Risk Management Strategies for Nebraska Grain and Oilseed Producers: A Stochastic Simulation and Analysis

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RISK MANAGEMENT STRATEGIES FOR NEBRASKA GRAIN AND OILSEED

PRODUCERS: A STOCHASTIC SIMULATION AND ANALYSIS

by

Jim A. Jansen

A THESIS

Presented to the Faculty of
The Graduate College at the University of Nebraska
In Partial Fulfillment of Requirements
For the Degree of Master of Science

Major: Agricultural Economics

Under the Supervision of Professor Bradley D. Lubben

Lincoln, Nebraska

August 2012
Uncertainty in revenue for grain and oilseed operations located across Nebraska exists due to commodity price volatility and yield variability. Several risk management tools enable producers to deal with financial losses from revenue declines including crop insurance, marketing strategies, and government farm programs. Producers may need to combine multiple tools for an effective risk management strategy, but research lacks on integrating these tools currently available to producers across the state. Actions amongst individuals actively engaged in the industry show their plans to deal with revenue declines may lead to less than optimal strategies.

Stochastic simulation utilizing eight representative farms across Nebraska allows for the analysis of risk management strategies. Attributes of these farms reflect the average size, productivity, and variability, expressed by operations across the eight National Agricultural Statistical Districts of the state. Also, the simulation of national, state, district, and county yields or prices are generated for the necessary parameters in the evaluation of various programs or products.

Conclusion drawn from these simulations indicate the optimal risk management strategy for a region of Nebraska, given a set of feasible prices and base 2011 yield and
price parameters. Current program participation and product utilization rates indicate
strategies employed by the majority of producers in the state do not sway far from these
simulated outcomes. Participating in higher levels of revenue protection crop insurance,
direct and counter-cyclical government programs, and using a short futures hedge when
marketing grain provided the greatest level of revenue protection subject to a producer’s
risk preference. Findings may change substantially dependent upon different price, yield,
or guarantee levels.
ACKNOWLEDGEMENTS

Countless hours have gone into the research involving the development, modeling, and writing process accumulating to this thesis. Without the support and review of University of Nebraska professionals and private grants, the project would have not been possible. Outside funding enabled evaluation of topics covered in this document to benefit crop and oilseed producers across the state. Farmers remain the driving force behind the agricultural industry and basis of the Agricultural Economics discipline. The end goal of this research has been to aid all producers in making more informed risk management decisions.

Members of my thesis committee providing recommendations and answering endless questions include: Dr. Bradley Lubben, Dr. Matthew Stockton, and Dr. Charles Wortmann. As chair and primary advisor, Dr. Bradley Lubben guided my education which ultimately shaped this thesis. His knowledge on agricultural policy and intricacies between various government programs and private products are reflected throughout by the rigor of this document. Dr. Matthew Stockton’s quantitative modeling abilities substantially aided in implementation of the representative stochastic model. As a source of knowledge outside Agricultural Economics, Dr. Charles Wortmann provided intuition on results to the Agronomy discipline and extension of findings.

Also serving an informal appointment, Mr. Roger Wilson’s assistance in modeling and simulation issues have greatly aided in the model’s ability to depict production relevant to those across the state. Finally, other individuals to mention include those of the Department of Agricultural Economics at the University of
Nebraska-Lincoln and my family. Through their coursework, discussions, and support, my ultimate success as a graduate student and completion of this thesis may be attributed.
GRANT INFORMATION

Produced in support of research project 10R-13-2/2 #779: "Incorporating Farm Programs and Risk Management Strategies for Profitable Soybean Production." Funding provided through the generous support of the Nebraska Soybean Board.
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<tr>
<td>ACRE</td>
<td>Average Crop Revenue Election Program</td>
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<tr>
<td>AFPC</td>
<td>Agricultural and Food Policy Center</td>
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<td>AGR</td>
<td>Adjusted Gross Revenue</td>
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<td>APH</td>
<td>Actual Production History</td>
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<td>ARAC</td>
<td>Absolute Risk Aversion Coefficients</td>
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<td>ARMS</td>
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<tr>
<td>ASD</td>
<td>Agricultural Statistical District</td>
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<td>CAT</td>
<td>Catastrophic Risk Protection Endorsement</td>
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<td>CCP</td>
<td>Counter-Cyclical Payment</td>
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<tr>
<td>CDF</td>
<td>Cumulative Distribution Function</td>
</tr>
<tr>
<td>CE</td>
<td>Certainty Equivalent</td>
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<td>CM</td>
<td>Cash Marketing</td>
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<td>CRB</td>
<td>Commodity Research Bureau</td>
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<tr>
<td>CV</td>
<td>Coefficient of Variation</td>
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<td>DAG</td>
<td>Directed Acyclic Graph</td>
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<tr>
<td>DCP</td>
<td>Direct and Counter-Cyclical Payment</td>
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<td>EV</td>
<td>Expected Value</td>
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<td>FAPRI</td>
<td>Food and Agricultural Policy Research Institute</td>
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<td>FBFM</td>
<td>Illinois Farm Business Farm Management</td>
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<td>FH</td>
<td>Futures Hedge</td>
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<td>FSA</td>
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<td>FSD</td>
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<td>KFMA</td>
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CHAPTER 1: INTRODUCTION

Nebraska’s geography, topography, soils and climate influence the scope and variety of cropping systems. Due to climatic variability and volatile commodity markets, farm-level crop revenue varies with these conditions. An assortment of revenue and price safety nets may reduce financial losses for those participating in federal farm programs. In addition, producers may choose from multiple crop insurance and marketing strategies to help manage risk. The complexity of these risk management alternatives often leave producers overwhelmed and may lead to less-than optimal decision making.

1.1 Motivation

As a leader in grain and oilseed production, Nebraska farm operations raised approximately 1.5 billion bushels of corn, 267 million bushels of soybeans, and 64 million bushels of winter wheat in 2010 (Nebraska Department of Agriculture, 2010). Farmers across Nebraska contribute a substantial share of commodity supplies feeding national demand for livestock feeds, renewable energy, exports, and other uses. While these multiple demands allow for numerous avenues to market grain and oilseed commodities, individual producers still face sizeable risk in crop revenue during the production process.

In each production cycle, crop producers raising grains and oilseeds make large monetary investments to raise commodities with an uncertain return. Depending upon an operation’s financial situation, capital may be constrained for a period exceeding 12 to 18 months. Expenses vary depending upon the production techniques and location in Nebraska, with crop revenue being the product of both yield and price. The types of
revenue losses may be either classified as shallow or deep on which the farm specific (idiosyncratic) and large scale (systemic) losses influence crop revenue (Zulauf, 2011). These two factors implicitly feed into a producer’s decision making based upon their risk tolerance and financial condition.

Environmental factors unique to the farm lead to idiosyncratic risk, whereas regional weather events such as drought or national price declines contribute to systemic risk. These factors play a role in the performance of various programs or products designed to reduce the effects of losses in yield or price. Historically farm-level yield shocks deviate randomly from trend projections. Commodity price volatility increased in recent years along with record high crop prices. For example, corn prices prior to 2006 averaged around $2.00 per bushel with a deviation of $0.50. With the advent of a nearly two- to three-fold increase in values, the volatility of prices have followed suit. Similar trends can be observed in both the soybean and wheat markets (Hailu & Weersink, 2011).

To deal with these revenue risks, grain producers have a variety of price- and/or revenue-based programs available. Using these programs or products simultaneously is a challenge due to the complexity and wide variation of productivity factors on individual farms. Relevant government programs include the Average Crop Revenue Election (ACRE) Program, the Direct and Counter-Cyclical Payment (DCP) Program, the Marketing Loan (ML) Program, and the Supplemental Revenue Assistance (SURE) Program. Federally-subsidized crop insurance products include Yield Protection (YP), Revenue Protection (RP), and Revenue Protection with a Harvest Price Exclusion (RP-HPE). Marketing strategies are also important to the discussion including hedging with futures, options, or cash-market alternatives.
Lubben and Novak (2010) classified the degree by which these programs or products interact to guard against adverse price, revenue, or production movements and the correlating levels of farm, area, or national scope. Intricacies and correlations between programs or products generates the necessary motivation for further evaluation to gain an understanding the effects these tools have on reducing negative variability of crop revenue and ultimately farm revenue generated from commodity sales. Analyzing the influence of production and climatic characteristics across Nebraska and how these elements interact will also further demonstrate the value of different strategies used across the state.

Zulauf (2011) defines even further the level of idiosyncratic and systemic risk protection available under each program or product. From these references, a feasible set of alternatives involving government programs, crop insurance and marketing strategies may be drawn. Current research shows individual producer decision makers may focus on products or programs with maximum payout anticipations instead of selecting combinations achieving optimal risk reduction (Lubben & Novak, 2010). Analyzing the feasible set of alternatives using DCP versus ACRE will explore payouts under each strategy.

Every crop producer located in the state of Nebraska has different financial, production, and risk tolerance or aversion characteristics. Even in scenarios where an individual’s balance sheet has a high level of equity, volatile price and yield movements put financial resources at substantial risk. Beginning or aggressively expanding producers with limited resources and objectives may be compromised when losses occur. The level of risk may vary across enterprises, but the overall goal remains maximizing
net crop revenue subject to risk. To accomplish this goal, each producer should develop a risk management strategy appropriate to his or her needs.

1.2 Objectives

The following research objectives focus on farm-level decision making relative to risk management programs and marketing strategies available to Nebraska crop producers. Whether from farm-specific variation in yield or national price declines, losses in revenue may be due to elements beyond an individual’s control. Developing a strategy to deal with these challenges allows a producer to cope with potential revenue losses. Due to the complexity of the interaction among alternatives, producers’ perception regarding these strategies may lead to less-than-optimal outcomes. Understanding how the portfolio of risk management programs and marketing strategies interact allows research to broaden the application by producers across different regions of the state.

The objective of this research includes:

1) Create a set of eight representative crop farms that display the average size, scale, and productivity factors associated with United States Department of Agriculture (USDA) National Agricultural Statistics Service-Agricultural Statistical Districts (NASS-ASDs). From these operations, a stochastic simulation will be used to produce yield and price distributions, drawing upon historical data and implied variations of individual producers.

2) Build a comprehensive set of revenue schedules to evaluate the effects of government programs ACRE, DCP, and ML; crop insurance products YP, RP,
and RP-HPE; and marketing tools including the use of hedging and cash market alternatives.

3) Using the programs or products defined in the revenue schedules, arrange a set of risk management tools in order to identify the results of various combinations of revenue protection regimes.

4) Simulate and summarize results to determine the effect of various strategies on farm-level crop revenue across different regions of the state showing potential variability of the regions.

These simulation results will build on other relevant studies. Other research has found, that optimal risk reduction strategy vary across different crops and regions (Woodward, Sherrick, & Schnitkey, 2010). The simulation results will demonstrate the effects environmental and climatic features have on crop revenue expectations and the optimum risk management strategy within a particular region of Nebraska. These results will help producers to make improved risk management decisions relative to their farm and location. Each producer faces different financial conditions and yield variability. Having a representative farm for each region allows producers to compare their farm against an operation reflecting the average attributes of an area.

1.3 Organization

The literature review in Chapter 2 discusses tools relevant to the farm including programs, policies, and marketing strategies which when integrated, create a producer’s risk management portfolio. Along with understanding the principles of these policies, the review will consider previous simulation work as a foundation to develop a crop revenue
model for Nebraska. As previous research has primarily focused on individual components of the risk management portfolio, combining these tools and focusing research efforts to sites specific to Nebraska combines the assumptions necessary to analyze different strategies across the state.

Based upon the literature review, Chapter 3 discusses the necessary procedures and methods to reach the research objectives. Stochastic simulation of yield and price distributions provides the underlying process to generate farm-level crop revenue distributions. Summarized results from individual farm simulations act as the basis for discussion in Chapter 4. Previously outlined risk management scenarios and the overall effects of a particular strategy had on a particular farm’s net crop revenue are summarized in the results section. The analysis provides insight on individual representative farms, but also across different regions of Nebraska.

These implications on farms and across districts are highlighted in Chapter 5. Insights from the results guide recommendations for future producer decisions, policy formation, and research. This analysis may serve as a basis for the next round of Farm Bill discussions. Budgetary issues may force producers to reconsider risk management tool integration given reduced program options or coverage levels.
CHAPTER 2: LITERATURE REVIEW

Revenue risk in crop operations comes from price volatility and yield variability caused by market and environmental factors. Nebraska crop producers face challenges when selecting the proper risk management strategy. Multiple options increase the complexity of selecting the right combination of tools. Previous research has focused on individual components of a producer’s risk management portfolio, such as government programs, crop insurance products, or marketing tools. A study of effective risk management strategies needs to consider all the components available to producers in Nebraska while drawing from results of other relevant studies.

2.1 Review of Risk Management Alternatives

Tools to manage crop revenue risk are regulated and overseen by different authorities. The Federal Government administers federal farm programs and supports the delivery of crop insurance products through private insurers. Marketing strategies may be carried out on publicly regulated exchanges or through private market transactions. All together these tools help producers protect against losses in yield, price, or revenue. In periods of dynamic yield or price shifts the performance of different alternative combinations may vary depending upon the focus of the protection.

The 2008 Farm Bill reauthorized federal farm programs, including price-based programs such as the DCP and ML program along with new revenue base safety nets ACRE and SURE (USDA Economic Research Service, 2008). ACRE protects actual revenue on a farm based on actual production, while DCP provides income support tied to price paid on historical base acres and program yields. The ML program or Loan
Deficiency Payments (LDPs) effectively provide a minimum price to producers for all eligible crops raised in the United States. The DCP program includes fixed guaranteed Direct Payments (DPs) decoupled from production and Counter-Cyclical Payments (CCPs) triggered by prices dropping below a specified target price (USDA Farm Service Agency, 2008). The revenue safety net in the ACRE program replaces the CCPs. When producers choose to participate in the ACRE program, the producers opt out of CCPs for the revenue safety net and reduce DPs by 20% and ML rates by 30% (USDA Farm Service Agency, 2009). SURE serves as the first legislative language to implement a permanent disaster program, but was authorized only through September 31, 2011 (USDA Farm Service Agency, 2011). All of these programs base revenue guarantees or price protection off of the national marketing year average (MYA) price.

Crop insurance products administered by the USDA Risk Management Agency (RMA) include YP, RP, and RP-HPE. A producer’s Actual Production History (APH) serves as the benchmark for these insurance products. YP offers financial payment to producers when an operation’s actual yield falls below the guarantee. RP and RP-HPE base similar support on a farm’s revenue guarantee. Both of the revenue products function in a similar manner by which payments are made when actual revenue drops below the predefined protection level. Under RP the revenue guarantee is calculated off the higher of the planting-time or harvest-time average futures price, while RP-HPE calculates the guarantee only on the planting-time average futures price (USDA Risk Management Agency, 2011a).

Finally, the third set of tools available to stabilize crop revenue come from marketing tools including futures, options, and cash contracts traded either on publically
regulated exchanges or transacted in private markets. A multitude of marketing options exist to offset price declines and stabilize revenue. In the most basic form, selling futures contracts or buying put options serve as the means to predefine a sale price of growing or harvested crops in the future (CME Group, 2011). Cash contracts predefine a commodities’ price in the future along with the delivery location. Cash marketing of crops involves directly selling the commodity at harvest-time.

All of these alternatives are relevant to the risk management discussion. Each act uniquely against revenue declines. Yield and price remain the core component of revenue. Interactions amongst the various options against yield or price declines create different levels of protection and expected payouts. Alternative marketing strategies only protect against price declines, whereas other crop revenue stabilization options may protect against yield declines as well.

2.2 Overlap and Participation Rates

Lubben and Novak (2010) present an overview of the various safety nets and price support options relevant to producers in Nebraska. In their analysis these options are either classified as affecting the farm, area, or national levels of risk along with the scope of protection guarding against price, revenue, or production declines. In Figure 2.1, adapted and revised from Lubben and Novak, updates to the decision aid schematic show the various options available to producers during the 2011 production year and how the tools overlap or integrate to form the farm income crop revenue safety net.
Figure 2.1 The Farm Income Safety Net

In addition to the tools previously reviewed, Figure 2.1 notes the Adjusted Gross Revenue (AGR), Catastrophic Risk Protection Endorsement (CAT), Group Risk Plan (GRP), Group Risk Income Protection (GRIP), Group Risk Income Protection-Harvest Revenue Option (GRIP/H), and Pasture, Range, and Forage (PRF) insurance options offered by RMA, as well as hedging. Although producers have these alternatives available, GRP, GRIP, and GRIP/H offer support upon county production and CAT serves as a minimal insurance product paying in the event of severe damages. The CAT, GRP, GRIP, and GRIP/H tools are not considered in this analysis. AGR and PRF remain in pilot stages for select qualifying operations (USDA Risk Management Agency, 2011a). Types of hedging activities may vary across farms, but an active marketing plan should incorporate a sales strategy as part of the risk management tool portfolio.

Crop insurance participation rates in Nebraska shows RP, RP-HPE, and YP account for about 99% of all policies written during 2011. Aggregating insured corn, soybean, and wheat acreages indicates RP is preferred for the vast majority of units at 84.5%, YP second at 11.6%, and RP-HPE third at 3.9% (USDA Risk Management
Similar analysis may be drawn about USDA Farm Service Agency (FSA) programs denoted in Figure 2.1. CCP participation during the 2010 production year in Nebraska represents 74.2% of total farm acres enrolled versus only 25.8% for ACRE (USDA Farm Service Agency, 2011). These statistics highlight the underlying assumptions producers make regarding the performance and expected level of protection when selecting government programs and crop insurance products.

Zulauf (2011) expands further on the elements of a farm income safety net when describing the interactions between government programs and private insurance products. By design, these tools create overlap, but crop insurance focuses on farm-specific idiosyncratic hazards, whereas government programs cover widespread systemic losses. Declines in crop revenue may be attributed to a loss that falls in either category. A comprehensive analysis of farm-level crop revenue must include a study of the tools and strategies producers are currently using to cover these potential revenue losses.

2.3 Safety Net Decisions

Crop producers face a multitude of potential farm program, crop insurance, and marketing combinations when devising a risk management strategy. Pennings, Isengildina-Massa, Irwin, Garcia, and Good (2008) note potential combinations of risk management tools to consider in the decision making process increase at a factorial rate with each additional instrument, but underlying factors influence the process. Through analyzing the 2001 Agricultural and Resource Management Surveys (ARMS), Uematsu and Mishra (2010) found operator characteristics such as age, being raised on a farm, off-farm labor, total acres, and capital costs all had a positive influence on the adoption of
risk management tools. Participation rates with crop insurance products and government programs were found to increase with operation size.

Velandia, Rejesus, Knight, and Sherrick (2009) found similar results utilizing a 2001 survey of Illinois, Indiana, and Iowa corn and soybean farmers about operator characteristics and utilization of different strategies. A second finding shows producers consider how net return distributions interact with various revenue stabilization instruments. Connections between revenue stabilization strategies and idiosyncratic and systemic risk serve as the basis for a producer’s use of the tools. Operator characteristics also guide preferences and selection of different risk management tools.

Policy discussions during the 2008 Farm Bill formation period created the ACRE program in addition to the CCP and DP previously available. Cooper (2009) discussed how a revenue-based program was initially projected to be more effective than previously-established price-based income support and ad hoc disaster programs for a producer’s bottom line. Although moving towards greater protection against revenue declines, ACRE does not serve as a direct substitute for crop insurance or disaster programs. ACRE and CCP focus on state revenue or national price risk coming from aggregated systemic risk. Crop insurance or disaster programs focus on the farm-level production risk advancing from idiosyncratic risk (Shields, Monke, & Schnepf, 2010).

While keeping these risk attributes in mind, Woolverton and Young (2009) outlined ACRE enrollment questions which producers must evaluate when deciding to participate. Primary factors to consider include price and yield expectations, state versus farm-level yield correlation, cash flow changes with a reduction in rates with the DPs or LDPs, and risk preferences. Coble, Dismukes, and Thomas (2007) elaborated on the
issue of farm-level correlations with state yields even further. Strong correlation with individual farm yields and state averages may generate large program payments. Low correlations between farm and state crop revenue can lead to poor program performance.

Campiche and Harris (2010) cited previous sources on overlap between potential payments from revenue protection under ACRE and crop insurance, but the true risk distributions show overlap limited to 5% or less. Taking this factor into account, producers may gain the greatest protection by selecting both ACRE and crop revenue insurance. Revenue guarantees with ACRE reflect price and yield levels closer to actual production, whereas DCP price supports coupled with historical bases may not reflect current cropping patterns and productivity levels. Given these fundamental differences in ACRE and DCP, low participation rates indicate producers in Nebraska must expect potential ACRE payouts to be less than the declines in DPs. Discrepancies between producer actions and literature on decision making suggest areas for further inquiry.

Participation in different hedging activities remains correlated with purchases of crop insurance products (Velandia et al., 2009). Selection of different tools from the portfolio of programs or products shows these activities do not have mutually-exclusive properties. Operator characteristics coupled with expectations about currently-available tools serve as the basis to guide risk decisions. The production aspects of producers across Nebraska may lead to one strategy being preferable for a region, but not necessarily across the entire state. These questions may be answered through the stochastic simulation modeling of yields and prices.
2.4 Simulation Models

Simulation and forecast modeling relevant to portfolio analysis of risk management tools has historically focused on either a sector-level analysis or representative-farm comparison. This type of research serves as the basis for identifying a modeling and analysis procedure relevant to farm-level decisions in Nebraska. Building upon previous simulation modeling and incorporating the scope and variability of Nebraska farms leads to analysis relevant to the diversity of cropping patterns across the state.

At a sector level, the Food and Agricultural Policy Research Institute (FAPRI) (2011) provides annual agricultural baseline projections and policy analysis. However, estimates provided by the FAPRI model are aggregated and may not reflect the outcomes relevant for farm-level decision making. Projected values do provide value in national policy debates and overall judgment of expected performance of major sectors composing the agricultural industry. Forecast values serve as a baseline in farm-level simulation modeling done at Texas A&M University (Richardson, Outlaw, Knapek, Raulston, Herbst, Anderson, & Klose, 2011).

In another sectoral analysis, Coble and Dismukes (2008) outlined potential average payouts from integrating government programs and crop insurance across eligible acres across the United States. Dismukes, Arriola, and Coble (2010) further evaluated potential ACRE payouts across the United States and identified average variability rates of yields pertinent to the program’s revenue triggers. Their results also reaffirmed the importance of correlation between farm and state-level yields related to the likelihood of potential ACRE payouts. Zulauf and Orden (2010) took a historical
perspective in evaluating national ACRE program costs in lieu of CCPs and a reduction in DPs during the 1996 to 2008 period and forecasts for 2008 to 2012. These findings show ACRE would have reduced government expenditures during the historical period, but would have increased them during the forecast.

Projections from the FAPRI model serve as parameters for farm-level modeling taking place at the Agriculture and Food Policy Center (AFPC) at Texas A&M University. The models used by AFPC evaluate different risk alternatives for approximately 98 representative crop, livestock, and dairy farms strategically located across the United States to forecast the financial health of these operations under alternative policies and production scenarios. Nebraska’s contribution to the AFPC project are two representative grain farms located in the south central portion of the state measuring 2,400 and 4,300 acres in size (Richardson et al., 2011). These models, while generally representative, lack the detail for wide application across the state.

Based off the north-central Iowa, northern Arkansas, and southern Texas representative farms in the AFPC annual model, Knapek, Richardson, Outlaw, and Raulston (2011) evaluated eight different simulation scenarios involving various government and crop insurance combinations. This study used the coefficient of variation to measure the effects of the various combinations on net farm revenue. Findings of interest to Nebraska grain and oilseed producers indicated crop insurance coupled with the available government programs provides the lowest coefficient of variation versus any single option alone. Raulston, Richardson, Outlaw, and Knapek, (2011) also uses a set of AFPC representative farms to evaluate the performance of whole-farm revenue insurance in place of available government programs.
Woodard, et al. (2010) expand upon previous crop insurance studies by integrating a multi-crop framework in the simulation analysis of crop insurance products relevant to producers in Illinois. Yield distributions utilized in their investigation came from the Illinois Farm Business Farm Management (FBFM) record keeping system historical data series. This study indicates farm-level insurance outperforms the county product equivalent due to a producer’s yields having lower correlations with the larger aggregated distributions. Also, the evaluation of a single-crop model versus a multi-crop framework significantly influences results on expected revenue distributions.

Drawing upon the FBFM and Kansas Farm Management Association (KFMA) yield series, Zulauf, Schnitkey, and Langemeier (2010) modeled a more extensive evaluation by incorporating the interactions between ACRE, SURE, and RP. Results show that 75% RP has a larger impact for Kansas farms, whereas ACRE provides greater protection for Illinois farms. These findings highlight the influence that geographical and climatic patterns have on the performance of various risk management tools.

With the diversity in size, numbers, and location of farms throughout Nebraska, previous studies and research are not sufficient upon which to base decisions for all producers in the state. Many of the previous research studies highlight findings on selected tools. A theme common amongst previous studies and many forecasting methods is to use information from the past such as variability to predict possible future yield and price distributions. Clearly, the literature indicates that understanding interactions among the various programs, products, or marketing strategies provides the most insight on how the optimal risk management strategy might be given different
regions of the state. Previous models and procedures serve as a basis to develop a system to evaluate risk management decisions involving the portfolio of options available.

2.5 Summary of Literature Reviewed

Nebraska crop producers face risk in the form of uncertainty in prices and yields. Government programs, crop insurance products, and marketing strategies create the portfolio of risk management tools producers have at their disposal. By design, these instruments create overlap in protection against yield, price, or revenue declines. Expectations about the performance of these tools affect the decision producers make when implementing risk management strategies.

Previous research focuses at an aggregate level to evaluate policy costs as well as the overall health of the agricultural sector in the United States. Also, these models have only a few farms that are not fully representative of Nebraska agriculture. As the optimal risk management strategy varies depending upon a producer’s size and location, more specific modeling is needed. Referencing literature cited above, farm-level risk management modeling with application for Nebraska crop producers is developed in the next chapter to focus on evaluating alternative strategies utilizing the portfolio of risk management tools across different regions of the state.
CHAPTER 3: MATERIALS AND METHODS

Stochastic simulation modeling serves as the foundation for assessing scenarios when implementing different risk management strategies. The diversity in scale, cropping patterns, and production methods across Nebraska creates challenges when constructing representative farms for regions across the state. Forming a set of representative farms depicting typical characteristics and attributes allows for the assessment of different levels of risk exposure and management decisions on crop revenue. Cropping patterns, yield expectations, and actual variability differ with climatic patterns and soil types. Parameters expressing the average acreage, crop mix, and productivity factors must be representative of the farms used in the following analysis to establish an appropriate simulation.

3.1 Representative Model of Nebraska Crop Production

To estimate program parameters relevant to the different Nebraska crop production areas, a set of commodity yields and prices need to be modeled for the simulation of crop revenue, government programs, crop insurance products, and marketing strategies. The relevant set of parameters includes yields at the national, state, district, county, and farm level along with relevant prices. While national and state yield distributions are relevant across Nebraska, selecting the appropriate districts, counties, and farm-level locations needs further evaluation. Also, price ranges for cash sales, government programs, and crop insurance products all require appropriate basis adjustments to the base simulation price.
3.1.1 Geographical Regions

The geography of Nebraska varies across the state causing production systems and cropping patterns to differ due to these properties. These physical features influence cropping patterns and expected trend yields seen throughout the state. Irrigation remains a strong feature for many operations because of available water sources. Irrigated crops have higher expected yield projections and less variability than dryland grain and oilseed crops. Crops not receiving additional moisture from irrigation and solely relying on precipitation for water will be referenced as dryland crops. Accurately assessing the productivity and cropping acreages must take into account these unique attributes.

Figure 3.1 Nebraska National Agriculture Statistics Service-Agricultural Statistical Districts (NASS-ASDs) and Representative County Simulation Sites

The NASS-ASDs subdivide Nebraska’s 93 counties into eight regions. Figure 3.1 displays the eight NASS-ASDs for Nebraska. Consistent with NASS’s definitions the
districts are named as well as numbered. Counties within each district share similar production characteristics and yield expectations. Also in Figure 3.1, one county per district has been outlined as a representative county within the district. The districts and their representative counties include: Northwest 10 – Morrill, North 20 – Holt, Northeast 30 – Wayne, Central 50 - Sherman, East 60 – Butler, Southwest 70 – Hayes, South 80 – Kearney, and Southeast 90 – Saline. These counties represent the typical attributes of a district’s productivity and cropping patterns. Specifying districts and counties showing representative attributes of Nebraska crop production allows for parameter estimation of crop yields from historical NASS records.

3.1.2 Commodity Prices

Crop revenue, government programs, crop insurance products, and marketing strategies under evaluation require modeling of different prices. At the most basic level, crop revenue equals the yield times the cash selling price per bushel at harvest for a particular commodity. Government programs including ACRE and CCP base safety nets off the national MYA price. The ML safety net is calculated from adjusted national price and national average loan rates. Crop insurance products such as YP, RP, and RP-HPE base indemnities either off the average of planting-time or harvest-time price for a particular commodity futures contract. Finally, forward contracting, hedging, options, or marketing strategies involving a combination of these tools also use futures prices corresponding to a particular commodity futures contract.

Price parameter specification limits the complexity of modeling while capturing the appropriate relationships. The difference between the planting-time and harvest-time average futures prices is used as a proxy to simulate price variability. Daily futures price
series from commodity exchanges are maintained by the Commodity Research Bureau (CRB) (Commodity Research Bureau, 2011). Based upon these historical records annual deviations from the planting-time price to the harvest-time price were determined to serve as the stochastic price elements.

The simulated harvest-time futures price provides the basis from which other price parameters are derived. Historical MYA prices reported by NASS allowed for generating a 10-year average fixed basis between harvest-time futures prices and MYA prices (USDA National Agricultural Statistics Service, 2011). MYA prices recorded by NASS relevant to the model include one each at the national and state level. Government programs that rely on a national MYA price utilize the simulated futures price plus the national MYA basis, whereas the farm-level revenue calculations use the harvest-time futures plus the state MYA basis to determine a cash price.

### 3.1.3 Crop Acres and Yields

Crop acres and yields necessary for evaluating effects of risk management tools include national, state, district, county, and representative farm yields. Also, at the farm level, crop acreage and mix reflecting the average characteristics of a farm operating in each NASS-ASD need to be developed. To derive these characteristics, a variety of data sets contain the necessary elements to project crop mix or yields, variability, and farm size. Historical variations from expectations serve as the basis for determining deviations from trend yields.

NASS maintains annual yield and harvested acreage data for the national, state, district, and county levels (USDA National Agricultural Statistical Service, 2011). In some regions or counties, data was limited due to confidentiality issues. Using available
county-level acreage and yield values, the irrigation and dryland cropping practices for all major crops in Nebraska can be aggregated to the district level. These values show distinct cropping patterns across major regions of Nebraska. Wheat production is concentrated in the western part of the state, whereas soybean acres are concentrated in the eastern area. Irrigation is a practice factor throughout the state.

Annual yield data series observed from the NASS database including the nation, state, districts, and counties serve as the foundation for stochastic simulation values. Trend yields are estimated at the national, state, and district level leaving the deviations from trend as a measure of crop variability in a specific area. County yields were regressed directly off of district yields according to crop and practice. Also, to estimate farm-level yields, an implied volatility procedure utilizing RMA crop insurance product quotes allowed for the expansion of county yields to the farm level to express idiosyncratic risk elements. Yields selected for simulation were chosen based upon the percentage of overall crops comprising harvested cropland acres for a particular area.

Farm-level revenue modeling requires crop yields and acreages representative of operations in a given district or county. To gain a broader perspective on the size and scale of Nebraska farm operations, the 2007 Census of Agriculture conducted by USDA NASS provides cropland acres and total number of operators sorted according to gross farm income ranges (USDA National Agricultural Statistics Service, 2009). Operations in Nebraska with gross farm income above $100,000 per year account for the greatest percentage of overall commodity production. Therefore, using acres and farm numbers from these operations provides a set of representative farms that reflect typical commodity production in Nebraska. Based upon operations in the 2007 Census of
Agriculture meeting the income parameters, the total cropland acres and producers at the
district level were aggregated from the county data. Dividing these two figures provides
the average number of cropland acres per representative site in each district.

From the aggregated harvested acres data at the county level, these values were
weighted at the district level to determine the percent of each major crop and practices for
the respective region. These values were multiplied by the average number of cropland
acres for each representative farm to create the acreage distributions in Table 3.1. The
farms in each column are named according to the geographic regions which these farms
represent. Crops are excluded from a representative farm if they are not a significant
part of the district’s crop mix.

### Table 3.1 Representative Farm Sites with Cropland Acres, Expected Yields, and
Actual Production History (APH)

<table>
<thead>
<tr>
<th>Crop Irdigated</th>
<th>Farm 10</th>
<th>Farm 20</th>
<th>Farm 30</th>
<th>Farm 40</th>
<th>Farm 50</th>
<th>Farm 60</th>
<th>Farm 70</th>
<th>Farm 80</th>
<th>Farm 90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn Dryland</td>
<td>-</td>
<td>157.2</td>
<td>380.2</td>
<td>126.8</td>
<td>273.4</td>
<td>282.6</td>
<td>171.5</td>
<td>377.7</td>
<td></td>
</tr>
<tr>
<td>Soybeans Irrigated</td>
<td>-</td>
<td>329.1</td>
<td>147.7</td>
<td>206.0</td>
<td>173.7</td>
<td>96.9</td>
<td>303.7</td>
<td>173.8</td>
<td></td>
</tr>
<tr>
<td>Soybeans Dryland</td>
<td>-</td>
<td>303.9</td>
<td>-</td>
<td>259.8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>377.5</td>
<td></td>
</tr>
<tr>
<td>Winter Wheat</td>
<td>874.4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>522.3</td>
<td>167.0</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1247.3</td>
<td>1377.3</td>
<td>1062.0</td>
<td>1127.5</td>
<td>1025.8</td>
<td>1604.3</td>
<td>1200.8</td>
<td>1209.3</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Expected Yields 2011 (bu./acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn Irrigated</td>
</tr>
<tr>
<td>Corn Dryland</td>
</tr>
<tr>
<td>Soybeans Irrigated</td>
</tr>
<tr>
<td>Soybeans Dryland</td>
</tr>
<tr>
<td>Winter Wheat</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Actual Production History 2001-2010 (bu./acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn Irrigated</td>
</tr>
<tr>
<td>Corn Dryland</td>
</tr>
<tr>
<td>Soybeans Irrigated</td>
</tr>
<tr>
<td>Soybeans Dryland</td>
</tr>
<tr>
<td>Winter Wheat</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Table 3.1 also displays expected farm-level trend yields in 2011 and APH yields
based upon the 2001-2010 time period. Using the county level yields and adding in a
stochastic, idiosyncratic risk element creates the farm-level yields. Implied yield volatility from crop insurance premiums was used to generate the stochastic element necessary to derive yield variability representative to those crops being modeled at the farm level. Also, crops modeled at the district and county level were appropriately correlated with those represented at the farm level. District and county yields are modeled only for those crops and practices that are included at the representative farm level.

Other acreage and yield parameters relevant to the farm level for analysis of risk management tools relate to government programs. ACRE, CCP, and DP require base acre and yield parameters. For this analysis, total base acres are assumed to equal total cropland acres for each of the representative farms. The ACRE Olympic average yield for a particular farm equals the average of the APH yields over the past five years with high and low values dropped from the tabulations. Planted acres for the ACRE program reflect those crops actually being raised for the current production year, whereas those for DP and CCP reflect those established by historical values for previous production years specified by a particular farm bill program. Also program yields reflect those of historical records available from a weighted data set maintained by USDA-FSA (USDA Farm Service Agency, 2006).

Depicting the scale, productivity, and crop mix of farms across Nebraska remains a challenge due to the sheer number of operations. The eight representative farms across the state aim to accurately reflect the typical crop revenue attributes for major geographical regions. Equally important to the model is the positive and negative interactions among yield and price variables. Observing correlations between these
relationships allows for idiosyncratic and systemic relationships to flow throughout the simulation.

3.2 Correlated Model

Previously cited literature outlines the purpose of correlations between yield and price distributions in stochastic simulations. Depending upon the interactions of price with various levels of yield aggregation, performance of risk management tools may vary. At the base of the modeling procedure, a moving linear trend was fitted to the yield data to determine deviations from projections. Price deviations were calculated as the deviation in the average futures prices between planting time and harvest time. The raw deviations were non-stationary and were detrended to account for biases resulting from trend due to technological and productivity gains over time. Finally, a multi-step procedure was used to determine and model the directionality of correlations between yield and price parameters to allow for their full expression between simulation variables.

3.2.1 Yield and Price Deviations

Over time, yield and price parameters either positively or negatively deviated from expectations. These variations account for systemic and idiosyncratic shocks expressed across various production levels. As the level of yield aggregation decreases, the deviations from trend increase due to the effects of decreasing averaging over smaller land areas. These historical deviations serve as the source of variability in the simulation model. Stochastic deviations are assumed to have normalized distributions based upon preliminary analysis failing to reject the null hypothesis. Yield deviations were calculated for all crops and practices and evaluated at the national, state, and district
levels, whereas the county and farm-level yields were regressed directly from higher-level yields. Table 3.2 shows the 42 calculated yield deviations along with the corresponding regions, cropping practices, and values.

For every yield deviation, a series of Ordinary Least Squares (OLS) moving trend regression were fitted for each 30 years of data. For example, the 1990 deviation for irrigated corn in District 30 represents a forecast of the derivation from the linear trend fitted to the actual data between 1960 and 1989. The following year’s calculation, 1991, bases the deviation off the OLS refitted to 1961 to 1990. This process is repeated annually so that readjustments of the linear trend were included. The method accounts for structural changes, such as increases in productivity to happen over time. Deviations for price represent the difference between the planting-time and harvest-time average futures price to determine expected fall harvest price. Subject to a basis difference, the stochastic futures deviations create the price values for all revenues, programs, and products evaluated.
Table 3.2 National, State, and District Yield Variable Deviations

<table>
<thead>
<tr>
<th>Variable</th>
<th>Region</th>
<th>Crop</th>
<th>Practice$^1$</th>
<th>Value</th>
<th>Variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>crnfutprdv</td>
<td>United States</td>
<td>corn</td>
<td>futures prices</td>
<td>deviation</td>
<td></td>
</tr>
<tr>
<td>soyfutprdv</td>
<td>United States</td>
<td>soybeans</td>
<td>futures prices</td>
<td>deviation</td>
<td></td>
</tr>
<tr>
<td>hrwwhtfutprdv</td>
<td>United States</td>
<td>hard red</td>
<td>futures price</td>
<td>deviation</td>
<td></td>
</tr>
<tr>
<td>uscrntotylddv</td>
<td>United States</td>
<td>corn</td>
<td>total yield</td>
<td>deviation</td>
<td></td>
</tr>
<tr>
<td>ussoytotylddv</td>
<td>United States</td>
<td>soybean</td>
<td>total yield</td>
<td>deviation</td>
<td></td>
</tr>
<tr>
<td>uswhttotylddv</td>
<td>United States</td>
<td>wheat</td>
<td>total yield</td>
<td>deviation</td>
<td></td>
</tr>
<tr>
<td>necrnirrylddv</td>
<td>Nebraska</td>
<td>corn</td>
<td>irrigated yield</td>
<td>deviation</td>
<td></td>
</tr>
<tr>
<td>necrdryylddv</td>
<td>Nebraska</td>
<td>corn</td>
<td>total yield</td>
<td>deviation</td>
<td></td>
</tr>
<tr>
<td>nesoyirrylddv</td>
<td>Nebraska</td>
<td>soybean</td>
<td>irrigated yield</td>
<td>deviation</td>
<td></td>
</tr>
<tr>
<td>nesoydryylddv</td>
<td>Nebraska</td>
<td>soybean</td>
<td>dry yield</td>
<td>deviation</td>
<td></td>
</tr>
<tr>
<td>newhttotylddv</td>
<td>Nebraska</td>
<td>wheat</td>
<td>total yield</td>
<td>deviation</td>
<td></td>
</tr>
</tbody>
</table>

D10crnirrylddv       | District 10     | corn       | irrigated yield | deviation  |
D20crnirrylddv       | District 20     | corn       | irrigated yield | deviation  |
D30crnirrylddv       | District 30     | corn       | irrigated yield | deviation  |
D50crnirrylddv       | District 50     | corn       | irrigated yield | deviation  |
D60crnirrylddv       | District 60     | corn       | irrigated yield | deviation  |
D70crnirrylddv       | District 70     | corn       | irrigated yield | deviation  |
D80crnirrylddv       | District 80     | corn       | irrigated yield | deviation  |
D90crnirrylddv       | District 90     | corn       | irrigated yield | deviation  |
D20crndryylddv       | District 20     | corn       | dry yield      | deviation  |
D30crndryylddv       | District 30     | corn       | dry yield      | deviation  |
D50crndryylddv       | District 50     | corn       | dry yield      | deviation  |
D60crndryylddv       | District 60     | corn       | dry yield      | deviation  |
D70crndryylddv       | District 70     | corn       | dry yield      | deviation  |
D80crndryylddv       | District 80     | corn       | dry yield      | deviation  |
D90crndryylddv       | District 90     | corn       | dry yield      | deviation  |
D20soyirrylddv       | District 20     | soybean    | irrigated yield | deviation  |
D30soyirrylddv       | District 30     | soybean    | irrigated yield | deviation  |
D50soyirrylddv       | District 50     | soybean    | irrigated yield | deviation  |
D60soyirrylddv       | District 60     | soybean    | irrigated yield | deviation  |
D70soyirrylddv       | District 70     | soybean    | irrigated yield | deviation  |
D80soyirrylddv       | District 80     | soybean    | irrigated yield | deviation  |
D90soyirrylddv       | District 90     | soybean    | irrigated yield | deviation  |
D30soydryylddv       | District 30     | soybean    | dry yield      | deviation  |
D60soydryylddv       | District 60     | soybean    | dry yield      | deviation  |
D90soydryylddv       | District 90     | soybean    | dry yield      | deviation  |
D10whttotylddv       | District 10     | wheat      | total yield    | deviation  |
D70whttotylddv       | District 70     | wheat      | total yield    | deviation  |
D80whttotylddv       | District 80     | wheat      | total yield    | deviation  |

$^1$ Total cropping practices include all irrigated and dryland production and acreage for a particular region.
3.2.2 Detrending Deviations

To account for changes occurring in corn, soybean, and wheat yields, including deviations due to technological and productivity advancements, an OLS regression was used to detrend deviations of actual production from the linear projections. To be consistent, all deviations from the linear projections were detrended for each level of yield and price. With the relatively small sample size of deviations from the linear projections, the OLS proved to be the most effective method to handle the stationarity issue. Once the deviations from the linear trend projections were detrended, the following correlation procedure was utilized to allow for relationships to carry through at every price and yield levels.

3.2.3 Correlation Procedure

Lubben and Jansen (2010) have shown that correlation relationships involving MYA prices along with national, state, district, and county crop yields in Nebraska. These values show yields and prices at various levels have statistically significant relationships. Depending upon the particular variable, programs or products under evaluation may preform differently depending upon the strength of yield and price correlations to the critical program value. Correlations must be maintained between the 96 stochastic yield and price variables. Every draw of the simulation needs to relay the correlative effects of yields and price elements on other variables. To achieve this goal, an approach using a base correlation matrix coupled with sorted Directed Acyclic Graphs (DAGs) allows for observation of the respective relationships. This procedure illustrates the relationships amongst variables at a given level of statistical significance.
First in the model, a correlation matrix simultaneously draws the relationship between 12 national and state time-adjusted yield parameters along with the respective price. These become the base values of the model. Given the software used, increasing the number of relationships beyond these 12 parameters causes singularity and non-convergence in the correlation matrix. Relationships between lower aggregation levels such as district, county, and farm level yields still need to be calculated with respect to the underlying correlations. A multi-step procedure involving TETRAD IV, yield regressions, and crop insurance yield calibrations allows for the interactions to carry through at the lower aggregation levels.

The various relationships involving the state and district time-adjusted yield deviations were decomposed using TETRAD IV software to determine the causal nature of the variables to each other (Spirtes, Sheines, Ramsey, & Glymour, 2005). First the deviations were sorted according to cropping practices involving irrigation and dryland production. Limitations in TETRAD IV do not allow for all 42 state and district yield variables listed in Table 3.2 to be analyzed all in the same DAG pattern. Correlations between state and district variables show the strongest relationships involving those by irrigation practice. Sorting irrigated and dryland time-adjusted deviations does not imply a mutually exclusive property between the production methods, but a higher level of relationship relevance and stability.

After sorting and uploading the variables to TETRAD IV, a DAG search produced in Figure 3.2 for the irrigated variables and Figure 3.3 for the dryland counterparts outline the causal relationships. Arrows or edges connecting the variable sets show the directionality and relationships of patterns. Output images were sorted
according to the base state variables leading lower aggregation level time-adjusted
district deviations. Based upon this assumption, district to state arrow directionalities
were reversed to reflect the larger state groups making them lower level variables. This
method assures that outcomes of all variables are consistent with the next higher level of
aggregation.

A line connecting two variables in a DAG, but not possessing an arrow to infer
causality in flow indicates an undirected edge. For these outlines the assumption was
made that the state or higher-level district variables directed the unspecified edge in the
lower level respective relationships. Also, DAG do not allow circular references among
variables. Undirected edges and arrows in Figure 3.2 and Figure 3.3 use Fischer’s z-test
statistics to determine the DAG relationships which have statistical significance. Any
relationship failing to be statistically different from zero are not displayed on the
resulting image.

Figure 3.2 displays the appropriate relationships between the 17 irrigated time-
adjusted yield deviations. Depending upon the strength of these interactions, causality of
the direct edges relays the direction. Simulation distributions must take these interactions
into consideration when modeling the system to examine yield variability on crop
revenue across different regions. Assumptions made about correlations between yield
parameters are affirmed by DAG analysis.
Figure 3.2 Irrigated State and District Yield Deviation Directed Acyclic Graph (DAG)

Observations about Figure 3.2 carry through for the 16 dryland time-adjusted yield deviations in Figure 3.3. Due to the limitations in cropping practices involving dryland production, fewer regions have dryland soybeans versus irrigated soybeans. Based upon the DAG diagram, district time-adjusted yield deviations were regressed on the leading state or district variables according to the relationships documented. These relationships between nodes allows for the identification of independent variables with regards to a particular dependent variable.
As the linkage between district and county yields remain high due to a strong correlation, direct relationships between these variables was drawn without a DAG search. By using this assumption, the direct relationships by crop and production practice between district and county variables serve as a basis of regressing lower-level yields off the higher-level yields. By using this approach, correlations can be properly identified and used, assuring a feasible simulation. Historical county yields by crop and practice serve as the dependent variable in the regression off the independent higher-level district yields. County simulation variables were not adjusted for the trend resulting from the
time progression because independent district yields already account for this element in the model.

To derive yields representative of expectations and variability for the model farms, a stochastic component was added to the simulated county level yields in which a particular farm lies. Miranda’s (1991) implied volatility procedure utilizing crop insurance premiums allows for county level variability to be adjusted to the farm level. The calibration method assumes crop insurance premiums are assessed at actuarially fair rates. Also, the expected county and farm-level yield for a particular crop and practice must be the same. Through this process, the average variability expressed by farms operating in a particular county was obtained.

By modeling the distributions through the procedure described statistically significant correlation relationships carry through with each random draw generated. Observing these associations or connections between the revenue components remains the core principle needed for evaluating a cohesive risk management strategy given a set of alternatives. The following system of equations outlines the specific simulation and regression procedures applied to generate stochastic yield and price distributions. Each formula elaborates on national, state, district, county, or farm-level aggregation.

3.2.4 Equations

Estimated harvest-time average futures price distributions are simulated using equation 3.1. Using a planting-time price for the starting parameter, the simulated harvest-time average futures price draws upon historical variability to create the price distribution. Adjusting the simulated harvest-time average futures price with a fixed
basis produces the necessary cash price series for the risk management strategies under evaluation.

\[
\widehat{hP}_{kt} = E(hP_{kt}) + \widehat{\varepsilon}_{kt}
\]  

(3.1)

where \(\widehat{hP}_{kt}\) = simulated harvest-time 30-day average futures price for harvest delivery of crop \(k\) in time period \(t\)

\[E(hP_{kt}) = \text{expected harvest-time futures price for harvest delivery of crop } k \text{ in time period } t\]

\(\widehat{\varepsilon}_{kt}\) = estimated residual of futures price deviation between the expected average futures price and the actual harvest-time average futures price for crop \(k\) in time period \(t\) where \(\widehat{\varepsilon}_{kt} \sim N(0, h\sigma_{kt}^2)\)

for \(k = \{\text{corn, soybeans, wheat}\}\)

\(t = \text{time period 2011}\)

and \[E(hP_{kt}) = \bar{p}_{kt} + E(hV_{kt})\]

\(\bar{p}_{kt}\) = base planting-time 30-day average futures price for harvest delivery of crop \(k\) in time period \(t\)

\(E(hV_{kt}) = \text{expected futures price deviation between planting-time and harvest-time average futures price for harvest delivery of crop } k \text{ in time period } t\)

and \(E(hV_{kt})\) is estimated from the following equation:

where \(hV_{kt} = \hat{\gamma}_0 + \hat{\gamma}_1 (year) + \widehat{\varepsilon}_{kt}\)

\(\hat{\gamma}_0\) = estimated intercept for the trend in price deviations of crop \(k\)

\(\hat{\gamma}_1\) = estimated slope for the trend in price deviations of crop \(k\)

\(\widehat{\varepsilon}_{kt}\) as previously defined

where the regression is calculated on futures price deviation between planting-time and harvest-time average futures price for harvest delivery of crop \(k\) in time period \(t\) for the time period \(\{t-30, ..., t-1\}\)

Estimated national MYA cash prices are simulated using equation 3.2. Using a fixed basis derived from the previous five years of historical data, the simulated harvest-time futures price was adjusted to reflect the national MYA cash price. Basis adjustments reflect the forces leading to the differences between the two price series.
\[
\bar{P}_{kt} = \bar{hP}_{kt} + \bar{M}_{kt}
\]

where \( \bar{P}_{kt} \) = simulated national marketing year average cash price for crop \( k \) in time period \( t \)
\( \bar{hP}_{kt} \) = simulated harvest-time 30-day average futures price for harvest delivery of crop \( k \) in time period \( t \)
\( \bar{M}_{kt} \) = estimated basis between the simulated harvest-time 30-day average futures price for harvest time delivery and national marketing year average cash price of crop \( k \) in time period \( t \)

for \( k = \{\text{corn, soybeans, wheat}\} \)
\( t = \text{time period 2011} \)

and
\[
\bar{M}_{kt} = \frac{\sum_{t=2}^{t-1} (P_{kt} - hP_{kt})}{5}
\]

\( \bar{M}_{kt} \) = estimated national marketing year basis from simulated futures harvesting average for crop \( k \) in time period \( t \)
\( P_{kt} \) = national marketing year average cash price for crop \( k \) in time period \( t \)
\( hP_{kt} \) = harvest-time 30-day average futures price for harvest delivery of crop \( k \) in time period \( t \)

where the basis estimate is calculated on the average difference of \( P_{kt} - hP_{kt} \) for crop \( k \) in time period \( \{t-5,\ldots,t-1\} \)

Similar to the national MYA price average cash price equation, the state marketing year average cash price is simulated using equation 3.3. Once again, using the simulated harvest-time futures price serves as the base parameter, a fixed basis adjustment to this price series creates the state MYA cash price. This simulated series serves as the price parameter for the cash selling price of all grains marketed by the representative farms.

\[
\bar{sP}_{kt} = \bar{hP}_{kt} + \bar{M}_{kt}
\]

where \( \bar{sP}_{kt} \) = simulated state marketing year average cash price for crop \( k \) in time period \( t \)
\( \bar{hP}_{kt} \) = simulated harvest-time 30-day average futures price for harvest delivery of crop \( k \) in time period \( t \)
\( \tilde{sM}_{kt} \) = estimated basis between the simulated harvest-time 30-day average futures price for harvest time delivery and state marketing year average cash price of crop \( k \) in time period \( t \)

for \( k = \{ \text{corn, soybeans, wheat} \} \)

\( t = \) time period 2011

and

\[
\tilde{sM}_{kt} = \frac{1}{5} \sum_{t-5}^{t-1} (SP_{kt} - \bar{SP}_{kt})
\]

\( \tilde{sM}_{kt} \) = estimated state marketing year basis from simulated futures harvesting average for crop \( k \) in time period \( t \)

\( SP_{kt} \) = state marketing year average cash price for crop \( k \) in time period \( t \)

\( \bar{SP}_{kt} \) = harvest-time 30-day average futures price for harvest delivery of crop \( k \) in time period \( t \)

where the basis estimate is calculated on the average difference of \( SP_{kt} - \bar{SP}_{kt} \) for crop \( k \) in time period \( \{t-5,...,t-1\} \)

National crop yield distributions are simulated using formula 3.4 by using a trend line projection and past variability to generate the simulated distribution. Through a system of moving trend lines, yield deviations were obtained from actual historical data. Based upon this variability, projections for the simulation year create the national yield distributions of the model. Trend adjustments were made to the deviations to reflect productivity advancements of crop varieties.

\[
\bar{ny}_{kt} = E(nY_{kt}) + \bar{\epsilon}_{kt}
\]

(3.4)

where \( \bar{ny}_{kt} \) = simulated national yield for crop \( k \) in time period \( t \)

\( E(nY_{kt}) \) = expected national yield for crop \( k \) in time period \( t \)

\( \bar{\epsilon}_{kt} \) = estimated residual of the yield deviation between the trend adjusted national yield and the actual national yield for crop \( k \) in time period \( t \) where \( \bar{\epsilon}_{kt} \sim N(0, \bar{\sigma}^2_{kt}) \)

for \( k = \{ \text{corn, soybeans, wheat} \} \)

\( t = \) time period for production year 2011

and

\[ E(nY_{kt}) = \hat{\beta}_{0k} + \hat{\beta}_{1k} \text{(year)} + E(\bar{ny}_{kt}) \]

\( \hat{\beta}_{0k} \) = estimated intercept for the trend in yield of crop \( k \)

\( \hat{\beta}_{1k} \) = estimated slope for the trend in yield of crop \( k \)
\[ E(\bar{n}V_{kt}) = \text{expected yield deviation between the expected national yield and the actual national yield for crop } k \text{ in time period } t \]

where the regression is calculated on yields from time period \{t-30,..t-1\}

and \[ E(\bar{n}V_{kt}) \] is estimated from the following equation:

where \[ \bar{n}V_{kt} = \hat{\gamma}_{0k} + \hat{\gamma}_{1k}(year) + \bar{n}\epsilon_{kt} \]
\[ \hat{\gamma}_{0k} = \text{estimated intercept for the trend in yield deviations of crop } k \]
\[ \hat{\gamma}_{1k} = \text{estimated slope for the trend in yield deviations of crop } k \]
\[ \bar{n}\epsilon_{kt} \text{ as previously defined} \]

where the regression is calculated on deviations from trend line yields for the period \{t-30,..t-1\} and the trend yield in period t is calculated from regression on yields in period \{t-30,..,t-1\}

State crop yield distributions are simulated using formula 3.5 following a similar procedure as equation 3.4. Once again, by using trend line yields coupled with past variation, the simulated projections reflect anticipated crop yield distributions at the state level. Also, moving trend line yields was used to obtain deviations from expected yield and were trend adjusted to reflect advancements in productivity.

\[ \bar{S}Y_{kt} = E(sY_{kt}) + \bar{s}\epsilon_{kt} \] (3.5)

where \[ \bar{S}Y_{kt} = \text{simulated state yield for crop } k \text{ in time period } t \]
\[ E(sY_{kt}) = \text{expected state yield for crop } k \text{ in time period } t \]
\[ \bar{s}\epsilon_{kt} = \text{estimated residual of the yield deviation between the trend adjusted state yield and the actual state yield for crop } k \text{ in time period } t \text{ where} \]
\[ \bar{s}\epsilon_{kt} \sim N(0, \sigma_{kt}^2) \]

for \( k = \{\text{corn, soybeans, wheat}\} \)
\( t = \text{time period for production year 2011} \)

and \[ E(sY_{kt}) = \hat{\beta}_{0k} + \hat{\beta}_{1k}(year) + E(\bar{s}V_{kt}) \]
\[ \hat{\beta}_{0k} = \text{estimated intercept for the trend in yield of crop } k \]
\[ \hat{\beta}_{1k} = \text{estimated slope for the trend in yield of crop } k \]
\[ E(\bar{s}V_{kt}) = \text{expected yield deviation between the expected state yield and the actual state yield for crop } k \text{ in time period } t \]
where the regression is calculated on yields from time period \(\{t-30, \ldots, t-1\}\)

and \(E(s_{kt})\) is estimated from the following equation:

\[
\overline{s_{kt}} = \hat{p}_{0k} + \hat{p}_{1k}(\text{year}) + \overline{\varepsilon}_{kt}
\]

where \(\hat{p}_{0k}\) = estimated intercept for the trend in yield deviations of crop \(k\)

\(\hat{p}_{1k}\) = estimated slope for the trend in yield deviations of crop \(k\)

\(\overline{\varepsilon}_{kt}\) as previously defined

where the regression is calculated on deviations from trend line yields for the period \(\{t-30, \ldots, t-1\}\) and the trend yield in period \(t\) is calculated from regression on yields in period \(\{t-30, \ldots, t-1\}\)

To capture the relationships between equations 3.1, 3.4, and 3.5 the error terms of \(\overline{h_{kt}}, \overline{\varepsilon}_{kt}, \text{and} \ \overline{s_{kt}}\) are correlated. By observing and maintaining these correlated relationships, the model accounts for systemic risk shocks. These correlations may be positive or negative and will vary in terms of the strength of a relationship. To carry these relationships between the respected equations in the model the following error terms are correlated.

where 

\(\overline{h_{kt}}\) = estimated residual of futures price deviation between the expected average futures price and the actual harvest-time average futures price for crop \(k\) in time period \(t\) where \(\overline{h_{kt}} \sim N(0, \sigma^2_{h_{kt}})\)

\(\overline{\varepsilon}_{kt}\) = estimated residual of the yield deviation between the expected national yield and the actual national yield for crop \(k\) in time period \(t\) where \(\overline{\varepsilon}_{kt} \sim N(0, \sigma^2_{\varepsilon_{kt}})\)

\(\overline{s_{kt}}\) = estimated residual of the yield deviation between the expected state yield and the actual state yield for crop \(k\) in time period \(t\) where \(\overline{s_{kt}} \sim N(0, \sigma^2_{s_{kt}})\)

for \(k = \{\text{corn, irrigated corn, dryland corn, soybeans, irrigated soybeans, dryland soybeans, wheat}\}\)

\(t = \text{time period 2011}\)

Residuals are then correlated using the mxn matrix \([\rho]\) for all \(\overline{h_{kt}}, \overline{\varepsilon}_{kt}, \overline{s_{kt}}\) error terms

where \(m = n = 12\)
District crop yields are simulated using equation 3.6. This formula follows a similar procedure to national and state yields, where a trend line projection and deviation creates the simulated value. District yield deviations were obtained by finding the difference between the moving trend line projection and actual historical data. After trend adjusting these deviations, the variables were then regressed off other state or district deviations according to cropping practice guided by the DAG search.

\[
\hat{Y}_{ikt} = E(Y_{ikt}) + \hat{\varepsilon}_{kt}
\]  

(3.6)

where \( \hat{Y}_{ikt} \) = simulated district \( i \) yield for crop \( k \) in time period \( t \)

\( E(Y_{ikt}) \) = expected district \( i \) yield for crop \( k \) in time period \( t \)

\( \hat{\varepsilon}_{ikt} \) = estimated residual of the yield deviation between the trend adjusted district \( i \) yield and the actual district \( i \) yield for crop \( k \) in time period \( t \) where

\( \hat{\varepsilon}_{kt} \sim N(0, \hat{\sigma}^{2}_{kt}) \)

for

\( i = \{10, 20, 30, 50, 60, 70, 80, 90\} \)

\( k = \{\text{irrigated corn, dryland corn, irrigated soybeans, dryland soybeans, wheat}\} \)

\( t = \text{time period for production year 2011} \)

and

\( E(Y_{ikt}) = \hat{\beta}_{0k} + \hat{\beta}_{1k}(\text{year}) + E(\hat{\varepsilon}_{ikt}) \)

\( \hat{\beta}_{0k} \) = estimated intercept for the trend in yield of crop \( k \)

\( \hat{\beta}_{1k} \) = estimated slope for the trend in yield of crop \( k \)

\( E(\hat{\varepsilon}_{ikt}) \) = expected yield deviation between the expected district \( i \) yield and the actual district \( i \) yield for crop \( k \) in time period \( t \)

where the regression is calculated on yields from time period \( \{t-30...t-1\} \)

and \( E(\hat{\varepsilon}_{ikt}) \) is estimated from the following equations:

where

\( \hat{\varepsilon}_{ikt} = \hat{\gamma}_{0k} + \hat{\gamma}_{1k}(\text{year}) + \hat{\varepsilon}_{ikt} \)

\( \hat{\gamma}_{0k} \) = estimated intercept for the trend in yield deviations of crop \( k \)

\( \hat{\gamma}_{1k} \) = estimated slope for the trend in yield deviations of crop \( k \)

\( \hat{\varepsilon}_{ikt} \) = estimated DAG residual for the relationship between state and other district yields and district \( i \) yields for crop \( k \)

and

\( \hat{\omega}_{ikt} = \delta_{0ik} + \sum^{k} \delta_{1ik}(\hat{\varepsilon}_{kt}) + \sum^{ik} \delta_{2ik}(\hat{\omega}_{ikt}) + \hat{\varepsilon}_{kt} \)
$\delta_{0ik}$ = estimated intercept for the relationship between state and other district yields and district $i$ yields for crop $k$
$\delta_{1ik}$ = estimated slope for the relationship between state and district $i$ yields for crop $k$
$\delta_{2ik}$ = estimated slope for the relationship between state and other district yields and district $i$ yields for crop $k$
$\delta_{pki}$ as previously defined

where $\delta_{pki}$ is estimated from regression of time series adjusted deviations at the district level on time series adjusted deviations at the state and district level using hierarchal estimation procedures determined through the Tetrad DAG for $i = \{10, 20, 30, 50, 60, 70, 80, 90\}$ and $k = \{\text{irrigated corn, dryland corn, irrigated soybeans, dryland soybeans, wheat}\}$

Following a direct relationship to district yields, county yields are simulated using equation 3.7. The expected county yield and standard deviation are regressed off the district corresponding district yield by crop and practice. Regressing county yields off of district yields carries correlations between each level of the simulation.

$$\bar{Y}_{jkt} = E(cY_{jkt}) + \bar{e}_{jkt}$$

where $\bar{Y}_{jkt}$ = simulated county $j$ yield for crop $k$ in time period $t$
$E(cY_{jkt})$ = expected county $j$ yield for crop $k$ in time period $t$
$\bar{e}_{jkt}$ = estimated residual of the yield deviation between the trend adjusted county $j$ yield and the actual county $j$ yield for crop $k$ in time period $t$ where $\bar{e}_{jkt} \sim N(0, \sigma^2_{jkt})$

for $j = \{\text{Morrill, Holt, Wayne, Sherman, Butler, Hayes, Kearney, Saline}\}$
$k = \{\text{irrigated corn, dryland corn, irrigated soybeans, dryland soybeans, wheat}\}$
$t = \text{time period for production year 2011}$

and $E(cY_{jkt}) = \hat{\beta}_{0k} + \hat{\beta}_{1k}(\bar{Y}_{ikkt}) + \bar{e}_{jkt}$
$\hat{\beta}_{0k}$ = estimated intercept for the relationship between district and county yields of crop $k$
$\hat{\beta}_{1k}$ = estimated slope for the relationship between district and county yields of crop $k$
$\bar{e}_{jkt}$ = as previously defined

where $\bar{e}_{jkt}$ is estimated from the regression of county $j$ yields calculated on simulated district $i$ yield of crop $k$ in time period $t$ in which $\{i, j\}$ take on the following
Farm-level yields are simulated using equation 3.8. Yields on the representative farms have an average equal to county yield, but a variability level implied from crop insurance premiums for the 2011 production year. Miranda’s formula allowed for the calibration of county-level yields to the representative farm.

$$\hat{Y}_{ikt} = E(fY_{ikt}) + \hat{\varepsilon}_{ikt}$$

(3.8)

where

- $\hat{Y}_{ikt}$ = simulated farm $i$ yield for crop $k$ in time period $t$
- $E(fY_{ikt})$ = expected farm $i$ yield for crop $k$ in time period $t$
- $\hat{\varepsilon}_{ikt}$ = estimated residual of the yield deviation between the trend adjusted farm yield and the actual farm yield for crop $k$ in time period $t$ where $\hat{\varepsilon}_{ikt} \sim N(0, f\sigma^2_{kt})$

for $i = \{10, 20, 30, 50, 60, 70, 80, 90\}$
- $k = \{\text{irrigated corn, dryland corn, irrigated soybeans, dryland soybeans, wheat}\}$
- $t = \text{time period for production year 2011}$

and $E(fY_{ikt}) = cY_{jkt}$

where expected farm $i$ yield for crop $k$ in time period $t$ is equal to the county $j$ yield for crop $k$ in time period $t$

and $\hat{\varepsilon}_{ikt}$ is the idiosyncratic farm-level risk determined by using Miranda’s formula to expand county yield variability into farm-level variability that generates quoted RMA premium rates.

Similar to Coble and Dismukes’(2008) procedure, Miranda’s Formula (1991) was used to expand a county yield to a farm-level yield expressing idiosyncratic risk implied by the RMA crop insurance quotes specific to farms lying in a particular county. Crop insurance premiums utilized in calibrating the yields had an assumed APH yield equal to
the farm’s specific county. Also, quotes obtained were for the 2011 production year (Farmdoc, 2011).

\[
\bar{Y}_{ikt} = E(fY_{ikt}) + c\beta_{jkt}(\bar{Y}_{jkt} - E(fY_{ikt})) + \bar{\epsilon}_{ikt}
\]

where \( \bar{Y}_{ikt} \) = simulated farm \( i \) yield for crop \( k \) in time period \( t \)
\( E(fY_{ikt}) \) = expected farm \( i \) yield for crop \( k \) in time period \( t \)
\( f\beta_{ikt} \) = measures the responsiveness in farm \( i \) yield for crop \( k \) in comparison to county \( j \) yield for crop \( k \) in time period \( t \)
\( \bar{Y}_{jkt} \) = simulated county \( j \) yield for crop \( k \) in time period \( t \)
\( E(cY_{jkt}) \) = expected county \( j \) yield for crop \( k \) in time period \( t \)
\( \bar{\epsilon}_{ikt} \) = represents the estimated idiosyncratic level risk from calibrating county \( j \) yield for crop \( k \) to an average standard deviation equivalent to the expected variation on farm \( i \) for crop \( k \) in time period \( t \) where \( \bar{\epsilon}_{ikt} \sim N(0, f\sigma^2_{ikt}) \)

for \( i = \{10, 20, 30, 50, 60, 70, 80, 90\} \)
\( j = \{\text{Morrill, Holt, Wayne, Sherman, Butler, Hayes, Kearney, Saline}\} \)
\( k = \{\text{irrigated corn, dryland corn, irrigated soybeans, dryland soybeans, wheat}\} \)
\( t = \text{time period for production year 2011} \)

and \( E(fY_{ikt}) = E(cY_{jkt}) \)

where expected farm \( i \) yield for crop \( k \) in time period \( t \) is equal to the expected county \( j \) yield for crop \( k \) in time period \( t \)

and \( c\beta_{jkt} = 1 \)

where one represents the acreage weight of all yields in the county

To derive the estimated farm-level standard deviation \( f\sigma^2_{ikt} \) from insurance premiums for crop \( k \) in time period \( t \), a grid search was used to find the minimum absolute value between the average expected premium rate and expected loss.

where \( \text{Min}\left|fPR_{ikt} - \bar{cELC}_{jkt}\right| \)

for \( fPR_{ikt} \) = the average effective premium rate for 65% coverage crop yield insurance on farm \( i \) for crop \( k \) during time period \( t \)
\( \bar{cELC}_{jkt} \) = simulated expected loss cost given in county \( j \) for crop \( k \) in time period \( t \)
and \[ \overline{cELC}_{ikt} = \left\{ \frac{fP_{ikt}\left(fC_{ikt}E\left(fY_{ikt}\right) - \hat{Y}_{ikt}\right)}{fP_{ikt}fC_{ikt}E\left(fY_{ikt}\right)} \right\} \]

for \( fP_{ikt} = \) crop insurance price guarantee on farm \( i \) for crop \( k \) in time period \( t \)
\( fC_{ikt} = \) coverage level on farm \( i \) for crop \( k \) in time period \( t \)

The expected loss cost was derived by comparing the ratio of indemnities conditioned on the guarantee \( fP_{ikt} \) and \( fC_{ikt} \). After setting \( fC_{ikt} \) equal to 0.65, a standard deviation grid search between 10 to 60 in intervals of 2 for \( \hat{\sigma}_{ikt} \) was conducted and identified the value which minimized the difference between \( fPR_{ikt} \) and \( \overline{cELC}_{ikt} \).

The series of simulation equations created the variables necessary for evaluating different risk management strategies. Equations established in the model ensured proper relationships and correlations are observed between each aggregation level. Validation preformed on the model ensured the integrity of the simulation results.

### 3.2.5 Validation

To validate the simulation model, 500 stochastically simulated yield and price draws were used to verify the distribution against actual historical data. These iterations were produced using a randomized year instead of the fixed trend year of 2011 to allow for the comparison of actual and simulated sample means and variances. Evaluations of results were similar when using normalized distributions for prices and yields at different aggregation levels. Also, test statistics showed correlations between the model parameters were statistically significant. Validation verified the accuracy of relationships between different parameters to ultimately allow for evaluation of different risk management strategies across the representative farms.
3.3 Simulation Software

To analyze yield and price variables across different risk management strategies, each simulation must contain a sufficient number of draws from the underlying distribution to consistently express the variation present. Each alternative risk management strategy must carry the same variable distribution for each particular scenario. Comparing the effects stabilization strategies have on crop revenue requires efficient methodology to examine these values. Producers possessing different risk preferences require different methodologies to compare strategies. Incorporating these simulation and preference details is necessary to accurately assess different strategies.

3.3.1 SIMETAR

A model of the correlated equations is constructed and analyzed using the software package Simulation & Econometrics to Analyze Risk (SIMETAR) developed at Texas A&M University (Richardson, Schumann, & Feldman, 2008). As an add-on to the Microsoft Office 2010 Excel platform, distributions drawn in the program allow for each stochastic draw to maintain proper statistical relationships. Also, each random yield and price set can be used to analyze different risk management scenarios, allowing for comparison between the different approaches. Analysis tools incorporated in the simulation package have the ability to evaluate different alternatives given a range of risk preferences.

3.3.2 Procedure

Each analysis of the model utilizes 500 random draws from the yield and price distributions. To generate these yield and price sets, SIMETAR’s simulation engine
follows the Latin Hypercube iteration process. Under this methodology, each distribution being modeled must be stratified to cumulative probability scale from which each element has the likelihood of an equal draw. The Latin Hypercube’s main advantage over the other commonly utilized Monte Carlo technique is an accurate distribution of the cumulative probability scale, whereas the second methodology may over- or under-estimate a particular element of the distribution. Using 500 iterations under the Latin Hypercube simulation procedure allows for a draw to properly cover a representation of the moments within a set (Richardson, Schumann, & Feldman, 2004).

Each alternative risk management scenario is evaluated using the same yield and price set to compare and draw inferences from the strategies. Scenarios in SIMETAR allow for each exact moment in iteration to be repeated under a different revenue stabilization strategy. The analysis evaluates each alternative risk management strategy for the effect these tools have on stabilizing crop revenue given a producer’s risk preference. Tools incorporated in SIMETAR for the analysis of distributional outcomes include First Degree Stochastic Dominance (FSD), Second Degree Stochastic Dominance (SDS), Stochastic Dominance with Respect to a Function (SDRF), StopLight charts, and Stochastic Efficiency with Respect to a Function (SERF).

Base crop revenue without any revenue stabilization strategy serves as the standard for comparing the other eight risk management strategies. Using a constant risk aversion assumption with a decreasing relative risk preference, FSD and SDS rank Cumulative Distribution Functions (CDFs) drawn from the simulated revenue distributions and sorts these functions according to the probability of a certain level of income. The strategy which dominates in receiving the highest level of income serves as
the most ideal scenario, but may cross an opposing strategy for FSD and only once for SDS. A limitation of using this technique remains the assumption producers have a constant level of risk aversion, whereas individuals may have different preferences (Richardson, Klose, & Gray, 2000).

SDRF is similar to the SDS methodology, but allows for different risk aversion preferences. Based upon a producer’s wealth factor, a Risk Aversion Coefficient (RAC) allows for lower and upper parameters to evaluate the most efficient set based upon available alternatives. One limitation remains in that all pairwise correlation combinations must be run on the simulated distributions to determine the optimal scenario.

Another common method for ranking risky multiple scenarios involve StopLight charts. These images graphically display the probability over multiple scenarios the likelihood of favorable (green) results, unfavorable (red) results, and results between the two parameters (yellow). To establish the favorable and unfavorable criteria, values must be established to display the output in appropriate ranges. Interpretation of the charts show the alternative with the greatest amount of green and the least red region indicate the most preferred scenario (Richardson et al., 2000).

SERF has advantages over the shortcomings of SDS and SDRF, but still allows for different preferences involving RACs. Under this process a Certainty Equivalent (CE) must be calculated for RACs between an upper and lower value for the risk-to-wealth factor. Next, a graph of the analyzed data indicates over a range of risk-to-wealth factors which CE for a particular alternative is the greatest. The measurement between
two CE points represents the amount of wealth which will be forgone if the producer had to accept the next lower set given a particular RAC range (Richardson et al., 2000).

A combination of these techniques allows for the analysis of simulated crop revenue distributions and risk management strategies. Selecting the appropriate alternatives or scenarios remains essential for drawing the appropriate inferences on crop revenue risk management strategies at the individual farm or region level. Also, these procedures allow for concluding inferences on the performance of the risk management alternatives across the state.

3.4 Scenarios

Producers have multiple risk management tools available to stabilize and reduce declines in crop revenue from losses in yield or price. These programs or products base guarantees off benchmark parameters. Depending upon the assumptions for base yield and price values, resulting simulation distributions may have significantly different results. When determining the values for base simulation prices, the purpose and design of various government programs must be kept in mind. In addition to the base simulation parameters, specific scenarios need selection to limit the scope of modeling complexity and allow for solid inferences to be drawn across multiple farms. Interactions at the individual farm level lead to inferences on strategies and potential policy implications for risk management tool design.

3.4.1 Alternatives

Producers face decisions on revenue stabilization strategies involving government programs, crop insurance products, and marketing tools. Figure 3.4 documents the
individual components of each available for a particular decision level through the end of the 2012 production year. At the core of revenue stabilization, these programs or products base guarantees off crop yield, price, or revenue. Decision makers do not make selection of a particular option mutually exclusive from a subsequent option (Pennings et al., 2008). For a given price and yield base, a total of 36 different scenarios exist if all of the options listed below were analyzed.

**Figure 3.4 Crop Revenue Risk Management Diagram**

Assumptions made regarding the selection of scenarios limit key output variable analysis to allow for a cohesive examination among the representative farms. Summary statistics drawn from simulation results indicate the effects different set strategies have on crop revenue. The results also can provide insight on future research and policy implications for programs and products.
3.4.2 Scenario Assumptions

To analyze a feasible set of scenarios involving crop revenue risk management alternatives, assumptions must be made about the underlying logic implied in producer level decision making. Alternative crop revenue stabilization tools documented in Figure 3.4 show producers have to make choices regarding government programs, crop insurance products, and marketing strategy levels. Based upon Figure 3.4, simulation scenarios outlined in Table 3.3 display nine alternatives to evaluate for the eight representative sites across Nebraska. These scenarios serve as the basis for discussion involving specified risk management strategies for the following analysis, results, and conclusion discussion.

Scenarios 1-9 in Table 3.3 show the base comparison and alternative strategies involving three different groups of risk management tools. In control case of Scenario 1, the farmer does not participate in any government program or purchase any crop insurance product and all commodities are cash marketed at harvest-time. Next, Scenarios 2-5 and 6-9 group the scenarios according to whether a producer participates in the government options of DCP or ACRE. Producers participating in either of these options have a base guaranteed DP; rational producers will choose to participate in one of the two not considering any limits or costs of farm program participation. Separate from the guaranteed revenue, producers make assumptions about the performance of DCP versus ACRE in stabilizing systemic losses through either revenue or price guarantees. Evaluating whether a reduction in direct payments associated with participating in ACRE outweighs the potential crop revenue stabilization received under the newer program remains a fundamental question.
Table 3.3 Simulation Scenarios including Government Programs, Crop Insurance Products, and Marketing Strategies

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Abbreviations</th>
<th>Government Program</th>
<th>Crop Insurance</th>
<th>Marketing Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1</td>
<td>NP-NI-CM</td>
<td>No Program</td>
<td>No Insurance</td>
<td>Cash Market</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>DCP-RP-CM</td>
<td>DCP</td>
<td>RP 70%</td>
<td>Cash Market</td>
</tr>
<tr>
<td>Scenario 3</td>
<td>DCP-RP-FH</td>
<td>DCP</td>
<td>RP 70%</td>
<td>Futures Hedge</td>
</tr>
<tr>
<td>Scenario 4</td>
<td>DCP-YP-CM</td>
<td>DCP</td>
<td>YP 70%</td>
<td>Cash Market</td>
</tr>
<tr>
<td>Scenario 5</td>
<td>DCP-YP-FH</td>
<td>DCP</td>
<td>YP 70%</td>
<td>Futures Hedge</td>
</tr>
<tr>
<td>Scenario 6</td>
<td>ACRE-RP-CM</td>
<td>ACRE</td>
<td>RP 70%</td>
<td>Cash Market</td>
</tr>
<tr>
<td>Scenario 7</td>
<td>ACRE-RP-FH</td>
<td>ACRE</td>
<td>RP 70%</td>
<td>Futures Hedge</td>
</tr>
<tr>
<td>Scenario 8</td>
<td>ACRE-YP-CM</td>
<td>ACRE</td>
<td>YP 70%</td>
<td>Cash Market</td>
</tr>
<tr>
<td>Scenario 9</td>
<td>ACRE-YP-FH</td>
<td>ACRE</td>
<td>YP 70%</td>
<td>Futures Hedge</td>
</tr>
</tbody>
</table>

1 Government Program-Crop Insurance Product-Marketing Strategy

2 DCP = Direct and Counter-Cyclical Program
ACRE = Average Crop Revenue Election

3 RP 70% = Revenue Protection 70%
YP 70% = Yield Protection 70%

Noted with corresponding levels of coverage.

After government program selection, producers must decide upon a crop insurance product and level of coverage. Participation rates indicate the top three policies sold to grain and oilseed producers in Nebraska during the 2010 production year, in order, include RP, YP, and RP-HPE. When examining coverage levels for these products on insured cropland acres, coverage rates for 70% account for the largest percentage of RP and RP-HPE units underwritten in the state. Due to very low sales of RP-HPE, this particular product is excluded from the analysis (USDA Risk Management Agency, 2011b). After taking these factors into account, an appropriate pair of crop insurance products to evaluate includes RP and YP with a coverage rate of 70%.

Finally, marketing strategies encompass the third component in this analysis. Producers have the ability to use a cash marketing (CM), futures hedge (FH), or options...
strategy in marketing of grain. Setting price protection at different levels remains a process reflecting a producer’s cost of production, personal perception, and anticipation of future events. Also, placement of options remains subjective depending upon strike prices and premium values or costs for a particular commodity. CM or a FH are less complicated to place and carryout for simulation scenario design. These two alternatives remain feasible alternatives when attempting to evaluate the effects of basic marketing strategies.

Under the CM alternative, producers are assumed to sell the entire simulated production at the state MYA price. Common hedging practices limit the amount of grain marketed before harvest in a particular production year up to the crop insurance guarantee and therefore, placing a hedge involving 70% of the expected yield would fit within industry standards. Based upon this reasoning, the two marketing strategies for analysis include cash marketing all production or hedging 70% of expected yield equivalent at the 30-day planting-time average futures price for a particular commodity, lifting the hedge at harvest time, and subsequently selling the actual production at the state MYA price.

All scenarios use the same starting 2011 expected yield projections and planting-time price averages. Also, guarantees for government programs and crop insurance products are consistent with those available during the 2011 production year.
CHAPTER 4: RESULTS

Results from the stochastic simulation serve as the foundation of analysis and conclusions to draw recommendations for producers. Depending upon risk preferences and financial conditions, an individual’s preferred strategy may vary. Since attitudes and preferences vary amongst producers, one single methodology cannot represent the decision-making standard for everyone. The goal and scope of this analysis focuses on determining how the optimal choice varies across different evaluation standards. Indirectly, the level of variability expressed across different regions of the state may affect estimates of risk and the optimal strategy depending upon an individual producer’s location.

4.1 Overview of Analysis Methods

Multiple methods exist to examine stochastic financial simulations. Each approach has various advantages and disadvantages with corresponding assumptions utilized to analyze a particular scenario. The five procedures utilized in this analysis include: Expected Value (EV), Coefficient of Variation (CV), Stochastic Dominance (SD), StopLight charts, and SERF. Each section evaluates the various assumptions necessary to employ one of the five stochastic procedures. Based upon these parameters, each analysis highlights the optimal scenario for a given farm and implications on the selection of risk management strategies across the state.

4.2 Results

The following stochastic analysis follows the order of EV, CV, SD, StopLight charts, and SERF. Within each section the optimal choice will be highlighted in a table.
format along with a summary of each procedure in the conclusion. References in Appendices A through D provide additional results for each analysis from which a section’s condensed tables or figures are drawn.

4.2.1 Expected Value

An EV represents the mean under a specific statistical distribution given a set of probabilities for occurrences involving each specific event. When applied to one of the nine different simulation scenarios for a particular representative farm, an EV indicates the anticipated average gross farm revenue under a specific alternative for each farm. This mean is the average gross farm revenue over the 500 randomized draws where each event has the same statistical probability of occurring for a specific scenario. In the case of expected gross farm revenue, the highest EV represents the most desired outcome. Gross farm revenue in the following analysis refers to income adjusted for net crop insurance and marketing costs.

Table 4.1 Expected Gross Farm Revenue by Representative Farm under Simulation Scenarios

<table>
<thead>
<tr>
<th>Representative Farm</th>
<th>Risk Management Scenarios¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>District 10 Farm</td>
<td>$604,574</td>
</tr>
<tr>
<td>District 20 Farm</td>
<td>1,359,031</td>
</tr>
<tr>
<td>District 30 Farm</td>
<td>1,007,463</td>
</tr>
<tr>
<td>District 50 Farm</td>
<td>1,190,801</td>
</tr>
<tr>
<td>District 60 Farm</td>
<td>900,449</td>
</tr>
<tr>
<td>District 70 Farm</td>
<td>1,175,721</td>
</tr>
<tr>
<td>District 80 Farm</td>
<td>1,136,410</td>
</tr>
<tr>
<td>District 90 Farm</td>
<td>946,216</td>
</tr>
</tbody>
</table>

¹ Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

Statistics provided in Table 4.1 highlight the expected gross farm revenue for the eight representative farms in Nebraska under the nine alternative simulation scenarios.

The highest EV by representative farm includes: DCP-RP-CM for District 10,
DCP-YP-FH in Districts 20 and 50, and DCP-RP-FH in Districts 30, 60, 70, 80, and 90.

A basic conclusion from the EV analysis shows participating in any of the risk management strategies provides larger expected gross farm revenue than the base scenario of NP-NI-CM. Also, none of the four scenarios containing ACRE were preferred using the EV procedure.

Table 4.2 Expected Gross Farm Revenue per Acre by Representative Farm under Simulation Scenarios

<table>
<thead>
<tr>
<th>Representative Farm</th>
<th>Risk Management Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>District 10 Farm</td>
<td>$484.70</td>
</tr>
<tr>
<td>District 20 Farm</td>
<td>986.72</td>
</tr>
<tr>
<td>District 30 Farm</td>
<td>948.66</td>
</tr>
<tr>
<td>District 50 Farm</td>
<td>1,056.14</td>
</tr>
<tr>
<td>District 60 Farm</td>
<td>877.83</td>
</tr>
<tr>
<td>District 70 Farm</td>
<td>732.84</td>
</tr>
<tr>
<td>District 80 Farm</td>
<td>946.39</td>
</tr>
<tr>
<td>District 90 Farm</td>
<td>782.42</td>
</tr>
</tbody>
</table>

1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

Analyzing the expected gross farm revenue on a per acre basis in Table 4.2 provides the same results as given in Table 4.1. Per acre average revenue comes from the expected gross farm revenue divided by the total number of cropland acres per farm.

Evaluating per acre revenue shows how the anticipated revenue varies across the state due to cropping practices and productivity differences with expected revenue typically lower in the western, more arid regions of the state.

One limitation of the EV procedure is the inability to take into consideration the variability of gross farm revenue. Some producers may be more receptive to reducing revenue variability. The ability of producers to tolerate revenue losses may be subject to the level of variability in farm revenue when suffering yield or price declines. When analyzing gross farm revenue with a CV measurement, a level of variability may be defined for the set of risk management strategies.
4.2.2 Coefficient of Variation

The CV measures the proportion of the standard deviation to the mean for a set of data. A standard deviation measures the dispersion of a set of data from the mean. When interpreting the CV over a set of scenarios, the smallest percentage value indicates the distribution with the least variation relative to the mean. Producers seeking the lowest revenue variability relative to the mean across the set of scenarios would choose the outcome with the lowest CV value. The lowest CV measurement may or may not have the highest expected value.

Table 4.3 Expected Gross Farm Revenue (GFR) and Coefficient of Variation (CV) by Representative Farm under Simulation Scenarios

<table>
<thead>
<tr>
<th>Representative Farm</th>
<th>Risk Management Scenarios1</th>
<th>Variable2</th>
</tr>
</thead>
<tbody>
<tr>
<td>District 20 Farm</td>
<td>GFR ($) 1,359,031 1,401,590 1,411,524 1,402,079 1,412,012 1,405,182 1,405,736 1,405,670</td>
<td>CV (%) 21.90 19.11 17.50 19.44 17.81 19.19 17.89 20.74</td>
</tr>
<tr>
<td>District 30 Farm</td>
<td>GFR ($) 1,007,463 1,032,497 1,036,303 1,031,480 1,035,286 1,028,682 1,027,665 1,031,472</td>
<td>CV (%) 17.50 15.96 14.38 16.21 14.59 15.90 14.22 16.98</td>
</tr>
<tr>
<td>District 50 Farm</td>
<td>GFR ($) 1,190,801 1,229,695 1,239,896 1,229,884 1,240,086 1,224,142 1,223,343 1,224,353</td>
<td>CV (%) 22.47 17.94 16.00 14.22 17.67 13.40 18.44 13.87</td>
</tr>
<tr>
<td>District 60 Farm</td>
<td>GFR ($) 900,449 935,833 939,096 933,758 937,022 931,515 929,441 932,704</td>
<td>CV (%) 17.31 14.81 13.26 15.23 13.58 14.87 13.31 15.30 13.63</td>
</tr>
<tr>
<td>District 70 Farm</td>
<td>GFR ($) 1,175,721 1,232,241 1,238,018 1,230,367 1,236,144 1,225,559 1,231,336 1,223,685 1,229,462</td>
<td>CV (%) 21.75 17.22 16.82 18.31 17.32 17.82 16.91 18.41 17.42</td>
</tr>
<tr>
<td>District 80 Farm</td>
<td>GFR ($) 1,156,410 1,172,856 1,177,524 1,172,099 1,176,767 1,167,120 1,171,788 1,166,364 1,171,032</td>
<td>CV (%) 16.76 14.83 13.47 15.15 13.73 14.90 13.53 15.22 13.79</td>
</tr>
<tr>
<td>District 90 Farm</td>
<td>GFR ($) 946,216 988,838 991,511 986,875 989,548 984,143 986,817 992,180 984,854</td>
<td>CV (%) 18.11 15.22 14.10 15.54 14.35 15.29 14.16 15.60 14.41</td>
</tr>
</tbody>
</table>

1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.
2 GFR = Expected Gross Farm Revenue
CV = Coefficient of Variation

CV values for the eight representative farms under the nine different simulation scenarios are displayed in Table 4.3. Further detail on the minimums, maximums, and standard deviations of the revenue distributions may be viewed in Table A.1 of Appendix A. Analysis of Table 4.3 shows the lowest CV for all representative farms as
DCP-RP-FH. This is counter to the EV analysis for some districts, where the most optimal outcomes for representative farms were DCP-RP-CM in District 10 and DCP-YP-FH in District 20 and 50. EV for these farms and scenarios have higher monetary values, but also have higher CV. In comparison to gross farm revenue, the differences are relatively small, but show a fundamental difference in the two procedures.

Reducing revenue variability versus seeking the highest expected value introduces probability in forming confidence intervals of revenue distributions. Having the lowest coefficient of variation in one of the nine scenarios shows the operation may have the least variability, but may limit beneficial movements in commodity price with a futures hedge. For certain operations, the least variability in gross farm revenue may be the most desired. Coupling distributional probabilities with expected values presents another manner in which to analyze the nine scenarios. SD represents the methodology to evaluate the probability and expected value of a distribution under a given risk preference which overcomes the limitations of EV and CV.

4.2.3 Stochastic Dominance

Analysis tools included under the SD category include FSD, SDS, and SDRF. In the FSD methodology the basic assumption is that the risk taker prefers more money to less (Richardson & Outlaw, 2008). When related to probability theory, this concept implies a scenario with the highest likelihood to occur when the scenarios are ranked on a CDF chart.
Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

Figure 4.1 Gross Farm Revenue Cumulative Distribution Function (CDF) Approximations in District 70 for Alternative Scenarios

1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.
As an example CDF chart, Figure 4.1 displays the nine simulation scenarios for the representative farm in District 70 with the corresponding statistical probability and ranking of each alternative. Refer to Appendix B containing Figures B.1 through B.8 for the CDF charts involving all eight representative farms. An approximation for the probability of receiving a certain level of gross farm revenue or less under a given scenario may be identified by locating dollar value on the x-axis, tracing vertically up to the appropriate CDF curve, and then following horizontally over to the corresponding probability on the y-axis. FSD shows the most preferred scenario as the alternative furthest to the right on CDF chart, which has the largest probability of obtaining the greatest level of farm revenue.

Analysis of Figures B.1 through B.8 in Appendix B shows a similar pattern to the CDF of Figure 4.1. In all of the CDFs, the ability to identify one scenario FSD to the other alternatives is not possible. FSD requires all elements of a particular scenario to not overlap an opposing alternative when graphed on a CDF chart. Clearly overlap occurs for the nine alternative risk management scenarios. One interesting point to note regarding the CDF charts involves the NP-NI-CM scenario which does not utilize an active crop insurance product or government program. The horizontal distance between the NP-NI-CM scenarios and the opposing scenarios may be attributed to DPs and subsidized crop yield or revenue insurance.

FSD does not provide an optimal recommendation for the representative farms because of the overlaps in the gross farm revenue CDFs involving the nine alternative scenarios. SDS methodology overcomes the limitations of FSD, but requires two major assumptions. First, the technique assumes the decision-maker has constant absolute risk
aversion with decreasing preferences for more risky alternatives. Secondly, this process disregards a decision-maker’s utility function. Also, SDS has to rank all of the possible pairs of risk management scenarios which may result in an analyzed set with more than one optimal outcome (Richardson & Outlaw, 2008).

The third stochastic dominance procedure relevant to analysis of CDF charts incorporates utility. SDRF couples SDS with utility by introducing constant RACs. Lower and upper RAC values are set according to an individual’s risk preference. Problems with this process occur when the decision-maker has preferences which are different for the lower and upper RAC values, as more than one optimal outcome may exist in a set of alternatives. Similar to SDS, all pairwise correlations of the simulation scenarios must be analyzed and could result in an efficient set being very small (Richardson & Outlaw, 2008). Due to these issues, SDS and SDRF do not provide clear abilities to analyze the nine different risk management scenarios.

CDF charts display the probability of ascertaining a certain level of revenue under a particular simulation scenario. Without a concise stochastic dominance methodology to rank these approaches, the shortcomings of EV and CV analysis still present problems. The StopLight procedure provides an approach not limited by the issues of SD, yet still represents the probability of achieving a defined level of revenue and allows the analysis to take into consideration different risk preferences.

4.2.4 StopLight Charts

StopLight charts measure the probability of favorable and unfavorable events given critical cut-off values. These limits are placed according to the decision-maker’s preference in financial simulations; the values represent the probability of achieving a
certain level of revenue or income. An appropriate parameter for many revenue purposes relates to the ability to cover different types of expenses. Based upon the probability of reaching these levels of income an optimal strategy may be identified depending upon the decision-maker’s risk preference.

The probabilities of achieving benchmark parameters in a StopLight chart correspond to red (unfavorable), yellow (cautionary), and green (favorable) events in a bar chart format. Unfavorable events represent the likelihood of falling below the lower cut-off value. Next, cautionary developments show the probability of an outcome occurring between the lower and upper cut-off value. Finally, the favorable events happen when the simulation draw exceeds the upper cut-off value (Outlaw and Richardson, 2008). Depending upon the critical lower and upper cut-off values used in the analysis, the probabilities may change significantly.

In general, for risk-averse individuals, the most preferred alternative appears as the scenario containing the least red (unfavorable) and most green (favorable). Using this methodology to select the optimal outcome is consistent with utility theory. Individuals are assumed to gain more satisfaction from more revenue compared to less and more satisfaction from higher probabilities of achieving critical levels of revenue (Richardson & Outlaw, 2008). StopLight charts combine probability and risk preferences in a manner which overcomes the shortcomings of EV, CV, and SD techniques. For the purpose of analyzing the nine alternative risk management scenarios, a set of critical values and preferences are constructed from production estimates.

Approximations for variable and total crop production expenses come from USDA Economic Research Service (ERS) ARMS 2009-2010 Annual Cost and Return
Estimates for corn, soybeans, and wheat. These surveys group Nebraska crop producers into three different ARMS regions. The 2009-2010 analysis reports allowed for the estimation of variable and total economic costs on a percentage basis of per-acre crop production values. Variable costs include the operating costs of seed, fertilizer, chemicals, custom operations, fuel, lube, electricity, repairs, purchases of irrigation water, and interest on operating costs. Total costs include all variable costs in addition to hired labor, opportunity costs of unpaid labor, capital recovery of machinery and equipment, opportunity costs of land (rental rate), taxes and insurance, and general farm overhead (USDA Economic Research Service, 2012).

Next, expenses for the representative farms are estimated as a percentage of expected revenue under the NP-NI-CM scenario on a per acre basis according to the ARMS region in which these farms would be found. By multiplying these estimates by the corresponding number of acres by crop type, costs were summed for the entire operation. Approximations for these variable and total economic expenses provide critical cut-off values to gauge stochastic gross farm revenues.

As an example StopLight chart, Figure 4.2 displays the nine simulation scenarios for the representative farm in District 70 with lower and upper cut-off values of $699,198 and $1,131,710. Refer to Appendix C containing Figures C.1 through C.8 for the StopLight charts involving all eight representative farms. The lower and upper cut-off values represent estimated variable and total economic costs of production for the representative farm in District 70.
**Lower Cut-Off Value** 699,198  
**Upper Cut-Off Value** 1,131,710

<table>
<thead>
<tr>
<th>Scenario</th>
<th>P(U)</th>
<th>P(C)</th>
<th>P(F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NP-NI-CM</td>
<td>0.03</td>
<td>0.38</td>
<td>0.58</td>
</tr>
<tr>
<td>DCP-RP-CM</td>
<td>0.00</td>
<td>0.36</td>
<td>0.64</td>
</tr>
<tr>
<td>DCP-RP-FH</td>
<td>0.00</td>
<td>0.34</td>
<td>0.66</td>
</tr>
<tr>
<td>DCP-YP-CM</td>
<td>0.00</td>
<td>0.36</td>
<td>0.64</td>
</tr>
<tr>
<td>DCP-YP-FH</td>
<td>0.00</td>
<td>0.34</td>
<td>0.66</td>
</tr>
<tr>
<td>ACRE-RP-CM</td>
<td>0.00</td>
<td>0.38</td>
<td>0.62</td>
</tr>
<tr>
<td>ACRE-RP-FH</td>
<td>0.00</td>
<td>0.34</td>
<td>0.66</td>
</tr>
<tr>
<td>ACRE-YP-CM</td>
<td>0.00</td>
<td>0.37</td>
<td>0.63</td>
</tr>
<tr>
<td>ACRE-YP-FH</td>
<td>0.00</td>
<td>0.34</td>
<td>0.66</td>
</tr>
</tbody>
</table>

1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

2 $P(U) = $ Probability of Unfavorable Event  
   $P(C) = $ Probability of Cautionary Event  
   $P(F) = $ Probability of Favorable Event

**Figure 4.2 Gross Farm Revenue StopLight Chart in District 70 for Alternative Scenarios**
As an example scenario in Figure 4.2, NP-NI-CM shows the distribution of the simulated crop revenue distribution without participating in any government programs, crop insurance products, or marketing strategies. Under this scenario, only about a 3.0% probability exists of not being able to cover variable expenses and 41% is the probability of not meeting total costs. More interestingly, a 58.0% chance exists of exceeding estimated total costs. The remaining eight scenarios all exceed estimated variable costs and do not show any unfavorable (red) regions on the respective bars of the alternatives.

Assuming each operation has risk-averse preferences, the optimal scenario is the one which has the highest probability of exceeding total costs. In the event two scenarios have the same probability of exceeding total costs, the alternative having the higher expected value is identified as the optimal outcome. For the entire set of representative farms, DCP-RP-FH serves as the optimal outcome, except for District 50, where DCP-YP-FH provides the most desired outcome. The only difference between the two scenarios comes from the crop insurance selection of YP instead of RP in District 50.

For further detail on individual StopLight charts of the representative farms, refer to Appendix C containing Figures C.1 through C.8. Each chart in the Appendix C represents the StopLight analysis for each farm using estimated variable and total expenses for that farm as the lower and upper cut-off critical values. Table 4.4 provides a summary of these charts under the nine different simulation scenarios. Intervals shown in the table represent the likelihood of expected gross farm revenue exceeding total costs, greater than variable costs and less than total costs, and falling below variable costs. These levels represent the probability of favorable, cautionary, and unfavorable event depictions of the StopLight charts in Figures C.1 through C.8.
Table 4.4 Expected Gross Farm Revenue (GFR) and StopLight Chart Analysis
Summarizing Simulation Scenarios

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected GFR</td>
<td>$604,574</td>
<td>$644,894 $641,226 $643,533 $643,865 $640,024 $636,956 $639,283 $635,595</td>
</tr>
<tr>
<td>Prob(GFR &gt; TC)</td>
<td>31.8%</td>
<td>25.4% 23.2% 25.4% 23.4% 26.6% 24.0% 26.6% 24.4%</td>
</tr>
<tr>
<td>Prob(VC &lt; GFR ≤ TC)</td>
<td>1.8%</td>
<td>0% 0% 0% 0% 0% 0% 0% 0% 0%</td>
</tr>
<tr>
<td>Critical Values</td>
<td>Variable Costs (VC)</td>
<td>$249,543 Total Costs (TC) = $539,213</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected GFR</td>
<td>$1,359,031</td>
<td>$1,401,590 $1,411,524 $1,402,079 $1,412,012 $1,395,248 $1,405,182 $1,395,736 $1,405,670</td>
</tr>
<tr>
<td>Prob(GFR &gt; TC)</td>
<td>80.2%</td>
<td>86.6% 86.8% 86.0% 86.4% 84.6% 86.4% 85.2% 85.8%</td>
</tr>
<tr>
<td>Prob(VC &lt; GFR ≤ TC)</td>
<td>19.4%</td>
<td>13.4% 13.2% 14.0% 13.6% 15.4% 13.6% 14.8% 14.2%</td>
</tr>
<tr>
<td>Critical Values</td>
<td>Variable Costs (VC)</td>
<td>$533,515 Total Costs (TC) = $1,089,536</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected GFR</td>
<td>$1,007,463</td>
<td>$1,032,497 $1,036,303 $1,031,480 $1,035,286 $1,028,682 $1,032,488 $1,027,665 $1,031,472</td>
</tr>
<tr>
<td>Prob(GFR &gt; TC)</td>
<td>89.2%</td>
<td>93.8% 94.8% 93.0% 94.0% 93.4% 94.4% 92.6% 93.6%</td>
</tr>
<tr>
<td>Prob(VC &lt; GFR ≤ TC)</td>
<td>10.8%</td>
<td>6.2% 5.2% 7.0% 6.0% 6.6% 5.6% 7.4% 6.4%</td>
</tr>
<tr>
<td>Critical Values</td>
<td>Variable Costs (VC)</td>
<td>$352,428 Total Costs (TC) = $796,831</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Expected GFR</td>
<td>$1,190,801</td>
<td>$1,229,695 $1,239,896 $1,229,884 $1,240,086 $1,224,142 $1,234,343 $1,224,332 $1,234,533</td>
</tr>
<tr>
<td>Prob(GFR &gt; TC)</td>
<td>66.6%</td>
<td>70.0% 73.2% 70.0% 73.2% 69.4% 72.4% 69.4% 72.6%</td>
</tr>
<tr>
<td>Prob(VC &lt; GFR ≤ TC)</td>
<td>32.0%</td>
<td>30.0% 26.8% 30.0% 26.6% 27.6% 30.6% 27.4%</td>
</tr>
<tr>
<td>Critical Values</td>
<td>Variable Costs (VC)</td>
<td>$553,746 Total Costs (TC) = $1,078,379</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>District 60 Farm</th>
<th>StopLight Cut-Offs</th>
<th>NP-NL-CM DCP-RP-CM DCP-RP-FH YP-YM YP-YP-FH ACRE-YM ACRE-YP-FH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected GFR</td>
<td>$900,449</td>
<td>$935,833 $939,096 $933,758 $937,022 $931,515 $934,778 $939,441 $932,704</td>
</tr>
<tr>
<td>Prob(GFR &gt; TC)</td>
<td>88.4%</td>
<td>97.2% 98.2% 96.0% 97.8% 96.6% 98.2% 95.8% 98.0%</td>
</tr>
<tr>
<td>Prob(VC &lt; GFR ≤ TC)</td>
<td>11.6%</td>
<td>2.8% 1.8% 4.0% 2.2% 3.4% 1.8% 4.2% 2.0%</td>
</tr>
<tr>
<td>Critical Values</td>
<td>Variable Costs (VC)</td>
<td>$311,692 Total Costs (TC) = $711,338</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Expected GFR</td>
<td>$1,175,721</td>
<td>$1,232,241 $1,236,018 $1,236,144 $1,235,559 $1,231,336 $1,223,685 $1,229,442</td>
</tr>
<tr>
<td>Prob(GFR &gt; TC)</td>
<td>58.2%</td>
<td>63.6% 66.4% 63.6% 66.2% 62.2% 65.6% 62.6% 65.6%</td>
</tr>
<tr>
<td>Prob(VC &lt; GFR ≤ TC)</td>
<td>38.4%</td>
<td>36.4% 33.6% 36.4% 33.8% 37.8% 34.4% 37.4% 34.4%</td>
</tr>
<tr>
<td>Critical Values</td>
<td>Variable Costs (VC)</td>
<td>$699,198 Total Costs (TC) = $1,131,710</td>
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</table>

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<thead>
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<tbody>
<tr>
<td>Expected GFR</td>
<td>$1,341,410</td>
<td>$1,372,856 $1,377,524 $1,372,099 $1,375,677 $1,167,120 $1,171,788 $1,166,364 $1,171,032</td>
</tr>
<tr>
<td>Prob(GFR &gt; TC)</td>
<td>68.0%</td>
<td>74.0% 75.2% 74.2% 75.2% 72.6% 74.8% 72.8% 74.4%</td>
</tr>
<tr>
<td>Prob(VC &lt; GFR ≤ TC)</td>
<td>32.0%</td>
<td>26.0% 24.8% 25.8% 24.8% 27.4% 25.2% 27.2% 25.6%</td>
</tr>
<tr>
<td>Critical Values</td>
<td>Variable Costs (VC)</td>
<td>$562,166 Total Costs (TC) = $1,051,547</td>
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</table>

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected GFR</td>
<td>$948,216</td>
<td>$988,838 $991,511 $986,875 $989,548 $984,143 $986,817 $982,180 $984,854</td>
</tr>
<tr>
<td>Prob(GFR &gt; TC)</td>
<td>67.4%</td>
<td>80.4% 83.0% 79.8% 81.8% 79.6% 82.0% 78.4% 81.0%</td>
</tr>
<tr>
<td>Prob(VC &lt; GFR ≤ TC)</td>
<td>32.4%</td>
<td>19.6% 17.0% 20.2% 18.2% 20.4% 18.0% 21.6% 19.0%</td>
</tr>
<tr>
<td>Critical Values</td>
<td>Variable Costs (VC)</td>
<td>$408,343 Total Costs (TC) = $855,988</td>
</tr>
</tbody>
</table>

1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.
2 GFR = Gross Farm Revenue
VC = Variable Costs including estimated seed, fertilizer, chemicals, custom operations, fuel, lube, electricity, repairs, purchased irrigation water, and interests on operating capital expenses.
TC = Total Costs include variable and estimated hired labor, opportunity cost of unpaid labor, capital recovery of machinery and equipment, opportunity costs of land (rental rate), taxes, insurance, and general farm overhead expenses.
General observations show the probability of expected gross farm revenue falling below variable costs is negligible for 2011. Given starting yield and price scenario baselines, the amount of simulated gross crop revenue has an extremely low probability of not being able to cover variable costs. Risk management scenarios excluding the NP-NI-CM alternative show participating in one of these arrangements allows for guarantees to exceed all estimated variable costs for all eight representative farms.

Results vary considerably on the probability of these operations covering variable expenses, but not covering total costs. Several factors contribute to this result, including crop mix and production practices modeled for each representative farm. As an example, those representative farms with more irrigated acres and those located in the eastern portion of the state have less simulated negative revenue outcomes compared to those of the western panhandle. Similar results exist for the likelihood of exceeding total costs.

StopLight charts provide a stochastic analysis procedure which couples probability and expected outcomes together. Some shortcomings of previous analysis tools including EV, CV, and SD are overcome by the StopLight chart analysis. One assumption limiting the StopLight analysis comes from the constant risk aversion assumption. Being able to evaluate risk preferences over a range of different preferences and drawing references from these depictions is a fundamental goal of this analysis. Similar to SDRF, SERF allows for the ranking of multiple scenarios over different risk preferences given a defined level of wealth.

4.2.5 Stochastic Efficiency with Respect to a Function

SERF analyzes stochastic scenarios given a particular range of risk preferences and wealth. Unlike SDRF which requires a specified risk aversion level, SERF allows
for the ranking of multiple scenarios typically ranging from a neutral to extremely risk-averse range. Results can then be ranked according to the particular risk aversion class (Richardson & Outlaw, 2008). Also, across the general classes of preferences summaries may be drawn regarding the performance of the nine risk management scenarios.

The range of risk preferences ranked by the SERF analysis includes risk neutral and slightly, normally, moderately, and extremely risk averse. These classes either rank preferences in SERF according to RAC or Absolute Risk Aversion Coefficients (ARAC). The difference between the two coefficients involves the assumptions behind the levels of wealth. RAC ranks preferences according to a relative or generalized level, whereas ARAC accounts for the decision-maker’s level of wealth. In the case of the representative farms, the level of wealth (assets) is estimated for ARAC values to use in the SERF analysis.

Approximations for asset values on each of the eight representative farms come from the average asset turnover ratio in Nebraska. This ratio comes from the weighted summation of income and assets on farms with a gross farm income classification above $100,000 in the USDA ERS ARMS Farm Financial and Crop Production Practices: Farm Structure and Finance 2010-2011 data in Nebraska. These operations represent producers in all eight NASS-ASDs (USDA Economic Research Service, 2011). Dividing these two summed values equates to an average asset turnover rate of 25.23% in Nebraska during the 2010 production year. Income and asset values during the 2010 production year represent comparable economic forces as those expected in 2011 allowing for this value to serve as a comparable approximation.
Applying the average asset turnover ratio to each representative farm’s expected gross income under the NP-NI-CM scenario generates estimated asset values reflecting the size and scope of each operation. SERF analysis uses these estimates to establish a level of wealth in calculating the ARAC values. To generate the ARAC values, the constant relative RAC for each respective preference level was divided by the estimated wealth level for each individual farm. The constant relative RAC values include 0 for risk neutral and 0.5 for slightly, 1 for normally, 2 for moderately, and 4 for extremely risk averse.

Based upon the range of ARAC values, the SERF procedure ranks the Certainty Equivalents (CEs) for each scenario on the representative farm. A CE represents the sum of wealth necessary to achieve a particular level of utility under a negative exponential utility function. This equation takes into consideration a particular wealth and ARAC value when estimating the utility achieved under a particular risk preference (Richardson and Outlaw, 2008). The resulting SERF chart ranks each alternative risk management scenario under the range of specified ARAC values. For a given ARAC level, the most desired alternative is the one with highest CE value. The vertical difference between two particular lines on a SERF chart represents the level of wealth that would need to be added to the lower CE scenario to generate utility equal to the higher CE scenario.

As an example SERF chart, Figure 4.3 displays the nine alternative risk management scenarios under a negative exponential utility function with ARAC values ranging from 0 (risk neutral) to 0.0000009 (extremely risk averse) for the representative farm of District 70. Refer to Appendix D containing Figures D.1 through D.8 for the SERF charts involving each of the eight representative farms. Figure 4.3 shows the
DCP-RP-FH (light blue line) alternative ranks as the optimal strategy across all ARAC preferences. This scenario achieves the highest CE values under each ARAC position.

Next, the DCP-YP-FH scenario ranks second under this particular SERF analysis.

Scenarios do not rank the same across all risk preferences if one risk management CE equation crosses another risk management CE equation. As an example in Figure 4.3 when determining the third and fourth most desired outcomes, the utility function for the DCP-RP-CM and ACRE-RP-FH cross approximately half-way through the ARAC spectrum. For approximately the first half of the ARACs (less risk-averse) the DCP-RP-CM ranks as the third most preferred, but when ACRE-RP-FH crosses above this scenario the second alternative then has higher preferences (among more risk-averse ARACs). The ability of different utility functions to cross in a SERF chart highlights that a given optimal choice ranking is relative for a particular position on the ARAC spectrum. Analysis of how the optimal choice varies across the range of RAC values can still provide insight on the general performance of a particular scenario.
Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

Figure 4.3 Gross Farm Revenue Stochastic Efficiency with Respect to a Function (SERF) Analysis in District 70 for Alternative Scenarios

1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.
Table 4.5 summarizes the eight figures of D.1 through D.8 in Appendix D involving the SERF analyses of the eight representative farm simulation scenarios. Each summary ranks the nine risk management scenarios for a given risk preference and ARAC value. These rankings sorted the alternatives by assigning those with the highest CE the greatest preference. The optimal choice and ranking of the scenarios varies depending upon the preference and representative farm. CEs displayed with the negative exponential utility functions cross periodically in analysis. When drawing an overall summary of Table 4.5, a specific ARAC level must be defined or assumptions regarding the crossing inverse utility functions have to be taken into consideration to define the optimal set of strategies.

For individual risk preferences and associated ARAC levels, the SERF procedure appropriately identifies the dominant strategy for each alternative choice. Trying to rank the optimal strategy for each individual farm causes conflicting results due to crossing CE lines in District 20 and 50. Only three cases involving these two representative farms exist where the CE lines cross for the optimal choice. Assuming the most desired risk management choice is the alternative which has the most number-one rankings across the five ARAC levels in each farm analysis allows for identification of an optimal strategy.
Table 4.5 Representative Farms Stochastic Efficiency with Respect to a Function (SERF) Summaries for Alternative Scenarios

<table>
<thead>
<tr>
<th>District 10 Farm</th>
<th>Risk Management Scenarios</th>
<th>District 20 Farm</th>
<th>Risk Management Scenarios</th>
<th>District 30 Farm</th>
<th>Risk Management Scenarios</th>
<th>District 50 Farm</th>
<th>Risk Management Scenarios</th>
<th>District 60 Farm</th>
<th>Risk Management Scenarios</th>
<th>District 70 Farm</th>
<th>Risk Management Scenarios</th>
<th>District 80 Farm</th>
<th>Risk Management Scenarios</th>
<th>District 90 Farm</th>
<th>Risk Management Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Preference</td>
<td>ARAC&lt;sup&gt;2&lt;/sup&gt;</td>
<td>NP-NI-CM DCP-RP-CM DCP-RP-FH DCP-YP-CM DCP-YP-FH ACRE-RP-CM ACRE-RP-FH ACRE-YP-CM ACRE-YP-FH</td>
<td>Neutral</td>
<td>0.0000000</td>
<td>9</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>7</td>
<td>6</td>
<td>8</td>
<td>Neutral</td>
<td>0.0000000</td>
</tr>
<tr>
<td>Slightly</td>
<td>0.0000002</td>
<td>9</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>7</td>
<td>6</td>
<td>8</td>
<td>Slightly</td>
<td>0.0000001</td>
<td>9</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Normal</td>
<td>0.0000004</td>
<td>9</td>
<td>6</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>8</td>
<td>4</td>
<td>7</td>
<td>3</td>
<td>Normal</td>
<td>0.0000002</td>
<td>9</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Moderately</td>
<td>0.0000008</td>
<td>9</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>7</td>
<td>6</td>
<td>8</td>
<td>Moderately</td>
<td>0.0000004</td>
<td>9</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Extremely</td>
<td>0.0000017</td>
<td>9</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>7</td>
<td>6</td>
<td>8</td>
<td>Extremely</td>
<td>0.0000007</td>
<td>9</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Risk Preference</td>
<td>ARAC&lt;sup&gt;2&lt;/sup&gt;</td>
<td>NP-NI-CM DCP-RP-CM DCP-RP-FH DCP-YP-CM DCP-YP-FH ACRE-RP-CM ACRE-RP-FH ACRE-YP-CM ACRE-YP-FH</td>
<td>Neutral</td>
<td>0.0000000</td>
<td>9</td>
<td>6</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>8</td>
<td>4</td>
<td>7</td>
<td>3</td>
<td>Neutral</td>
<td>0.0000000</td>
</tr>
<tr>
<td>Slightly</td>
<td>0.0000001</td>
<td>9</td>
<td>6</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>8</td>
<td>4</td>
<td>7</td>
<td>3</td>
<td>Slightly</td>
<td>0.0000002</td>
<td>9</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Normal</td>
<td>0.0000002</td>
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<td>5</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>7</td>
<td>3</td>
<td>8</td>
<td>4</td>
<td>Normal</td>
<td>0.0000003</td>
<td>9</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Moderately</td>
<td>0.0000004</td>
<td>9</td>
<td>5</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>7</td>
<td>3</td>
<td>8</td>
<td>4</td>
<td>Moderately</td>
<td>0.0000006</td>
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<td>4</td>
<td>1</td>
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<tr>
<td>Extremely</td>
<td>0.0000008</td>
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<td>5</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>7</td>
<td>3</td>
<td>8</td>
<td>4</td>
<td>Extremely</td>
<td>0.0000011</td>
<td>9</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Risk Preference</td>
<td>ARAC&lt;sup&gt;2&lt;/sup&gt;</td>
<td>NP-NI-CM DCP-RP-CM DCP-RP-FH DCP-YP-CM DCP-YP-FH ACRE-RP-CM ACRE-RP-FH ACRE-YP-CM ACRE-YP-FH</td>
<td>Neutral</td>
<td>0.0000000</td>
<td>9</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>7</td>
<td>4</td>
<td>8</td>
<td>6</td>
<td>Neutral</td>
<td>0.0000000</td>
</tr>
<tr>
<td>Slightly</td>
<td>0.0000001</td>
<td>9</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>7</td>
<td>4</td>
<td>8</td>
<td>6</td>
<td>Slightly</td>
<td>0.0000002</td>
<td>9</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Normal</td>
<td>0.0000002</td>
<td>9</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>7</td>
<td>4</td>
<td>8</td>
<td>6</td>
<td>Normal</td>
<td>0.0000003</td>
<td>9</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Moderately</td>
<td>0.0000004</td>
<td>9</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>7</td>
<td>4</td>
<td>8</td>
<td>6</td>
<td>Moderately</td>
<td>0.0000005</td>
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<tr>
<td>Extremely</td>
<td>0.0000009</td>
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<td>2</td>
<td>7</td>
<td>4</td>
<td>8</td>
<td>6</td>
<td>Extremely</td>
<td>0.0000011</td>
<td>9</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.
2 ARAC = Absolute Risk Aversion Coefficient. Refer to Richardson and Outlaw (2009) for further discussion on ARAC.
Observations drawn from Table 4.5 with the given assumptions and limitations show the optimal choices include: DCP-RP-CM for District 10, DCP-YP-FH for District 20, and DCP-RP-FH for Districts 30 through 90. Once again not participating in any government programs, crop insurance products, or marketing strategies represented by the NP-NI-CM scenario provides the least desired alternative consistently across all preferences and outcomes. Ranking of alternatives between the most- and least-desired management scenarios shows mixed results.

Limitations and shortcomings posed by the EV, CV, SD, and StopLight analysis procedures are overcome with the SERF methodology given certain assumptions and limitations. SERF allows for the ranking of revenue distributions through the use of expected values, variability of revenue, and different risk preferences. One single methodology cannot provide the exclusive means to analyze simulation results without shortcomings. SERF provided the most effective procedure given the scope of the analysis, but drawing inferences from the previous four procedures is still valuable.

4.3 Summary of Results

Five different analysis procedures including EV, CV, SD, StopLight and SERF were used to analyze the nine different simulation scenarios across the eight representative farms. From the analysis, an optimal set of alternatives were identified under each procedure. SD techniques either provided inconsistent techniques or did not meet the needs of this analysis and their results are not included in the following summary. Table 4.6 and Figure 4.4 present the results from the four remaining procedures utilized.
4.3.1 Summary of Strategies

Table 4.6 presents the summary of the optimal scenarios involving the EV, CV, StopLight, and SERF analysis. The optimal strategy for each farm under each analysis procedure is denoted with the number one. Also, each scenario’s total is summed across the eight representative farms in each analysis. These totals are then displayed in Figure 4.4 as a bar chart depiction.

At the most basic analysis level in Table 4.6, the EV procedure’s optimal choice was the scenario producing the highest average expected gross farm revenue. Results showed the highest EV by scenario and representative farm included: DCP-RP-CM for District 10, DCP-YP-FH in Districts 20 and 50, and DCP-RP-FH in Districts 30, 60, 70, 80, and 90. These results indicated that the alternatives involving the DCP as the government program choice and RP as the crop insurance product had the greatest preference for the representative farms. Another element of risk farms are concerned about involves the variability of revenue, which the EV procedure does not take into consideration when analyzing the alternative scenarios.
Table 4.6 Summary of Preferred Stochastic Results for Representative Farms under Alternative Scenarios

<table>
<thead>
<tr>
<th>Expected Gross Farm Revenue (GFR)</th>
<th>Risk Management Scenarios ¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>District 10 Farm</td>
<td>1</td>
</tr>
<tr>
<td>District 20 Farm</td>
<td>1</td>
</tr>
<tr>
<td>District 30 Farm</td>
<td>1</td>
</tr>
<tr>
<td>District 50 Farm</td>
<td>1</td>
</tr>
<tr>
<td>District 60 Farm</td>
<td>1</td>
</tr>
<tr>
<td>District 70 Farm</td>
<td>1</td>
</tr>
<tr>
<td>District 80 Farm</td>
<td>1</td>
</tr>
<tr>
<td>District 90 Farm</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>0 1 5 0 2 0 0 0 0 0 0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Coefficient of Variation (CV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>District 10 Farm</td>
</tr>
<tr>
<td>District 20 Farm</td>
</tr>
<tr>
<td>District 30 Farm</td>
</tr>
<tr>
<td>District 50 Farm</td>
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<tr>
<td>District 60 Farm</td>
</tr>
<tr>
<td>District 70 Farm</td>
</tr>
<tr>
<td>District 80 Farm</td>
</tr>
<tr>
<td>District 90 Farm</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>StopLight Charts</th>
</tr>
</thead>
<tbody>
<tr>
<td>District 10 Farm</td>
</tr>
<tr>
<td>District 20 Farm</td>
</tr>
<tr>
<td>District 30 Farm</td>
</tr>
<tr>
<td>District 50 Farm</td>
</tr>
<tr>
<td>District 60 Farm</td>
</tr>
<tr>
<td>District 70 Farm</td>
</tr>
<tr>
<td>District 80 Farm</td>
</tr>
<tr>
<td>District 90 Farm</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stochastic Efficiency with Respects to a Function (SERF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>District 10 Farm</td>
</tr>
<tr>
<td>District 20 Farm</td>
</tr>
<tr>
<td>District 30 Farm</td>
</tr>
<tr>
<td>District 50 Farm</td>
</tr>
<tr>
<td>District 60 Farm</td>
</tr>
<tr>
<td>District 70 Farm</td>
</tr>
<tr>
<td>District 80 Farm</td>
</tr>
<tr>
<td>District 90 Farm</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

¹ Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

CV overcomes some of the limitations imposed by the EV analysis by combining the mean and standard deviation of gross farm revenue. With this evaluation process, the alternative showing the lowest CV provides the least relative revenue variability on a
farm. The DCP-RP-FH alternative proved to be the optimal scenario across all farms for the CV analysis as Table 4.6 summarizes. However the CV did not determine the optimal choice on all of the representative farms to necessarily have the highest EV. Under that analysis DCP-RP-CM in District 10 and DCP-YP-FH in Districts 20 and 50 provided the most desired results. These scenarios provided slightly higher anticipated averages under the set of alternatives available by $3,668 in District 10, $488 in District 20, and $190 in District 50. Although negligible in value when compared to the overall expected gross farm revenue, the results still present a fundamental difference between the two methodologies.

Solely relying on the highest EV or lowest CV does not take into consideration the probability of achieving a certain level of revenue. SD involves FSD, SDS, and SDRF that allows for the ranking of stochastic distributions under various probability levels and assumptions. Analysis of the CDF charts showed each representative farm’s revenue distribution under one scenario overlaps multiple times with another alternative, which eliminates the FSD and SDS methodologies from analyzing the revenue distributions. SDRF could analyze the various scenarios, but requires a predefined RAC level that only encompasses one particular risk aversion level.

Shortcomings introduced by EV, CV, or SD provided the motivation to consider other analysis procedures. StopLight charts introduced a methodology to evaluate the probability of achieving different levels of revenue involving a stochastic distribution. Critical cut-off values established under this process represented estimated variable and total crop production expenses. The optimal choice with this process involved the outcome with the highest probability of covering total crop production expenses. Table
4.6 indicates that the DCP-RP-FH served as the optimal strategy for all representative farms except District 10 where the preferred alternative was DCP-YP-FH. Although each individual can interpret each StopLight chart independently, the scope of the analysis seeks to rank different risk management scenarios for a variety of risk preferences.

Introduced as the final technique to analyze the nine stochastic scenarios, SERF allowed for the ranking of different alternatives and risk preferences. Each farm had a level of assets estimated to determine the ARACs necessary for the SERF analysis. Preferences established from the ARACs ranged from risk neutral to extremely risk averse. Under this procedure the optimal scenario was identified as the one with the highest rank across all of the preferences. Under the SERF analysis, optimum scenarios by the representative farms included: DCP-RP-CM for District 10, DCP-YP-FH in District 20 and DCP-RP-FH in Districts 30, 50, 60, 70, 80, and 90 as shown in Table 4.6.

4.3.2 Implications for Nebraska

Individual farm-level stochastic analysis results presented in Table 4.6 were compiled to draw overall summaries involving all of the procedures. From these results, the bar chart in Figure 4.4 presents the optimal strategies given the EV, CV, StopLight charts and SERF analysis. Definite trends may be observed from the overall performance of these programs across the set of representative farms.
Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

GFR = Expected Gross Farm Revenue, CV = Coefficient of Variation, StopLight = StopLight charts, and SERF = Stochastic Efficiency with Respect to a Function.

Figure 4.4 Bar Chart Depiction of Preferred Stochastic Results for Representative Farms under Alternative Scenarios

Overall, Figure 4.4 shows the DCP-RP-FH scenario provided the greatest number of optimal outcomes across the four different stochastic analysis procedures and across the eight representative farms. All representative farms were better off participating in a scenario involving a government program and crop insurance product instead of the NP-NI-CM alternative. One can ascertain from this result that participating in a government program and purchasing a crop insurance policy increases and stabilizes gross farm revenue to a degree. Several reasons may explain and suggest why
participating in the various risk management strategies provides greater protection to a representative farm’s revenue.

As part of the Farm Bill through the end of the 2012 crop production year, producers may choose to either participate in DCP or ACRE. Either of these programs have DPs, which distributes direct monetary payments based upon historical base acres and yields. DPs under ACRE are at a reduced rate, but in either case monetary payments received by the operations are a guaranteed source of income subject to FSA compliance requirements. Implications for crop producers are that participation in DCP or ACRE is beneficial to their gross farm revenue.

Another observation from Figure 4.4 shows participation in scenarios involving DCP are more desired over the ACRE alternative for the representative farms. The performance of these programs is influenced greatly by the yield and price distributions simulated in the model. Price and yield expectations during the 2011 production year are considerably higher than guarantees or price support levels established under the ACRE and DCPs. While ACRE had guarantees closer to price expectations of 2011 when compared to the DCP supports, the risk reduction effects gained with this program do not exceed the reduction in DPs. Recommendations drawn on this analysis regarding current government program options suggest the DCP program outperforms ACRE under current price and yield expectations and variability levels expressed in the representative farm model. Commodity programs provided through the USDA FSA beyond 2012 remain unknown, but serve as an area for future research.

Figure 4.4 shows that beside the most preferable scenario of DCP-RP-FH, the DCP-YP-FH and DCP-RP-CM alternatives are the second and third most desirable
outcomes but were far behind. Representative farms in Districts 30, 60, 70, 80, and 90 had results consistently picking the DCP-RP-FH scenario as the optimal outcome. The only difference for the representative farms in Districts 20 and 50 selecting the DCP-YP-FH scenario as the most preferred scenario relates to the crop insurance choice of RP versus YP in the risk management strategy. Also, the optimal outcome DCP-RP-CM for District 10 differs from the DCP-RP-FH by using a CM strategy instead of a FH. This summary shows that the representative farms in Districts 10, 20, and 50 act as the outliers in the analysis.

Differences between the expected gross farm revenue of the DCP-RP-FH scenario and optimal strategies identified in Districts 10, 20, and 50’s representative farms amount to $3,668, $488, and $190. In relative comparison to the expected gross farm revenue, these amounts are small and insignificant. Still, evaluating the difference in marketing strategies or crop insurance products provides some explanation. Underlying acreage distributions and yield expectations across the three farms lead to the differences in performance of these strategies.

NASS-ASDs 10, 20, and 50 lie in the western, north central, and central regions of Nebraska. The representative farm in District 10 has unique cropland acres in comparison to the other eight operations. Similar to other representative farms in size, District 10’s representative farm has approximately 30 and 70 percent of the cropland acres in corn and winter wheat respectively. District 20’s representative farm has a cropland acreage distribution of 65, 24, and 11 percent involving irrigated corn, irrigated soybeans, and dryland corn respectively. Also, the representative farm in District 50 follows a similar distribution where 71, 18, and 11 percent of the land is in irrigated corn,
irrigated soybeans, and dryland corn once again. The location of these representative farm districts and distribution of total cropland acres varies from the five other farms.

The representative farm in District 10 with a negative FH gain under the DCP-RP-FH scenario leads to stronger performance of CM with the DCP-RP-CM alternative. Evaluation of the base planting-time average futures price versus harvest-time average futures price shows on average the winter wheat contract ends higher for hard red winter wheat, but only slightly lower for corn. These differences show the futures hedge loss and gain for the two crops raised on the representative farm partially offset each other, but in net end up with a loss. Several reasons may lead to the notably higher average hard red winter wheat futures harvest price. Contract performance, liquidity, and the number of market participants may influence the historical price deviations and ultimately lead to the higher harvest-time prices.

Finally, YP under the DCP-YP-FH strategy outperforms RP in the DCP-RP-FH alternative on the representative farms in Districts 20 and 50. In each case either representative farm has about 90% of the total cropland acres irrigated. Assuming the crop insurance premium rates are actuarially fair, representative farms should prefer the RP crop insurance policy due to the rate of government subsidization and methodology used to calibrate farm-level yield variability.

RP and YP crop insurance have subsidization rates at levels greater than 50 percent of the policy. Assuming farm-level yield deviations are calibrated appropriately, producers should choose the product providing the greatest level of protection being RP. YP only provides protection to yield losses, whereas RP covers both yield and price risk which encompasses both systemic and idiosyncratic elements. The relatively small
differences in expected revenue between the two scenarios show a producer would be just about as well off to participate in the DCP-RP-FH. Also, since both farms encompass predominately irrigated practices, this leads to lower yield risk, but little protection from systemic price shocks. A risk-averse operation would prefer the greater level of protection with the DCP-RP-FH instead of the DCP-YP-FH.

In summary, the DCP-RP-FH strategy serves as the dominant strategy across the majority of representative farms given price and yield expectations of 2011. Simulation procedures utilized to evaluate the results included: EV, CV, SD, StopLight, and SERF. These procedures did show that the optimal strategy did not carry through to all of the procedures for representative farms in Districts 10, 20, and 50. Differences were negligible in comparison to overall farm revenue. Unique yield and price parameters of these farms may have led to the differences.
CHAPTER 5: CONCLUSION AND IMPLICATIONS

Summaries drawn from the stochastic simulation assist producers with decision making involving crop production across Nebraska. As risk management tools progress over time, so will the strategies employed by producers. This progression creates the need for further research. The scope of this analysis focused on evaluating risk management strategies encompassing government programs, crop insurance products, and marketing strategies for the 2011 production year.

5.1 Conclusions and Implications

The following section summarizes major contributions and results found by the research proceedings. Initial motivations (Chapter 1) focused the direction of the literature review (Chapter 2). These references provided the foundation to design the correlated model for simulating alternative risk management strategies (Chapter 3). Analysis procedures involving EV, CV, SD, StopLight charts, and SERF allowed for ranking of the stochastic results (Chapter 4) across different representative farms to obtain conclusions regarding the performance of these strategies. Implications may be drawn for producer-level decision making across Nebraska. Although focused to a specific set of tools and yield and price expectations related to the 2011 production year, results provide insight on risk management strategies and decision making. The results also suggest areas for future research and policy discussions.

5.1.1 Motivation and Objectives

As a leader in the agricultural industry, farmers in Nebraska face unique farm-specific (idiosyncratic) and wide-spread (systemic) risk elements influencing crop yields
and correlated prices. Also, Chapter 1 identified relevant government programs, crop insurance products, and marketing strategies available to producers to deal with adverse declines in crop revenue. Combining underlying risk elements with available management tools provided the motivation for the research. The goal and scope of the analysis was to design a correlated model which would represent the scale and diversity of crop producers across the state and stochastically simulate crop revenue distributions with related programs or products. From the set of risk management strategies and representative farms depicted in the model, conclusions were drawn regarding the performance of these programs across regions of different variability in Nebraska.

5.1.2 Review of Literature and Model

To accomplish the report’s objectives, literature reviewed in Chapter 2 provided insight on risk management tools available for crop production along with direction on previous research involving farm-level modeling in Nebraska. Risk management tools fall into the classification of government programs, crop insurance products, or marketing strategies. The 2008 Farm Bill reauthorized traditional income support programs like ML, DP, and CCP tied to price. ACRE was also introduced in the 2008 legislation and ties support to crop revenue guarantees. At the producer level, operations must decide whether to participate in CCP or ACRE, but receive a reduced DP rate when selecting ACRE.

Crop insurance administered by the USDA-RMA includes YP, RP, and RP-HPE. These programs base guarantees off either yield or revenue involving an APH yield and planting- or harvest-time average futures prices. A variety of marketing strategies exist by using futures or option contracts traded on public exchanges for protection against
declines in commodity prices. At the most basic level hedging with futures or options are feasible alternatives to cash marketing for producers. The interactions of the various tools are not mutually exclusive as literature cites the scope of protection that guards against price, revenue, or production risk at the farm, area, or national level.

A review of previous studies shows substantial evaluation of individual components of the risk management portfolio at the producer level, but not an evaluation of a cohesive combination of the tools. These studies did however provide insight on the performance and shortcomings of each individual tool across a variety of production conditions. One conclusion apparent from the research shows models used to evaluate the tools have not focused on farm-level decision-making across Nebraska. These models, either at a sector or farm level, established a baseline from which to build the representative farm model of Nebraska agriculture.

To design the representative farm model of Nebraska crop production, various yield and price parameters were necessary to simulate risk management tools and determine revenue distributions. Chapter 3 reviewed the differences in size, cropping pattern, and productivity factors across different regions of Nebraska. Differences in cropping practices across Nebraska correlate well with acreage and yield data of the NASS-ASDs. These regions subdivide Nebraska’s 93 counties into eight areas. Based upon the scope of the analysis, one representative farm was formulated for each NASS-ASD where the size, cropping patterns, irrigation practices, and yield history reflect the average attributes of those found across counties lying in the region.

Yields simulated in the model included those at the national, state, district, county, and farm level. Also, simulated prices reflect the deviation between the planting-
and harvest-time average futures price. To adjust for national or state MYA cash prices, a fixed basis was added to the simulated harvest-time prices. Prices and yields in the model were correlated. Using time-adjusted deviations from trend for key variables, the system of equations allowed for observed correlations to be maintained and modeled directly.

A correlation matrix involving national- and state-level variables served as the base for the simulation. DAG procedures were used to analyze district yield deviations and regress yields off relevant state and district yields by cropping practice. County yields were directly regressed off the simulated district yields. Finally, a stochastic component using Miranda’s formula was added to the county yields to reflect average farm-level variability expressed in the representative county for each NASS-ASD. Through the base correlation matrix and series of regression equations, the representative farm model carried correlations through each level of aggregation.

5.1.3 Summary of Strategies and Results

Previous literature reviewed in Chapter 2 identified the set of risk tools relevant to producers across Nebraska. Besides introducing the simulation procedure, Chapter 3 summarized the formation of the different strategies utilized in the different scenarios of the model. The first scenario acts as the base strategy where each representative farm cash markets all grains produced at the simulated MYA price and does not participate in farm programs or crop insurance. Four of the remaining scenarios utilized DCP while the other four selected ACRE as the government program choice. Logically producers will participate in one of these two programs since these tools do not cost anything (not
counting program limits or participation costs) and provide guaranteed revenue through the DP.

Historical data showed two of the most popular crop insurance choices included RP and YP at the seventy-percent protection level. Also, when coupling a novel hedge with crop insurance producers typically do not pre-price more than the APH guarantee. Combining the crop insurance and marketing strategies with the two government program choices led to a total of eight risk management strategies along with the base alternative not utilizing any of the various tools. Table 3.3 summarized these nine scenarios. After the formulation of these strategies, each scenario was simulated 500 times with the same yield and price draws.

Chapter 4 analyzed these results with the EV, CV, SD, StopLight, and SERF procedures. Each procedure had various advantages and disadvantages. At the most the basic level the EV showed DCP-RP-CM was the optimal strategy for the representative farm in District 10, DCP-YP-FH in Districts 20 and 50, and DCP-RP-FH in Districts 30, 60, 70, 80, and 90. One shortcoming of the EV technique was the inability to analyze the variability of the crop revenue. CV took into consideration the variability of crop revenue in the analysis. The CV technique found the DCP-RP-FH alternative was the optimal choice across all representative farms for an operation seeking the lowest level of relative variability in crop revenue.

Review of the CDF charts of each representative farm found that the SD would not provide consistent results or improve upon the EV or CV techniques. Also, CDF charts showed most of the revenue distributions had a significant amount of overlap. StopLight charts improved on CV by taking into consideration not only the variability of
the representative farms’ revenue, but also the probability of achieving a certain level of revenue. These levels can relate to producer risk preferences.

Benchmarks estimated with StopLight charts relate to the probability of being able to cover estimated variable and total costs related to crop production. The optimal choice under this technique was the strategy which had the highest probability of covering total estimated expenses. All of the representative farms except for District 50 had DCP-RP-FH as the optimal strategy. Once again, DCP-YP-FH was the most preferred scenario for the representative farm in district 50. Besides the EV procedure assuming a risk-neutral producer attitude, all of the previous techniques assumed risk-averse preferences when determining the optimal strategy.

SERF introduced the methodology to rank the performance of the risk management strategy across a variety of risk preferences ranging from neutral to extremely risk-averse. Ranking the procedures to determine the optimal outcome showed DCP-RP-FH was the preferred alternative for the representative farms in most districts. In Districts 10 and 20, DCP-RP-CM and DCP-YP-FH were the optimal strategies respectfully. Definite trends developed regarding the performance of the nine alternatives as the DCP-RP-FH alternative served as the most common choice, although outlier cases did exist.

5.1.4 Implications for Producers on Management Decisions

Simulated risk management strategies reflected the alternatives available during the 2011 production year. Yield and price expectations along with tools available in the future will change. However, these results do provide insight for the upcoming production years and producer decision making. Overall, except for the representative
farms in Districts 10, 20, and 50, the optimal scenario was DCP-RP-FH. The results in these three districts are not consistent with the overall set, but producers in these areas would still choose participation in a government program involving DCP over ACRE.

Implications for Nebraska crop producers point to participation in DCP, RP, and FH as carrying the greatest benefits for reducing negative crop revenue variability. Regions in the western and central portions of Nebraska have unique yield and crop rotation attributes that may influence the performance of these various tools. DCP outperforms ACRE due to current price and yield levels in comparison to program support levels. Both programs would trigger support payments far below current expected price and yield levels. While support payments are not expected, the guaranteed DP with DCP are higher than those under ACRE. Also, assuming crop insurance rates are actuarially fair, producers should consider purchasing these products due to current subsidy levels. Finally, FH versus only CM of the crop shows farm-level crop revenue experiences less variability by using futures. This may also lead to producers experiencing margin calls in rapid upswings of prices.

5.2 Areas of Future Research

Simulation results reflected the relevant combinations of government programs, crop insurance products, and marketing strategies available during the 2011 production year with correlated yield and price expectations. These three broad categories will likely remain relevant to risk management strategies utilized by producers across Nebraska in the future. Individual tools within these categories will probably evolve and progress over time to satisfy economic and production conditions of the period. Future research
should focus on improving the performance of these products to better aid producers in dealing with declines in crop revenue.

5.2.1 Future Production Years

Each production year, the set of risk management strategies should be reformulated to reflect available tools and simulated under current yield and price expectations. The base yield and price parameters of each production year’s simulation may have a significant influence on the performance of various strategies. Identifying these unique production attributes will be important for future producers in certain regions of the state to make good decisions. Also, expanding the number of representative farms across Nebraska in the model would provide additional value to producers with more operations available for comparison.

Creating a producer-based decision interface which links to the representative farm model could aid producers in evaluating their individual risk management strategies. An interface that allows producers to input historical yields, parameters necessary for the various tools, and risk management strategies could be linked with the correlated model and produce simulation results reflecting actual farms. Also, that process would carry through the respective correlations previously identified at larger yield or price aggregation levels to the individual producer’s operation.

5.2.2 2012 Farm Bill Proposals and Beyond

Government farm program choices involving ACRE and DCP will only remain available through the 2012 production year. Different interest groups and commodity organizations have proposed various farm program alternatives during the national debt
resolution debate of 2011 and the development of the 2012 Farm Bill. Many of these program proposals would create a crop revenue safety net similar to ACRE, but without any DP or a state-wide trigger. Some other proposals would still utilize a price support guarantee (Shields & Schnepf, 2011). In either case, the design of the representative farm model can easily allow for the evaluation of these various revenue or price safety net proposals. Simulation results provide insight on the design and resulting performance of government programs.

5.2.3 Future Crop Insurance Policies

The role of crop insurance across Nebraska has evolved over time with the rise in commodity prices and increase in expected yields. Also, depending upon the design of future farm programs, the relevance of crop insurance may increase even more. Within each crop insurance policy are various levels of coverage. Evaluating different strategies involving different levels of coverage may identify better combinations of the various tools. Refinements to these products will also likely develop in the future. As a pilot program during the 2012 production year, producers have the option to trend adjust their APH yields due to an average increase in the productivity of the major crops (USDA Risk Management Agency, 2011c). This pilot program serves as an example of another relevant study to perform and analyze across the set of representative farms.

5.2.4 Marketing Decisions

A multitude of marketing strategies exist involving futures, options, forward contracts, and cash sales. Opportunities exist to study various combinations across the set of representative farms and interactions with other programs or products.
Understanding the motivation behind the placement and timing of marketing strategies poses another interesting question. Also, developing a price set to reflect basis specific to a certain region of Nebraska during different periods of the marketing season would add further insight on marketing decisions across the state.

5.3 Summary

Variability and productivity factors of Nebraska lead to unique farm-specific as well as wide-spread risk elements. Risk management tools available to producers include government programs, crop insurance products, and marketing strategies. Previous research did not completely define, combine, and simulate an appropriate set of risk management strategies relevant to different regions of Nebraska. Results from this research of defined risk management strategies show selecting DCP as the government program choice, with a 70% RP crop insurance policy, and hedging 70% of the expected production provides the greatest benefit for the majority representative farms during the 2011 production year.

Results from the simulation provide direction for future research. Increasing the number of representative farms in the model or creating a user-based interface would allow producers to base decisions off more specific simulation results. Proposals for farm programs beyond 2012 should be evaluated on the representative farm model to provide direction with policy development. Pilot crop insurance programs may be another area to evaluate along with a multitude of marketing strategies. All three of these risk management tools provide areas for further evaluation as policy and economic conditions evolve.
REFERENCES


Economics, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln.


Nebraska Department of Agriculture. (2011, February). *Nebraska Agriculture Fact Card*. Retrieved September 8, 2011, from Nebraska Department of Agriculture:

http://www.agr.ne.gov/facts.pdf


Meeting. Corpus Christi, TX: Department of Agricultural Economics, Louisiana State University.


http://www.ers.usda.gov/Data/CostsAndReturns/testpick.htm


Agriculture Farm Service Agency:


### APPENDICES

**Appendix A Reference Tables**

#### Table A.1 Representative Farm Simulation Summary Statistics for Alternative Scenarios

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1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.
1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

Figure B.1 Gross Farm Revenue Cumulative Distribution Function (CDF) Approximations in District 10 for Alternative Scenarios

\[^1\]
Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

Figure B.2 Gross Farm Revenue Cumulative Distribution Function (CDF) Approximations in District 20 for Alternative Scenarios

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1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.
Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

Figure B.3 Gross Farm Revenue Cumulative Distribution Function (CDF) Approximations in District 30 for Alternative Scenarios

1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.
Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

Figure B.4 Gross Farm Revenue Cumulative Distribution Function (CDF) Approximations in District 50 for Alternative Scenarios

1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.
Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

**Figure B.5** Gross Farm Revenue Cumulative Distribution Function (CDF) Approximations in District 60 for Alternative Scenarios

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1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.
Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

Figure B.6 Gross Farm Revenue Cumulative Distribution Function (CDF) Approximations in District 70 for Alternative Scenarios

1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.
Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

Figure B.7 Gross Farm Revenue Cumulative Distribution Function (CDF) Approximations in District 80 for Alternative Scenarios

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1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.
Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

Figure B.8 Gross Farm Revenue Cumulative Distribution Function (CDF) Approximations in District 90 for Alternative Scenarios\(^1\)
Appendix C Stoplight Charts

Figure C.1 Gross Farm Revenue StopLight Chart in District 10 for Alternative Scenarios

1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

2 $P(U)$ = Probability of Unfavorable Event
$P(C)$ = Probability of Cautionary Event
$P(F)$ = Probability of Favorable Event
Figure C.2 Gross Farm Revenue StopLight Chart in District 20 for Alternative Scenarios

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1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

2 \( P(U) \) = Probability of Unfavorable Event
\( P(C) \) = Probability of Cautionary Event
\( P(F) \) = Probability of Favorable Event
Table 3.3 shows the probabilities of various events for different scenarios. The table includes the following scenarios:

- **NP-NI-CM**
- **DCP-RP-CM**
- **DCP-RP-FH**
- **DCP-YP-CM**
- **DCP-YP-FH**
- **ACRE-RP-CM**
- **ACRE-RP-FH**
- **ACRE-YP-CM**
- **ACRE-YP-FH**

The lower cut-off value is 352,428, and the upper cut-off value is 796,831. The probabilities of various events are as follows:

- **P(U)** (Probability of Unfavorable Event) for each scenario is 0.00.
- **P(C)** (Probability of Cautionary Event) is 0.11 for some scenarios, 0.06 for others.
- **P(F)** (Probability of Favorable Event) is 0.89 for some scenarios, 0.94 for others.

Figure C.3 Gross Farm Revenue StopLight Chart in District 30 for Alternative Scenarios

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1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

2 $P(U)$ = Probability of Unfavorable Event

$P(C)$ = Probability of Cautionary Event

$P(F)$ = Probability of Favorable Event
Figure C.4 Gross Farm Revenue StopLight Chart in District 50 for Alternative Scenarios

1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

2 P(U) = Probability of Unfavorable Event
   P(C) = Probability of Cautionary Event
   P(F) = Probability of Favorable Event
**Figure C.5 Gross Farm Revenue StopLight Chart in District 60 for Alternative Scenarios**

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<td>0.00</td>
<td>0.02</td>
<td>0.98</td>
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1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

2 \( P(U) \) = Probability of Unfavorable Event

\( P(C) \) = Probability of Cautionary Event

\( P(F) \) = Probability of Favorable Event

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**Notes:**

- Lower Cut-Off Value: 311,692
- Upper Cut-Off Value: 711,338
Lower Cut-Off Value 699,198  
Upper Cut-Off Value 1,131,710  

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<tr>
<td>$P(U)^2$</td>
<td>0.03</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>$P(C)$</td>
<td>0.38</td>
<td>0.36</td>
<td>0.34</td>
<td>0.36</td>
<td>0.34</td>
<td>0.38</td>
<td>0.34</td>
<td>0.37</td>
<td>0.34</td>
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<tr>
<td>$P(F)$</td>
<td>0.58</td>
<td>0.64</td>
<td>0.66</td>
<td>0.64</td>
<td>0.66</td>
<td>0.62</td>
<td>0.66</td>
<td>0.63</td>
<td>0.66</td>
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</table>

1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

2 $P(U)$ = Probability of Unfavorable Event  
$P(C)$ = Probability of Cautionary Event  
$P(F)$ = Probability of Favorable Event

**Figure C.6 Gross Farm Revenue StopLight Chart in District 70 for Alternative Scenarios**

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Figure C.7 Gross Farm Revenue StopLight Chart in District 80 for Alternative Scenarios

1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

2 $P(U)$ = Probability of Unfavorable Event
   $P(C)$ = Probability of Cautionary Event
   $P(F)$ = Probability of Favorable Event
**Figure C.8 Gross Farm Revenue StopLight Chart in District 90 for Alternative Scenarios**

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</thead>
<tbody>
<tr>
<td>(P(U))</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>(P(C))</td>
<td>0.32</td>
<td>0.20</td>
<td>0.17</td>
<td>0.20</td>
<td>0.18</td>
<td>0.20</td>
<td>0.18</td>
<td>0.22</td>
<td>0.19</td>
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<tr>
<td>(P(F))</td>
<td>0.67</td>
<td>0.80</td>
<td>0.83</td>
<td>0.80</td>
<td>0.82</td>
<td>0.80</td>
<td>0.82</td>
<td>0.78</td>
<td>0.81</td>
</tr>
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</table>

1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

2 \(P(U)\) = Probability of Unfavorable Event  
\(P(C)\) = Probability of Cautionary Event  
\(P(F)\) = Probability of Favorable Event

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Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

Figure D.1 Gross Farm Revenue Stochastic Efficiency with Respect to a Function (SERF) in District 10 for Alternative Scenarios
Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

**Figure D.2** Gross Farm Revenue Stochastic Efficiency with Respect to a Function (SERF) Analysis in District 20 for Alternative Scenarios

\(^1\) Refer to Table 3.3 for a description on simulation scenarios and abbreviations.
Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

Figure D.3 Gross Farm Revenue Stochastic Efficiency with Respect to a Function (SERF) Analysis in District 30 for Alternative Scenarios

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1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.
Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

Figure D.4 Gross Farm Revenue Stochastic Efficiency with Respect to a Function (SERF) Analysis in District 50 for Alternative Scenarios

1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.
Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

Figure D.5 Gross Farm Revenue Stochastic Efficiency with Respect to a Function (SERF) Analysis in District 60 for Alternative Scenarios

1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.
Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

Figure D.6 Gross Farm Revenue Stochastic Efficiency with Respect to a Function (SERF) Analysis in District 70 for Alternative Scenarios

1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.
Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

Figure D.7 Gross Farm Revenue Stochastic Efficiency with Respect to a Function (SERF) Analysis in District 80 for Alternative Scenarios
Refer to Table 3.3 for a description on simulation scenarios and abbreviations.

Figure D.8 Gross Farm Revenue Stochastic Efficiency with Respect to a Function (SERF) Analysis in District 90 for Alternative Scenarios

1 Refer to Table 3.3 for a description on simulation scenarios and abbreviations.