The efficacy of risk management strategies among dairy producers

by

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Abstract

The United States dairy industry is a cornerstone of the agriculture economy, contributing significantly to rural livelihoods and the food system. However, it faces significant market volatility, fluctuating milk prices, and increasing input costs which threaten the financial stability of dairy producers. Effective risk management tools are critical to mitigating these risks and ensuring the sector's long-term sustainability.

This study assesses the efficacy of Dairy Margin Coverage (DMC) as a risk management tool to mitigate the risk of price volatility. Based on the available data, we analyzed the DMC by applying program choices to historical (ex-post) data spanning from 2000 to 2024 across six regions (Illinois, Kansas, Michigan, Minnesota, Ohio, and Wisconsin). These treatments were compared to a control in which no risk management practices were adopted. Stochastic dominance and efficiency were used to compare the performance.

The results of the risk management analysis show that DMC protects against and mitigates dairy farmer risks as it consistently reduces variances of dairy margins in Illinois, Kansas, Michigan, Minnesota, Ohio, and Wisconsin relative to the control of no risk management practices. Furthermore, dairy producers who elected a margin between $9.50 and $6.50 under the DMC program were better off in terms of lower income variance, as these coverage levels provided greater stability and reduced financial fluctuations compared to lower coverage levels or non-participation. The minimum coverage percentage and coverage level that yields a statistically significant difference in the Income Over Feed Cost relative to no risk management varies by state. Illinois, Michigan, Ohio, and Wisconsin have the minimum coverage rate, covering up to 35% of milk production at the $9.50 margin coverage level. Also, the result of our stochastic dominance shows that there is a statistically significant difference between DMC practices relative to no risk

management practices at the upper levels of margin coverage and upper levels of production history coverage (75% to 95%).

The analysis also reveals a gap between the program's expectations and practical outcomes, it shows a disconnect between the national DMC program and the state’s actual margins. The findings indicate that the program does not effectively provide payments when they are most needed but does pay out a good bit when it is not needed at the state level. These findings underscore the importance of tailoring the program to regional dynamics to enhance its effectiveness. This research provides critical insights for policymakers and stakeholders seeking to enhance the resilience and stability of the dairy industry through effective risk management strategies.

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Chapter 1 – Introduction

1.1 Background of the Study

In the United States, the dairy industry represents a vital segment of the agricultural economy, contributing significantly to the nation's food supply and rural livelihoods. The dairy industry's progression has brought technological advancement, jobs, and contribution to state and national Gross Domestic Product (Frisvold, 2021). The dairy industry was the third largest contributor to total agriculture cash receipts for the U.S. in 2022, according to the USDA Economic Research Service (2022). U.S. revenue from milk and milk products was over $56.1 billion, accounting for 12.3 percent of total agricultural cash receipts, trailing only cattle and calves ($78 billion) and corn ($56.8 billion).

As important as this sector is to U.S. agriculture, U.S. dairy farmers have faced numerous challenges and risks that have significantly affected their profitability over the past few decades. These multifaceted challenges include market price volatility, fluctuations in feed and input costs, climate and environmental uncertainties, changes in consumer preferences, and evolving regulatory landscapes, all contributing to the decline in overall milk production (Wolf, and Karszes 2023).

Among the challenges and risks that have significantly affected dairy farmers' profitability, the increasing volatility of milk prices is the primary source of dairy farm revenue risk (Wolf et al., 2016). Table 1 displays summary statistics for the U.S. All-Milk Prices between 1990 and 2024, including the mean, standard deviation, and coefficient of variation. The coefficient of variation, a measure of volatility relative to the mean, is calculated as the standard deviation divided by the mean. The coefficients of variation for All-Milk prices increased in the second half of the last 34-year period, increasing from 14.96% in the 1990 to 2007 period to 17.03% in the 2008 to 2024 period. Table 1: Level and variation of monthly US milk prices ($/cwt), 1990 to 2024

Period	All milk price ($/cwt)		
	Mean	Standard Deviation	Coefficient of Variation
1990-2007	13.94	2.08	0.1496
2008-2024	18.78	3.20	0.1703

Source: USDA- NASS (2024)

In response to this volatility, dairy farmers are increasing their usage of various risk management tools initiated by the U.S. government (USDA, 2021). One of these risk management tools is Dairy Margin Coverage (DMC). DMC is a voluntary risk management program for dairy producers that was primarily initiated and designed to improve the margin of milk producers and replace the Margin Protection Program (MPP) in 2019 (USDA, 2019). DMC expanded coverage choices for dairy producers while focusing on dairy margins. Conceptually, DMC offers protection to dairy producers when the difference between the All-Milk price and the feed cost at the national level is below a margin coverage level selected by the producer (USDA, 2019). Historically, dairy producers have been slow to adopt risk management tools, largely due to the complexity of available programs and limited familiarity with their benefits (Wolf, 2012). However, the Dairy Margin Coverage (DMC) has resulted in increased participation since its' introduction under the 2018 Farm Bill. When DMC became available in 2019, approximately 74% of eligible dairy operations were enrolled in the program (USDA, 2024). However, initial hesitancy was evident, as many producers remained uncertain about its effectiveness in mitigating financial risks associated with volatile milk prices and feed costs (Bozic, 2022).

Previous research related to risk management tools by Pennings and Meulenberg (1997), Velandia et al. (2009), Wolf (2012), Tudor et al. (2014), Asravor (2019), and Skevas et al. (2021) focuses on the usage of risk management tools or the adoption of risk management tools. None of these studies evaluate the effectiveness of using DMC to protect margin. Studies by Martinez et al. (2021) focused on the utilization of Dairy Margin Coverage in the Southeast while Yu and Gabrielyan (2023) investigated the participation patterns of the DMC program among U.S. dairy producers. There is a notable gap in research regarding the optimal choices. This research aims to cover the gap. This study aims to directly examine the efficacy of using DMC in protecting the margin at all coverage levels and a covered percentage of 5 million pounds of annual milk production, the limitation of the amount covered under Tier 1 of the DMC program.

1.2 Objective

This study analyzes the efficacy of Dairy Margin Coverage in protecting dairy farmers' margins.

The objectives of this study were as follows:

1. To estimate the statistical impact of Dairy Margin Coverage on dairy producers' gross margin across various regions.
2. To determine the regional differences in the realized margin and the actual DMC payout.
3. To determine the optimal percent of production coverage and margin protection level that is most effective in managing margin risk for a dairy farmer.

1.3 Thesis Outline

This thesis is divided into five chapters. A thorough review of relevant literature on risk management strategies, the U.S. Government's efforts in stabilizing the dairy industry, and how volatility has affected the operating margin of dairy producers, as well as dairy risk management tools and practices is presented in Chapter 2. Chapter 3 describes the data and methods adopted for this study, while Chapter 4 details the data analysis and results. Finally, the study's conclusions are presented in Chapter 5.

Chapter 2 – Literature Review

This chapter presents a review of the relevant literature on dairy margin volatility and related risk management strategies. The first section reviews the U.S. government's efforts in stabilizing the dairy industry and how volatility has impacted the operating margin of dairy producers. The second part discusses dairy risk management tools and practices. Finally, the research investigated farmers' adoption of risk management tools, identifying the gaps in the literature.

2.1 The Dairy Market

Like many of its counterparts throughout the developed world, the U.S. dairy industry has a long history of government intervention in price control to increase dairy producer income and ensure orderly marketing of a bulky and perishable product (USDA, 2023). An example of a policy program implemented to help dairy farmers in the U.S. by stabilizing dairy milk prices is the Federal Milk Marketing Orders (FMMOs) (Chouinard et al., 2010, Swanepoel, G. 2014). The United States operates 11 FMMOs and establishes minimum prices that milk processors must pay to producers based on the end use of the milk. These pricing structures help stabilize the dairy market, but market-based pricing continues to play a significant role, especially with Class III milk futures influencing the broader milk price structure (Jesse & Cropp, 2008; Shields, 2009).

Despite these efforts, price volatility in the dairy sector has increased since the 1980s due to the perishable nature of milk, seasonal production, and a combination of an inelastic demand with unanticipated supply variation caused by weather and disease (Anthony and Gregor, 2021). Another factor in this volatility increase started after a reduction in price support levels with the passage of the 2014 Farm Bill, leading to greater volatility in Class III milk prices (Wolf &

Widmar, 2014). The volatility has been measured through the coefficient of variation, which has shown an increase from 13.9% during 1990 - 2007 to 18.78% between 2008 and 2024 (USDA-NASS, 2024) as shown in Table 1 above.

In terms of operating costs, dairy feed costs have also experienced similar volatility to milk prices, due to the global market expansion over recent decades (Informa Economics, Inc., 2010). Generally, the feed cost of production per hundredweight of milk has increased since 2000 (Figure 1), driven by various macroeconomic factors, including fluctuating commodity prices and increased operational costs (Madre and Devuyst, 2016). This volatility creates financial uncertainty for dairy producers, complicating business planning and leading to thin or negative profit margins. Gillespie et al. (2024) asserted that larger dairy farms, benefiting from economies of scale, face different cost structures compared to smaller operations. As milk prices fluctuate, smaller farms bear a heavier financial burden due to their higher per-unit costs, particularly for labor and feed, increasing their vulnerability to market changes.

Moreover, Gillespie et al. (2024) emphasize that dairy farms' use of advanced technology and management practices plays a critical role in determining their ability to manage volatility. Larger operations, which are more likely to adopt cost-saving technologies, are better positioned to weather price fluctuations. On average, larger farms cover their operating costs in most years, while smaller farms may struggle with lower efficiency and higher costs per unit of milk. Thus, volatility in milk prices and production costs disproportionately affect smaller producers, exacerbating financial risks for those with less ability to absorb market shocks (Gillespie et al. 2024).

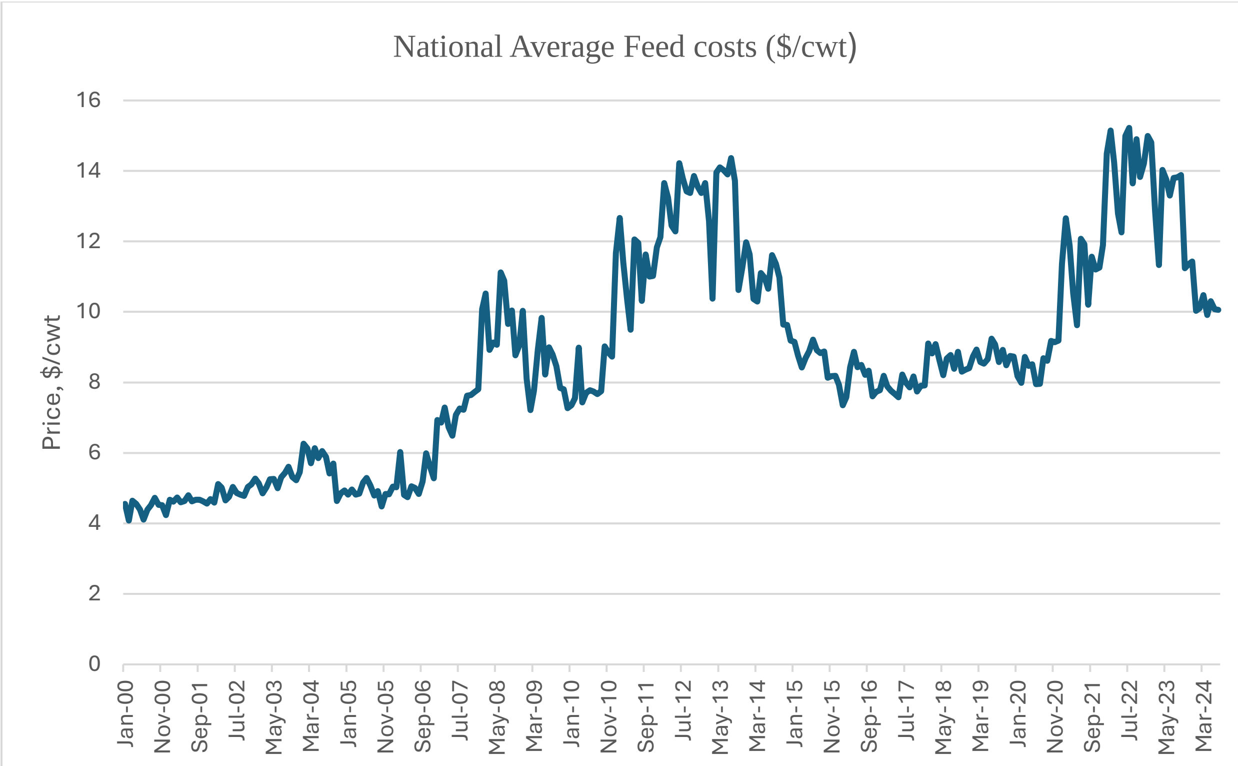


Figure 1 – National Average Feed Cost (Corn price, Soybean meal price, and Alfalfa price)
Source: USDA- NASS (2024)

2.2 Dairy Risk Management Tools and Practices

Risk management in the dairy industry has been determined generally by policies and tools that address and enhance the profitability of the dairy producer (Newton et al., 2016). The federal government and the private industry offered support programs and instruments for dairy producers to weather adverse market conditions. The 2018 Farm Bill amended the 2014 Farm Bill, modifying the Margin Protection Program (MPP) to create the Dairy Margin Coverage (DMC), which provides payout relief when income minus feed drops below certain pre-selected levels. The federal government further assists private industry in offering insurance contracts for dairy producers. These contracts include the Livestock Gross Margin – Dairy (LGM-Dairy) protection, and the Dairy Revenue Protection (DRP) program to ensure a dairy producer's revenue offered through private insurers is assisted by the USDA's Risk Management Agency (RMA).

Adoption of these tools varies significantly among farmers due to demographic and institutional factors. For instance, younger and more educated farmers are generally more likely to adopt risk management practices (Velandia et al., 2009). Larger farmers tend to use more risk management tools to enhance capital and manage potential short-term losses such as transaction costs and margin calls (Coffey & Schroeder, 2019). Studies by Coffey and Schroeder (2019) of large-scale Midwest grain farmers found a positive correlation between average farm size and the probability of hedging with futures and a positive impact from using hedges. Likewise, Tudor et al. (2014) showed a tendency to utilize more risk management tools increases with farm gross income.

Given the diverse adoption patterns of risk management tools among farmers, the specific tools available for managing milk price risk play a crucial role in shaping producer participation. Dairy farmers, like their counterparts in grain and livestock production, have access to several price risk management options tailored to their industry. The risk management tools available for managing farm milk price risk include forward contracts, futures, options contracts, and Dairy Revenue Protection. A brief discussion of these sets the stage for the Dairy Margin Coverage program that will be the focus of this research.

DRP, which was designed by the American Farm Bureau Federation, American Farm Bureau Insurance Services (AFBIS), and other collaborators, is a revenue insurance program that aims to protect against the risk of unexpected declines in the revenue of dairy products every quarter, including unforeseen decreases in milk production, unexpected declines in milk prices, or both (Newton, 2017). Dairy Revenue Protection which was developed as well as approved through the Federal Crop Insurance Act's 508(h) process, enables private bodies (AFBF, AFBIS) to develop insurance products that are in the best interests of crop producers, follow sound insurance principles, and are actuarially appropriate (USDA, 2019). The program went on sale on October 9, 2018 (coverage began during the first quarter of 2019) and is approved for sales in all counties of the 50 states.

A forward contract is just an agreement between a milk buyer and a dairy farmer or a cooperative association of dairy farmers. The dairy farmer or the cooperative sells a stipulated quantity of milk for a stated period in the future at a set price (USDA, 2019). Dairy farmers will receive the contract price regardless of the announced FMMO milk price that month.

A futures contract is a contract that is traded on a futures exchange for the delivery of a specified commodity at a specified time and place of delivery or to cash settle the price difference (CME Group, 2018). Dairy-related futures contracts may be an effective risk management tool but are not widely used by farmers for several reasons. Anderson and Ibendahl (2000) noted that smaller producers may not have the ability to produce sufficient milk to cover a future milk contract for 2,000 hundredweight of milk in one month. Also, holding a futures market position requires the trader to maintain a margin account representing a trader's equity. When futures prices move against a trader's open position, money is taken from the margin account to cover the losses, which requires more money to be added into the account to maintain equity.

2.2.1 Dairy Margin Coverage (DMC)

Dairy Margin Coverage (DMC) is a voluntary risk management program for dairy producers that was primarily initiated and designed to improve the margin for milk producers (USDA, 2019). It replaced the Margin Protection Program (MPP) through the 2018 Farm Bill and offers a more flexible and comprehensive safety net for producers of all sizes (USDA, 2019). The program allows dairy farmers to insure a portion of their milk production history, with income over feed cost coverage levels ranging from $4.00 to $9.50 per hundredweight (cwt), offered in $0.50 increments. Producers can enroll annually and choose to cover between 5% and 95% of their milk production history, allowing them to tailor their protection based on their financial risk tolerance and market conditions. DMC provides margin protection by issuing payments when the difference between the national All-Milk price and the estimated national feed cost is below a margin coverage level that is selected by the producer (USDA, 2019). This ensures that dairy farmers receive financial assistance when market conditions result in lower-than-expected profit margins (USDA, 2019).

DMC is viewed as more attractive than its predecessor MPP for dairy producers because (a) the producer is provided with free catastrophic coverage (there is a small administrative fee), and (b) producers can purchase higher margin protection at lower premium costs offered. The milk produced by the farm level is divided into two basic tiers as shown in Table 2: TIER 1, which is designed to cover the first 5 million pounds of milk production per year, and TIER 2 can be used to cover any historic milk production greater than the 5 million pounds per year.

Table 2: Dairy Margin Coverage Premium Schedule by Tier

Coverage Level	Tier 1 Premium per cwt for covered production history of 5 mil lbs. or less	Tier 2 Premium per cwt, all years for covered production history over 5 mil lbs.
$4	None	None
$4.50	$0.0025	$0.0025
$5.00	$0.005	$0.005
$5.50	$0.030	$0.100
$6.00	$0.050	$0.310
$6.50	$0.070	$0.650
$7.00	$0.080	$1.107
$7.50	$0.090	$1.413
$8.00	$0.100	$1.813
$8.50	$0.105	N/A
$9.00	$0.110	N/A
$9.50	$0.150	N/A

Source: USDA (2019)

USDA's Dairy Margin Coverage is based on the Actual Dairy Production Margin (ADPM), a calculation representing the national average income over feed costs (IOFC) in dollars per hundredweight (cwt) of milk produced. The margin is calculated using average monthly All-Milk prices and prices for corn, soybean meal, and alfalfa hay at the national level (USDA, 2019). The ADPM is mathematically expressed as:

$ADPM_t = IOFC_t$ ………….. (2.1)

Given:

$IOFC_t = M_t – FC_t$ …………………………. (2.2)

Where:

$IOFC_t$ = Income Over Feed Cost at time t

M_t = All-Milk Price /cwt at time t, and

FC_t = Feed Cost /cwt at time t

The estimate for feed cost was done based on the ADPM formula to convert corn, soybean meal, and alfalfa hay into a cost per cwt Mark et al. (2016). This equation is:

$FC_t = 1.0728*C_t + 0.00735*S_t + 0.0137*A_t$ ………… (2.3)

Where:

C_t = National corn price /bushel at time t,

S_t = National soybean meal price /ton at time t, and

A_t = National alfalfa price /ton.

The multipliers are provided as a part of the program as set by the 2018 Farm Bill. Combining the above values, the ADPM can be written:

$ADPM_t = M_t - (1.0728*C_t + 0.00735*S_t + 0.0137*A_t)$ 2.4

If a milk producer decides to participate in the DMC program, they are automatically enrolled at the \$4.00/cwt margin coverage level after paying a \$100 administrative fee. There is not premium for this level of coverage. This provides baseline protection for their first 5 million pounds of milk production annually (Tier 1). Producers can then opt to purchase additional margin coverage up to \$9.50/cwt for their first 5 million pounds of milk production annually (Tier 1). For milk production exceeding 5 million pounds annually (Tier 2), producers can purchase coverage for the balance in Tier 2 premiums, which are higher than Tier 1 premiums.

As the DMC program is relatively new, no previous studies have examined the program's effectiveness in mitigating margin revenue for dairy producers. Skevas et al. (2021) examined how the national income-over-feed-cost margin (All milk price – feed cost), a key metric used to determine payments under the MPP and DMC, correlates with individual dairy farm-level milk receipts and feed expenses. They found that while the national income-over-feed-cost margin is moderately related to farm-level margins, the correlation varies depending on whether farms produce or purchase their feed. This implies that the national margin is a useful indicator for predicting broad trends in market feed cost and milk prices but does not fully account for the variability in financial performance experienced by individual farms, particularly those with different feed procurement strategies.

Mark et al. (2016) used ex-post market data to analyze the effectiveness of the Margin Protection Program for dairy producers (MPP-Dairy) in reducing downside risk and increasing net margins for farms of different sizes across various U.S. regions While they varied the level of production to assess the impact on different farm sizes, they did not account for cost differences, meaning that economies of scale were not considered in their analysis. They found out that the program could significantly mitigate financial risks faced by dairy farmers by offering margin protection at various coverage levels, ranging from \$4.00 to \$8.00 per hundredweight (cwt). Small farms, with production histories below four million pounds annually, benefited most from higher coverage levels, experiencing notable increases in average net margins and reduced downside risk. Medium and large farms, with production histories of 20 million and 40 million pounds, respectively, also benefited, but the optimal coverage level for these farms was \$6.00 per cwt due to the higher premiums associated with covering larger production volumes. The program's payouts are triggered based on the Actual Dairy Production Margin (ADPM).

Yu and Gabrielyan (2023) investigate the participation patterns of the DMC program among U.S. dairy producers by utilizing a unique and novel farm-level dataset that combines the DMC program participation data and Coronavirus Farm Assistance Program (CFAP) participation data to study the U.S. dairy producers. They considered whether the larger farms make program choices that result in greater returns from the program. It was found that, in general, farm size is positively correlated to the likelihood of participating in the program and positively related to the possibility of making margin coverage choices that lead to maximum net returns from the program. While this study combined DMC and CFAP participants, our study isolates DMC's efficacy as an individual tool.

2.3 Gaps in Literature

The existing literature on risk management within the dairy industry has contributed to understanding the various tools available to producers, such as Dairy Margin Coverage (DMC) and Dairy Revenue Protection (DRP). However, there are notable gaps that this research seeks to address. Firstly, much of the literature focuses on the adoption of DMC as a risk management tool. A study by Yu and Gabrielyan (2023) investigated the participation patterns of the DMC program among U.S. dairy producers but has yet to fully explore their effectiveness in mitigating risks, particularly in the face of recent market volatility.

Another significant gap is the need for more focus on exploring all the coverage levels offered by DMC to dairy farmers and the optimal coverage levels. While some studies have analyzed and explored selected coverage levels, the potential synergistic effects of optimal coverage level and coverage percent offered by DMC to dairy farmers have yet to be sufficiently explored and this study aimed to bridge that gap. Also, this study aims to note regional differences in DMC by providing a current analysis of the efficacy of DMC across various regions in the U.S., focusing on all coverage levels and the optimal level. By addressing these underexplored areas, this research will offer valuable insights that can inform both policymaking and the strategic decisions of dairy producers.

Chapter 3 - Data and Methods

In this chapter, we present the data sources and quantitative methods used in our analysis of the efficacy of Dairy Margin Coverage for dairy producers to mitigate margin risk. The first section discusses the methods adopted for the study. The second section details the statistical methods used in this study, including Stochastic Dominance with Respect to a Function, and the last section outlines the data utilized in the work.

3.1 Methodology

In this section, we examine the impact of Dairy Margin Coverage on dairy producers in different regions. To do so, we need an estimate of their Income Over Feed Cost (IOFC), a critical indicator of the operating margins achieved by dairy farmers. To estimate their IOFC, we used the structure of the ADPM formula and followed the general process laid out in Mark et al. (2016) to calculate the margin using average monthly All-Milk prices and prices for corn, soybean meal, and alfalfa hay at the regional level from 2000 to 2024. This calculation is a proxy for the region's average operating margin achieved by dairy farmers without risk management strategies.

$OM_{r,t}^{NR}$ = $IOFC_{rt}$ ……………………………………… (3.1)

Where:

$OM_{r,t}^{NR}$ = Operating margin with no risk management in $/ cwt.

$IOFC_{rt}$ = Income over feed cost,

r = Region, and

t = Month.

As with the explanation of ADPM in Chapter 2, IOFC can be broken down further.

$IOFC_{rt} = M_{rt} – FC_{rt}$ …………………………. (3.2)

Where:

M_{rt} = Regional All Milk Price /cwt at time t

FC_{rt} = Regional Feed Cost /cwt at time t

Feed cost in our study is measured utilizing the formulaic process proscribed in the DMC policy and as defined for ADPM in Chapter 2.

$FC_{rt} = 1.0728*C_{rt} + 0.00735*S_{rt} + 0.0137*A_{rt}$……….. (3.3)

Where:

C_{rt}: Regional corn price /bushel at time t,

S_{rt}: Regional soybean meal price /ton at time t, and

A_{rt}: Regional alfalfa price /ton

Combining the above, the regional calculation for profit margin with no risk management is:

$OM_{r,t}^{NR} = M_{rt} – (1.0728*C_{rt}+ 0.00735*S_{rt} + 0.0137*A_{rt})$……………………. (3.4)

To consider the impact of DMC on the regional dairy's gross margin, we subtracted the premiums paid for the elected coverage and added any indemnities paid by the national program. The estimate of the impact of DMC coverage for a region's gross margin was determined by multiplying the percentage of coverage by the level of margin coverage elected in the Dairy Margin Coverage program. Because the IOFC is based on a cwt basis rather than total production, it is appropriate to adjust the per cwt indemnity of DMC to represent per cwt basis[1]. This indemnity is then added to the OMNR, and the cost of the premiums is subtracted. The operating margin achieved under DMC was calculated using Equation 3.5

$OM_{r,t}^{RM}$ = $IOFC_{rt}$ + σ (DMC_t) ………….. (3.5)

Where:

$OM_{r,t}^{RM}$ = Operating margin achieved using risk management in $/ cwt.

$IOFC_{rt}$ = Income over feed cost, as defined in equation 3.2 above

σ = Covered percentage (it ranges between 5% to 95%)

DMC_t = DMC margin coverage level ($4 to $9.5)

Given:

DMC_t = (D_t – P_t)………………………………….. (3.6)

Where:

D_t = National Indemnity at time *t* (amount received when payment is triggered)

P_t = Premium cost of DMC per cwt (see Table 3)

Where:

D_t = CL – $IFOC_t$ when CL > $IFOC_t$ else = 0………………. (3.7)

Where;

CL = Elected coverage level

$IFOC_t$ = Income over feed cost at the National level at time t

Therefore, the operating margin with risk management practices is

$OM_{r,t}^{RM}$ = $IOFC_{rt}$ + σ (D_t – P_t) …………... (3.8)

Table 3: Dairy Margin Coverage Premium Schedule by Tier

Coverage Level	Tier 1 Premium per cwt for covered production history of 5 mil lbs. or less	Tier 2 Premium per cwt, all years for covered production history over 5 mil lbs.
$4	None	None
$4.50	$0.0025	$0.0025
$5.00	$0.005	$0.005
$5.50	$0.030	$0.100
$6.00	$0.050	$0.310
$6.50	$0.070	$0.650
$7.00	$0.080	$1.107
$7.50	$0.090	$1.413
$8.00	$0.100	$1.813
$8.50	$0.105	N/A
$9.00	$0.110	N/A
$9.50	$0.150	N/A

Source: USDA (2019)

Furthermore, we initially explored data from the Federal Milk Marketing Orders (FMMOs) and the top ten milk-producing states in the U.S. to ensure a comprehensive analysis in our methodology. Unfortunately, the data was not widely available. Six states (Illinois, Kansas, Michigan, Minnesota, Ohio, and Wisconsin) were identified for which complete and consistent datasets were available.

All-Milk price, as well as corn, and alfalfa hay prices data were available for all the selected states. Soybean meal prices were available for seven locations throughout the country: Decatur and Chicago, IL; Kansas City and St. Louis, MO; Memphis, TN; Minneapolis, MN; and Portland, OR. To construct our soybean meal price, we pivoted using only the Central Illinois Soybean Meal price because of the history of the data. We computed both an estimated rail and an estimated truck price. The truck price was used as it better reflects the feed mill price. The seasonal adjustment from rail to truck is based only on two years of data because USDA has only been publishing an SBM truck price since the beginning of 2022.

The following steps were used to adjust soybean meal prices to a state without a soybean meal price quote.

Step 1: Central Illinois Soybean meal price was chosen as step 1.

Step 2: A monthly difference between the Central Illinois Soybean meal price quote and the state of interest was computed.

Step 3: cents/lb price difference was computed by dividing the soybean price difference from step 2 by 60 (there are 60 lbs in a bushel of soybeans).

Step 4: The value obtained in step 3 was multiplied by 2000 to obtain a per ton value. This calculation gives a measure of the difference between soybeans in the region versus the soybean meal reporting state, which is theoretically the cost of transportation between the two regions.

Step 5: The SBM price for the location identified in Step 1 was taken and the estimated cost per ton for transportation (computed in Step 4) was added to get the estimated soybean meal price for the region of concern.

3.2 Data

The historical (ex-post) data for monthly All-Milk, corn, and alfalfa hay prices for the state and national level came from USDA, National Agricultural Statistics Service, Quick Stats (https://www.nass.usda.gov/Quick_Stats/). The USDA Agricultural Marketing Service, Livestock, Poultry, & Grain portal (https://www.marketnews.usda.gov/mnp/ls-home) was used for historical soybean meal prices. This data was used to construct the regional operating margin a dairy farmer faces without utilizing risk management, which is consistent with the approach taken by Mark et al. (2016). The data are monthly from January 2000 to July 2024.

3.3 Method of Analysis

The risk management strategy was analyzed using summary statistics, cumulative distribution functions, and stochastic analysis to determine which strategies were most effective in managing margin risk for a dairy farmer. Following examples of Harrison (1998) and Kauffman and Tauer (1986), who analyzed cattle risk management and dairy farm management, respectively, first and second-order stochastic dominance analysis is utilized. Stochastic efficiency with respect to a function (SERF), was also adopted in this study to determine the efficacy of the risk management strategy to no risk management.

3.3.1 Stochastic Dominance with Respect to a Function (SDRF)

Stochastic dominance with respect to a function (SDRF) has been used to evaluate outcomes with uncertainty involved. It can be represented using Equation 3.9:

$$\int_{r1}^{r2}[G(z) - F(z)]u^1(z)dz \geq 0 \qquad \ldots\ldots\ldots\ldots\ldots (3.9)$$

Where:

G(z) is the CDF of option 1,

F(z) is the CDF of option two,

u is the upper-risk aversion coefficient, and

z is the operating margin attained by the given strategy

SDRF can be shown visually through a cumulative distribution function (CDF). For first-order stochastic dominance, a CDF curve that is further right and never crosses the CDF of a second distribution is said to have First Order Stochastic Dominance over the second distribution. For any given value on the x-axis (representing the outcome of interest), the probability of achieving less than or equal to that value is lower for the dominant distribution. In other words, the dominant distribution reflects a higher likelihood of better outcomes. First-order stochastic dominance is the least discriminating stochastic dominance method for ranking risky alternatives (Richardson, J.W., 2008). If the CDFs for the risky alternatives do not cross, this is the preferred method for ranking alternatives.

Second-order stochastic dominance occurs when CDF curves cross, but the integral (or the area under the curve) from negative infinity to any point under the dominant CDF is always less than or equal to that of the dominated CDF. This means the curves can cross, but the overall advantage either favors the dominating distribution or is equal to it. Second-order stochastic dominance assumes the decision maker is risk averse so the risk aversion coefficients (RACs) must be positive, indicating a preference for lower-risk alternatives (Richardson, J.W., 2008).

Stochastic dominance provides flexibility in evaluating uncertainty and accommodates varying levels of risk aversion, particularly through second-order dominance, which is valuable for decision-making under uncertainty. In the graphical representation of the cumulative distribution functions, an intuitive insight, simplify comparisons between distributions. However, it can be difficult to discern whether CDFs cross, and if they do, whether the integrals ever invert simply using the graphical method. To address this, it is necessary to calculate the CDF for all values of Income Over Feed Cost (IOFC) to accurately determine dominance relationships across the full distribution. The calculations and plots for this analysis were performed using Simetar, which provides an efficient framework for generating stochastic dominance comparisons and visualizing the results.

3.3.2 Stochastic Efficiency with Respect to a Function (SERF)

Stochastic efficiency with respect to a function (SERF) is used as a risk ranking procedure that evaluates alternatives based on their risk-return profiles. Unlike SDRF, SERF involves comparing each alternative with all the other alternatives simultaneously (Hardaker et al., 2004). Ribera, Hons, and Richardson (2004) used SERF to compare conventional and no-till farming methods in farming systems. SERF is a procedure of ranking risk alternatives based on their certainty equivalents (CEs) for alternative Absolute Risk Aversion Coefficients (ARACs) using an exponential utility function (Richardson, J.W., 2008). Certainty equivalents are dynamic and established by the data set being analyzed using the following calculation in Equation 3.10.

$$CE = -exp(ARAC * M(x)) \quad \ldots\ldots\ldots\ldots\ldots\ldots .. (3.10)$$

Where:

CE is the certainty equivalent

ARAC is the average risk aversion coefficient (ARAC), a parameter that quantifies the decision-maker's level of risk aversion for a given region and time. Higher values of ARAC indicate a greater aversion to risk, meaning the decision-maker values certainty more highly and is less willing to accept variability in outcomes. Conversely, lower values of ARAC suggest risk neutrality or risk tolerance. In this analysis, ARAC values are computed based on data from six states from January 2000 to July 2024.

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

The SERF was plotted using Simetar and graphs were generated by plotting the certainty equivalents of each risk alternative against the corresponding ARAC levels. Simetar also generated the ARAC

3.4 Summary

This chapter provides a discussion of the data sources and statistical methods used. The historical (ex-post) data for the empirical analysis was gathered from secondary sources for six states (Illinois, Kansas, Michigan, Minnesota, Ohio, and Wisconsin) spanning from 2000 to 2024. Following the approach by Mark et al. (2016), the data was used to construct the regional operating margin dairy farmers face without utilizing risk management and was compared with the estimated results of using the risk management strategy of DMC.

Chapter 4 -Results and Analysis

The findings of this study are presented in this chapter. The main objective of this study was to explore the efficacy of Dairy Margin Coverage in protecting dairy farmers' margins in the U.S. Specifically, we want to determine what percentage of coverage and coverage level gives dairy producers the least volatile results for their realized margin. The analysis results describe the efficacy of DMC as a risk management tool and compare it with no risk management results. Also, Stochastic Dominance with Respect to a Function and Stochastic Efficiency with Respect to a Function were used to determine the efficacy of the risk management strategy to no risk management. Finally, the chapter discusses the findings and implications of these findings for the dairy industry.

4.1 Summary Statistics

Table 4.1 presents the summary statistics of All-Milk price data for the national level and all six states examined. At the national level, the mean All-Milk price is $17.33 per hundredweight (cwt), with a standard deviation of 3.67. The minimum national price recorded is $11.00, while the maximum reached $27.20.

Ohio has the highest mean price of All-Milk at $18.03. It is followed by Minnesota and Illinois, with mean all-milk prices of $17.65 and $17.68, respectively. Kansas has the lowest mean price at $17.00. The standard deviation is relatively consistent across the states, with values ranging from $3.62 in Michigan to $3.82 in Minnesota. This suggests that while absolute prices differ, the degree of All-Milk price volatility is relatively uniform across the regions.

The minimum and maximum prices underscore regional differences. The highest recorded price of $28.00 is observed in Ohio, while the lowest minimum price of $10.40 is in Kansas. These extremes highlight the diverse economic landscapes in which dairy producers operate, with some states experiencing more favorable price conditions than others.

In summary, the All-Milk price data reveals important regional differences in dairy economics, with Ohio facing the most favorable conditions on average and Kansas facing relatively less advantageous prices. The price range varies from a low of $10.40 in Kansas to a high of $28.00 in Ohio, while price volatility remains relatively consistent across states, with standard deviations ranging from $3.62 in Michigan to $3.82 in Minnesota.

Table 4.1 shows the summary statistics of corn price data. At the national level, the average price of corn is $3.886, with a standard deviation of $1.57. The minimum recorded national price is $1.52, while the maximum price is $7.63. At the state level, Ohio records the highest mean price of $3.992, while Minnesota reports the lowest mean price at $3.708. Kansas has the highest standard deviation of $1.63, whereas Wisconsin has the lowest standard deviation at $1.53. Regarding the price range, Minnesota records the lowest minimum price at $1.40, while Ohio exhibits the highest maximum price at $8.09.

Similarly, the summary statistics of soybean meal prices are presented in Table 4.1. At the national level, the average soybean meal price is $314.70, with a standard deviation of $104.02. The minimum recorded national price is $153.75, while the maximum price is $564.26. At the state level, Ohio records the highest mean price of $321.84, while Minnesota reports the lowest mean price at $309.08. Michigan has the highest standard deviation of $106.95, whereas Wisconsin has the lowest standard deviation at $103.91. The minimum and maximum prices underscore regional differences. The highest recorded price of $581.09 is observed in Ohio, while the lowest minimum price of $137.11 is in Kansas.

Table 4.1 also shows the summary statistics for the alfalfa price data. At the national level, the average price of alfalfa is \$154.72, with a standard deviation of \$50.25. The minimum recorded national price is \$76.00, while the maximum price is \$288.00. At the state level, Ohio records the highest mean price of \$169.07, while Minnesota reports the lowest mean price at \$121.02. Kansas has the highest standard deviation of \$53.68, whereas Ohio has the lowest standard deviation at \$32.94. Regarding the price range, Wisconsin records the lowest minimum price at \$40, while Kansas exhibits the highest maximum price at \$286.

The summary statistics of the calculated feed cost (details are presented in Equation 3.3) are also presented in Table 4.1. At the national level, the mean feed cost is \$8.60 per hundredweight (cwt) of milk produced, with a standard deviation of \$3.00. The minimum national feed cost recorded is \$4.08, while the maximum reaches \$15.22.

Across the states, Minnesota has the lowest average feed cost at \$7.91, which may indicate more favorable conditions for sourcing or producing feed in the state. Ohio, on the other hand, has the highest mean feed cost at \$8.96, suggesting higher input costs that could impact the overall dairy margin. Kansas and Michigan have relatively similar mean feed costs of \$8.45 and \$8.41, respectively, indicating comparable feed price conditions. Illinois, at \$8.50, closely aligns with the national average.

Furthermore, the standard deviation shows some regional differences. Kansas has the highest variability at \$3.06, implying more significant price swings in feed costs over time. In contrast, Ohio shows the lowest variability at \$2.72, suggesting a more stable feed cost.

The minimum and maximum feed costs also illustrate regional disparities. The lowest feed cost is observed in Minnesota at \$3.60, reflecting potentially lower production or sourcing costs.

The highest maximum feed cost is recorded at the national level ($15.22), but among states, Kansas reaches $15.17, reinforcing its higher average feed cost burden.

Table 4.1: Summary Statistics Table

All milk price							
	National level	Illinois	Kansas	Michigan	Minnesota	Ohio	Wisconsin
Mean	17.33	17.68	17.0	17.21	17.65	18.03	17.52
SD	3.67	3.78	3.69	3.62	3.82	3.66	3.67
Minimum	11	10.5	10.4	11	10.7	11.4	10.8
Maximum	27.2	27.1	26.1	26.5	28	26.5	27.4
Corn price							
	National level	Illinois	Kansas	Michigan	Minnesota	Ohio	Wisconsin
Mean	3.89	3.91	3.99	3.87	3.71	3.99	3.80
SD	1.57	1.56	1.63	1.54	1.55	1.58	1.53
Minimum	1.52	1.54	1.68	1.51	1.40	1.59	1.58
Maximum	7.63	7.58	7.82	7.96	7.54	8.01	7.39
Soybean meal price							
	National level	Illinois	Kansas	Michigan	Minnesota	Ohio	Wisconsin
Mean	314.70	319.77	311.99	318.08	309.08	321.84	312.37
SD	104.02	104.95	104.35	106.95	103.96	106.22	103.91
Minimum	153.75	142.04	137.37	140.56	142.22	141.04	140.70
Maximum	564.26	577.76	557.76	564.43	564.43	581.09	571.09

Table 4.1: Summary Statistics Table (cont.)

Alfalfa price							
	National level	Illinois	Kansas	Michigan	Minnesota	Ohio	Wisconsin
Mean	154.72	142.71	137.11	140.71	121.02	169.07	124.23
SD	50.25	35.63	53.68	44.33	46.42	32.94	49.85
Minimum	76	81	63	55	58	105	40
Maximum	288	195	286	250	265	256	275
Feed cost							
	National level	Illinois	Kansas	Michigan	Minnesota	Ohio	Wisconsin
Mean	8.60	8.50	8.45	8.41	7.91	8.96	8.08
SD	3.0	2.74	3.06	2.81	2.88	2.72	2.80
Minimum	4.08	4.13	4.09	3.80	3.60	4.58	3.65
Maximum	15.22	14.28	15.17	14.51	14.48	14.95	14.75

4.2 Dairy Margin Coverage

This study examines all margin coverage levels ($4.00 - $9.50 per cwt) and all different percent of production coverage levels (5 - 95 percent) of the five million production history of the DMC Tier 1. The choice of Tier 1 is due to its availability to all dairy farmers regardless of the size of the operation. We use Simetar, a statistical software to analyze the margin coverage level ($4 – $9.50) and allow the software to rank the coverage level and covered percent from most preferred to least preferred. The $9.50 coverage level was ranked first across all regions. For the sake of simplicity and manageable discussion, the results for the $9.50 coverage level are detailed in this chapter. The results of all the margin coverage levels are presented in Appendix 1.

Operating margins for Dairy Margin Coverage (DMC) were calculated and compared to the operating margins if risk management was not utilized (see Table 4.2a). The analysis revealed that for all the selected states, DMC's operating margin resulted in a higher realized operating margin than the strategy of not using risk management. This implies that DMC has the potential to protect farmers' margins from milk volatility. Similarly, the operating margin achieved at the $9.50 coverage level varies across the states. The operating margin ($10.77/cwt) was highest in Wisconsin.

The primary goal of risk management is to manage the distribution of margins rather than simply focusing on a higher operating margin. The concern of the distribution must look at the dispersion of the distribution, not simply the measures of central tendency. The results of our analysis show the effect of Dairy Margin Coverage in reducing the standard deviation of the dairy margins as shown in Table 4.2b. This outcome suggests that DMC strategy does generate higher returns and reduces the variation in the realized operating margin for the dairy producer. This result is similar to that found by Mark et al. (2016) when examining the MPP program, a predecessor to the DMC program.

4.3 Dairy Margin Coverage Payouts

The Dairy Margin Coverage (DMC) program determines payouts based on whether the milk margin (milk price minus feed costs) falls below the selected coverage level. Whereas the national payout is consistent for every state, the operating margin results differ from state to state due to the state's economic conditions as reflected in the state’s Income Over Feed Cost calculation.

In Illinois, 82.1% of the time the state's average margin dropped below the coverage level of $9.50, they did not receive any benefits from the program. Conversely, 37.7% of the time they received a payment when their state average was above the coverage level. Similarly, 57% of the time the state's average margin dropped below the coverage level of $9.50 in Kansas, they did not receive any benefits from the program. Contrarily, 29.2% of the time they received a payment when their state average was above the coverage level.

Furthermore, in Michigan, 60.7% of the time the state's average margin dropped below the coverage level of $9.50, they did not receive any benefits from the program. Conversely, 28.6% of the time they received a payment when their state average was above the coverage level, indicating similar conditions to Kansas. However, 88.7% of the time the state's average margin dropped below the coverage level of $9.50 in Minnesota, they did not receive any benefits from the program. Contrarily, 36.4% of the time they received payment when their state average was above the coverage level.

In Ohio, 66.3% of the time the state's average margin dropped below the coverage level of $9.50, they did not receive any benefits from the program. Conversely, 26.3% of the time they received a payment when their state average was above the coverage level. Similarly, 92.2% of the time the state's average margin dropped below the coverage level of $9.50 in Wisconsin, they did not receive any benefits from the program. Contrarily, 38.5% of the time they received a payment when their state average was above the coverage level.

This analysis highlights the disconnect between the national DMC program and the state's actual margins. The findings indicate that the program does not effectively provide payments when they are most needed but does pay out a good bit when it is not needed at the state level. Across the states, producers often experience margin declines below the coverage threshold without receiving support, while in many instances, payments are triggered even when margins are above the coverage level. This inconsistency suggests a misalignment between the program's intended purpose and its actual performance. Overall, the record of how often the program hits its intended effort is poor.

4.4 Margin Coverage Level

We further analyze the margin coverage level of DMC to determine the coverage level where farmers find the best impact from DMC as shown in Table 4.4. The results show that dairy producers were better off regarding lower variance when electing a coverage level between \$6.50 and \$9.50. Also, the minimum coverage percentage and coverage level that yields a statistically significant difference in the IOFC relative to no risk management varies by state. Illinois, Michigan, Ohio, and Wisconsin have the lowest minimum coverage rate at 30% of milk production at the \$9.50 margin coverage level. Kansas and Minnesota start seeing a significant impact at 35% of milk production at the \$9.50 margin coverage level. Given these findings, dairy producers should consider electing a coverage level between \$9.50 and \$6.50 to reduce variance and improve financial stability.

Table 4.2a: Dairy Mean Income over feed cost (IOFC) of No Risk Management Vs DMC at $9.50 coverage level

	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
IL NRM	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18
IL DMC	9.25	9.32	9.39	9.46	9.53	9.60*	9.67*	9.74*	9.81*	9.88*	9.95*	10.02*	10.09*	10.16*	10.23*	10.30*	10.37*	10.44*	10.51*
KS NRM	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55
KS DMC	8.62	8.69	8.76	8.83	8.90	8.97	9.04*	9.11*	9.18*	9.25*	9.32*	9.39*	9.46*	9.53*	9.60*	9.67*	9.74*	9.81*	9.88*
MI NRM	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80
MI DMC	8.87	8.94	9.01	9.08	9.15	9.22*	9.29*	9.36*	9.43*	9.50*	9.57*	9.64*	9.71*	9.78*	9.85*	9.92*	9.99*	10.06*	10.13*
MN NRM	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75
MN DMC	9.81	9.88	9.95	10.02	10.09	10.16	10.23*	10.30*	10.37*	10.44*	10.51*	10.58*	10.65*	10.72*	10.79*	10.86*	10.93*	11.00*	11.07*
OH NRM	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07
OH DMC	9.14	9.21	9.28	9.35	9.42	9.49*	9.56*	9.63*	9.70*	9.77*	9.84*	9.90*	9.97*	10.04*	10.11*	10.18*	10.25*	10.32*	10.39*
WS NRM	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44
WS DMC	9.51	9.58	9.63	9.72	9.79	9.86*	9.93*	10.00*	10.07*	10.14*	10.21*	10.28*	10.35*	10.42*	10.49*	10.56*	10.63*	10.70*	10.77*

* Significant at 0.05 level of significant compared to no risk management strategy

Table 4.2b – Standard Deviation of No Risk Management Vs DMC at $9.50 Coverage Level

	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
IL NRM	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52
IL DMC	2.45	2.38	2.31	2.25*	2.18*	2.12*	2.05*	1.99*	1.93*	1.87*	1.81*	1.77*	1.71*	1.66*	1.61*	1.56*	1.52*	1.49*	1.45*
KS NRM	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55
KS DMC	2.49	2.42	2.36	2.29*	2.23*	2.17*	2.11*	2.05*	1.99*	1.94*	1.89*	1.84*	1.79*	1.75*	1.71*	1.67*	1.63*	1.60*	1.58*
MI NRM	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61
MI DMC	2.55	2.48	2.42	2.36*	2.30*	2.24*	2.19*	2.13*	2.08*	2.03*	1.98*	1.93*	1.89*	1.85*	1.81*	1.77*	1.74*	1.71*	1.69*
MN NRM	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74
MN DMC	2.67	2.60	2.54	2.47*	2.40*	2.34*	2.28*	2.21*	2.15*	2.10*	2.04*	1.98*	1.93*	1.88*	1.83*	1.79*	1.75*	1.71*	1.67*
OH NRM	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55
OH DMC	2.48	2.41	2.34	2.27*	2.21*	2.14*	2.08*	2.02*	1.95*	1.89*	1.84*	1.78*	1.73*	1.68*	1.63*	1.58*	1.54*	1.50*	1.47*
WS NRM	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58
WS DMC	2.51	2.44	2.37	2.31*	2.24*	2.18*	2.11*	2.05*	1.99*	1.93*	1.87*	1.82*	1.77*	1.72*	1.67*	1.62*	1.58*	1.55*	1.51*

* Significant at 0.05 level of significant compared to no risk management strategy

Table 4.3: Dairy Margin Coverage Payouts vs. Realized Margins

	Illinois	Kansas	Michigan	Minnesota	Ohio	Wisconsin
Number of periods	295	295	295	295	295	295
Number of periods No risk mgt. < 9.5	67	86	89	53	276	64
Number of payouts No risk mgt. < 9.5	12 (17.9%)	37 (43.0%)	35 (39.3%)	6 (11.3%)	93 (33.7%)	5 (7.80%)
Number of no payments when No risk mgt. <9.5	55 (82.1%)	49 (57%)	54 (60.7%)	47 (88.7%)	183 (66.3%)	59 (92.2%)
Number of periods No risk mgt. >9.5	228	209	206	242	19	231
Number of payouts when No risk mgt. >9.5	86 (37.7%)	61 (29.2%)	59 (28.6%)	88 (36.4%)	5 (26.3%)	89 (38.5%)
Number of no payout when No risk mgt. > 9.5	142 (62.3%)	148 (70.8%)	147 (71.4%)	154 (63.6%)	14 (73.7%)	142 (61.5%)

Table 4.4 – Optimal Margin Coverage Level and Percent of Coverage

	$9.5	$9.00	$8.50	$8.00	$7.50	$7.00	$6.50	$6.00	$5.50	$5.00	$4.50	$4.00
	5-95%	5-95%	5-95%	5-95%	5-95%	5-95%	5-95%	5-95%	5-95%	5-95%	5-95%	5-95%
Illinois	30*	40*	50*	55*	85	-	-	-	-	-	-	-
Kansas	35*	50*	65*	65*	90*	-	-	-	-	-	-	-
Michigan	30*	40*	50*	65*	90*	-	-	-	-	-	-	-
Minnesota	35*	40*	50*	70*	95*	-	-	-	-	-	-	-
Ohio	30*	40*	50*	65*	90*	-	-	-	-	-	-	-
Wisconsin	30*	40*	50*	65*	90*	-	-	-	-	-	-	-

* Significant at 0.05 level of significance

To determine whether there is a statistically significant difference in means between Dairy Margin Coverage (DMC) and No Risk Management at a \$9.50 coverage level, we employed a paired t-test of means, a statistical method used to compare the mean of two groups. The result of the DMC means at a \$9.50 coverage level was statistically different from the No Risk Management strategy at the 5 percent significance level (see Table 4.5).

Table 4.5 – Dairy Margin Coverage vs No Risk Management t-test Results

	Illinois	Kansas	Michigan	Minnesota	Ohio	Wisconsin
***t*-stat**	7.8296	7.5967	7.3234	7.1033	7.7417	7.6194
p-value	0.0000	0.0000	0.0000	0.0000	0.000	0.0000
***t*-crit**	1.9640	1.9640	1.9640	1.9640	1.9640	1.9640

H_0: Difference between means = 0; N=295; P <0.05

An F-test was conducted to compare the variances of Dairy Margin Coverage and the strategy of no-risk management in all regions. This test considers the effect of a risk management strategy to reduce volatility at a five percent statistically significant level compared to the no risk management strategy. The F-test results are presented in Table 4.6, which shows that DMC in all regions for dairy producers at a \$9.50 coverage level have statistically different variances compared to not using risk management.

Table 4.6- Dairy Margin Coverage vs No Risk Management F-test Results

	Illinois	Kansas	Michigan	Minnesota	Ohio	Wisconsin
F-stat	0.3316	0.3806	0.4182	0.3714	0.3318	0.3428
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
F-crit	0.8252	0.8252	0.8252	0.8252	0.8252	0.8252

H_0: Difference between variance = 0; N=295; P <0.05

A Stochastic Dominance with Respect to a Function (SDRF) analysis was performed to determine the impact of the DMC program versus no risk management tools. This was done for each region. Simetar, an analytic software for evaluating stochastic dominance, was used to rank the preference level and test for first- and second-order stochastic dominance. Figure 4.1 shows the cumulative distribution functions (CDFs) of operating margin achieved with the use of DMC compared to no risk management usage. The CDF curve for DMC lies to the right of the curve for no risk management, indicating that DMC consistently provides higher operating margins across a wide range of outcomes. When comparing the two distributions, the shape of the CDF curves suggests that for any given probability level, the operating margin achieved under DMC is higher than that achieved without risk management.

From Table 4.7, we see that DMC usage was not first-order stochastic dominant to that of the No Risk Management strategy as the table was empty and signifies that nothing was first-order stochastic dominant but was second-order stochastic dominant. The results show that the coverage percentage (95% to 75%) at a $9.50 coverage level dominates the NRM strategy. This result means these strategies provide the potential of better protection against risk and uncertainty, offering greater security and higher expected utility to risk-averse individuals. The stochastic dominance of the Illinois strategies reflects their ability to reduce exposure to milk price volatility.

The $9.50 margin coverage level at a covered percent of 95 on a 5 million pounds production history dominates the covered percent of 75 at a $9.50 coverage level, indicating that higher levels of coverage yield more favorable outcomes for risk-averse producers. These strategies mitigate risk more effectively by ensuring that a larger portion of potential losses are covered, thus offering greater financial stability and reducing the overall variance in returns versus choosing a low covered percent. This implies that DMC is an effective risk management tool for dairy farmers, as it helps stabilize and manage potential losses. As such, dairy producers should utilize DMC at a high coverage level and higher percent coverage to manage risk based on the result of our analysis.

Figure 4.1 – Cumulative Distribution Function Comparing Dairy Margin Coverage results to no Risk Management.

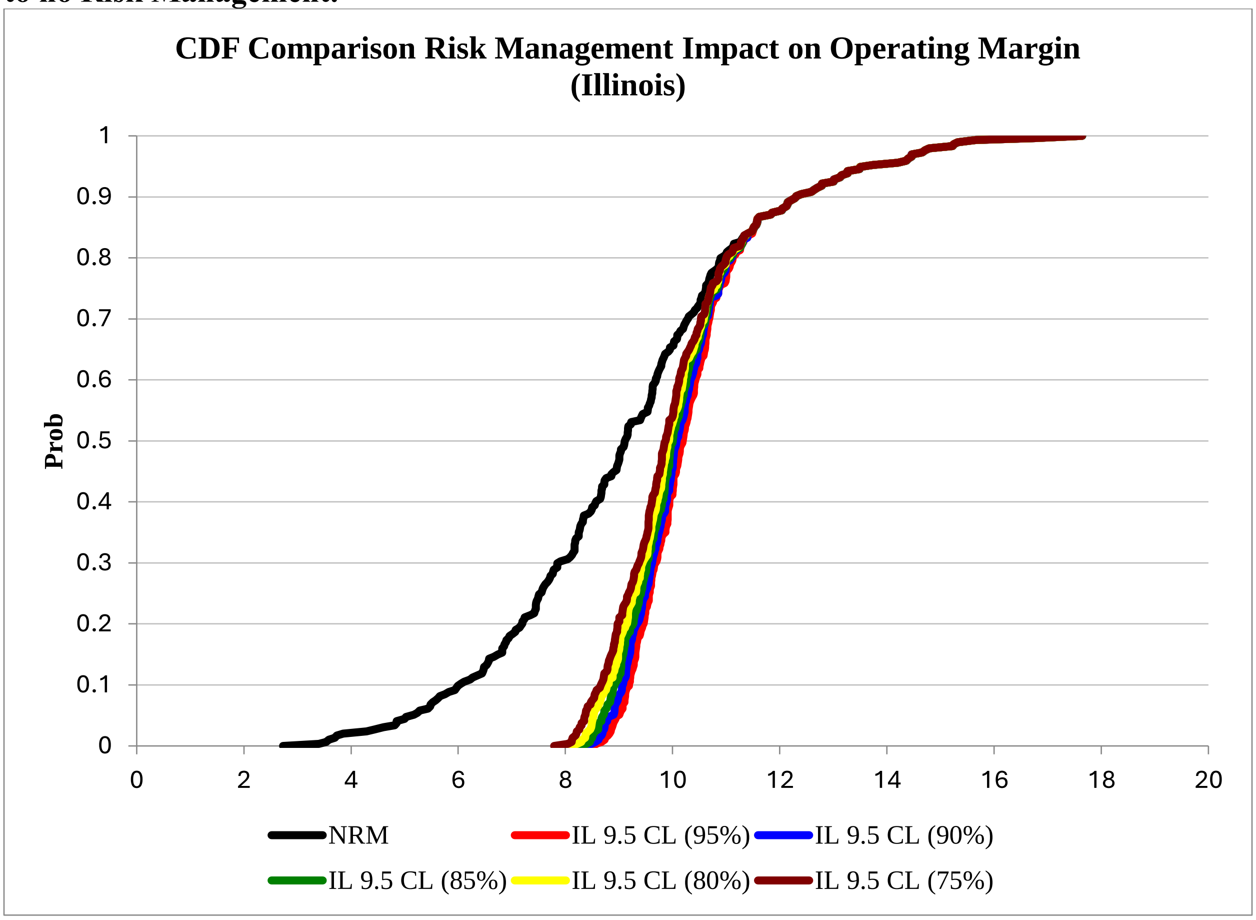


Table 4.7: Estimates of First and Second-Degree Stochastic Dominance for Illinois

First Degree Dominance Table

	NRM	IL 9.5 CL (95%)	IL 9.5 CL (90%)	IL 9.5 CL (85%)	IL 9.5 CL (80%)	IL 9.5 CL (75%)
NRM FDD:						
IL 9.5 CL (95%) FDD:	No FDSD		No FDSD	No FDSD		No FDSD
IL 9.5 CL (90%) FDD:						
IL 9.5 CL (85%) FDD:						
IL 9.5 CL (80%) FDD:						
IL 9.5 CL (75%) FDD:						

Second Degree Dominance Table

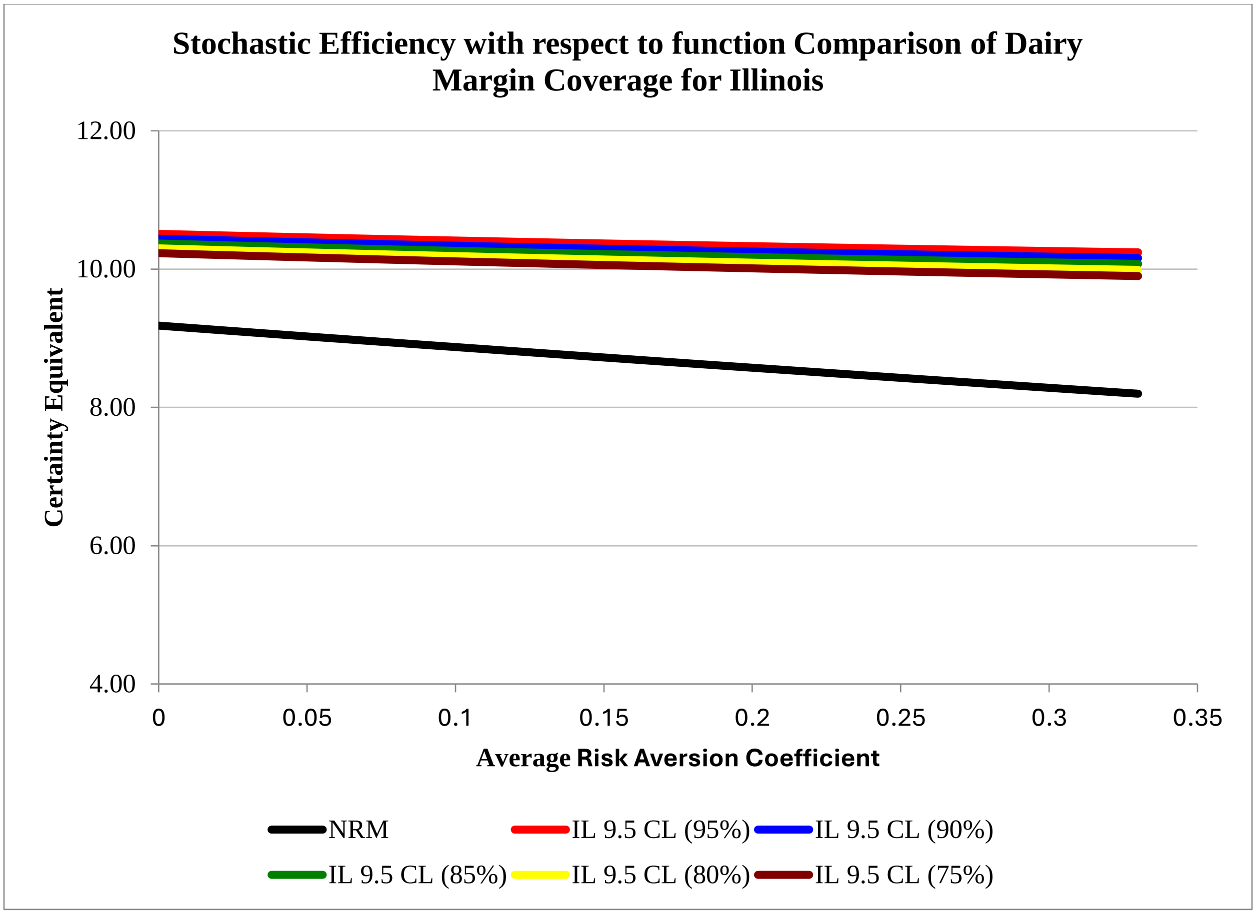
	NRM	IL 9.5 CL (95%)	IL 9.5 CL (90%)	IL 9.5 CL (85%)	IL 9.5 CL (80%)	IL 9.5 CL (75%)
NRM SDD:						
IL 9.5 CL (95%) SDD:	NRM		IL 9.5 CL (90%)	IL 9.5 CL (85%)	IL 9.5 CL (80%)	IL 9.5 CL (75%)
IL 9.5 CL (90%) SDD:	NRM			IL 9.5 CL (85%)	IL 9.5 CL (80%)	IL 9.5 CL (75%)
IL 9.5 CL (85%) SDD:	NRM				IL 9.5 CL (80%)	IL 9.5 CL (75%)
IL 9.5 CL (80%) SDD:	NRM					IL 9.5 CL (75%)
IL 9.5 CL (75%) SDD:	NRM					

Stochastic Efficiency with Respect to a Function (SERF) enables us to evaluate the success of a strategy concerning the risk attitude that a dairy farmer might exhibit in each region. SERF analyzes decision alternatives by comparing their Certainty Equivalents (CEs) across a range of risk aversion coefficients, known as Absolute Risk Aversion Coefficients (ARACs). In Figure 4.2, the Certainty Equivalent (CE) is plotted across different ARAC values. The relatively flat curve in the figure indicates that the operating margins expected under the Dairy Margin Coverage (DMC) program remain almost the same regardless of the risk attitude of the decision-maker. This consistency suggests that whether the dairy farmer is highly risk-averse or more risk-neutral, the outcomes under the DMC scenario do not vary significantly in terms of certainty equivalent returns.

As the ARAC varies from low to high, it reflects a transition from a risk-neutral decision-maker to one who is highly risk-averse. A flat CE curve across the range of ARAC values suggests that the benefits of DMC compared to no risk management are relatively stable, offering similar certainty equivalent returns regardless of the level of risk aversion. Such consistency across a range of risk preferences indicates the reliability of DMC as a risk management strategy.

Overall, across all states analyzed (Illinois, Kansas, Michigan, Minnesota, Ohio, and Wisconsin), the SERF shows a preference for DMC to the no risk management strategy as it consistently outperforms no risk management (NRM). This implies that DMC is an effective risk management tool for dairy producers to manage risk, resulting in better financial stability across various levels of risk aversion. Adopting DMC can help to reduce margin risk for producers in these states based on the result of our analysis.

Figure 4.2 – Stochastic Efficiency Analysis of Dairy Margin Coverage versus No Risk Management



4.5 Discussion

The study provided many important findings regarding the Dairy Margin Coverage program. The first major finding is that DMC yields an operating margin that is statistically higher and with less variability than compared to not using risk management tools. The second major finding is the margin coverage level ($4 - $9.50) where farmers were benefited versus not. According to our analysis, dairy producers enjoyed a lower variance of gross margin when electing a margin coverage level between $9.50 and $6.5. They did not benefit from participating in the program when they elected a margin less than $6.50. Also, the minimum coverage percentage and coverage level that yields a statistically significant difference in the IOFC relative to no risk management varies by state. Illinois, Michigan, Ohio, and Wisconsin have the lowest coverage rates that result in a benefit to the producer, covering up to 30% of milk production respectively at the $9.50 margin coverage level.

The third major finding is that the DMC strategy exhibits Second Degree Stochastic Dominance over no-risk management, indicating that these risk management tools have the potential to manage the margin risk of dairy producers. Also, the $9.50 margin coverage level at a covered percent of 95 on a 5 million pounds production history dominates the covered percent of 75 at a $9.50 coverage level, indicating that higher levels of coverage yield more favorable outcomes for risk-averse producers. These strategies mitigate risk more effectively by ensuring that a larger portion of the potential losses is covered, thus offering greater stability and reducing the overall variance in returns versus choosing a low covered percent.

Another major finding is our analysis of DMC payouts reveals a gap between the program's expectations and its practical outcomes. Producers may perceive the DMC as a tool to manage margin risk. However, the result of our payout matrix suggests that the program's match payouts with low state margins varies significantly by state. Ohio States received a proportionately higher number of payouts, aligning well with producers' expectations. In contrast, states such as Illinois and Wisconsin, despite having periods below the margin threshold, saw fewer payouts, which may lead to frustration or skepticism among producers regarding the program's reliability.

Chapter 5- Conclusion, Limitations of Study, and Future Research

5.1 Conclusion

The findings of this research offer significant implications for dairy producers, playing a vital role in managing the impact of market volatility in the dairy market. The results of the risk management analysis revealed that DMC consistently yields higher operating margins across all regions compared to scenarios without risk management. It is also an effective way to protect against and mitigate margin risks as it consistently reduces variance of the calculated dairy margins. The Stochastic Dominance with Respect to a Function (SDRF) indicates that DMC exhibits second-order dominance over the no-risk management strategy in all regions, suggesting that it provides a more favorable risk-return trade-off for dairy farmers. Furthermore, Stochastic Efficiency with Respect to a Function (SERF) demonstrates a clear preference for DMC compared to the no-risk management strategy. This indicates that based on the result of our findings, DMC is a tool for mitigating margin risk, thereby protecting dairy farmers' profitability. As such, Dairy Margin Coverage as a risk management tool could give dairy farmers a better sense of security, allowing them protection from margin risk and maintaining a more stable margin in their business operations based on the result of our analysis.

Another finding of this research is that dairy producers were better off regarding lower variance when electing a margin coverage between $9.50 and $6.5 and worse off when electing a margin coverage of less than $6.50. At the same time, the minimum coverage percentage and coverage level that yields a statistically significant difference in the IOFC relative to no risk management varies by state. Illinois, Michigan, Ohio, and Wisconsin have the lowest effective coverage rates, covering up to 30% of milk production at the $9.50 margin coverage level while Kansas and Minnesota have effective coverage rates, covering up to 35% of milk production at the

$9.50 margin coverage level. Given these findings, dairy producers should consider electing the upper levels of margin coverage between $9.50 and $6.50 and upper levels of production history coverage (75% to 95%) to reduce variance and improve financial stability.

Finally, the findings of our research highlight regional disparities in the effectiveness of Dairy Margin Coverage (DMC), which may influence the perception of producers. In states like Minnesota and Wisconsin, DMC failed to provide payments in 88.7% and 92.2%, respectively, of periods when margins fell below $9.50/cwt, suggesting that producers in these regions may view the program as unreliable. Conversely, Kansas and Michigan experienced higher payout frequencies (43.0% and 39.2%, respectively) when their margins were below the coverage level, making DMC appear more beneficial. Additionally, the misalignment between DMC payouts and actual margin indicates that DMC may not provide adequate support when needed or expected, leading to skepticism about its effectiveness and potentially poor perceptions in regions where it underperforms.

5.2 Limitations of Study

This research has resulted in many significant findings for the dairy industry. However, there are limitations to the study that could be the focus of further research. The data available for this research limits the work to only selected regions. If prices for All-Milk, corn, soybean meal, and alfalfa were available in other regions, this model could be applied more extensively.

Additionally, this study does not account for differences in operation size, which can significantly influence risk management decisions. Larger dairy operations may have different risk exposures, financial resilience, and access to market-based tools compared to small and mid-sized farms. Incorporating operation size would provide a more nuanced understanding of how DMC performs under varying economic and production scales.

This study focused solely on DMC as a risk management tool. Comparing DMC with other risk management tools and strategies could offer a more comprehensive view of the options available to dairy producers and the most optimal risk management strategy available across multiple risk management tools. Other risk management strategies that could be included in future research include Dairy Revenue Protection, futures, options, input hedging, forward contracting, swaps, and even vertical integration advantages.

5.3 Future Research

This study investigates the impacts of DMC on protecting dairy farmers' margins. However, there are some ways the research on dairy risk management could be extended. Similar studies could be done using primary data to better understand the impact of risk management tools based on the size of the operation, accounting for economies of scale. Analyzing how farm size influences the effectiveness and cost-efficiency of DMC and other risk management strategies could provide valuable insights into tailoring policies and tools to specific operational contexts.

Consideration of the efficacy of DMC in different regions, especially those regions with higher production amounts, would be helpful. That would require the availability of all prices. Alternatively, a different method for measuring costs and All-Milk prices could allow for different analysis irrespective of the data availability. One such method could be a simulation based on market conditions.

Future studies could also consider other risk management strategies at once, comparing one tool versus another. This study looked extensively at the results among the choice options with one tool. With the addition of other risk management strategies, the analysis of their impact on operating margin and other budgetary benchmarks could help the dairy producers and policy makers in making decisions across the array of risk management tools. Studying the results across tools could provide further clarity on the most optimal risk management package for dairy producers.

Lastly, future research could benefit from simulating the effects of risk management strategies under different market conditions. By modeling scenarios such as fluctuating milk prices, feed costs, or policy changes, researchers could better understand the resilience of risk management tools across diverse economic environments. This approach would provide deeper insights into the dynamic nature of dairy markets and help identify the optimal strategies for producers to manage risks effectively.

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Appendix 1 Dairy Mean Income over feed cost (IOFC) of No Risk Management Vs DMC by State

Table A1.1: Illinois Dairy Mean Income over feed cost (IOFC) of No Risk Management Versus DMC at $4.00-$9.50 coverage level

C.L	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85 %	90 %	95 %
NRM	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18	9.18
4.00	9.18	9.19	9.19	9.19	9.19	9.19	9.20	9.20	9.20	9.20	9.20	9.21	9.21	9.21	9.21	9.21	9.21	9.22	9.22
4.50	9.19	9.19	9.19	9.19	9.20	9.20	9.20	9.21	9.21	9.21	9.22	9.22	9.22	9.22	9.23	9.23	9.23	9.24	9.24
5.00	9.19	9.19	9.20	9.20	9.20	9.21	9.21	9.22	9.22	9.23	9.23	9.23	9.24	9.24	9.25	9.25	9.26	9.26	9.26
5.50	9.19	9.19	9.20	9.21	9.21	9.22	9.22	9.23	9.24	9.24	9.25	9.25	9.26	9.27	9.27	9.28	9.28	9.29	9.30
6.00	9.19	9.20	9.21	9.22	9.22	9.23	9.24	9.25	9.26	9.27	9.27	9.28	9.29	9.30	9.31	9.32	9.32	9.33	9.34
6.50	9.19	9.21	9.22	9.23	9.24	9.25	9.26	9.28	9.29	9.30	9.31	9.32	9.33	9.35	9.36	9.37	9.38	9.39	9.40
7.00	9.20	9.22	9.23	9.25	9.26	9.28	9.30	9.31	9.33	9.34	9.36	9.38	9.39	9.41	9.42	9.44	9.46	9.47	9.49
7.50	9.21	9.23	9.25	9.27	9.30	9.32	9.34	9.36	9.39	9.41	9.43	9.45	9.48	9.50	9.52	9.54	9.56*	9.59*	9.61*
8.00	9.21	9.24	9.28	9.31	9.34	9.37	9.40	9.43	9.46	9.49	9.52*	9.55*	9.58*	9.62*	9.65*	9.68*	9.71*	9.74*	9.77*
8.50	9.22	9.27	9.31	9.35	9.39	9.43	9.48	9.52	9.56	9.60*	9.64*	9.68*	9.77*	9.77*	9.81*	9.85*	9.89*	9.93*	9.98*
9.00	9.24	9.29	9.35	9.40	9.46	9.51	9.57	9.62*	9.68*	9.73*	9.79*	9.84*	9.90*	9.95*	10.00*	10.06*	10.11*	10.17*	10.22*
9.50	9.25	9.32	9.39	9.46	9.53	9.608*	9.67*	9.74*	9.81*	9.88*	9.95*	10.02*	10.09*	10.16*	10.23*	10.30*	10.37*	10.44*	10.51*

* Significant at 0.05 level of significant compared to no risk management strategy

Table A2 – Illinois Standard Deviation of No Risk Management Versus DMC at $4.00-$9.50 Coverage Level

C.L	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
NRM	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52	2.52
4.00	2.52	2.51	2.51	2.51	2.50	2.50	2.50	2.49	2.49	2.48	2.48	2.48	2.47	2.47	2.47	2.46	2.46	2.46	2.45
4.50	2.52	2.51	2.50	2.50	2.49	2.49	2.48	2.47	2.47	2.46	2.46	2.45	2.45	2.44	2.44	2.43	2.43	2.42	2.42
5.00	2.51	2.51	2.50	2.49	2.48	2.47	2.46	2.46	2.45	2.44	2.43	2.43	2.42	2.41	2.41	2.40	2.39	2.39	2.38
5.50	2.51	2.50	2.49	2.48	2.47	2.45	2.44	2.43	2.42	2.41	2.40	2.39	2.38	2.37	2.37	2.36	2.35	2.34	2.32
6.00	2.51	2.49	2.48	2.46	2.45	2.43	2.42	2.40	2.39	2.38	2.36	2.35	2.34	2.33	2.32	2.31	2.30	2.28*	2.27*
6.50	2.50	2.48	2.46	2.44	2.42	2.40	2.38	2.37	2.35	2.33	2.32	2.30	2.28*	2.27*	2.25*	2.24*	2.23*	2.21*	2.20*
7.00	2.50	2.47	2.44	2.42	2.39	2.37	2.34	2.32	2.30	2.28*	2.26*	2.24*	2.22*	2.20*	2.18*	2.16*	2.14*	2.13*	2.11*
7.50	2.49	2.45	2.42	2.39	2.36	2.33*	2.30*	2.27*	2.24*	2.21*	2.18*	2.16*	2.13*	2.11*	2.08*	2.06*	2.04*	2.02*	2.00*
8.00	2.48	2.44	2.40	2.36	2.32	2.28*	2.24*	2.20*	2.17*	2.13*	2.10*	2.06*	2.03*	2.00*	1.97*	1.95*	1.92*	1.90*	1.87*
8.50	2.47	2.42	2.37	2.32	2.27*	2.22*	2.18*	2.13*	2.09*	2.05*	2.00*	1.96*	1.93*	1.89*	1.85*	1.82*	1.79*	1.76*	1.74*
9.00	2.46	2.40	2.34	2.28*	2.23*	2.17*	2.11*	2.06*	2.01*	1.96*	1.91*	1.86*	1.81*	1.77*	1.73*	1.69*	1.66*	1.62*	1.59*
9.50	2.45	2.38	2.31	2.25*	2.18*	2.12*	2.05*	1.99*	1.93*	1.87*	1.81*	1.77*	1.71*	1.66*	1.61*	1.56*	1.52*	1.49*	1.45*

* Significant at 0.05 level of significant compared to no risk management strategy

Table A3: Kansas Dairy Mean Income over feed cost (IOFC) of No Risk Management Versus DMC at $4.00-$9.50 coverage

C.L	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
NRM	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55	8.55
4.00	8.55	8.55	8.56	8.56	8.56	8.56	8.56	8.57	8.57	8.57	8.57	8.57	8.58	8.58	8.58	8.56	8.56	8.56	8.59
4.50	8.55	8.56	8.56	8.56	8.57	8.57	8.57	8.57	8.58	8.58	8.58	8.59	8.59	8.59	8.60	8.60	8.60	8.60	8.61
5.00	8.56	8.56	8.56	8.57	8.57	8.58	8.58	8.58	8.59	8.59	8.60	8.60	8.61	8.61	8.61	8.62	8.62	8.63	8.63
5.50	8.56	8.56	8.57	8.57	8.58	8.59	8.59	8.60	8.60	8.61	8.62	8.62	8.63	8.63	8.64	8.65	8.65	8.66	8.66
6.00	8.56	8.57	8.57	8.58	8.59	8.60	8.61	8.62	8.63	8.63	8.64	8.65	8.66	8.67	8.68	8.68	8.69	8.70	8.71
6.50	8.56	8.57	8.59	8.60	8.61	8.62	8.63	8.64	8.66	8.67	8.68	8.69	8.70	8.71	8.73	8.74	8.75	8.76	8.77
7.00	8.57	8.58	8.60	8.62	8.63	8.65	8.66	8.68	8.70	8.71	8.73	8.74	8.76	8.78	8.79	8.81	8.82	8.84	8.86
7.50	8.57	8.60	8.62	8.64	8.66	8.69	8.71	8.73	8.75	8.78	8.80	8.82	8.84	8.87	8.89	8.91	8.93	8.96*	8.98*
8.00	8.58	8.61	8.64	8.67	8.71	8.74	8.77	8.80	8.83	8.86	8.89	8.92	8.95*	8.98*	9.01*	9.05*	9.08*	9.11*	9.14*
8.50	8.59	8.63	8.68	8.72	8.76	8.80	8.84	8.88	8.93	8.97	9.01	9.05	9.09*	9.14*	9.18*	9.22*	9.26*	9.30*	9.34*
9.00	8.61	8.66	8.72	8.77	8.82	8.88	8.93	8.99	9.04	9.10*	9.15*	9.21*	9.26*	9.32*	9.37*	9.43*	9.48*	9.54*	9.59*
9.50	8.62	8.69	8.76	8.83	8.90	8.97	9.04*	9.11*	9.18*	9.25*	9.32*	9.39*	9.46*	9.53*	9.60*	9.67*	9.74*	9.81*	9.88*

* Significant at 0.05 level compared to no risk management strategy

Table A4: Kansas Standard Deviation of No Risk Management Versus DMC at $4.00-$9.50 Coverage Level

C.L	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
NRM	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55
4.00	2.55	2.55	2.54	2.54	2.54	2.53	2.53	2.53	2.52	2.52	2.52	2.52	2.51	2.51	2.51	2.50	2.50	2.50	2.50
4.50	2.55	2.54	2.54	2.53	2.53	2.52	2.52	2.51	2.51	2.50	2.50	2.49	2.49	2.49	2.48	2.28	2.47	2.47	2.47
5.00	2.55	2.54	2.53	2.52	2.52	2.51	2.50	2.50	2.49	2.48	2.48	2.47	2.46	2.46	2.45	2.45	2.44	2.44	2.43
5.50	2.54	2.53	2.52	2.51	2.50	2.49	2.48	2.47	2.47	2.46	2.45	2.44	2.43	2.42	2.42	2.41	2.40	2.40	2.39
6.00	2.54	2.53	2.51	2.50	2.48	2.47	2.46	2.45	2.43	2.42	2.41	2.40	2.39	2.38	2.37	2.36	2.35	2.34	2.34
6.50	2.53	2.52	2.50	2.48	2.46	2.44	2.43	2.41	2.39	2.38	2.36	2.35	2.34	2.32	2.31*	2.30*	2.28*	2.27*	2.26*
7.00	2.53	2.50	2.48	2.46	2.43	2.41	2.39	2.37	2.35	2.33	2.31*	2.29*	2.27*	2.25*	2.24*	2.22*	2.20*	2.19*	2.18*
7.50	2.52	2.49	2.46	2.43	2.40	2.37	2.34	2.31*	2.28*	2.26*	2.23*	2.21*	2.19*	2.16*	2.14*	2.12*	2.10*	2.09*	2.07*
8.00	2.51	2.47	2.43	2.39	2.36	2.32	2.28*	2.25*	2.22*	2.18*	2.15*	2.12*	2.09*	2.07*	2.04*	2.01*	1.99*	1.97*	1.95*
8.50	2.50	2.46	2.41	2.36	2.31	2.27*	2.23*	2.18*	2.14*	2.10*	2.07*	2.03*	1.99*	1.96*	1.93*	1.90*	1.87*	1.85*	1.82*
9.00	2.50	2.44	2.38	2.33	2.27*	2.22*	2.17*	2.12*	2.07*	2.02*	1.98*	1.93*	1.89*	1.85*	1.82*	1.78*	1.75*	1.72*	1.70*
9.50	2.49	2.42	2.36	2.29*	2.23*	2.17*	2.11*	2.05*	1.99*	1.94*	1.89*	1.84*	1.79*	1.75*	1.71*	1.67*	1.63*	1.60*	1.58*

* Significant at 0.05 level of significant compared to no risk management strategy

Table A5: Michigan Dairy Mean Income over feed cost (IOFC) of No Risk Management Versus DMC at $4.00-$9.50 coverage

C.L	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
NRM	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80
4.00	8.80	8.80	8.81	8.81	8.81	8.81	8.81	8.81	8.82	8.82	8.82	8.82	8.82	8.83	8.83	8.83	8.83	8.83	8.83
4.50	8.80	8.81	8.81	8.81	881	8.82	8.82	8.82	8.83	8.83	8.83	8.83	8.84	8.84	8.84	8.85	8.85	8.85	8.86
5.00	8.80	8.81	8.81	8.82	8.82	8.82	8.83	8.83	8.84	8.84	8.85	8.85	8.85	8.86	8.86	8.87	8.87	8.88	8.88
5.50	8.81	8.81	8.82	8.82	8.83	8.84	8.84	8.85	8.85	8.86	8.86	8.87	8.88	8.88	8.89	8.89	8.90	8.91	8.91
6.00	8.81	8.82	8.82	8.83	8.84	8.85	8.86	8.87	8.87	8.88	8.89	8.90	8.91	8.92	8.92	8.93	8.94	8.95	8.96
6.50	8.81	8.82	8.83	8.85	8.86	8.87	8.88	8.89	8.90	8.91	8.93	8.94	8.95	8.96	8.97	8.99	9.00	9.01	9.02
7.00	8.82	8.83	8.85	8.86	8.88	8.90	8.91	8.93	8.94	8.96	8.98	8.99	9.01	9.03	9.04	9.06	9.07	9.09	9.11
7.50	8.82	8.84	8.87	8.89	8.91	8.93	8.96	8.98	9.00	9.02	9.05	9.07	9.09	9.11	9.14	9.16	9.18	9.20*	9.23*
8.00	8.83	8.86	8.89	8.92	8.95	8.98	9.02	9.05	9.08	9.11	9.14	9.19	9.20*	9.23*	9.26*	9.29*	9.32*	9.36*	9.39*
8.50	8.84	8.88	8.92	8.97	9.01	9.05	9.09	9.13	9.18	9.22*	9.26*	9.30*	9.34*	9.38*	9.43*	9.47*	9.51*	9.55*	9.59*
9.00	8.85	8.91	8.96	9.02	9.07	9.13	9.18	9.24*	9.29*	9.35*	9.40*	9.46*	9.51*	9.57*	9.62*	9.68*	9.73*	9.79*	9.84*
9.50	8.87	8.94	9.01	9.08	9.15	9.22*	9.29*	9.36*	9.43*	9.50*	9.57*	9.64*	9.71*	9.78*	9.85*	9.92*	9.99*	10.06*	10.13*

* Significant at 0.05 level of significant compared to no risk management strategy

Table A6: Michigan Standard Deviation of No Risk Management Versus DMC at $4.0-$9.50 Coverage Level

C.L	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
NRM	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61
4.00	2.61	2.61	2.60	2.60	2.60	2.59	2.59	2.59	2.58	2.58	2.58	2.57	2.57	2.57	2.56	2.56	2.56	2.55	2.55
4.50	2.61	2.60	2.60	2.59	2.59	2.58	2.58	2.57	2.57	2.56	2.56	2.55	2.55	2.54	2.54	2.53	2.53	2.53	2.52
5.00	2.61	2.60	2.59	2.58	2.58	2.57	2.56	2.55	2.55	2.54	2.53	2.53	2.52	2.52	2.51	2.50	2.50	2.49	2.49
5.50	2.60	2.59	2.58	2.57	2.56	2.55	2.54	2.53	2.52	2.52	2.51	2.50	2.49	2.48	2.47	2.47	2.46	2.45	2.45
6.00	2.60	2.59	2.57	2.56	2.55	2.53	2.52	2.51	2.50	2.48	2.47	2.46	2.45	2.44	2.43	2.42	2.41	2.41	2.40
6.50	2.59	2.58	2.56	2.54	2.52	2.51	2.49	2.47	2.46	2.44	2.43	2.42	2.40	2.39	2.38	2.37*	2.35*	2.34*	2.33*
7.00	2.59	2.57	2.54	2.52	2.50	2.47	2.45	2.43	2.41	2.39	2.38	2.36*	2.34*	2.32*	2.31*	2.29*	2.28*	2.27*	2.25*
7.50	2.58	2.55	2.52	2.49	2.46	2.44	2.41	2.38	2.36*	2.33*	2.31*	2.29*	2.26*	2.24*	2.22*	2.21*	2.19*	2.17*	1.16*
8.00	2.57	2.54	2.50	2.46	2.42	2.39	2.36*	2.32*	2.29*	2.26*	2.23*	2.20*	2.17*	2.15*	2.12*	2.10*	2.08*	2.06*	2.04*
8.50	2.57	2.52	2.47	2.43	2.38	2.34*	2.30*	2.26*	2.22*	2.18*	2.15*	2.11*	2.08*	2.05*	2.02*	1.99*	1.97*	1.94*	1.92*
9.00	2.56	2.50	2.45	2.39	2.34*	2.29*	2.24*	2.19*	2.15*	2.10*	2.06*	2.02*	1.98*	1.95*	1.91*	1.88*	1.85*	1.83*	1.80*
9.50	2.55	2.48	2.42	2.36*	2.30*	2.24*	2.19*	2.13*	2.08*	2.03*	1.98*	1.93*	1.89*	1.85*	1.81*	1.77*	1.74*	1.71*	1.69*

* Significant at 0.05 level of significant compared to no risk management strategy

Table A7: Minnesota Dairy Mean Income over feed cost (IOFC) of No Risk Management Versus DMC at $4.00-$9.50 coverage

C.L	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
NRM	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75
4.00	9.75	9.75	9.75	9.75	9.75	9.76	9.76	9.76	9.76	9.76	9.77	9.77	9.77	9.77	9.77	9.77	9.78	9.78	9.78
4.50	9.75	9.75	9.75	9.76	9.76	9.76	9.77	9.77	9.77	9.77	9.78	9.78	9.78	9.79	9.79	9.79	9.80	9.80	9.80
5.00	9.75	9.75	9.76	9.76	9.77	9.77	9.77	9.78	9.78	9.79	9.79	9.80	9.80	9.80	9.81	7.81	7.82	7.82	7.83
5.50	9.75	9.76	9.76	9.77	9.77	9.78	9.79	9.79	9.80	9.80	9.81	9.82	9.82	9.83	9.83	9.84	9.85	9.85	9.86
6.00	9.75	9.76	9.77	9.78	9.79	9.79	9.80	9.81	9.82	9.83	9.84	9.84	9.85	9.86	9.87	9.88	9.89	9.89	9.90
6.50	9.76	9.77	9.78	9.79	9.80	9.81	9.83	9.84	9.85	9.86	9.87	9.88	9.90	9.91	9.92	9.93	9.94	9.95	9.97
7.00	9.76	9.78	9.79	9.81	9.83	9.84	9.86	9.87	9.89	9.91	9.92	9.94	9.96	9.97	9.98	10.00	10.02	10.04	10.05
7.50	9.77	9.79	9.81	9.84	9.86	9.88	9.90	9.92	9.95	9.97	9.99	10.01	10.04	10.06	10.08	10.10	10.13	10.15	10.17*
8.00	9.78	9.81	9.84	9.87	9.90	9.93	9.96	9.99	10.02	10.05	10.09	10.12	10.15	10.18*	10.21*	10.24*	10.27*	10.30*	10.33*
8.50	9.79	9.83	9.87	9.91	9.95	10.00	10.04	10.08	10.12	10.16*	10.20*	10.25*	10.29*	10.33*	10.37*	10.41*	10.45*	10.50*	10.54*
9.00	9.80	9.85	9.91	9.96	10.12	10.07	10.13	10.18*	10.24*	10.29*	10.35*	10.40*	10.45*	10.51*	10.57*	10.62*	10.68*	10.73*	10.79*
9.50	9.81	9.88	9.95	10.02	10.09	10.16	10.23*	10.30*	10.37*	10.44*	10.51*	10.58*	10.65*	10.72*	10.79*	10.86*	10.93*	11.00*	11.07*

* Significant at 0.05 level of significant compared to no risk management strategy

Table A8: Minnesota Standard Deviation of No Risk Management Versus DMC at $4.0-$9.50 Coverage Level

C.L	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
NRM	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74
4.00	2.74	2.73	2.73	2.72	2.72	2.72	2.71	2.71	2.71	2.70	2.70	2.70	2.69	2.69	2.69	2.68	2.68	2.68	2.67
4.50	2.73	2.73	2.72	2.72	2.71	2.70	2.70	2.69	2.69	2.68	2.68	2.67	2.67	2.66	2.66	2.65	2.65	2.64	2.64
5.00	2.73	2.72	2.71	2.71	2.71	2.69	2.68	2.67	2.67	2.66	2.65	2.64	2.64	2.63	2.62	2.62	2.61	2.60	2.60
5.50	2.73	2.72	2.71	2.69	2.68	2.67	2.66	2.65	2.64	2.63	2.62	2.61	2.60	2.59	2.58	2.57	2.56	2.56	2.55
6.00	2.72	2.71	2.69	2.68	2.66	2.65	2.63	2.62	2.61	2.59	2.58	2.57	2.55	2.54	2.53	2.52	2.51	2.50	2.49
6.50	2.72	2.70	2.68	2.66	2.64	2.62	2.60	2.58	2.56	2.55	2.53	2.51	2.50	2.48	2.47*	2.45*	2.44*	2.42*	2.41*
7.00	2.71	2.69	2.66	2.64	2.61	2.59	2.56	2.54	2.52	2.49	2.47*	2.45*	2.43*	2.41*	2.39*	2.37*	2.36*	2.34*	2.32*
7.50	2.71	2.67	2.64	2.61	2.58	2.54	2.51	2.48	2.46*	2.43*	2.40*	2.37*	2.35*	2.32*	2.30*	2.28*	2.25*	2.23*	2.21*
8.00	2.70	2.66	2.62	2.57	2.54	2.50	2.46*	2.42*	2.39*	2.35*	2.32*	2.28*	2.25*	2.22*	2.19*	2.16*	2.14*	2.11*	2.09*
8.50	2.69	2.64	2.59	2.54	2.49	2.45*	2.40*	2.35*	2.31*	2.27*	2.23*	2.19*	2.15*	2.11*	2.08*	2.04*	2.01*	1.98*	1.95*
9.00	2.68	2.62	2.56	2.50	2.45*	2.39*	2.34*	2.28*	2.23*	2.18*	2.13*	2.09*	2.04*	2.00*	1.96*	1.92*	1.88*	1.84*	1.81*
9.50	2.67	2.60	2.54	2.47*	2.40*	2.34*	2.28*	2.21*	2.15*	2.10*	2.04*	1.98*	1.93*	1.88*	1.83*	1.79*	1.75*	1.71*	1.67*

* Significant at 0.05 level of significant compared to no risk management strategy

Table A9: Ohio Dairy Mean Income over feed cost (IOFC) of No Risk Management Versus DMC at $4.00-$9.50 coverage

C.L	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
NRM	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07
4.00	9.07	9.07	9.07	9.07	9.08	9.08	9.08	9.08	9.08	9.09	9.09	9.09	9.09	9.09	9.09	9.10	9.10	9.10	9.10
4.50	9.07	9.07	9.08	9.08	9.08	9.08	9.09	9.09	9.09	9.10	9.10	9.10	9.11	9.11	9.11	9.11	9.12	9.12	9.12
5.00	9.07	9.08	9.08	9.08	9.09	9.09	9.10	9.10	9.11	9.11	9.11	9.12	9.12	9.13	9.13	9.13	9.14	9.14	9.15
5.50	9.07	9.08	9.08	9.09	9.10	9.10	9.11	9.11	9.12	9.13	9.13	9.14	9.14	9.15	9.16	9.16	9.17	9.17	9.18
6.00	9.08	9.08	9.09	9.10	9.11	9.12	9.12	9.13	9.14	9.15	9.16	9.17	9.17	9.18	9.19	9.20	9.21	9.22	9.22
6.50	9.08	9.09	9.10	9.11	9.12	9.14	9.15	9.16	9.17	9.18	9.19	9.21	9.22	9.23	9.24	9.25	9.26	9.28	9.29
7.00	9.08	9.10	9.12	9.13	9.15	9.16	9.18	9.20	9.21	9.23	9.24	9.26	9.28	9.29	9.31	9.32	9.34	9.36	9.37
7.50	9.09	9.11	9.13	9.16	9.18	9.20	9.22	9.25	9.27	9.29	9.31	9.34	9.36	9.38	9.40	9.43	9.45	9.47*	9.49*
8.00	9.10	9.13	9.16	9.19	9.22	9.25	9.28	9.31	9.35	9.38	9.41	9.44	9.47*	9.50*	9.53*	9.56*	9.59*	9.62*	9.65*
8.50	9.11	9.15	9.19	9.23	9.28	9.32	9.36	9.40	9.44	9.48*	9.53*	9.57*	9.61*	9.65*	9.69*	9.73*	9.78*	9.82*	9.86*
9.00	9.12	9.18	9.23	9.29	9.34	9.40	9.45	9.51*	9.56*	9.61*	9.67*	9.72*	9.78*	9.83*	9.89*	9.94*	10.00*	10.05*	10.11*
9.50	9.14	9.21	9.28	9.35	9.42	9.49*	9.56*	9.63*	9.70*	9.77*	9.84*	9.90*	9.97*	10.04*	10.11*	10.18*	10.25*	10.32*	10.39*

* Significant at 0.05 level of significant compared to no risk management strategy

Table A10: Ohio Standard Deviation of No Risk Management Versus DMC at $4.0-$9.50 Coverage Level

C.L	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
NRM	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55
4.00	2.55	2.54	2.54	2.53	2.53	2.53	2.52	2.52	2.51	2.51	2.51	2.50	2.50	2.49	2.49	2.49	2.48	2.48	2.47
4.50	2.54	2.54	2.53	2.53	2.52	2.51	2.51	2.50	2.49	2.49	2.48	2.48	2.47	2.47	2.46	2.45	2.45	2.44	2.44
5.00	2.54	2.53	2.52	2.52	2.51	2.50	2.49	2.48	2.47	2.46	2.46	2.45	2.44	2.43	2.43	2.42	2.41	2.41	2.40
5.50	2.54	2.52	2.51	2.50	2.49	2.48	2.47	2.46	2.45	2.44	2.43	2.42	2.41	2.40	2.39	2.38	2.37	2.36	2.35
6.00	2.53	2.52	2.50	2.49	2.47	2.46	2.44	2.43	2.41	2.40	2.39	2.37	2.36	2.35	2.34	2.33	2.31	2.30*	2.29*
6.50	2.53	2.51	2.49	2.47	2.45	2.43	2.41	2.39	2.37	2.36	2.34	2.32	2.31*	2.29*	2.27*	2.26*	2.25*	2.23*	2.22*
7.00	2.52	2.50	2.47	2.44	2.42	2.39	2.37	2.35	2.32	2.30*	2.28*	2.26*	2.24*	2.22*	2.20*	2.18*	2.16*	2.15*	2.13*
7.50	2.52	2.48	2.45	2.42	2.38	2.35	2.32	2.29*	2.26*	2.23*	2.21*	2.18*	2.15*	2.13*	2.10*	2.08*	2.06*	2.04*	2.02*
8.00	2.51	2.47	2.42	2.38	2.34	2.30*	2.26*	2.23*	2.19*	2.16*	2.12*	2.09*	2.06*	2.02*	2.00*	1.97*	1.94*	1.92*	1.89*
8.50	2.50	2.45	2.40	2.35	2.30*	2.25*	2.20*	2.16*	2.11*	2.07*	2.03*	1.99*	1.95*	1.91*	1.88*	1.84*	1.81*	1.78*	1.75*
9.00	2.49	2.43	2.37	2.31*	2.25*	2.20*	2.14*	2.09*	2.03*	1.98*	1.93*	1.88*	1.84*	1.79*	1.75*	1.71*	1.67*	1.64*	1.61*
9.50	2.48	2.41	2.34	2.27*	2.21*	2.14*	2.08*	2.02*	1.95*	1.89*	1.84*	1.78*	1.73*	1.68*	1.63*	1.58*	1.54*	1.50*	1.47*

* Significant at 0.05 level of significant compared to no risk management strategy

Table A11: Wisconsin Dairy Mean Income over feed cost (IOFC) of No Risk Management Versus DMC at $4.00-$9.50 coverage

C.L	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
NRM	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44
4.00	9.45	9.45	9.45	9.45	9.45	9.45	9.46	9.46	9.46	9.46	9.46	9.47	9.47	9.47	9.47	9.47	9.48	9.48	9.48
4.50	9.45	9.45	9.45	9.46	9.46	9.46	9.46	9.47	9.47	9.47	9.48	9.48	9.48	9.48	9.49	9.49	9.49	9.50	9.50
5.00	9.45	9.45	9.46	9.46	9.46	9.47	9.47	9.48	9.48	9.49	9.49	9.49	9.50	9.50	9.51	9.51	9.52	9.52	9.52
5.50	9.45	9.46	9.46	9.47	9.47	9.48	9.49	9.49	9.50	9.50	9.51	9.51	9.52	9.53	9.53	9.54	9.54	9.55	9.56
6.00	9.45	9.46	9.47	9.48	9.49	9.49	9.50	9.51	9.52	9.53	9.53	9.54	9.55	9.56	9.57	9.58	9.58	9.59	9.60
6.50	9.46	9.47	9.48	9.49	9.50	9.51	9.52	9.54	9.55	9.56	9.57	9.58	9.59	9.61	9.62	9.63	9.64	9.65	9.66
7.00	9.46	9.48	9.49	9.51	9.52	9.54	9.56	9.57	9.59	9.60	9.62	9.64	9.65	9.67	9.69	9.70	9.72	9.73	9.75
7.50	9.47	9.49	9.51	9.53	9.56	9.58	9.60	9.62	9.65	9.67	9.69	9.71	9.74	9.76	9.78	9.80	9.83	9.85*	9.87*
8.00	9.47	9.51	9.54	9.57	9.60	9.63	9.66	9.69	9.72	9.75	9.78	9.81	9.85*	9.88*	9.91*	9.94*	9.97*	10.00*	10.03*
8.50	9.49	9.53	9.57	9.61	9.65	9.69	9.74	9.78	9.82	9.86*	9.90*	9.94*	9.99*	10.03*	10.07*	10.11*	10.15*	10.19*	10.24*
9.00	9.50	9.55	9.61	9.66	9.72	9.77	9.83	9.88*	9.94*	9.99*	10.05*	10.10*	10.16*	10.21*	10.27*	10.32*	10.38*	10.43*	10.48*
9.50	9.51	9.58	9.63	9.72	9.79	9.86*	9.93*	10.00*	10.07*	10.14*	10.21*	10.28*	10.35*	10.42*	10.49*	10.56*	10.63*	10.70*	10.77*

* Significant at 0.05 level of significant compared to no risk management strategy

Table A12: Wisconsin Standard Deviation of No Risk Management Versus DMC at $4.0-$9.50 Coverage Level

C.L	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
NRM	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58
4.00	2.58	2.57	2.57	2.57	2.56	2.56	2.55	2.55	2.55	2.54	2.54	2.54	2.53	2.53	2.53	2.52	2.52	2.52	2.51
4.50	2.58	2.57	2.56	2.56	2.55	2.54	2.54	2.53	2.53	2.52	2.52	2.51	2.51	2.50	2.49	2.49	2.48	2.48	2.47
5.00	2.57	2.56	2.56	2.55	2.54	2.53	2.52	2.51	2.51	2.50	2.49	2.48	2.48	2.47	2.46	2.46	2.45	2.44	2.44
5.50	2.57	2.56	2.55	2.53	2.52	2.51	2.50	2.49	2.48	2.47	2.46	2.45	2.44	2.43	2.42	2.41	2.40	2.39	2.39
6.00	2.57	2.55	2.53	2.52	2.50	2.49	2.47	2.46	2.45	2.43	2.42	2.41	2.39	2.38	2.37	2.36	2.35	2.34*	2.33*
6.50	2.56	2.54	2.52	2.50	2.48	2.46	2.44	2.42	2.40	2.39	2.37	2.35	2.34*	2.32*	2.30*	2.29*	2.27*	2.26*	2.25*
7.00	2.55	2.53	2.50	2.47	2.45	2.42	2.40	2.38	2.35	2.33*	2.31*	2.29*	2.27*	2.25*	2.23*	2.21*	2.19*	2.17*	2.16*
7.50	2.55	2.51	2.48	2.45	2.41	2.38	2.35	2.32*	2.29*	2.26*	2.24*	2.21*	2.18*	2.16*	2.13*	2.11*	2.09*	2.07*	2.05*
8.00	2.54	2.50	2.45	2.41	2.37	2.33*	2.30*	2.26*	2.22*	2.19*	2.15*	2.12*	2.09*	2.05*	2.03*	2.00*	1.97*	1.95*	1.92*
8.50	2.53	2.48	2.43	2.38	2.33*	2.28*	2.24*	2.19*	2.15*	2.10*	2.06*	2.02*	1.98*	1.94*	1.91*	1.88*	1.84*	1.81*	1.79*
9.00	2.52	2.46	2.40	2.34	2.29*	2.23*	2.17*	2.12*	2.07*	2.02*	1.97*	1.92*	1.88*	1.83*	1.79*	1.75*	1.71*	1.68*	1.65*
9.50	2.51	2.44	2.37	2.31*	2.24*	2.18*	2.11*	2.05*	1.99*	1.93*	1.87*	1.82*	1.77*	1.72*	1.67*	1.62*	1.58*	1.55*	1.51*

* Significant at 0.05 level of significant compared to no risk management strategy

Appendix 2 Stochastic Dominance Result

Table 2.1: Estimates of First and Second-Degree Stochastic Dominance for Kansas

First Degree Dominance Table

	NRM	KS 9.5 CL (95%)	KS 9.5 CL (90%)	KS 9.5 CL (85%)	KS 9.5 CL (80%)	KS 9.5 CL (75%)
NRM FDD:						
KS 9.5 CL (95%) FDD:						
KS 9.5 CL (90%) FDD:						
KS 9.5 CL (85%) FDD:						
KS 9.5 CL (80%) FDD:						
KS 9.5 CL (75%) FDD:						

Second Degree Dominance Table

	NRM	KS 9.5 CL (95%)	KS 9.5 CL (90%)	KS 9.5 CL (85%)	KS 9.5 CL (80%)	KS 9.5 CL (75%)
NRM SDD:						
KS 9.5 CL (95%) SDD:		NRM	KS 9.5 CL (90%)	KS 9.5 CL (85%)	KS 9.5 CL (80%)	KS 9.5 CL (75%)
KS 9.5 CL (90%) SDD:		NRM		KS 9.5 CL (85%)	KS 9.5 CL (80%)	KS 9.5 CL (75%)
KS 9.5 CL (85%) SDD:		NRM			KS 9.5 CL (80%)	KS 9.5 CL (75%)
KS 9.5 CL (80%) SDD:		NRM				KS 9.5 CL (75%)
KS 9.5 CL (75%) SDD:		NRM				

Figure A2.1 – Cumulative Distribution Function Comparing DMC results on Operating Margin to no Risk Management in Kansas

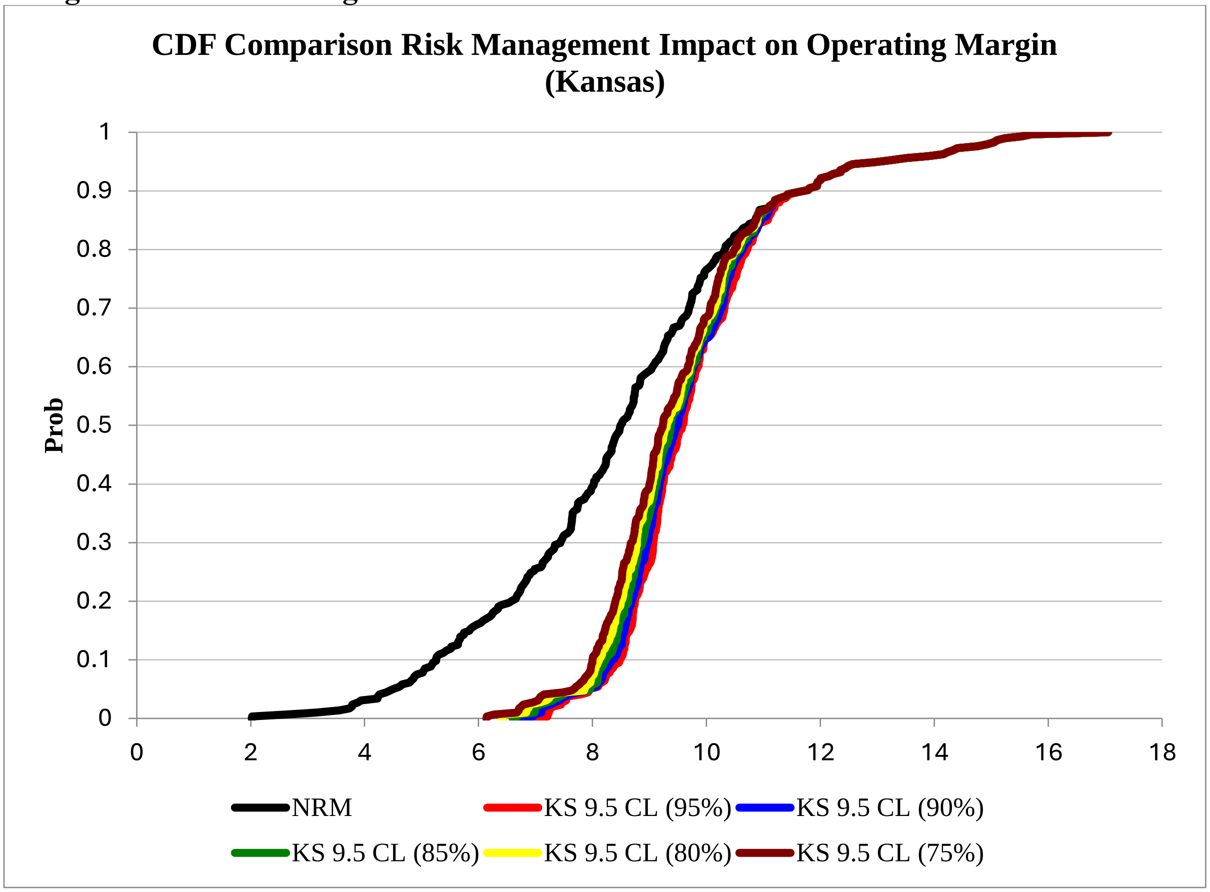

Table 19: Estimates of First and Second-Degree Stochastic Dominance for Michigan

First Degree Dominance Table

	NRM	MI 9.5 CL (95%)	MI 9.5 CL (90%)	MI 9.5 CL (85%)	MI 9.5 CL (80%)	MI 9.5 CL (75%)
NRM FDD:						
MI 9.5 CL (95%) FDD:						
MI 9.5 CL (90%) FDD:						
MI 9.5 CL (85%) FDD:						
MI 9.5 CL (80%) FDD:						
MI 9.5 CL (75%) FDD:						

Second Degree Dominance Table

	NRM	MI 9.5 CL (95%)	MI 9.5 CL (90%)	MI 9.5 CL (85%)	MI 9.5 CL (80%)	MI 9.5 CL (75%)
NRM SDD:						
MI 9.5 CL (95%) SDD:	NRM					
MI 9.5 CL (90%) SDD:	NRM					
MI 9.5 CL (85%) SDD:	NRM					
MI 9.5 CL (80%) SDD:	NRM					
MI 9.5 CL (75%) SDD:	NRM					

Figure 6 – Cumulative Distribution Function Comparing DMC results on Operating Margin to no Risk Management in Michigan

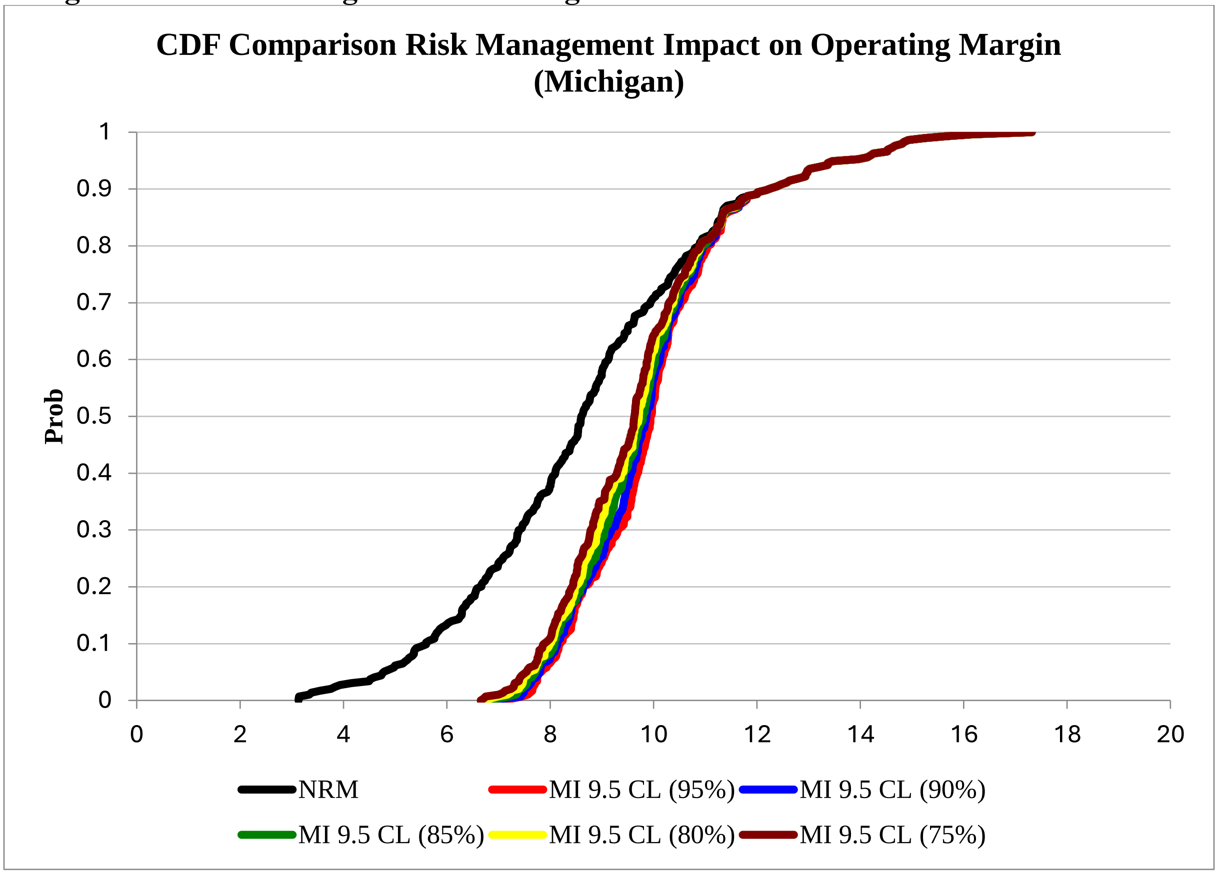

Table 20: Estimates of First and Second-Degree Stochastic Dominance of Minnesota

First Degree Dominance Table

	NRM	MN 9.5 CL (95%)	MN 9.5 CL (90%)	MN 9.5 CL (85%)	MN 9.5 CL (80%)	MN 9.5 CL (75%)
NRM FDD:						
MN 9.5 CL (95%) FDD:						
MN 9.5 CL (90%) FDD:						
MN 9.5 CL (85%) FDD:						
MN 9.5 CL (80%) FDD:						
MN 9.5 CL (75%) FDD:						

Second Degree Dominance Table

	NRM	MN 9.5 CL (95%)	MN 9.5 CL (90%)	MN 9.5 CL (85%)	MN 9.5 CL (80%)	MN 9.5 CL (75%)
NRM SDD:						
MN 9.5 CL (95%) SDD:	NRM		MN 9.5 CL (90%)	MN 9.5 CL (85%)	MN 9.5 CL (80%)	MN 9.5 CL (75%)
MN 9.5 CL (90%) SDD:	NRM			MN 9.5 CL (85%)	MN 9.5 CL (80%)	MN 9.5 CL (75%)
MN 9.5 CL (85%) SDD:	NRM				MN 9.5 CL (80%)	MN 9.5 CL (75%)
MN 9.5 CL (80%) SDD:	NRM					MN 9.5 CL (75%)
MN 9.5 CL (75%) SDD:	NRM					

Figure 7 – Cumulative Distribution Function Comparing DMC results on Operating Margin to no Risk Management Minnesota

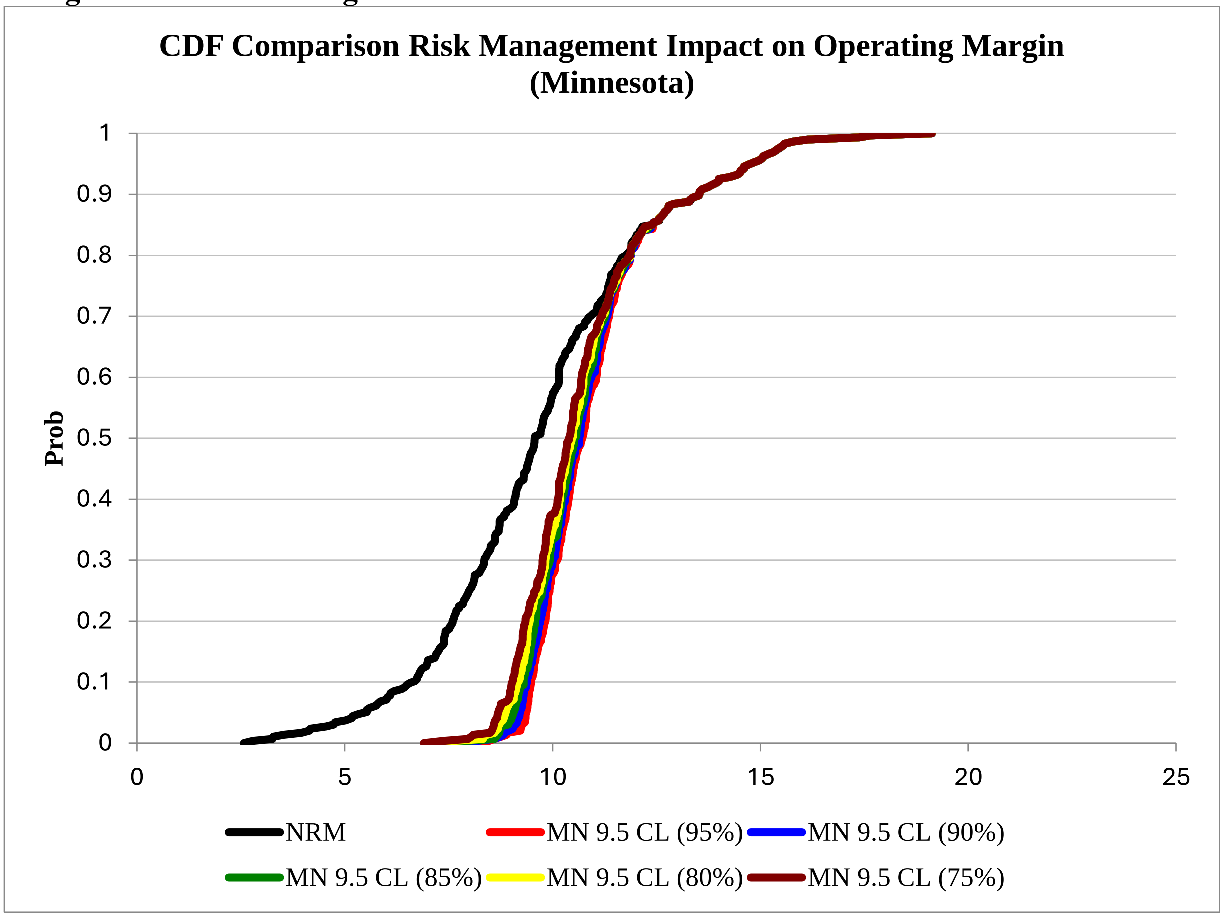

Table 21: Estimates of First and Second-Degree Stochastic Dominance for Ohio

First Degree Dominance Table

	NRM	OH 9.5 CL (95%)	9.5 CL (90%)	OH 9.5 CL (85%)	OH 9.5 CL (80%)	OH 9.5 CL (75%)
NRM FDD:						
OH 9.5 CL (95%) FDD:						
9.5 CL (90%) FDD:						
OH 9.5 CL (85%) FDD:						
OH 9.5 CL (80%) FDD:						
OH 9.5 CL (75%) FDD:						

Second Degree Dominance Table

	NRM	OH 9.5 CL (95%)	9.5 CL (90%)	OH 9.5 CL (85%)	OH 9.5 CL (80%)	OH 9.5 CL (75%)
NRM SDD:						
OH 9.5 CL (95%) SDD:	NRM			OH 9.5 CL (85%)	OH 9.5 CL (80%)	OH 9.5 CL (75%)
9.5 CL (90%) SDD:	NRM			OH 9.5 CL (85%)	OH 9.5 CL (80%)	OH 9.5 CL (75%)
OH 9.5 CL (85%) SDD:	NRM				OH 9.5 CL (80%)	OH 9.5 CL (75%)
OH 9.5 CL (80%) SDD:	NRM					OH 9.5 CL (75%)
OH 9.5 CL (75%) SDD:	NRM					

Figure 8 – Cumulative Distribution Function Comparing DMC results on Operating Margin to no Risk Management in Ohio

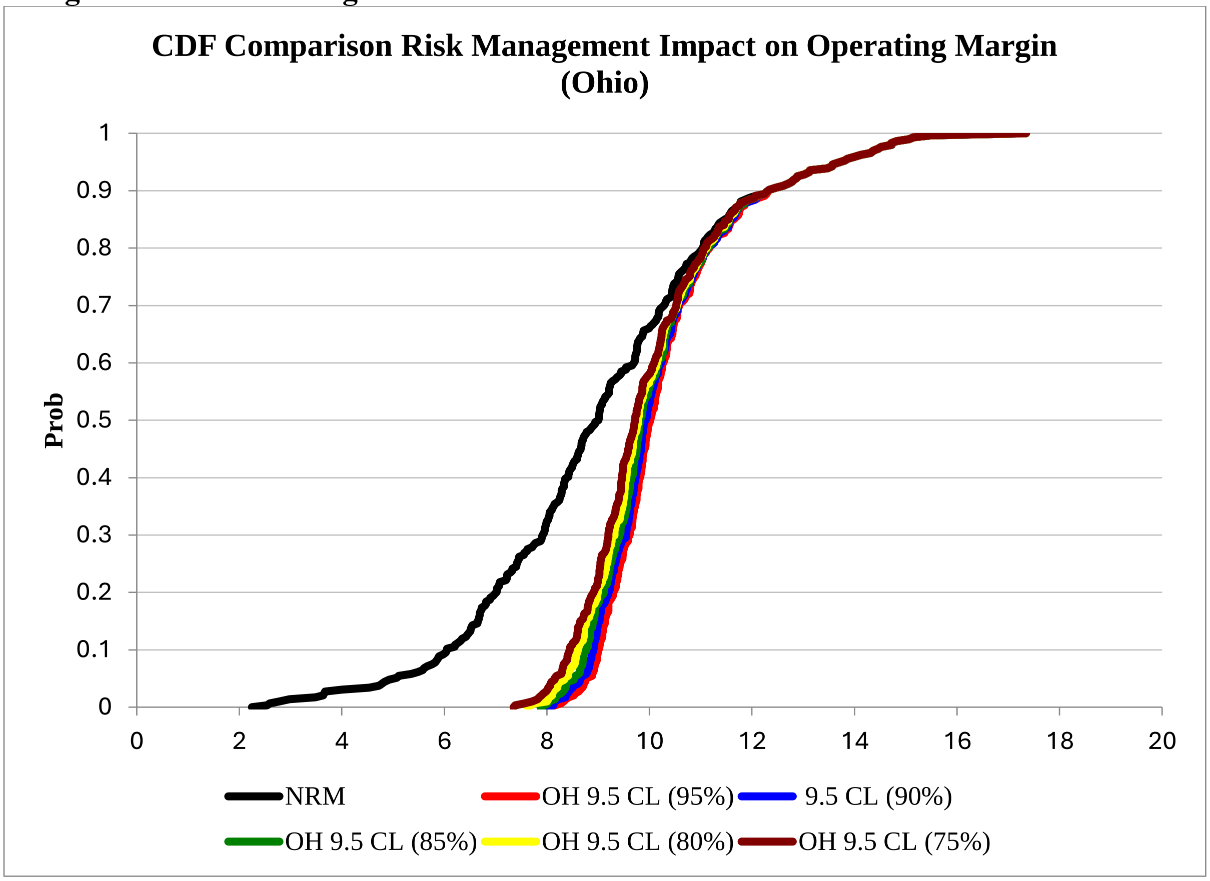

Table 22: Estimates of First and Second-Degree Stochastic Dominance for Wisconsin

First Degree Dominance Table

	NRM	WS 9.5 CL (95%)	WS 9.5 CL (90%)	WS 9.5 CL (85%)	WS 9.5 CL (80%)	WS 9.5 CL (75%)
NRM FDD:						
WS 9.5 CL (95%) FDD:						
WS 9.5 CL (90%) FDD:						
WS 9.5 CL (85%) FDD:						
WS 9.5 CL (80%) FDD:						
WS 9.5 CL (75%) FDD:						

Second Degree Dominance Table

	NRM	WS 9.5 CL (95%)	WS 9.5 CL (90%)	WS 9.5 CL (85%)	WS 9.5 CL (80%)	WS 9.5 CL (75%)
NRM SDD:						
WS 9.5 CL (95%) SDD:	NRM					WS 9.5 CL (75%)
WS 9.5 CL (90%) SDD:	NRM					WS 9.5 CL (75%)
WS 9.5 CL (85%) SDD:	NRM					WS 9.5 CL (75%)
WS 9.5 CL (80%) SDD:	NRM					WS 9.5 CL (75%)
WS 9.5 CL (75%) SDD:	NRM					

Figure 9 – Cumulative Distribution Function Comparing DMC results on Operating Margin to no Risk Management in Wisconsin

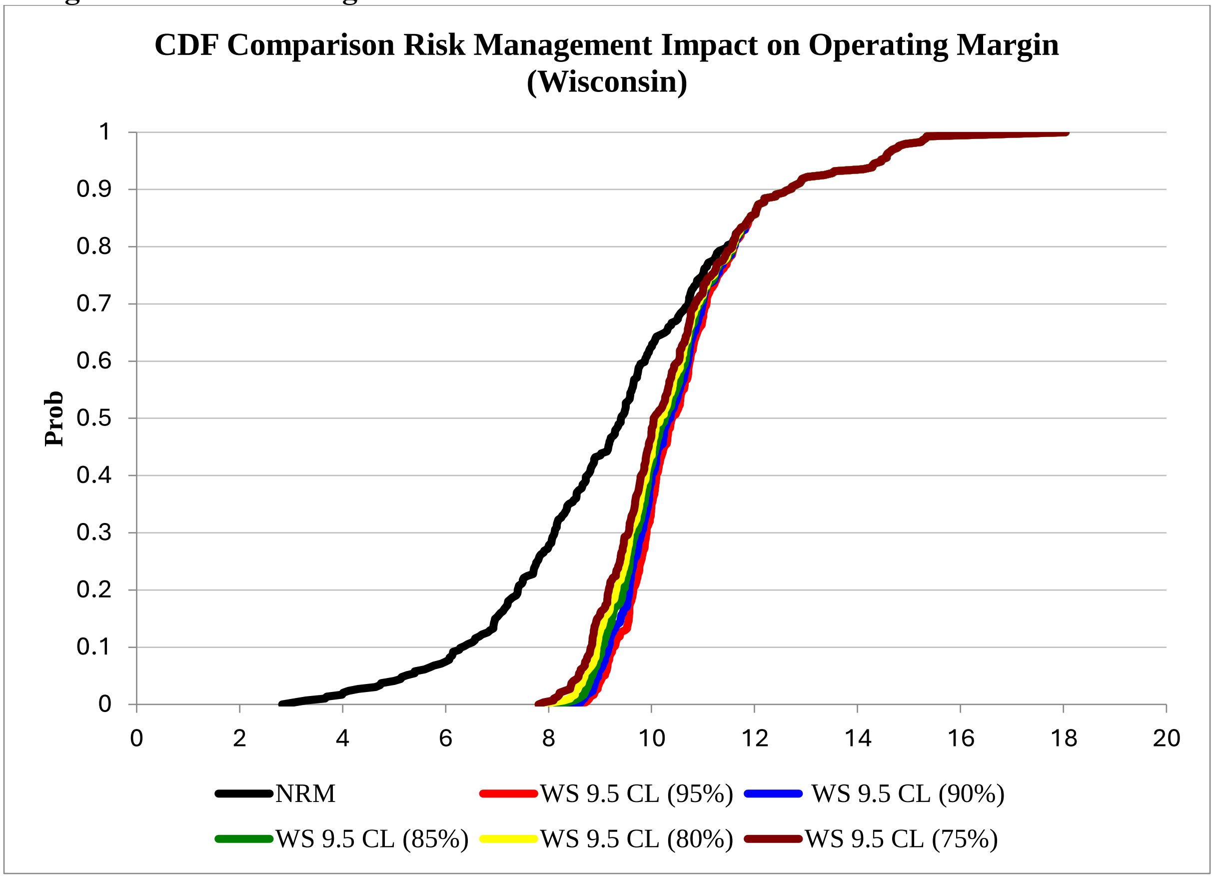

Figure 4.2b – Stochastic Efficiency Analysis of DMC versus No Risk Management in Kansas

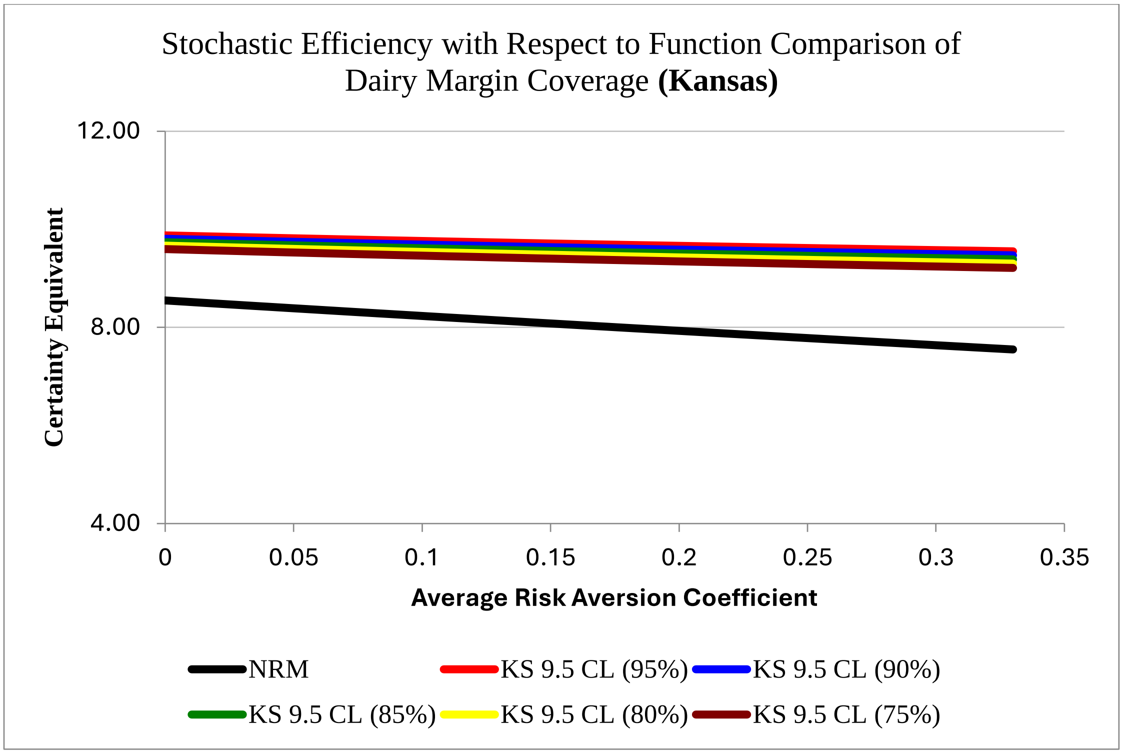

Figure 10 – Stochastic Efficiency Analysis of DMC versus No Risk Management in Michigan

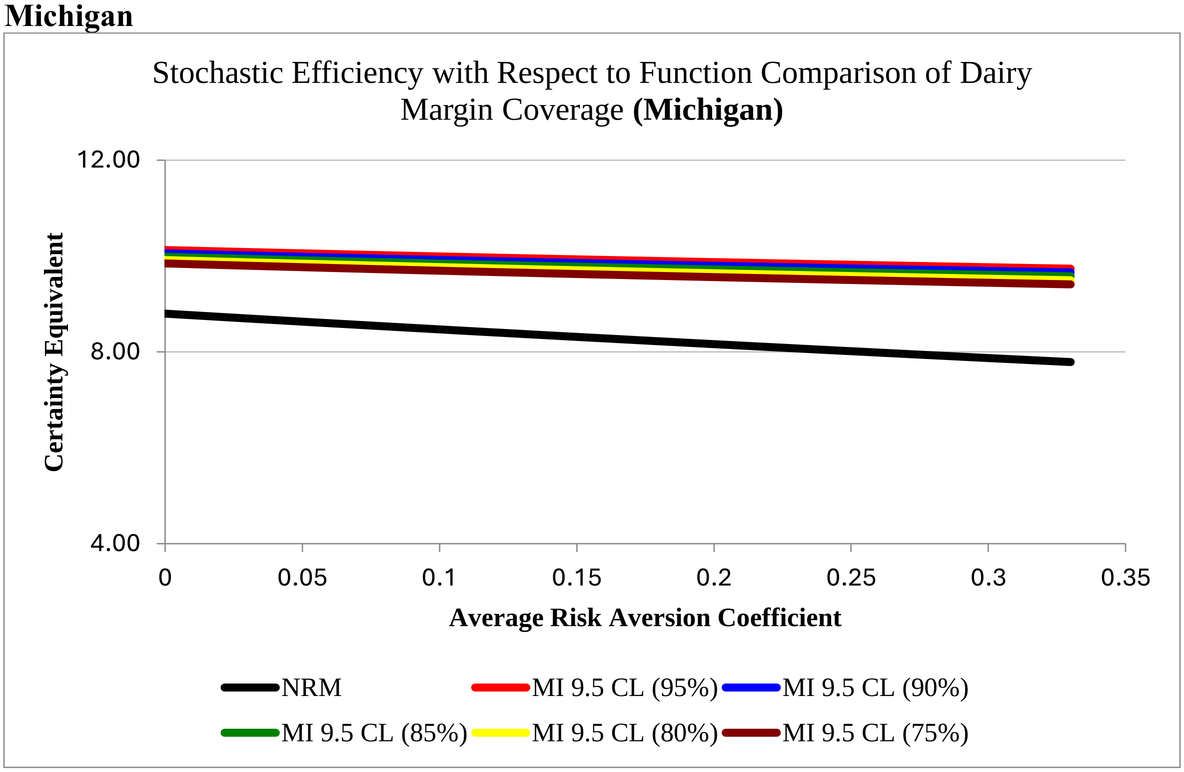

Figure 11 – Stochastic Efficiency Analysis of DMC versus No Risk Management in Minnesota

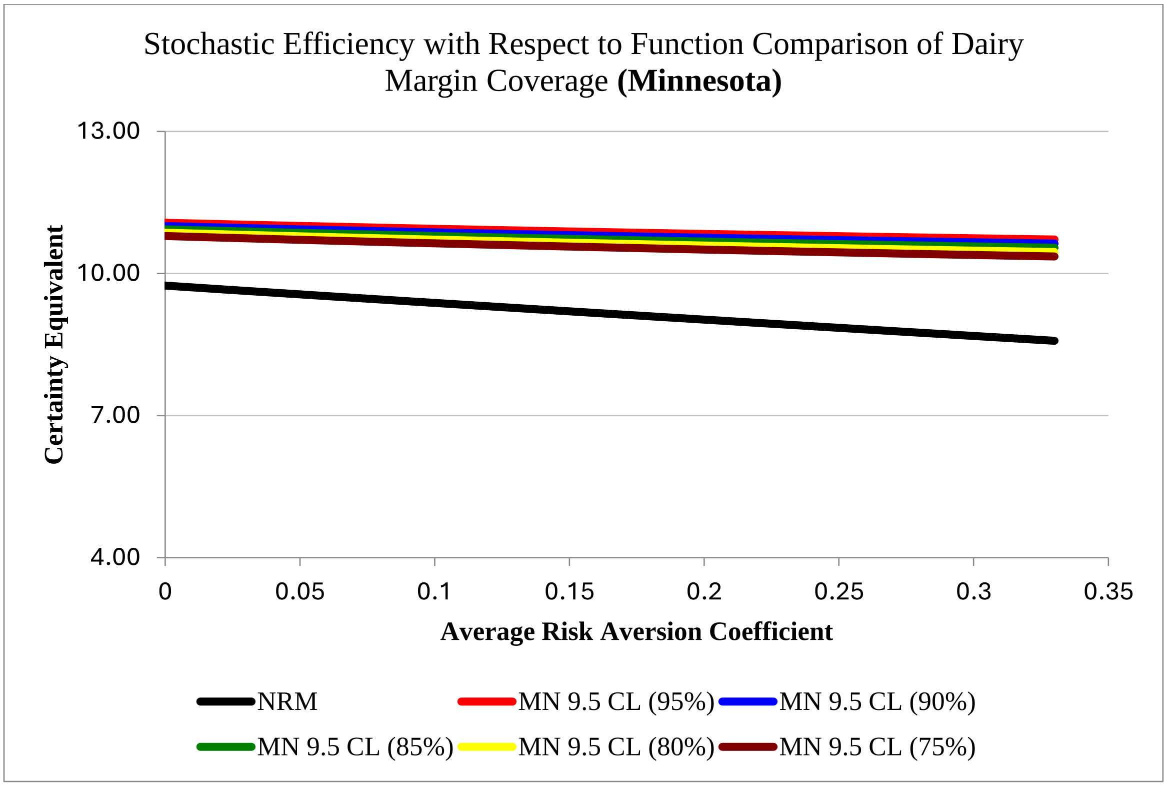

Figure 12 – Stochastic Efficiency Analysis of DMC versus No Risk Management in Ohio

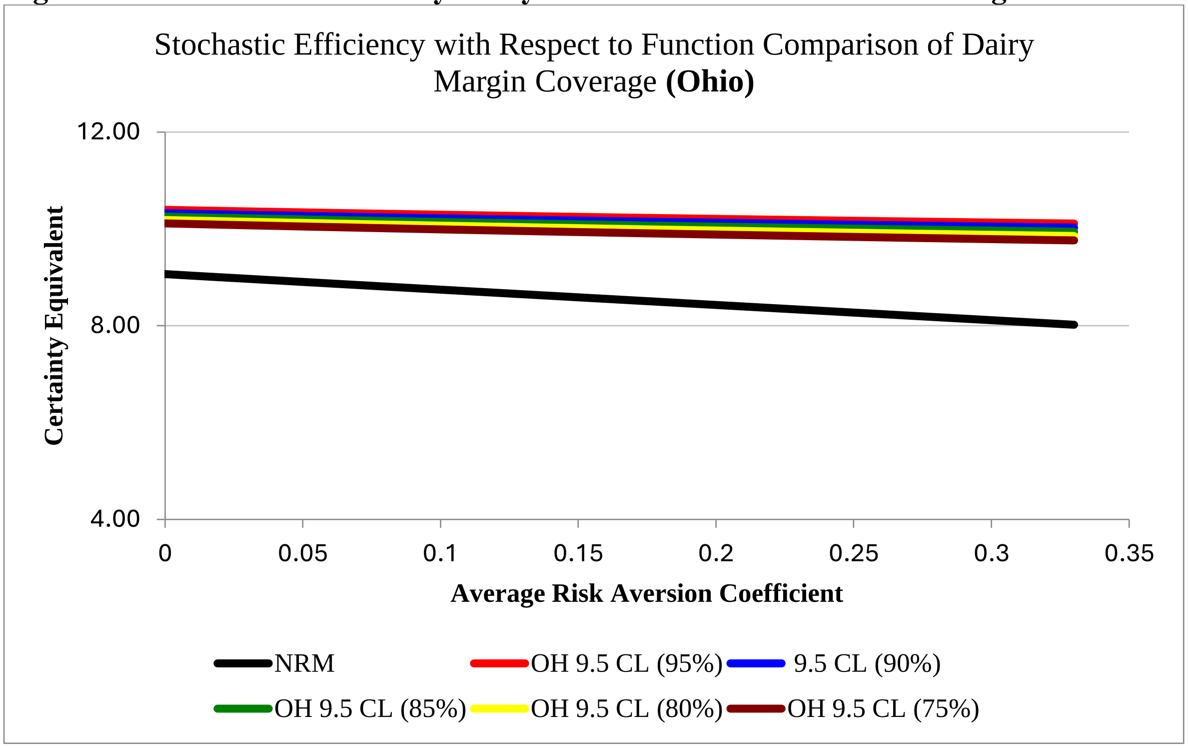

Figure 13 – Stochastic Efficiency Analysis of DMC versus No Risk Management in Wisconsin