Advisor (AgFA, 2009) program managed by the Center for Dairy Profitability (www.cdp.wisc.edu per AgFa.htm) at the University of Wisconsin over the 2004 to 2008 period. These data indicated similar sized dairy farms require an IOFC of at least $5 per cwt milk.

Purchasing a contract depends on a number of factors like the producer's marketing plan and market conditions during purchase. Risk management strategy adopted by a producer needs to account for all these factors. Earlier analyses by Drye and Cropp (2001) was done to measure the impacts on net income and cash liquidity of typical dairy operation utilizing alternative price risk management strategies during a period of rising and falling prices. To better understand the impact of purchasing a single contract versus different contracts insuring similar months for the same level of monthly production and TGIOFC for different time frames, a realistic marketing plan was assumed, where a producer enters into a contract every 3 months and insures 3 or 4 months at a time for same levels of monthly milk production. For example, a producer insures the first three months of the October 2008 contract (December 2008 through February 2009) and then enters into January 2009 contract insuring March through May 2009 and then April 2009 insuring June through September 2009. This latter type of 10 month strategy will be referred to as the "stacked strategy". This scenario was then compared to the "10-month strategy" where the producer enters into a single contract October 2008 for all the 10 months December 2008 to September 2009 for the same level of protection. Optimal solutions for these two scenarios were compared.

3.2.4 Analyses Performed

We solved the optimization problem represented by equations [7] to [12] for different TGIOFC. We present optimal solutions for different TGIOFC levels ranging from $4 per cwt to the maximum possible TGIOFC of $12.21 per cwt and for all farm milk to examine how the optimal insurance program could change with different targets. For each solution scenario, we report the optimal monthly milk coverage (i.e., %C_m), LGMPREM, FARMPREM, and NGIOFC $\left(= \text{GIOFC} - \text{FARMPREM} * \sum_{m=1}^{M} MQ_m \right)$. We also compare these optimal solutions with an alternative non-optimal strategy, where the same amount of TCP is covered as in the above least cost solution but it is insured evenly across the 10 months encompassed by the October 2008 contract. Optimal strategies to reach a TGIOFC of $5 per cwt milk were also compared for a stacked marketing plan as discussed in earlier section.

Under certain market conditions, it might seem better to take an insurance contract than not insure at all. In this analysis, the market conditions for the October 2008 insurance contract were considered and the actual prices and expected prices for Class III, Corn and SBM were used (Table 3.6). As presented in Table 3.2, it is assumed that a producer had 20,016 cwt of farm milk for the 10- month period (December 2008 through September 2009). A TGIOFC was generated for Non-optimal strategy with 50% insured production and this TGIOFC was used in the least cost model applied to the 10-month and stacked strategies. All farm milk was valued at the actual prices and the Net IOFC was calculated under each strategy. Net IOFC was compared to the actual farm revenue under a no LGM-Dairy contract scenario.

3.3 RESULTS AND DISCUSSION

3.3.1 The Impact of Alternative Income Targets on Optimal Insurance Design

Table 3.3 is used to show the optimal coverage percentages (i.e., $\%C_m$) under alternative TGIOFC levels using a 10-month planning period. As a reference, a contract assuming 100% coverage production every month would generate a FARMPREM of $0.82 per cwt milk and a TGIOFC of $12.21 per cwt milk. However, if a dairy farmer's TGIOFC is $5 per cwt milk, the least cost contract to secure this TGIOFC would be to insure all the production during the first 3 months and less than 100% for the remaining months. The least cost contract that returns a $5 TGIOFC results in a FARMPREM of $0.30/cwt for farm milk, an LGMPREM value of $0.67/cwt of insured milk with approximately 44% of the farm's production over the December 2008 to September 2009 period being insured. The total insurance cost would be $6,005.

As discussed earlier, a TGIOFC of $5 per cwt milk is considered the lower bound of TGIOFC calculated for comparative Wisconsin farms. For a TGIOFC of $6/cwt milk, the optimal contract would insure approximately 53% of the farm's production over the insurance period at a FARMPREM of $0.37/cwt over all milk and LGMPREM of $0.69/cwt of insured milk. The total insurance cost at this TGIOFC would be $7,406. As shown in Table 3.3, nearby contract months were first selected and in higher proportion than the more distant months.

Although, we used a hypothetical Wisconsin dairy farm for the analysis, the framework presented here is applicable to any dairy farm regardless of size and location. We assumed a fixed amount of feed per unit of milk produced over the insurance period, but the model can easily be used to allow for the use of different amounts of feed per unit of milk across months (Understanding Dairy Markets, LGM-Dairy Least Cost, 2010).

3.3.2 Comparison of Optimal LGM-Dairy Contract Designs Versus Non-Optimal Strategies

Tables 3.3 and 3.4 are used to compare the program performance for the optimal and non-optimal strategies, where non-optimal strategy covers the same percentage of total monthly production but this coverage is spread evenly across 10 months. As expected, FARMPREM as a percentage of the TGIOFC is lower with the optimal strategy. For example, to insure a TGIOFC of $5/cwt of farm milk, the optimal insurance cost is $6,005, FARMPREM is 6.1% of TGIOFC, and the optimal coverage is 44% of the production. The non-optimal strategy with the same coverage of 44% for all the 10 months would cost $7,205 and would be 6.7% of the TGIOFC. In other words, the optimal strategy would cost $1,432 ($0.06/cwt) less than the non-optimal strategy, a 16.7% decrease.

To generate higher TGIOFC, greater amounts of milk are required to be insured. The optimal solution becomes closer to the non-optimal strategies at higher TGIOFC values. Alternatively, a contract is less valuable if the protection level is too low. A farmer's risk management strategy would need to find an optimal balance between the TGIOFC and the opportunity of having a lower differential premium price. For instance, we show in Table 3.4 that the ratio of the non-optimal FARMPREM and optimal FARMPREM decreases as the least cost covered production increases as a result of setting higher targets. At a %C of 35% (having a low TGIOFC), the non-optimal FARMPREM is 1.25 times the optimal FARMPREM and the % change in optimal FARMPREM over the non-optimal FARMPREM is 20.6%, whereas at 97% (having a high TGIOFC), it is 1.02 times the optimal FARMPREM and the percentage change in optimal FARMPREM over the non-optimal FARMPREM is 2.5%. This model was developed into a user-friendly web based application (Appendix A).

3.3.3 Optimal solution for a stacked strategy at TGIOFC of $5 per cwt milk.

Table 3.5 is used to show the difference in the FARMPREM of a single contract and the weighted average of FARMPREM for 3 different contracts with same monthly milk production and TGIOFC of $5/cwt farm milk. As noted above, setting a $5 target under a 10 month planning and purchase period, the FARMPREM is $0.30/cwt of all milk generating a total premium of $6,005 and 44% of the 10 month production being insured. Under a 3,3,4 stacked strategy with a $5 target for each insurance purchase as the objective, the least cost percent coverages are 23%, 36% and 40% for the Oct '08, Jan '09 and April '09 contracts, respectively. The least cost FARMPREM values were $0.26/cwt, $0.30/cwt and $0.34/cwt for these contracts. The weighted average of FARMPREM for all farm milk with the stacked strategy is $0.305/cwt and the cost of insurance for all farm milk is $6,105. It is $100 costlier than the long term 10-month strategy and the change in premium is 1.7%. The % of FARMPREM over TGIOFC is 6 % for both the strategies. However when the total production covered under these strategies is compared, the difference is obvious. For the stacked strategy, the total optimal coverage is 11,009 cwt milk, which accounts to 55% of the all farm milk (20,016 cwt milk) compared to 8,807 cwt (44%) under the 10 month strategy. This indicates that for the time period analyzed, to reach the same level of TGIOFC of $5/cwt farm milk, a producer can insure more milk at the same cost with a stacked strategy when compared to a 10-month strategy. Is should be remembered that the above results are conditional on the specific time period analyzed.

3.3.4 Evaluation of performance of different risk management strategies

Table 3.6 is used to compare the Net IOFC for different risk management strategies. Net IOFC is calculated using actual farm revenue, indemnity and the premium under each strategy. If a producer did not enter into October 2008 LGM-Dairy contract, then the actual farm revenue was $169,253 and the expected farm revenue was $243,606 for the 10 month period (December 2008 through September 2009), a difference of $74,353. For the stacked strategy however, since different insurance contracts were used, the expected prices for March, April and May 2009 as of January 2009 were considered and for the months of June, July, August and September 2009, expected prices as on April 2009 were considered. The expected farm revenue for the stacked strategy was $206,333.

If a producer used the non-optimal strategy insuring 50% of his farm production for each month in the 10-month insurance period, the Net IOFC for all farm milk was $9.9 per cwt. The TGIOFC under this contract was $5.69 per cwt milk. This was used as the TGIOFC to get the optimal solutions under the 10-month optimal strategy and the stacked strategy. The Net IOFC for all farm milk under the non-optimal strategy was $9.6 per cwt and under the stacked strategy was $7.3 per cwt milk. The % change in Net IOFC from the actual farm revenue was 17% and 14% for the non-optimal as well as 10-month optimal strategy. For the stacked strategy, the % change in Net IOFC from the actual farm revenue was -13%. Since the expected prices in October 2008 were higher than the actual prices (Table 3.7), Net IOFC was lower compared to the expected farm revenue for all the three strategies. However, the premium for all farm milk (FARMPREM) under the 10-month optimal strategy as well as stacked strategy was $0.06 per cwt less than that under the non-optimal strategy accounting to $1201 savings on the all farm milk.

3.4 CONCLUSIONS

Dairy farmers interested in using the LGM-Dairy insurance as a price risk management tool could save premium costs by designing an optimized LGM-Dairy contract. This study demonstrates that for similar levels of coverage (i.e., proportion of total milk production insured), there are substantial differences in insurance premium cost depending upon the distribution of the production insured over the 10 month LGM-Dairy contract. For a dairy farmer insuring about half of the farm production, this premium could be 80% lower for the optimal 10-month strategy than for the non-optimal one. Further to reach the same level of TGIOFC of $5 per cwt milk, a producer can insure more amount of milk at the same cost with a stacked strategy when compared to a 10-month strategy. However these results may vary according to time periods since market conditions, while entering into a contract can have a significant impact on the premiums under all the three strategies. Hence adoption of a certain risk management strategy remains a complex decision from a producer's perspective.

There are several extensions to our model that should be undertaken to increase its applicability as a risk management tool for US dairy farm operators. First, given that corn and SBM feeding rates impact insurance premiums these rates could be considered decision variables by the producers. Secondly, given the availability of the use of traditional options-based risk management strategies, it is important to extend the above optimization model to include the use of dairy and grain bundled options strategies as an alternative to achieve the desired income over feed cost target. Thus, in this extended model, the producer would be able to perform a portfolio analysis to choose between the use of LGM-Dairy, a bundled options strategy or a combination of the two.

3.5 REFERENCES

Agriculture Financial Advisor (AgFA). 2009. University of Wisconsin Center for Dairy Profitability Financial Benchmarks. http://cdp.wisc.edu/AgFA.htm. Accessed 14 August 2009.

Cabrera, V. E., B. W. Gould, and M. Valvekar. 2009. Livestock gross margin insurance for Dairy cattle: An analysis of program performance and cost under alternative policy configurations. Agricultural and Applied Economics Association 2009 Annual Meeting, July 26-28, 2009,Milwaukee, Wisconsin 49262.

Drye, P & R.A Cropp. (2001). *Price risk management strategies for dairy producers: A historical analysis*. Retrieved June 1, 2010, from http://www.aaa.wisc.edu.

Lasdon, L.S., R.L. Fox, and M.W. Ratner. 1974. Nonlinear optimization using the generalized reduced gradient method. Revue Fran~aise dtAutomatique, Informatique et Recherche Operationelle, 8 annee, V-3.

National Agricultural Statistics Service (NASS). 2009. Wisconsin Dairy Statistics 1999-2008. http://www.nass.usda.gov/Statistics_by_State/Wisconsin/index.asp. Accessed 21 August 2009.

National Research Council (NRC). 2001. Nutrient Requirements of Dairy Cattle. 7th rev. ed. National Academy Press, Washington, DC.

Ragsdale, C. Spreadsheet modeling decision analysis. A practical introduction to Management science. 4th Ed. Thompson South Western, Mason, OH (2004).

Risk Management Agency (RMA). 2009a. Livestock gross margin for dairy cattle insurance policy: Underwritten rules. USDA Risk Management Agency. http://www.rma.usda.gov/policies/2010/lgm/10lgmdairyundrules.pdf. Accessed 14 August 2009.

Risk Management Agency (RMA). 2009b. Livestock gross margin insurance policy: Step by step instructions to calculate premium. USDA Risk Management Agency. http://www.rma.usda.gov/policies/2010/lgm/10lgmdairypremcalc.pdf. Accessed 14, August2009.

Valvekar,M., Cabrera, V.E, and Gould, B.W. 2010.Identifying Cost Minimizing Strategies for Guaranteeing Target Dairy Income over Feed Cost via Use of the LGM-Dairy Insurance Program. Journal of Dairy Science93:3350-3357.

Table 3.1 Description of Variables Used in the LGM-Dairy Cost Minimization Model

Variable	Unit	Description
$\%C_m$	%	Percentage of monthly insured (covered) production
$ACL3P_m$	\$ per cwt milk	Actual Class III milk price for month m
ACP_m	\$ per cwt corn	Actual corn price for month m.
ACTUALINDEM	\$ per cwt milk	LGM-Dairy actual indemnity
AIOFC	\$ per cwt milk	Actual income over feed cost
$ASBMP_m$	\$ per cwt SBM	Actual soybean meal price for month m
CF_m	cwt	Expected corn equivalents to be fed for month m
DL	\$ per cwt milk	Insurance deductible level
$ECL3P_m$	\$ per cwt milk	Expected Class III milk price for month m.
ECP_m	\$ per cwt corn	Expected corn price for month m.
EIOFC	\$ per cwt milk	Expected income over feed cost
$ESBMP_m$	\$ per cwt SBM	Expected soybean meal price for month m
FARMPREM	\$ per cwt milk	Total farm premium
GIOFC	\$ per cwt milk	Guaranteed income over feed cost
LGMINDEM	\$ per cwt milk	LGM-Dairy expected indemnity
LGMPREM	\$ per cwt milk	LGM-Dairy premium
M	-	Insurance month
MQ_m	cwt	Expected milk quantity to be produced in month m
NGIOFC	\$ per cwt milk	LGM-Dairy net guaranteed income over feed cost
SBM_m	cwt	Expected soybean meal equivalents to be fed for month m.
$SIOFC_t$	\$	Simulated income over feed cost for t^{th} simulation
T	-	Price simulation scenario
TCP	Cwt	Total covered milk production in a contract period
TGIOFC	\$ per cwt milk	Total farm target guaranteed income over feed cost

Table 3.2. Milk Sales and Default Feed Amounts Used for a Representative 120-Cow Wisconsin Dairy Farm Producing 19,985 lb per Cow per Year for October 2008 Livestock Gross Margin Insurance for Dairy (LGM-Dairy) Contract

Coverage month	MQ[1] (cwt)	CF[2] (tons per cwt)	SBM[3](tons per cwt)
December-08	1,962	27.47	3.92
January-09	1,974	27.64	3.95
February-09	1,806	25.28	3.61
March-09	2,010	28.14	4.02
April-09	1,974	27.64	3.95
May-09	2,094	29.32	4.19
June-09	2,040	28.56	4.08
July-09	2,094	29.32	4.19
August-09	2,076	29.06	4.15
September-09	1,986	27.80	3.97
Total	20,016	280.23	40.03

[1]MQ is the total milk production expected to be sold.
[2]CF is the total corn equivalent amount expected to be fed to obtain total milk production.
[3]SBM is the total soybean meal equivalent amount expected to be fed to obtain total milk production.

Table 3.3. Optimal Percentage of Production Insured under Alternative Target Guaranteed Income Over Feed Cost (TGIOFC) for October 2008 LGM-Dairy Contract

TGIOFC ($ per cwt milk)	4	5	6	7	8	9	10	11	12.21
Coverage month	Optimal monthly coverage (%)								
December 2008	100	100	100	100	100	100	100	100	100
January 2009	100	100	100	100	100	100	100	100	100
February 2009	100	100	100	100	100	100	100	100	100
March 2009	0	41	100	100	100	100	100	100	100
April 2009	2	23	29	95	100	100	100	100	100
May 2009	0	0	0	9	42	84	100	100	100
June 2009	14	16	13	14	30	51	77	100	100
July 2009	22	29	38	28	41	44	63	100	100
August 2009	1	0	0	4	4	21	45	68	100
September 2009	26	44	61	81	99	100	100	100	100
Optimal total coverage (%)	35	44	53	62	71	79	88	97	100
FARMPREM ($ per cwt milk)	0.23	0.30	0.37	0.44	0.52	0.61	0.69	0.78	0.82
LGMPREM ($ per cwt milk)	0.64	0.67	0.69	0.72	0.74	0.76	0.79	0.81	0.82
FARMPREM as % of TGIOFC	5.8%	6.0%	6.2%	6.3%	6.5%	6.8%	6.9%	7.1%	6.7%
Total Insurance Cost (All milk, $)	4,604	6,005	7,406	8,807	10,408	12,210	13,811	15,612	16,413
NGIOFC ($ per cwt milk)	4.23	5.3	6.37	7.44	8.52	9.61	10.69	11.78	12.21

Table 3.4 Comparison of Optimal and Non-Optimal Strategies for October 2008 Contract for Same Amount of Total Production Covered

	Optimal strategy		Non-Optimal Strategy[1]		
Total Production Covered (%)	TGIOFC ($ per cwt milk)	FARMPREM ($ per cwt milk)	TGIOFC ($ per cwt milk)	FARMPREM ($ per cwt milk)	Non-optimal FARMPREM / Optimal FARMPREM
35	4.00	0.23	4.27	0.29	1.25
44	5.00	0.30	5.37	0.36	1.20
53	6.00	0.37	6.47	0.43	1.18
62	7.00	0.44	7.57	0.51	1.16
71	8.00	0.52	8.67	0.58	1.12
79	9.00	0.61	9.64	0.65	1.06
88	10.00	0.69	10.74	0.72	1.05
97	11.00	0.78	11.84	0.80	1.02

[1]The same proportion of total milk production covered as the optimal solution, but evenly distributed every insurance month.

Table 3.5 Comparison of FARMPREM for a 10-Month Strategy with a Stacked Strategy at a TGIOFC of $5 per cwt milk

	10-month strategy	**Stacked strategy**		
Optimal % C_m for different coverage months	October 2008	3 month October 2008	3 month January 2009	4 month April 2009
month1	100%	100%	0%	0%
month 2	100%	18%	0%	0%
month3	100%	13%	0%	0%
month4	41%	0%	100%	0%
month5	23%	0%	94%	0%
month6	0%	0%	4%	0%
month7	16%	0%	0%	100%
month8	29%	0%	0%	75%
month9	0%	0%	0%	7%
month10	44%	0%	0%	33%
Total production covered (%)	44%	23%	36%	40%
FARMPREM ($/cwt)	0.3	0.26	0.3	0.34
Total Insurance Cost (All farm milk[1], $)	6,005	1,493	1,823	2,787
All farm milk available (cwt)	20,016	5742	6078	8196

[1] All farm milk is the total milk marketings available to be insured under the insurance period. For the stacked marketing plan, all farm milk is considered for 3 or 4 months according to the time of contract.

Table 3.6 Comparison of Non-Optimal Strategy at 50% Covered Production with 10-Month Strategy and Stacked Strategy at a TGIOFC of $5.694 per cwt

Items of comparison	**Non-optimal Strategy**	**10-month Optimal Strategy**	**Stacked strategy[2]**
Premium ($)	8,219	6,924	7,043
Indemnity ($)	37,245	30,012	13,783
Net IOFC ($)	198,279	192,341	146,800
Net IOFC for All farm milk ($/cwt)	9.9	9.6	7.3
% change in Net IOFC from expected farm revenue[3]	-18.6%	-21%	-29%
% change in Net IOFC from actual farm revenue[1]	17%	14%	-13%
Net indemnity for All farm milk ($ per cwt)	1.86	1.49	0.69
Premium for All farm milk ($ per cwt)	0.41	0.35	0.35

[1] The actual farm revenue if there is no insurance contract, calculated for the 10 month insurance contract based on actual prices of Class III milk, corn and SBM is $169,253.

[2] For the stacked marketing plan, the all farm milk is considered for 3 or 4 months according to the time of contract.

[3] Expected farm revenue if there is no insurance contract, calculated for the 10 month insurance contract based on expected prices of Class III milk, corn and SBM in October 2008 is $243,606.

For the stacked strategy, the expected prices for all the three commodities at the time of contract are considered. The expected farm revenue if the stacked strategy were not adopted would have been $206,333.

Table 3.7 Actual and Expected Prices for Class III Milk, Corn and SBM (December 2008 to September 2009)

Month	Actual Class III Milk Price ($/cwt)	Actual Corn price ($/bu)	Actual SBM price ($/ton)	Expected Class III Milk Price ($/cwt)	Expected Corn price ($/bu)	Expected SBM price ($/ton)
December 2008	15.1	3.3	252.0	14.5	4.1	279.0
January 2009	10.8	3.4	303.0	14.5	4.2	281.0
February 2009	9.3	3.5	293.0	14.5	4.2	283.0
March 2009	10.5	3.7	284.0	14.5	4.3	285.0
April 2009	10.8	3.9	326.0	14.8	4.3	286.0
May 2009	9.8	4.2	369.0	14.9	4.4	288.0
June 2009	9.9	3.8	368.0	15.2	4.5	290.0
July 2009	9.9	3.5	368.0	15.4	4.5	291.0
August 2009	11.2	3.3	387.0	15.6	4.6	291.0
September 2009	12.1	3.1	345.0	15.7	4.6	291.0

Chapter 4

RISK MANAGEMENT AND LGM-DAIRY INSURANCE: AN EMPIRICAL ANALYSIS

4.1 INTRODUCTION

As mentioned in Chapter 3, dairy producers must make several critical decisions when purchasing an LGM-Dairy insurance policy. These include the level of milk production to be insured every month (% C_m), expected feed use necessary to produce this insured production and the deductible (Gould et al., 2008). Increasing the deductible decreases the probability of receiving an indemnity payment and results in reduced premiums (Cabrera et al., 2009). Further, dairy producers may adopt a variety of risk management strategies besides LGM-Dairy. Earlier research on crop insurance participation confirmed that many of these varieties of strategies had negative effects on insurance participation (Knight and Coble, 1997). Subsidies are another important factor that can impact insurance participation. In their analysis of the U.S. crop insurance program, Gardner and Kramer (1986) concluded that premiums would have to be subsidized as much as 50 percent to achieve 50 percent participation.

Individual risk preferences can impact the incentive to reduce risk exposure using LGM-Dairy The incentive to insure and insurance decisions by agricultural producers have been treated extensively by Gould (1969), Mossin (1969), and Smith (1969). There has been an extensive research on choices under uncertainty. This includes the expected utility model, that implies that rational individuals maximize expected utility and their risk aversion utility functions are concave with respect to wealth and show diminishing marginal wealth utility. Expected Utility Theory states that the decision maker chooses between risky or uncertain prospects by comparing their expected utility values, i.e., the weighted sums obtained by adding the utility values of outcomes multiplied by their respective probabilities. If there were three amounts of income, y_i and assume that the y_i occurs with probabilities, p_i and if w were to be the decision maker's initial wealth, then the expected utility function is written as:

$$U_w = \sum_{i=1}^{3} pi.u\,(w + yi) \qquad [1]$$

The risk attitude is directly related to the curvature of the utility function with respect to wealth . Risk neutral individuals have linear utility functions, while risk seeking individuals have convex utility functions and risk averse individuals have concave utility functions with respect to wealth. Risk averse individuals perceive the utility they derive from a risky action as being less than the utility of a certain expected value. Expected utility model considers the dispersion of expected returns around the mean. This dispersion can be modeled using the expected utility model. Under the expected utility hypothesis, a decision maker has risk preferences represented by a utility function. We used the expected utility model to obtain varying optimal contracts according to risk preferences and insurance costs.

4.2 MATERIALS AND METHODS

4.2.1 Mathematical Description of the LGM-Dairy Program

Under LGM-Dairy farm operators can purchase insurance to establish a floor of an imputed IOFC. As noted above, an indemnity at the end of insurance period is the difference, if positive, between the expected IOFC (EIOFC) determined at insurance sign-up and actual IOFC (AIOFC) determined at the end of the insurance contract. To determine contract specific actuarially fair premiums, the RMA uses 5,000 simulated indemnities outcomes representing the distribution of income risk. These simulated indemnities are obtained using random draws of 30 correlated commodity prices (10 Class III, 10 corn and 10 SBM prices) and the specific contract design under consideration (Valvekar et al., 2010). These random draws are obtained from assumed lognormal probability density functions as outlined in the LGM-Dairy program policy.

The means of these prices are estimated as the average of the futures settle prices observed over the price discovery period defined as the 3 days ending on the last business Friday of each month. Price standard deviations are computed from the annualized implied volatility from "at-the-money" options over the same price discovery period. Implied volatilities are calculated using a modified Black-Scholes model (Chesney and Scott, 1989). The Black-Scholes model used to estimate the theoretical options price (OP) is a function of five important elements: the current futures price (FP), the option strike price (X), time remaining until contract expiration (q), risk-free interest rate (r), and volatility (V). This formula can be represented via the following:

$$OP = FP * N(d_1) - X * e^{-rq} * N(d_2) \qquad [2]$$

where: $$d_1 = \frac{\ln\left(\frac{FP}{X}\right) + \left(r + \frac{V^2}{2}\right)q}{V\sqrt{q}}$$

$$d_2 = d_1 - V\sqrt{q}$$

N(·) is the standard normal cumulative distribution function

An estimate of volatility is obtained by solving for V. The average of these implied volatilities from call and put premiums are taken and are de-annualized by multiplying by the square root of time remaining until futures contract settlement. The standard deviation of each price is then estimated as the product of the de-annualized volatility and mean price. The simulated distribution takes into account the minimum support price for milk and sets a truncated point at the support price. Thus, it is ensured that none of the simulated prices fall below the support price. For this Monte Carlo analysis, desired correlations among random variables are obtained by the variance reduction method (Iman and Conover, 1982). This method takes independent draws from various marginal distributions and re-sorts them to obtain the desired levels of correlations. The target correlation matrices are based on the historical rank correlations among corn and SBM futures prices from 1978 to 2005 and Class III milk futures from 1998 to 2005 (RMA, 2009b). Data from the Class III, corn and Soybean meal (SBM) futures and options markets at program sign-up are the foundation of the 5,000 simulations.

LGM-Dairy is an extremely flexible insurance program. Producers can elect to cover 1 to 10 months of IOFC and from 0 to 100% of these values for each month with the coverage percentage being allowed to vary. Decision-making depends on the amount of coverage levels vary according to risk preferences as well as the insurance overhead costs. . Unlike some crop insurance products, there are no producer premium subsidies associated with the purchase of LGM-Dairy. However there is an administrative and operating (A&O) subsidy payment of around 23% made from USDA to the insurance provider where the funds for such payments do not come from producer premiums. By program rule producer premiums are set equal expected indemnities plus a 3% insurance reserve. Besides A&O subsidy and 3% reserve, there are additional costs of insurance such as search costs etc. If all these costs are accounted for, it is hypothesized that the indirect insurance costs will exceed 3%. We conduct a sensitivity analysis by increasing the insurance reserve from 3% to 30% of the actuarially fair premium. Following the mean-variance model of risk management, purchasing an LGM-Dairy contract involves evaluating the trade-off between the cost of the insurance premium and the benefit of reduced risk exposure (Babcock ,2004). The objective of this study was to investigate factors affecting the participation decision of a farmer in a LGM-dairy insurance contract. This involves assessing the distribution of risk exposure and the effects of insurance costs on this distribution. Risk preferences are represented in expected utility model.

In Chapter 3 we reviewed an optimization model that identified acreage coverage that generates the least cost insurance premium for a predefined NGIOFC target for all farm milk In this chapter we compare the adoption characteristics of different contract periods, July 2009 and October 2008 LGM-Dairy contracts using the expected utility model of insurance purchase. These two contract months were selected to investigate the impact of market conditions on the insurance participation The year 2009 witnessed a downturn on the economy with significantly lower class III milk prices compared to the relatively high prices observed during most of 2008.. The objective of this analysis is to investigate the total optimal insurance participation rates, with a focus on the role of risk aversion, market conditions and insurance costs.

4.2.2 Assumptions and Scenarios for this model

To compare October 2008 and July 2009 LGM-Dairy contracts under similar program configurations, we considered a hypothetical dairy farm producing 240,000 cwt of milk in a 12 month period. For every month, constant level of milk production (2,000 cwt) was considered in our analysis. We assumed $0 deductible and used default corn and SBM equivalent feed rates per unit of milk produced according to the program policy. The net expected returns for the contracts were calculated for 50% of the total covered production (100,000 cwt) in the 10 month insurance period. Further details on calculation of net expected return are explained in the next section.

4.2.3 Estimation of Risk Exposure in the Presence of Revenue Insurance

The net expected return (π) obtained without insurance is denoted by $\pi^b(e)$, where e represents the random variables affecting risk exposure (i.e., milk price, feed cost). Expected return was assumed to be at 50% of the production. In the presence of insurance, the net return becomes

$$\pi(e_t) = \{(\pi^b(e_t) - RP) + LGMINDEM\} \quad [3]$$

where $\pi^b(e_t)$, the net return before entering into an insurance contract, is given by

$$\pi^b(e_t) = \sum_{m=1}^{M} \left[\left(MQ_m * SCL3P_{mt} - CF_m * SCP_{mt} - SBM_m * SSBMP_{mt} \right) \right] \quad [4]$$

where M is the planning period length (e.g., 1,…10), $\%C_m$ is the percentage of milk production covered. m represents production month and t represents a particular simulation of random variables e. MQ_m is the quantity of milk produced in the m^{th} month $SCL3P_{m,t}$ is the simulated Class III milk price for the m^{th} month and t^{th} simulation, $SCP_{m,t}$ and $SSBMP_{m,t}$ are the simulated corn and soybean meal price for the m^{th} month and t^{h} simulation, respectively, CF_m and SBM_m are the monthly corn and SBM feed equivalents.

RP is the risk premium that includes α % insurance overhead cost, where α % is 3% and 30% respectively

$$RP = (1 + \alpha / 100) * \frac{\sum_{t=1}^{5,000} Max\left[(\text{GIOFC} - \text{SIOFC}_t), 0 \right]}{5,000} \quad [5]$$

GIOFC is defined as the guaranteed income over feed cost

$$GIOFC = \sum_{m=1}^{10} \%C_m * (MQ_m * ECL3P_m - CF_m * ECP_m - SBM_m * ESBMP_m), \quad [6]$$

and the expected prices for class III milk, corn and SBM are represented by $ECL3P_m$, ECP_m

Similarly, simulated income over feed cost was defined as,

$$SIOFC_t = \sum_{m=1}^{10} \%C_m * (MQ_m * SCL3P_{mt} - CF_m * SCP_{mt} - SBM_m * SSBMP_{mt}) \quad (t=1 \text{ to } 5{,}000) \quad [7]$$

and

$$LGMINDEM = \frac{\sum_{t=1}^{5{,}000} Max[(GIOFC - SIOFC_t), 0]}{5{,}000} \quad [8]$$

4.2.4 Optimal Contract Design under the Expected Utility Maximization Model

The expected utility model was first used by von Neumann and Morgenstern (1944) and has been widely used to examine how risk aversion impacts decision-making under uncertainty. Under the expected utility hypothesis, a decision maker has risk preferences represented by a utility function U(τ) where τ are random variables that impact utility. The decision maker makes decisions so as to maximize expected utility E[U(τ)], where E is the expectation operator and the expectation is undertaken based on subjective probability of the value of τ (Chavas, 2004). If we replace τ in the above expectation we can assume that the decision of the degree of participation in the LGM-Dairy program can be examined within this framework.

To understand the risk attitudes, quantifying the degree of risk aversion is very important. However measuring the risk aversion is not simple. Risk aversion is reflected by the curvature of the utility function and measuring this curvature is not easy since the utility function is defined only up to a positive linear transformation. A simplest measure that is constant for a positive linear transformation of the utility function is absolute risk aversion function which is given by:

$$r_{a}(w) = - U^2(w) / U^1(w) \quad [9]$$

where w represents wealth and $U^2(w)$ and $U^1(w)$ represent second and first derivative of the utility function respectively (Hardaker et al., 2004).

Although $r_a(w)$ is unaffected by a positive linear transformation of the utility function, it depends on the monetary units of w. This units problem is overcome using an alternative measure called relative risk aversion coefficient, given by Arrow-Pratt, defined as

$r_{r}(w) = w * r_a(w)$ [10]

Relative risk aversion function is further categorized according to how it changes with respect to increasing wealth as increasing relative risk aversion, decreasing relative risk aversion and constant relative risk aversion (CRRA). CRRA assumes that the preferences among risky prospects are unchanged if all payoffs are multiplied by a positive constant (Hardaker et al., 2004). In this study, we used the generalized forms of utility functions in terms of CRRA. When the relative risk aversion parameter is one ($r_r = 1$), CRRA preferences reduce to a logarithmic function

$U(\pi) = ln(\pi)$ [11]

And when the relative risk aversion parameter r is positive but different from 1, CRRA preferences are given by power function (Hardaker et al., 2004; Chavas, 2004).

$U(\pi) = [1/(1-r_r)]\ \pi^{1-r}{}_{r}.$ [12]

Based on the magnitude of the relative risk aversion coefficient, the degree of risk aversion as classified by Anderson and Dillon (1992) are:

Hardly risk averse : $r_r = 0.5$

Normal /somewhat risk averse $r_r = 1$

Rather risk averse $r_r = 2$

Very risk averse $r_r = 3$

Extremely risk averse $r_r = 4$

Applying these functions to LGM-Dairy, the expected utility function can be derived as follows:

For r=1 and t= 5,000 simulations,

$E[U(\pi(e_t))] = \sum_{t=1}^{5000} \{\frac{1}{5000}\} * ln(\pi(e_t))]$ [13]

Where $E[U(\pi(e_t))]$ is the expected utility function for $(\pi(e_t))$. Under random sampling using 5,000 simulation points, the probability is 1/5,000.

Similarly, for $r_r > 0$ and and $r_r \neq 1$,

$E[U(\pi(e_t))] = \sum_{t=1}^{5000} \{\frac{1}{5000}\} * ln(\pi(e_t))]\ \{1/(1-r_r)\} * \pi(e_t)^{1-r}{}_{r}$ [14]

4.2.5 Participation in LGM-Dairy and the Expected Utility Maximization

Cabrera et al (2007) provides an analysis of based on the expected utility maximization model to study the role of climate forecasts in decision making under uncertain climate, prices, and risk aversion levels. Friedman and Savage (1954) showed how an expected utility model can provide representation of risk preferences, going from risk seeking to risk neutral to risk averse producers. For the present analysis with respect to LGM-Dairy participation, we can represent the maximization problem via the following:

$$\text{Max } \{ E[U(\pi(e_t))] \} \quad [15]$$

$$\text{subject to, } 0 \leq \%C_m \leq 1, \quad [16]$$

where $\%C_m$ is monthly percent insurance coverage, DL is deductible level ($/cwt), CF_m and SBM_m are the corn and soybean meal equivalents . π (e_t) represents net return for each simulation t. The objective function represented by [15] is nonlinear with respect to the decision variables as the contract-specific premiums are conditional on the decision variables chosen by the producer (Cabrera et al., 2009). We used the generalized reduced gradient method of nonlinear programming to solve this optimization problem (Lasdon et al., 1974). This method of solution allows for nonlinear constraints on the variables in the optimization process. The Excel Solver® software system was used determine the optimal solution. However, given the non-linear nature of the problem, there can be multiple feasible regions for a given problem. To ensure that we identify the global minimum, we set every insurance month coverage percentage to non-zero starting values (Ragsdale, 2004) and use different starting values.

As discussed earlier, the mean expected return with and without insurance participation are sensitive to the insurance costs. Although under the LGM-Dairy policy, the insurance overhead costs is fixed at 3%, we extended this analysis for different hypothetical overhead costs and conducted a sensitivity analysis by setting the cost as high as 30%.

4.3 RESULTS AND DISCUSSION

4.3.1 Expected Utility Maximization and LGM-Dairy Participation

Tables 4.1, 4.2 and 4.3 are used to present optimal solutions when the expected utility model is applied to the representative farm using data for October 2008 and July 2009. Table 4.1 is used to compare the overall insurance participation at different overhead costs and market conditions. For the October 2008 LGM-Dairy contract, at 3% overhead costs, the insurance participation varies from 45% to 66%. This difference in participation rate varies greatly when the costs of insurance are 30%. Participation rates vary from 0% to 37% as shown in Tables 4.1 and 4.2. Similarly for the July 2009 insurance contract, at 3% overhead costs, the insurance participation ranges from 37% to 62% and at overhead costs of 30%, the optimal insurance participation differs greatly with the level of risk aversion. At $r_r = 0.5$ (person not at all risk averse) and 1 (little risk averse person), there is no participation in insurance contract, wheras for $r_r = 2$ (rather risk averse person), it is 7%, at $r_r = 3$ (very risk averse), it is 22% and $r_r = 4$ (extremely risk averse), it is 30%.

Table 4.3 is used to reflect the monthly coverages under optimal July 2009 contract at 30% overhead costs. Results from expected utility maximization were validated using mean-variance analysis for the July 2009 contract at 30 % costs of insurance. Therefore, irrespective of the market conditions, as the level of risk aversion increases, the insurance participation increases and the distinction in the level of risk aversion is much more demarcated at higher insurance costs. Higher the cost of insurance, lower is the incentive to participate in an insurance contract.

4.3.2 Impact of market conditions on the optimal insurance participation

Tables 4.2 and 4.3 are used to show the optimal monthly coverages under similar program configurations for October 2008 and July 2009 LGM-Dairy contracts at 30% insurance costs. As mentioned earlier, these two contract months witnessed different market conditions at the time of the contract. Around October 2008, higher expected prices for Class III milk prevailed; wheras 2009 witnessed a downtrend in Class III milk. Market conditions in 2009 had worsened for the dairy producers. Given these market conditions, the potential IOFC that a dairy producer can gain was higher in 2008 compared to 2009.

As expected, the optimal coverages for different contracts. Optimal participation rates were lower in the July 2009 contract compared to October 2008 for similar program configurations at same levels of risk aversion and insurance costs. For example at r_r of 3, the insurance participation for the July 2009 insurance contract is 5 to 6% less than the participation in October 2008 contract. Participation rates are higher in October 2008 LGM-dairy contract, since better market conditions prevailed in October 2008 and expected IOFC by the producer were higher during October 2008. From a producer's perspective, potential loss due to declines in IOFC is higher in October 2008 contract than in July 2009. It is also evident that highly risk averse producers will participate in insurance more than producers who are not very risk averse under any market conditions and similar program configurations. Varying participation rates under different market conditions at the same levels of risk aversion could be due to the expected prices and volatility.

4.4 CONCLUSIONS

Expected utility maximization can be used to understand the participation rates in LGM-Dairy for different levels of risk aversion. Results from our analysis indicate that irrespective of the market conditions, as the level of risk aversion increases, the insurance participation increases and the distinction in the level of risk aversion is much more demarcated at higher insurance costs. This indicates that higher the cost of insurance, lower is the incentive to participate in an insurance contract. Secondly, insurance participation rates may vary according to market conditions at the time of the contract.

Future research should focus on subsidies in insurance policies, from a policy perspective. For example, investigating the impact of subsidies on insurance participation. Further the impact of asymmetric information on participation in LGM-Dairy has not been investigated in our analysis. Future research can take this into consideration. Impact of choices in deductible levels on the risk attitudes is another area of research.

4.5 REFERENCES

Anderson, J. R., and J.L Dillon, *Risk analysis in dryland farming systems.* FAO. Rome (Italy), 1992.

Babcock, A. Bruce, 2004. *Implications of Extending Crop Insurance to Livestock,* Agricultural Outlook Forum, February 2004, Iowa State University. http://www.card.iastate.edu/presentations/AgOutlookForum04.pdf.

Cabrera, V. E., D.Letson and G Podestá . 2007. The value of the climate information when farm programs matter. *Agricultural Systems*, 93, 25–42.

Cabrera, V. E., B. W. Gould, and M. Valvekar. 2009. *Livestock gross margin insurance for dairy cattle: An analysis of program performance and cost under alternative policy configurations.* Agricultural and Applied Economics Association 2009 Annual Meeting, July 26-28, 2009, Milwaukee, Wisconsin 49262. http://ageconsearch.umn.edu/bitstream/49262/2/610926.pdf.

Chavas, Jean-Paul. *Risk Analysis in Theory and Practice*. Elsevier Academic Press, New York, 2004.

Chesney, M., and L.,Scott, "Pricing European Currency Options: A Comparison of the Modified Black- Scholes Model and a Random Variance Model" , The Journal of Financial and Quantitative Analysis, Vol. 24, No. 3 (Sep., 1989), pp. 267-284.

Friedman, Milton and Leonard J. Savage. "The Utility Analysis of Choice Involving Risk" Journal of Political Economy 56(1948): 279-304.

Gardner, B.L and R.A. Kramer. 1986, "Experience with crop insurance programs in the United States", in: E Hazell, C. Pomareda and A.Valdrs, eds., Crop Insurance for Agricultural Development: Issues and Experience (Johns Hopkins Press, Baltimore) 195-222

Gould J.P. 1969, "The Expected Utility Hypothesis and the Selection of Optimal Deductibles for a Given Insurance Policy," J. Bus., Univ. Chicago, Apr. 1969, 42, 143-51.

Gould, B. W., P. D. Mitchell, and V. E. Cabrera. 2008. "*USDA's gross margin insurance program for dairy: What is it and can it be used for risk management".,* Marketing and Policy Briefing Paper, Department of Agricultural and Applied Economics, University of Wisconsin-Madison, http://future.aae.wisc.edu/pubs/pubs/show/339.

Hardaker, J., R, Huirne, J., Anderson and G, Lien, 2004. *Coping with Risk in Agriculture*. 2nd ed. Wallingford, U.K.: CABI Publishing.

Iman, R.L., and W.J. Conover, "A distribution-free approach to inducing rank correlation among input variables", Communications in Statistics - Simulation and Computation, Volume 11, Issue 3 1982 , pp. 311 – 334.

Knight, O.T., and K.H. Coble, "Survey of U.S. Multiple Peril Crop Insurance Literature since 1980", Review of Agricultural Economics*",* Volume 19, No. 1 (Spring - Summer, 1997), pp. 128-156

Lasdon, L.S., R.L. Fox, and M.W. Ratner. 1974. Nonlinear optimization using the generalized reduced gradient method. Revue Fran~aise dtAutomatique, Informatique et Recherche Operationelle, 8 annee, V-3.

Mossin,J.,1968. "Aspects of Rational Insurance Purchasing," J. Polit. Econ., July/Aug. 1968, 76, 533-68.

Ragsdale, C. 2004. *Spreadsheet modeling decision analysis. A practical introduction to management science.* 4th Ed. Thompson South Western, Mason, OH (2004).

Risk Management Agency (RMA). 2009b. Livestock gross margin for dairy cattle insurance policy: Frequently asked questions. USDA Risk Management Agency http://www.rma.usda.gov/policies/2010/lgm/10lgmdairyq&a.pdf. Accessed 14, August 2009.

Valvekar,M., Cabrera, V.E, and Gould, B.W, 2010."Identifying Cost Minimizing Strategies for Guaranteeing Target Dairy Income over Feed Cost via Use of the LGM-Dairy Insurance Program", Journal of Dairy Science, vol-93, issue 7 Pages 3350-3357 (July 2010).

Smith, V.L., 1968, "Optimal Insurance Coverage," J. Polit. Econ., Jan./Feb. 1968, 76, 68-77.

Table 4.1 Constant Relative Rate of Risk Aversion, Overhead Costs and Optimal Insurance Participation for October 2008 and July 2009 LGM-Dairy Contracts.

	Insurance overhead costs			
	3%	30%	3%	30%
r_r [1]	October 2008 LGM-Dairy contract		July 2009 LGM-Dairy contract	
0.5	45%	0%	37%	0%
1	56%	0%	52%	0%
2	64%	13%	59%	7%
3	66%	29%	61%	22%
4	66%	37%	62%	30%

[1] r_r is relative rate of risk aversion.

Table 4.2 Monthly Optimal Coverages for October 2008 under Expected Utility Maximization Model with 30% Overhead Costs.

r_r [1]	0.5, 1	2	3	4
December 2008	0%	1%	12%	0%
January 2009	0%	43%	53%	19%
February 2009	0%	23%	31%	8%
March 2009	0%	36%	43%	18%
April 2009	0%	32%	39%	16%
May 2009	0%	28%	36%	12%
June 2009	0%	32%	40%	16%
July 2009	0%	25%	35%	9%
August 2009	0%	33%	40%	17%
September 2009	0%	33%	40%	15%
Total optimal coverage (%)	0%	29%	37%	13%

[1] r_r is relative rate of risk aversion.

Table 4.3 Monthly Optimal Coverages for July 2009 under Expected Utility Maximization Model with 30% Overhead Costs.

r_r [1]	0.5,1	2	3	4
September 2009	0%	0%	0%	0%
October 2009	0%	0%	0%	15%
November 2009	0%	8%	37%	46%
December 2009	0%	7%	22%	32%
January 2010	0%	8%	26%	32%
February 2010	0%	9%	27%	37%
March 2010	0%	8%	25%	33%
April 2010	0%	9%	26%	33%
May 2010	0%	7%	22%	31%
June 2010	0%	11%	31%	40%
Total optimal coverage (%)	0%	7%	22%	30%

[1] r_r is relative rate of risk aversion.

SUMMARY AND CONCLUSIONS

We have shown that dairy farm operators interested in using the LGM-Dairy insurance as a price risk management tool could save substantial premium costs for obtaining a minimum level of production via the use of our nonlinear program least cost optimization software system. The objectives of this thesis were to understand the LGM-Dairy program characteristics and to describe and demonstrate an algorithm to identify optimal strategies by minimizing the premium cost at a pre-defined target guaranteed IOFC. A web based tool was developed to assist dairy producers in identifying the least cost insurance contract design given a desired target NIOFC per cwt of all farm milk and a given planning period.. The optimization model integrates the complex simulation and optimization models in a user-friendly decision support system. These tools help in identifying the optimal LGM-Dairy contract for any defined target income over feed cost and program configuration with varying deductibles, milk production or the feed equivalents expected to be fed. Since the model integrates simulation and optimization, the user can easily benefit by running the model back and forth by generating premium based on simulated revenues for the optimal %C. The tool encompasses all the components of LGM-Dairy and further integrates simulation and optimization to identify the optimal program configuration. The optimizer models are easily accessible and can be customized by the users according to their needs. This study demonstrates that for similar levels of coverage (i.e., proportion of total milk production insured), there are substantial differences in insurance premium cost depending upon the distribution of the production insured over the 10 month LGM-Dairy contract. This model can be a great resource in better decision making to all the dairy producers, extension agents, and dairy farm advisers.

Another objective of this study was to investigate the interplay between producer risk preferences, insurance costs and market conditions that could impact participation (i.e., proportion of total milk production insured) in the LGM-Dairy program. We undertake this analysis using expected utility framework for two different contracts under different market conditions. Optimal contracts for different rates of constant relative rate of risk aversion were analyzed. Results from our analysis indicate that irrespective of the market conditions, as the level of risk aversion increases, the insurance participation increases and the distinction in the level of risk aversion is much more demarcated at higher insurance costs. This indicates that higher the cost of insurance, lower is the incentive to participate in an insurance contract. Secondly, insurance participation rates may vary according to market conditions at the time of the contract.

APPENDIX A

A.1 WEB-BASED LGM-DAIRY OPTIMIZER TOOL

Recent advances in information technology and software products provide opportunities to develop Decision Support Systems (DSS) with the advantage of information dissemination for better decision making. There is a large variability in the farm income due to significant variability in farm productivity and prices of milk and feed. Further the complexity of decision making involved in Livestock Gross Margin insurance for Dairy cattle justifies the creation of a tool that can be easily accessed by dairy farmers and farmers' advisers in the United States. This tool can assist the dairy farmers to conduct an interactive "what-if" analysis and give optimal solutions for any program configuration.

The objective of this section is to describe web-based optimization model used to identify the LGM-Dairy insurance contract design that minimizes the premium cost per cwt of total farm milk of generating a predefined guaranteed income over feed cost. This tool can be used to identify optimal contract designs for any month since February 2000 to the previous month's insurance contract (January 2010). Thus these dynamic models integrate historical data. It also allows the user to perform analyses for current price data as the model is permanently updated with data.

A.2 GENERAL DESCRIPTION

The web-based LGM-Dairy optimizer identifies the least cost LGM-Dairy contract design at desired levels of income over feed costs. The mathematical description and formulation of the optimization model are already described in the earlier sections. As mentioned earlier, while entering into a contract, producers have several decisions to make like level of deductible, amount of production to be covered, and amount of feed to insure every month. Monthly milk production to be covered remains a very critical decision from the producer's perspective. The optimizer addresses this issue by suggesting the amounts of production to be covered every month given a target guaranteed income over feed cost (TGIOFC) at the least cost. The optimizer gives the least farm premium cost for a defined contract. Unlike LGM-Dairy premium, "farm premium" is the premium under the LGM-Dairy contract for total farm production, irrespective of the insured production. Similarly, farm guaranteed income over feed cost (Farm GIOFC) gives the level of IOFC for total farm. Farm IOFC should be greater than or equal to the target income over feed cost (TGIOFC). Thus the optimization problem seeks to minimize the farm premium with the farm GIOFC greater than or equal to Goal IOFC and gives the corresponding levels of optimal monthly production. In comparison to the usual LGM-Dairy contract, the only additional input required for the optimizer is the TGIOFC ($ per cwt) the producer would want to achieve. The TGIOFC usually varies between $2 per cwt to $11 per cwt according to the contract design and contract month. The producer may select any level of TGIOFC possible for a particular configuration, however the solution would indicate “solver solution not feasible” if TGIOFC is above the maximum possible GIOFC for the insurance period. The results indicate the least farm premium and the optimal monthly coverage for the selected program configuration and the defined TGIOFC. The decision variables are the percentage of farm milk to insure for each month of the insurance contract. This program uses by default the latest 3 days of trading data to provide an estimate of the costs of next month's LGM-Dairy insurance contract.

A.3 USING WEB-BASED LGM-DAIRY OPTIMIZER

This tool can be accessed at the webpage: ***http://tamarack.aae.wisc.edu/lgm_cov/*** and ***http://dairymgt.uwex.edu/lgm/lgm_cov.php.*** When accessing this address, the input page of the optimization program is displayed as in the figure A.1. In the above example, the model is set up premium costs using the most recent data available to estimate the cost of the January 2010 LGM-Dairy contract. User has to enter the planned milk production ($ per cwt), Corn and SBM equivalents in tons as prompted by the screen. Users can use the default feed amounts and can also upload their production data files. Further, the targets guaranteed income over feed cost and deductible are the other inputs to be entered by the user to run the optimization. Once all the data is entered, the user has to just click on the button “Calculate coverages to minimize premium for a target NGIOFC”. The results display the 3-day average

Class III, Corn and SBM futures settlement prices obtained from the trading days at the top of results data page as shown in Figure A.2. At the bottom of the page, the optimal monthly coverage percentages, i.e. %C are displayed along with the data on the insured milk production, corn and SBM equivalents, as shown in Figure A.3. Below this table, premium costs, GIOFC and NGIOFC information both at the aggregate level as well as per cwt of total farm are displayed.

A.4 CONCLUSION

This section gives the overview of the web-based LGM-Dairy optimizer. The optimizer integrates the complex simulation and optimization models in a user-friendly decision support system. This tool help in identifying the optimal LGM-Dairy contract for any defined target income over feed cost and program configuration with varying deductibles, milk production or the feed equivalents expected to be fed. Since the model integrates simulation and optimization, the user can easily benefit by running the model back and forth by generating premium based on simulated revenues for the optimal %C. The tool encompasses all the components of LGM-Dairy and further integrates simulation and optimization to identify the optimal program configuration. The optimizer model is easily accessible and can be customized by the users according to their needs. This tool can be a great resource in better decision making to all the dairy producers, extension agents and dairy farm advisers.

Optimum Coverage for LGM Insurance

Input your planned feed and milk production for LGM Dairy Insurance. This program will calculate the optimum coverage for lowering your premium for various deductible levels to aid you in your decision. For the month of **Jan 2010** we use the latest available data to estimate the premiums.

Target NGIOFC ($/cwt) 5.00

Choose your deductible level ($/cwt) 1.5

If you wish to upload a currently existing csv file containing your farm's data instead of typing it in, please click here

☐ Default Feeding Values?

Coverage Month	Production (cwt)	Corn Equiv (tons)	SBM Equiv (tons)
Mar 2010	4113	95.8	21.1
Apr 2010	4340	101.1	22.3
May 2010	4188	97.6	21.5
Jun 2010	4240	98.8	21.8
Jul 2010	4188	97.6	21.5
Aug 2010	4023	93.7	20.7
Sep 2010	4075	94.9	20.9
Oct 2010	4038	94.1	20.8
Nov 2010	4063	94.7	20.9
Dec 2010	4149	96.7	21.3

Figure A.1 Input page of the web based Least-cost Optimizer

Results

The calculations use futures and options prices from dates: **2009-12-23, 2009-12-24, 2009-12-28**
The chosen deductible is 1.5 $/cwt.

For the insurance months, the following are the mean milk prices and feed costs as estimated from the futures data:

Insured Months	Milk ($/cwt)	Corn Equiv ($/bu)	SBM Equiv ($/ton)
Mar 2010	14.62	4.10	300.00
Apr 2010	14.76	4.15	298.57
May 2010	15.06	4.20	297.13
Jun 2010	15.53	4.25	297.51
Jul 2010	15.94	4.29	297.90
Aug 2010	15.99	4.32	296.83
Sep 2010	16.13	4.35	292.83
Oct 2010	16.01	4.37	285.40
Nov 2010	15.88	4.39	284.90
Dec 2010	15.94	4.41	284.40

Figure A.2 Results page showing expected prices of milk, corn and soybean meal for January 2010 LGM-Dairy contract.

Insured Months	Production (cwt)	Corn Equiv (tons)	SBM Equiv (tons)	Recommended Coverage (%)
Mar 2010	4,113	57.6	8.2	100.00
Apr 2010	4,340	60.8	8.7	100.00
May 2010	4,188	58.6	8.4	100.00
Jun 2010	4,240	59.4	8.5	56.27
Jul 2010	4,188	58.6	8.4	24.44
Aug 2010	4,023	56.3	8.0	0.16
Sep 2010	4,075	57.1	8.2	0.00
Oct 2010	4,038	56.5	8.1	16.35
Nov 2010	4,063	56.9	8.1	4.59
Dec 2010	4,149	58.1	8.3	55.22

Download Excel File

This gives you a premium of $2,768 (0.07 $/cwt of All Milk). The GIOFC is $209,853 (5.07 $/cwt of all milk). The NGIOFC is $207,085 (5.00 $/cwt of all milk).

If you would like to evaluate premium costs using other coverage percentages, you can change the coverages above and estimate the LGM insurance premium using our Premium Calculator

Return to the Optimization Input Page

Figure A.3 Results page showing the optimal contract design for January 2010 LGM-Dairy contract