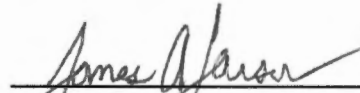


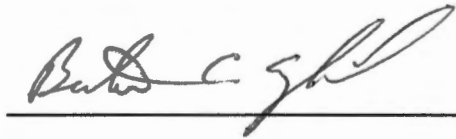
To the Graduate Council:

I am submitting herewith a thesis written by Walter Ray Philpot entitled "Economic Evaluation of Alternative Income Protection Strategies for West Tennessee Corn Producers." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.


James A. Larson, Major Professor

We have read this thesis
and recommend its acceptance:





Accepted for the council:


Associate Vice Chancellor and
Dean of The Graduate School

ECONOMIC EVALUATION OF ALTERNATIVE INCOME PROTECTION
STRATEGIES FOR WEST TENNESSEE CORN PRODUCERS

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Walter Ray Philpot
August 1998

AG-VET-MED.

Thesis

98

P354

DEDICATION

This thesis is dedicated to my parents
Laurie and Margret Philpot
who have always supported and encouraged
me in all that I have done.

ACKNOWLEDGMENTS

I wish to express my appreciation to the many people who have helped to make my experience at the University of Tennessee extremely rewarding. First, to my major professor, Dr. James Larson, who put many hours of effort into coaching me and never accepting less than he knew I was capable of. My former major professor, Dr. Jeffrey Stokes I want to thank for guidance in my choice of this thesis topic and also for his help since inception of the topic including tutoring. Also, special thanks go to the other members of my committee, Dr. Roland Roberts and Dr. Burton English who have been patient with my progress and filled in certain gaps of knowledge.

I also wish to express my appreciation to my fellow graduate students, especially Dr. Jose Velasquez, who have been a source of entertainment, inspiration, encouragement, and knowledge throughout the past two and a half years.

Much appreciation goes to the University of Tennessee Agricultural Experiment Station for the financial support of my curriculum and in the extension of this project to make it all possible.

The greatest appreciation of all goes to God and my parents who never turned their backs on me when I made mistakes in life.

Abstract

Tennessee corn producers may experience increased income volatility due to recent changes in federal government agricultural policies. Consequently, these farmers need information about the expected value and variability of net revenues for alternative crop insurance, futures hedging, and put option strategies to manage risk. The objectives of this study were 1) to evaluate how traditional hedging strategies, existing crop insurance programs, and new income protection strategies affect the expected value and variability of net revenue for a corn enterprise in West Tennessee; and 2) to identify from the traditional and new income protection alternatives, the risk - preferred strategies for different levels of farmer risk aversion behavior.

Stochastic simulation and stochastic dominance methods were used to achieve the objectives of the study. Corn yields for Obion County, Tennessee and November cash prices for the Northwest Tennessee market were randomly simulated along with futures prices in November and February. Crop insurance strategies evaluated were Crop Revenue Coverage (CRC), Multiple Peril Crop Insurance (MPCI), and Revenue Assurance (RA) were evaluated in conjunction with futures hedges and put options. Twenty simulations of 192 observations each were generated from random draws using a lognormal distribution. The yield and price data used to specify the expected value, variance, and covariance relationships in the model were for the 1988 through 1994 time period. Premiums for the insurance products were quoted directly from private insurance agents for the 1997 crop year. Fixed equipment and labor costs as well as variable and overhead expenses for 1997 were also subtracted from the simulated gross revenue.

The degree of accuracy for the simulated mean of net revenue as compared to the expected mean of net revenue was calculated in the form of a confidence interval. The simulated net revenue series for each income protection strategy was analyzed in terms of the tradeoffs among expected net revenues, variance of net revenues, and minimum net revenues averaged across twenty simulations. Probabilities of achieving various rates of return on investment were evaluated for each alternative income protection strategy. Simulated net revenue distributions (CDF's) for each strategy were analyzed using first-degree stochastic dominance and second-degree stochastic dominance criteria.

The top five strategies in order of descending mean net revenue were: (1) futures hedge on 100 percent of the historical yield average, (2) futures hedge on 50 percent of the historical yield average (3) combination of the 100 percent futures hedge and MPCCI with 65% yield coverage at \$2.45/bushel, (4) no crop insurance or futures hedging (cash market), and (5) combination of 100 percent futures hedge and MPCCI with 70 percent coverage at \$2.45/bushel. Producers interested in maximizing profit would not use crop insurance. In general, none of the crop insurance or hedging strategies were very effective in reducing the variability of net revenues and the relative riskiness when compared with not using any yield or price protection. However, RA at the 75 percent coverage level was the most effective strategy in setting a floor on the minimum value of net revenue. As a consequence, extremely risk averse producers may prefer a RA strategy as a way to manage income risk. Moreover, the cash market, RA, CRC, and MPCCI strategies were the most likely to cover all of the variable and fixed costs of production in the simulation. The strategies most likely to be in the second-degree stochastic dominance efficient set

were: (1) the cash market strategy, (2) RA at the 75 percent coverage level, (3) 100 percent futures hedge on average production, and (4) 50 percent futures hedge on average production. These strategies are risk efficient for risk neutral and risk averse decision makers.

TABLE OF CONTENTS

Part 1: Introduction

1) Introduction.....	1
2) Objectives.....	4
3) Representative Farm Situation.....	4
4) Review of Previous Studies.....	5
5) Risk Management Strategies Evaluated.....	8
References.....	12

Stochastic Simulation of Net Revenues for Alternative Income Protection Strategies

1) Introduction.....	14
2) Representative Farm Situation.....	16
3) Review of Literature.....	17
4) Methods and Data.....	19
A) Simulation Model.....	20
B) Strategies Simulated.....	24
C) Simulation Analysis.....	27
5) Results and Discussion.....	29
A) Model Evaluation.....	29
B) Net Revenue Evaluation.....	30
6) Summary and Conclusions.....	33
References.....	35
Appendix.....	39

Part 3: Stochastic Dominance Analysis of Net Revenues for Alternative Income Protection Strategies

1) Introduction.....	46
2) Representative Farm Situation.....	48
3) Review of Literature.....	49
4) Methods and Data.....	50
A) Simulation Model.....	51
B) Strategies Simulated.....	55
C) Stochastic Dominance Analysis.....	58
5) Results and Discussion.....	60
6) Summary and Conclusions.....	64
References.....	66
Appendix.....	69

Part 4: Summary

Summary.....	75
Vita.....	78

LIST OF TABLES

TABLE		PAGE
	Stochastic Simulation of Net Revenues for Alternative Income Protection Strategies	
1.	Obion County Corn yields and market prices used to estimate expected values and the variance-covariance coefficients for the simulation model.....	40
2.	The estimated variance-covariance coefficients for the simulation model.....	41
3.	Alternative income protection strategies simulated in the analysis.....	42
4.	Simulated net revenue statistics, averaged over twenty simulations.....	43
5.	Probability of Achieving alternative rates of return on investment in corn production.....	44
	Stochastic Dominance Analysis of Net Revenues for Alternative Income Protection Strategies	
1.	Obion County Corn yields and market prices used to estimate expected values and the variance-covariance coefficients for the simulation model.....	70
2.	The estimated variance-covariance coefficients for the simulation model.....	71
3.	Alternative income protection strategies simulated in the analysis.....	72
4.	Simulated net revenue statistics, averaged over twenty simulations.....	73
5.	Number of times strategies appeared in efficient sets out of twenty simulations.....	74

Part 1: Introduction

Introduction

The revenues that Tennessee farmers receive from the production of field crops are risky due to uncertain weather impacts on yields and uncertain market impacts on prices. Historically, producers have relied on the federal government to manage income risk through a price support program. Under the government program, farmers would receive a deficiency payment during periods when the market price fell below a specified target price. This payment would help farmers manage the downside income risk associated with adverse price movements. Producers were required under the program to restrict acreage grown in order to receive the deficiency payment. With the passage of the Federal Agricultural Improvement and Reform (FAIR) Act of 1996, deficiency payments for many crops were replaced by contract payments, and acreage reduction programs were eliminated. Contract payments were set for fixed amounts through the year 2002 and are not expected to change regardless of future prices and yields (Young and Shields, 1996). Now that these restrictions have been eliminated, farmers can grow what they think will be the most profitable crop given their expectations of price and yield at planting time.

A related development affecting farmers is lower global stocks for the major grains. Increased domestic consumption, higher exports from the United States, and less forfeiture of crops into government stocks due to changes in government policy, caused global stocks-to-use ratios for corn and wheat in 1995-1996 to fall to the lowest level since USDA began tracking stocks in 1960 (Harwood *et al.*, 1996). With lower stocks of grain to help buffer yearly supply and demand shocks, many analysts believe there will be

increased price volatility in the future. Increased planting flexibility and lower global stocks of grain may increase future income volatility for farmers unless a risk management strategy is used in conjunction with market signals. The FAIR Act and previous farm bill legislation have encouraged the development of alternative income protection strategies for farmers. These risk management products were designed to help farmers manage yield and price volatility in the absence of price support programs and acreage controls being phased out under the FAIR Act. These insurance products are offered through private insurance companies and are reinsured through the Federal Government. The products being offered to farmers include Catastrophic Coverage (CAT), Multiple-Peril Crop Insurance (MPCI), Group Risk Plan (GRP), Revenue Assurance (RA), Income Protection (IP), and Crop Revenue Coverage (CRC). The intended purpose of these products are to protect against low yields and/or low crop prices. Some of these products are currently available in Tennessee and others are expected to be available in the future. The feasibility of insurance alternatives in helping producers manage risk as measured by the expected value and variability of net revenues has not been evaluated for Tennessee. Information about the net revenue tradeoffs among traditional hedging strategies using futures and options, existing crop insurance programs, and new income protection programs would be useful in farm planning and decision making. Because these products are designed to reduce variability of income, a farmer's risk attitude is an important factor that may explain whether or not a specific income protection product is used. Farmers with alternative risk attitudes may prefer different income protection products based on the tradeoffs in expected value and variability of net revenues.

Objectives

The objectives of this study were: 1) to evaluate how traditional hedging strategies, existing crop insurance programs, and selected new income protection strategies affect the expected value and variability of net revenue for a representative crop enterprise in West Tennessee; and 2) to identify from the traditional and new income protection alternatives, the risk-preferred strategies for different levels of farmer risk aversion behavior.

Representative Crop Situation

For the purpose of this analysis, the farm modeled in this study is a large, commercial operation that obtains all of its income from farming activities. The specific field crop scenario modeled is a 1,000 corn enterprise in Obion County, Tennessee. Obion County is in Northwest Tennessee and is located near the southern edge of the U.S. corn belt. Approximately 10 percent of the 697 farms in Obion County had a farm size of more than 1,000 acres in 1992 (U.S. Department of Commerce, Bureaus of the Census). The reasons for using a corn production scenario to analyze net revenues for alternative income protection strategies are as follows. First, corn is an important enterprise alternative for farmers in northwest Tennessee. In 1997, Obion County was ranked number one in corn production in Tennessee with 69,000 acres planted (Tennessee Department of Agriculture, 1998). In addition, information about crop insurance products

for corn were readily available when compared with other crops grown in Tennessee. Finally, a single commodity was evaluated to facilitate the modeling of alternative income protection strategies. Potential correlations among alternative crops and commodity prices were not considered in this analysis. Larger diversified crop farms may be able to purchase crop insurance at a lower cost per acre than assumed in this analysis. On the other hand, farms with smaller corn acreage may incur slightly higher per acre costs to purchase insurance coverage due to service and other fees that do not vary with acreage. Modeling a single commodity such as corn represents the worst case scenario in terms of income risk.

Review of Previous Studies

Several researchers have evaluated the effectiveness of alternative income protection strategies since the passage of the FAIR Act. Harwood, *et al.* (1996) compared CRC, IP, MPCI, and forward contracting risk management strategies for corn producers in Illinois, Iowa, North Carolina, and South Dakota. They ranked the risk management alternatives based on the probability of revenue falling below 70 percent of an expected preplanting level. The results, from best to worst were IP and CRC followed by a combination of crop insurance and forward contracting, crop insurance alone, and forward contracting alone. However, the premiums to be charged to farmers were not included in the revenue assessment and no weight was given to strategies that would have resulted in higher probabilities of revenue above projected levels. Harwood, *et al.* also

analyzed data from the 1993 Farm Costs and Returns Survey and found that producers with higher farm sales were less likely to obtain insurance and more likely to hedge production.

Dhuyvetter and Kastens (1997) compared net revenues from no crop insurance versus using CAT, MPCI, and CRC coverage options for a dryland Kansas wheat farm. They also examined pre-harvest hedging strategies in conjunction with using insurance. CRC produced the highest minimum net revenue value (maxi-min criterion) among the alternatives analyzed. The maxi-min strategy is preferred by decision makers who are extremely risk averse (Grub, 1986). The MPCI plan maximized the highest expected mean net revenue among the alternatives. The strategy that maximizes expected net revenue is preferred by risk neutral decision makers. Furthermore, Dhuyvetter and Kastens observed that although the variability of revenues is generally lower with CRC than with MPCI, the advantage of CRC over MPCI decreases as the amount of production hedged increases.

Heifner and Coble (1997) used numerical integration to find the optimal futures and options hedge ratios in conjunction with crop insurance and forward contracting for corn producers in Dewitt County, Illinois. The crop insurance strategies that they evaluated were: 1) MPCI, 2) MPCI with replacement coverage, 3) IP, and 4) CRC. Their model accounted for differences in yield-price correlation and yield variability in order to apply their results over areas without a 'natural hedge' and/or high yield variability. Furthermore, the gains in hedging effectiveness were normalized under four different levels of risk aversion. Without forward pricing of production, IP and CRC were found to

be superior to MPCl in reducing risk over four combinations of yield-price correlation and yield variability. With forward pricing of production, IP and CRC also outperformed MPCl and provided protection to a farmer who has overcommitted productions through forward contracting.

Also available on the Chicago Board of Trade are new hedging tools such as corn yield insurance futures and options on corn yield insurance futures for some states. Miranda and Glauber stated that there is insufficient correlation between an individual farm's yield and measurements of aggregate yields so that a futures contract or option on a future contract based on aggregate yield shortfalls would offer adequate protection to this same individual. However, Tirupattur, Hauser, and Chaherli (1995) showed that crop yield futures can be used in conjunction with price futures to derive risk management benefits significantly higher than using either of the two alone. This was accomplished using Iowa corn and Illinois soybeans yield contracts as hedging alternatives for producers in Champaign County, Illinois. The following alternatives were evaluated: 1) a no-hedge scenario where revenue is determined by cash market prices and yields; 2) hedging using both price and yield futures. 3) hedging using just price futures; 4) hedging using just yield futures, 5) a no-hedge scenario where revenue is determined by the market and by participating in the former deficiency payment program, 6) a no-hedge scenario where revenue is determined by the market using Revenue Assurance at the 70 percent coverage level. Price and yield futures hedge for corn were 50 percent of the average production history for the corn yield futures hedge and 70 percent of production history for the corn price futures hedge. The price and yield futures hedge for soybeans were 80 percent of

the production yield history for the soybeans yield futures hedge and 90 percent of the production history for the soybean price futures hedge. The top three strategies evaluated by the probability of revenue falling below a threshold gross revenue level of \$95/acre were: 1) a no-hedge scenario where revenue is determined by the market and by participating in the former deficiency payment program, 2) hedging using both price and yield futures, and 3) hedging using just price futures. The top three strategies in minimizing variance of gross revenues were: 1) hedging using both price and yield futures; 2) hedging using just price futures; and 3) a no-hedge scenario where revenue is determined by the market and by participating in the former deficiency payment program. Although, the mean for the Revenue Assurance strategy ranked second to the deficiency payment strategy, it was also \$1.34/acre higher than the strategies using both yield and price futures. Gray *et al.* (1995) have shown that incomes could be stabilized and that payments to producers would be substantially less under RA than under the former price support programs.

Risk Management Strategies Evaluated

Farmers have a number of traditional and new risk management alternatives they can use to mitigate the effects of price and yield risk in the new environment. Doing nothing to obtain downside protection is one strategy farmers can follow. In this case, the producer would sell or store grain to sell at market prices. However, doing nothing may not be an optimal strategy depending on a farmers risk attitude. Several strategies have

been or are currently being introduced that farmers can use to mitigate price and yield risk. Futures market hedging provides a producer with the opportunity to “lock in” a price before harvest through the use of commodity futures and options contracts. The ability to lock in a price before harvest on a predetermined level of production allows a farmer to develop a floor below which gross revenues cannot fall. A futures contract legally obligates a holder to either deliver or accept delivery of the contracted commodity on or by some specified date in the future (National Futures Association). Here the farmer must make a financial commitment in the form of margin for futures contracts or premiums for options. Futures contracts on corn are for 5,000 bushels of no. 2 yellow corn. Traditionally, these contracts are used to hedge price risk. A corn producer making hedging decisions before planting will be interested in the basis, or the difference between the local cash price and the futures contract price. This difference is mainly due to transportation costs and time associated with shipping the corn from one destination to another.

A put option gives a producer the right to sell a specific futures contract at a specific price, but does not obligate the producer to sell if it becomes advantageous to let the put option expire. Buying put options provides a producer new possibilities in the use of futures by eliminating margin calls and by making the maximum loss from using futures equal to the initial option premium plus commission. The premium is “the market determined value of an option for a particular futures contract at a particular price level or ‘strike price’” (National Futures Association). So, a \$2.30 put option on the December corn contract will protect the producer from prices falling below \$2.30 as the producer

could then sell his option contracts for a profit in the amount of (\$2.30 minus the market price) times the number of bushels stated in the contract, typically 5,000. Futures and options strategies will be discussed in more detail in the following chapter.

There are also a variety of products available from private insurance companies but reinsured through the federal government such as: Catastrophic coverage (CAT), Multiple Peril Crop Insurance (MPCI), MPCI with replacement coverage, Group Risk Plan (GRP), Revenue Assurance (RA), Income Protection (IP), Crop Revenue Coverage (CRC), and Crop Revenue Coverage Plus (CRCPlus). In general, the purpose of these products is to provide a floor beyond which gross revenues cannot fall. This is accomplished by insuring levels of yield or gross revenue as a percentage of the operation's last five years of data. If no yield or revenue data series is available the local County average is used. Some of these products are currently available to a farmer depending on the state, crop, and product.

CAT coverage pays on 50 percent of actual yield at 60 percent of expected market price. MPCI coverage allows a producer to select a yield coverage level from 50 to 75 percent of the average from the last five years of historic yields. Whenever the harvested yield falls below the preselected coverage limit, an indemnity is paid at a per bushel rate set by the government. MPCI policies have been widely used in the recent past. The GRP coverage differs in that the farmer's crop production history does not enter the picture. When enrolling in this policy one will select a yield level and price for the county in which one resides. If the county average yield drops below the selected yield, an indemnity is paid. IP combines yield and price protection by setting an income guarantee per acre

based on historic yields and projected prices at harvest. The CRC products differ from an IP policy in that the producer will receive an indemnity calculated from either a base price or a harvest price, whichever is higher. This base price and the harvest price are the monthly moving averages for the daily settlement prices during the February and November trading periods of the December Corn futures contract respectively. As with an Asian option, this allows a producer to take advantage of an upside swing on the market. The CRCPlus policy allows the insured to increase the base price. This gives extra protection against a downside market swing. Along with GRP products, CRC is relatively new and also maintains a significant market share. Under a RA policy, 65 percent to 75 percent of historical five year moving average revenue is guaranteed to the producer. This product was originally proposed to be provided at low cost by the federal government, but is currently offered through private insurance companies in some locations.

This study will compare some of the alternatives available or expected to be available to West Tennessee Corn Producers, namely Multiple Peril Crop Insurance, Crop Revenue Coverage, futures hedges, put options hedges, and Revenue Assurance.

References

References

- Dhuyvetter, K.C., and T.L. Kastens. "Crop Insurance and Forward Pricing Linkages: Effects on Mean Income and Variance." *Proceeding of the NCR-134 Conference*. Chicago, Illinois , 1997, pp. 94-111.
- Gray, A., J. Richardson, and J. McClaskey. "Farm Level Impacts of Revenue Assurance." *Rev. of Agr. Econ.* 17(1995): 171-183.
- Harwood, J., Heifner, D., Coble, K., Perry, J. " Strategies for a New Risk Management Environment." *Agricultural Outlook*. 234 (October 1996): 24-30.
- Heifner, R., and K. Coble. "Optimizing Farmers' Joint Use of Forward Pricing and Crop Insurance by Comparing Revenue Distributions Estimated with Numerical Integration." *In Proceedings of the NCR-134 Conference*, Chicago, Illinois 1997.
- Miranda, M.J., and J.W. Glauber. "Uninsurable Systemic Risk and the Failure of Crop Insurance Markets: A Case for Area-Yield Options." Office of Economics, U.S. Dept of Agriculture. Washington D.C, August 1994.
- National Futures Association, "Understanding Opportunities and Risks in Futures Trading." Chicago, IL. 1986. pp.14.
- Tirupattur, V., R.J. Hauser and N.M. Chaherli. "Crop Yield Futures and Revenue Distributions." Department of Agricultural Economics, University of Illinois at Urbana-Champaign; Department of Economics, Iowa State University. Working Paper, (no- date)
- Young, E., and D.A. Shields. "1996 FAIR Act Frames Farm Policy for Seven Years." *Agricultural Outlook*. Supplement, U.S. Department of Agriculture, Economic Research Service, (April 1996): 1-21

Part 2: Stochastic Simulation of Net Revenues for Alternative Protection Strategies

Introduction

The revenues that Tennessee farmers receive from the production of field crops are risky due to uncertain weather impacts on yields and uncertain market impacts on prices. Historically, producers have relied on the federal government to manage income risk through a price support program. Under the government program, farmers would receive a deficiency payment during periods when the market price fell below a specified target price. These payments would help farmers manage the downside income risk associated with adverse price movements. Producers were required under the program to restrict acreage grown in order to receive the deficiency payment. With the passage of the Federal Agricultural Improvement and Reform (FAIR) Act of 1996, deficiency payments for many crops were replaced by contract payments, and acreage reduction programs were eliminated. Contract payments were set for fixed amounts through the year 2002 and are not expected to change regardless of future prices and yields (Young and Shields, 1996). Now that these restrictions have been eliminated, farmers can grow what they think will be the most profitable crop given their expectations of price and yield at planting time.

A related development affecting farmers is lower global stocks for the major grains. Increased domestic consumption, higher exports from the United States due to changes in government policy, and less forfeiture of crops into government stocks, caused global stocks-to-use ratios for corn and wheat in 1995-1996 to fall to the lowest level since USDA began tracking stocks in 1960 (Harwood *et al.*, 1996). With lower stocks of grain to help buffer yearly supply and demand shocks, many analysts believe there will be

increased price volatility in the future. The implications of increased planting flexibility and lower global stocks of grains will most likely increase future income volatility for farmers unless a risk management strategy is used in conjunction with market signals.

The FAIR Act and previous farm bill legislation have encouraged the development of alternative income protection strategies for farmers. These risk management products were designed to help farmers manage yield and price volatility in the absence of price support programs and acreage controls being phased out under the FAIR Act. These insurance products are offered through private insurance companies and are reinsured through the Federal Government. Some of these products are currently available in Tennessee and others are expected to be available in the future. The effectiveness of these insurance products in managing risk as measured by the expected value and variability of net revenues has not been evaluated for Tennessee farmers. Information about the net revenue trade offs among traditional hedging strategies using futures and options, existing crop insurance programs, and new income protection programs would be useful for farm planning and decision making. The objective of this study was to evaluate the expected value and variability of net revenues from alternative income protection strategies for a representative field crop in West Tennessee.

Representative Farm Situation

For the purpose of this analysis, the farm modeled in this study was a large, commercial operation that obtains all of its income from farming activities. The specific

field crop scenario modeled is a 1,000 acre corn enterprise in Obion County, Tennessee. Obion County is in northwest Tennessee and is located near the southern edge of the U.S. Corn Belt. Approximately 10 percent of the 697 farms in Obion County had a farm size of more than 1,000 acres in 1992 (U.S. Department of Commerce, Bureaus of the Census). The reasons for using a corn production scenario to analyze net revenues for alternative income protection strategies are as follows. First, corn is an important enterprise alternative for farmers in northwest Tennessee. In 1997, Obion County was ranked number one in corn production in Tennessee with 69,000 acres planted (Tennessee Department of Agriculture, 1998). In addition, corn is grown in nearly every County in Tennessee. Finally, a single commodity was evaluated to facilitate the modeling of alternative income protection strategies. Potential correlations among alternative crops and commodity prices were not considered in this analysis. Indeed, crop diversification is a risk reduction strategy upon which crop insurance can be purchased at a lower cost per acre than assumed in this analysis. By modeling only a single commodity, the actual risk incurred is representative of the worst case scenario for a producer.

Review of Literature

Several researchers have evaluated the effectiveness of alternative income protection strategies in mitigating risk in a post FAIR Act environment. Harwood, *et al.* (1996) compared Crop Revenue Coverage (CRC), Income Protection (IP), Multiple Peril Crop Insurance (MPCI), and forward contracting risk management strategies for corn

producers in Illinois, Iowa, North Carolina, and South Dakota. They ranked the risk management alternatives based on the probability of revenue falling below 70 percent of an expected preplanting level. The results, from best to worst were IP, CRC, a combination of crop insurance and forward contracting, crop insurance alone, and forward contracting alone. However, premiums were not included in the revenue assessment and no weight was given to strategies that would have resulted in higher probabilities of revenue above projected levels. Harwood, *et al.* also analyzed data from the 1993 Farm Costs and Returns Survey and found that producers with higher farm sales were less likely to obtain insurance and more likely to hedge production.

Dhuyvetter and Kastens (1997) compared net revenues from no crop insurance versus using CAT, MPCl, and CRC coverage options for a dryland Kansas wheat farm. They also examined pre-harvest hedging strategies in conjunction with using crop insurance. CRC produced the highest minimum net revenue value (maxi-min criterion) among the alternatives analyzed. The maxi-min strategy is preferred by decision makers who are extremely risk averse (Grub, 1986). The MPCl plan maximized the expected net revenue among the alternatives. The strategy that maximizes expected net revenue is preferred by risk neutral decision makers. Furthermore, Dhuyvetter and Kastens observed that although the variability of revenues is generally lower with CRC than with MPCl, the advantage of CRC over MPCl decreases as the amount of production hedged increases.

Heifner and Coble (1997) used numerical integration to find the optimal price futures and options hedge ratios in conjunction with crop insurance and forward

contracting for corn producers in Dewitt County, Illinois. The crop insurance strategies that they evaluated were: 1) MPCI, 2) MPCI with replacement coverage, 3) IP, and 4) CRC. Their model accounted for differences in yield-price correlation and yield variability in order to apply their results over areas without a ‘natural hedge’ and/or high yield variability. Furthermore, the gains in hedging effectiveness were normalized under four different levels of risk aversion. Without forward pricing of production, IP and CRC were found to be superior to MPCI in reducing risk over four combinations of yield-price correlation and yield variability. With forward pricing of production, IP and CRC also outperformed MPCI and provided protection to a producer who has overcommitted production through forward contracting. Gray et al. (1995) have shown that incomes could be stabilized and that payments to producers would be substantially less with Revenue Assurance (RA) than under the former price support programs.

Methods and Data

Simulation and enterprise budgeting methods were used to achieve the objectives of this study. Trapp defines simulation as “the process of numerically solving a computerized mathematical model in an attempt to reproduce the actual essential elements of an operating system (p.130).” Simulation facilitates experimentation with alternative income protection strategies and the evaluation of tradeoffs in the expected value and variability of net revenues among strategies. This section describes the simulation model, the data used in the model, and the hedging and insurance strategies simulated with the

model.

Simulation Model

The farm decision maker was assumed to make planting hedging and crop insurance decisions in February. The corn crop was assumed to be harvested and sold in November. For the futures hedge, the producer was assumed to sell a December corn futures contract in February and buy back the December futures contract in November. For the put option strategy, the producer was assumed to purchase a put option on the December corn contract in February and not exercise the option contract until the corn was sold in November. If the option premium did not have a positive value at harvest it was allowed to expire. Indemnity payments from crop insurance strategies were determined in November after the crop was harvested and sold. Net revenue (NR) for a farmer producing corn, hedging with futures and options, and purchasing crop insurance can be written as:

$$(1) \quad NR = P \times Y + HR - HC + ID - IC - OC,$$

where P is the cash price for corn (\$/bushel), Y is the yield of corn (lb/acre); HR is the revenue from pre-harvest hedging activities with futures or options (\$/acre); ID is the indemnity payment received from crop insurance activities (\$/acre); HC is the cost of hedging activities; IC is the premiums paid for crop insurance coverage (\$/acre); and OC

is the estimated variable expenses, fixed equipment and labor costs, and overhead expenses that do not change with the hedging or insurance strategies (\$/acre). This residual (NR) is the estimated return to a farmer for land, management and risk (Boehlje and Eidman, 1984). HR for the futures strategy was determined by the difference between futures contract prices in February and November and the basis, or the difference between the November futures and cash prices. This difference was multiplied by the bushels of production hedged. For the options strategy, HR was determined by multiplying the bushels of production hedged by the premium value of the option in November. HC for the futures hedge included commission expenses and taxes and interest costs on initial margin. ID is the payout made by the insurance company for a specified corn yield and/or corn price selection or for a specified level of gross revenue coverage.

To calculate Stochastic NR 's for the production, hedging, and crop insurance activities represented in equation (1), the five random values simulated were: 1) harvested corn yield, 2) the November cash corn price for Obion County, 3) the February futures price for the Chicago Board of Trade (CBOT) December corn contract, 4) the February put option premiums for the CBOT December Corn contract, and 5) the December futures price for the Chicago Board of Trade (CBOT) December corn contract. To simulate random values for the production, hedging, and insurance activities in equation (1), five random, correlated variates were generated as follows:

$$(2) \quad D = E + A^* R,$$

where D is a 5×1 vector of random values, E is a 5×1 vector of expected values, A^* is a 5×5 matrix of coefficients, and R is a 5×1 vector of lognormally distributed random

deviates. A lognormal distribution was assumed to preclude negative yields or commodity prices. A^* in equation (2) is an upper triangular matrix of coefficients derived from the estimated variance-covariance matrix of the five yield and price random variables (Clements, Mapp, and Eidman; Fishman).

Yield and price data reported in Table 1 were used to estimate expected (mean) values and variance-covariance coefficients for the simulation model. Obion County corn yields (1988-1996) were from *Tennessee Agriculture* (Tennessee Department of Agriculture). Northwest Tennessee November average cash market prices used to represent Obion County prices were from *Tennessee Market Highlights* (Tennessee Department of Agriculture). February and November averages for the December Corn contract were computed using data from the Chicago Board of Trade. Evaluations of the data for an inflationary trend in prices and upward trends in yields due to changes in technology were found to not be statistically significant at the 90% confidence level. The 1995 cash price of \$3.26/bushel was deemed to be an outlier that would bias upward the probability of a high corn price received by farmers and may overstate variability of net revenue experienced by farmers. Consequently, the 1988-94 portion of the time-series in Table 1 was used to estimate coefficients for this simulation model. Removing the 1995-96 years reduced the variability in gross revenue by approximately 50 percent.

To develop put option premiums for the simulation model, the November average futures price on the December contract was regressed on the February futures price on the December contract:

$$(3) \quad FP_{NOV} = \alpha_0 + (\alpha_1 \times FP_{FEB}) + \varepsilon_1,$$

where FP_{NOV} and FP_{FEB} are the November and February futures prices for the CBOT December corn contract, α_0 and α_1 are the estimated regression coefficients, and ε_i is the regression residuals. The residuals were used to calculate σ_ε^2 for inclusion as a stochastic variable in the Cholesky decomposition in A^* . The residuals and November futures price from the random variants were used to infer a futures price in February by solving equation (3) for the February futures price as follows:

$$(4) \quad \text{Inferred } FP_{FEB} = 1/\alpha_1 \times FP_{NOV} - \alpha_0 - \varepsilon_i .$$

Finally, the option price of the December contract at the end of February was derived by regressing the price of the option (OP) on the inferred February futures price.

$$(5) \quad OP = \beta_0 + (\beta_1 \times \text{Inferred } FP_{FEB}) + \omega_i .$$

The \$2.30 strike price and the 1988-94 time period were chosen due to data availability. The data from the CBOT lists final daily settlements for strike prices of \$2.10 and \$2.30 for each of the years in the 1988-1994 time series. One limitation of this method is that option prices for the \$2.30 strike were extremely “in the money” for many years of the time series. The result of which is expensive option premiums for the purchaser. This assumption of the options strategy fails to account for the value of the early exercise feature that is built into the option premium.

The estimated variance-covariance coefficients for the simulation model is presented in Table 2. The negative correlation of -0.8138 between yields and prices at harvest is indicative of the basic supply and demand relationship. Higher yields and production tend to produce lower prices. The correlation of .96065 between the TN cash and Futures in November is extremely high due to competitive markets. The correlation

coefficients of -0.7548 and -0.8138 display typical yield/price relationships with the November Futures and local prices respectively. The correlations of -0.7132, and -0.7849 between February futures and November prices in Tennessee and Chicago respectively are indicative of the relationship between storage costs and normal seasonal market trends. In other words, the November prices will be lower than in February during a normal marketing year due to a surplus at harvest.

Strategies Simulated

The 26 hedging and insurance strategies simulated with the model are outlined in Table 3. The per acre costs for each income protection strategy simulated are also in Table 3. The cash market strategy assumes that the farmer does not hedge against price risk, does not purchase insurance, and sells production on the cash market. The coverage levels for Revenue Assurance (RA), CRC, and MPCCI insurance products modeled were 65, 70, and 75 percent.

Currently, RA is not available in Tennessee. Consequently, premiums for RA in Obion County were determined in the following manner. Market quotes for Clay County, Iowa were obtained from the Deanna Orwig Agency (Personal communication with Deanna Orwig, Insurance Agent, Spencer, IA, February, 1998) for RA and CRC products. County-level yields for 1977 to 1997 were compared between Obion County TN and Clay County IA (Tennessee Department of Agriculture; Iowa Department of Agriculture). The coefficient of variation (CV) was calculated to estimate relative yield variability for each of

the two counties¹. The CV for Obion County was 23.1 compared with 17.3 for Clay County. It was assumed that the higher cost of the CRC products in Tennessee compared with Iowa is due to the higher yield variability as opposed to higher administrative costs for selling a product to a smaller customer base in Tennessee than in Iowa. Therefore, RA premiums were determined using a relative as opposed to an absolute difference in premiums for CRC and RA products. For each level of coverage, the Obion County RA premium was determined by dividing the RA premium by the CRC premium for Clay County, IA, and multiplying the resulting ratio by the Obion County CRC premiums quoted from the Jarmon Insurance Agency in Alexandria Indiana (Personal communication with Jerry Jarmon, Insurance agent, Alexandria, IN, September, 1997)². Although the aforementioned procedure calculates a close approximation for West Tennessee RA premiums, it is by no means exact. Therefore, RA premiums were also modeled at 75 and 125 percent of the previously determined RA premiums for each level of coverage.³

MPCI strategies modeled were 65, 70, and 75 percent of the 5-year average of Obion county corn yields. MPCI policies can be purchased at varying indemnity rates for the 70 and 75% yield selections. MPCI policies were modeled at the five levels of subsidized yield coverage and indemnity payment rates: 65 percent of yield at \$2.60 per

¹ Coefficient of variation = standard deviation ÷ mean × 100.

² RA, 65 percent level = \$2.92/acre ÷ \$8.49/acre × \$12.93/acre = \$4.45/acre
 RA, 70 percent level = \$5.45/acre ÷ \$12.45/acre × \$18.52/acre = \$8.25/acre
 RA, 70 percent level = \$8.42/acre ÷ \$18.07/acre × \$26.69/acre = \$12.44/acre

³ RA, 65 percent level = \$4.45/acre × .75 = \$3.34/acre; \$4.45/acre × 1.25 = \$5.56/acre
 RA, 70 percent level = \$8.25/acre × .75 = \$6.19/acre; \$8.25/acre × 1.25 = \$10.31/acre
 RA, 75 percent level = \$12.44/acre × .75 = \$9.33/acre; \$12.44/acre × 1.25 = \$15.55/acre

bushel, 70 percent at \$2.60 per bushel, 70 percent at \$2.42 per bushel, 75 percent at \$2.60 per bushel, 75 percent at \$2.26 per bushel, respectively. An Administrative fee of \$10 per policy was prorated over the 1,000 acre enterprise in addition to premium amounts.

MPCI premiums were also quoted from the Jarmon Insurance Agency (Personal communication with Jerry Jarmon, Insurance agent, Alexandria, IN, September, 1997).

The management alternatives involving the use of options contracts were limited to two routine hedging strategies on 100 percent (100% options) and 50 percent (50% options) of the historical average yield of 116 bushels per acre via the purchase of a \$2.30 put option. Round turn commissions and taxes of \$50.00 and \$1.72, respectively were also subtracted from gross income for each option and future contract purchased (Personal communication with Charlie Crawford, senior broker, Parker Grain Brokerage, Knoxville, TN, December 1997).

Hedging with futures contracts was considered both alone and in combination with MPCI to cover both price and yield risk. Future hedges were placed on 100 percent (100% futures hedge) and 50 percent (50% futures hedge) of the historical average yield. Interest on margin deposits was calculated at an 11 percent annual rate for eight months of the year. This interest was applied to 5 percent of the initial February futures price times the number of contracts purchased (National Futures Association). Interest charges on margin calls due to fluctuations in the futures price before harvest were ignored in the analysis.

The other costs of production in equation (1) that were subtracted from revenues when estimating net revenues were from Gerloff and Maxey (1997). These costs include

machinery, labor, and materials expenses to produce an acre of corn using 8-row equipment. The total variable expenses, fixed equipment and labor costs, and overhead expenses used in the simulation totaled \$170.40 per acre.

Simulation Analysis

The steps to analyze the output from the simulation model are as follows. First, a procedure suggested by Cambell, Lo, and MacKinlay (1997) was used to evaluate the accuracy of the model in simulating Obion County corn net revenues. Next, the simulated output for each income protection strategy was analyzed in terms of evaluating the tradeoffs among expected net revenues, variance of net revenues, and minimum net revenues. Finally, the probability of achieving various rates of return on investment was evaluated for alternative income protection strategies. Each of these steps is described in this section.

Cambell, Lo, and MacKinlay (1997) state that a confidence interval for a simulation run of n observations can be constructed in the following manner:

$$(6) \quad Pr \left(\hat{H}(0) - 1.96 \frac{\sigma_{NR}}{\sqrt{n}} \leq H(0) \leq \hat{H}(0) + 1.96 \frac{\sigma_{NR}}{\sqrt{n}} \right) = 0.95,$$

where $\hat{H}(0)$ is the sample mean of net revenue from the n - observation simulation run, 1.96 is the Z-value for the two-tailed t-test at the 95 percent probability level, σ_{NR} is the sample standard deviation from the n - observation simulation run, and $H(0)$ is the true

mean net revenue taken from the original data points. The following relationship from equation (6) was used to evaluate simulation accuracy for an n - observation simulation run using the cash market strategy:

$$(7) \quad SA = 1.96 \frac{\sigma_{NR}}{\sqrt{n}}$$

The larger the value of n , the tighter the simulated confidence interval is around the true expected net revenue and the higher the degree of accuracy. For a given value of n , there exists a 95 percent probability that the true mean net revenue will fall within the simulated confidence interval on each of 20 simulation runs that were conducted.

The probability of achieving zero, five, and 10 percent simple rates of return on investment in land, buildings, and equipment for corn production was evaluated. To estimate the probabilities, the number of times that simulated NR exceeds the value of land buildings and equipment by specified dollar amounts that will generate the specific rates of return was calculated for each strategy. The estimated per acre value of land, buildings, and equipment in Obion county used to calculate the dollar amount was \$1,447.¹ The net revenue dollar amounts that are required to achieve simple rates of return of zero, five, and 10 percent on the 1.447 million investment are \$0, \$72,358, and \$144,716.

¹ Obion County land, buildings, and equipment value of \$1,072 /acre in 1992 (US. Department of Commerce, Bureau of the Census). The \$1,072 was indexed to a 1996 value using a factor of 1.35 representing the increase in Tennessee average farm land values between 1992 and 1996 (Tennessee Department of Agriculture).

Results and Discussion

Model Evaluation

Net revenue statistics for the 26 strategies simulated are presented in table 4. The number of observations simulated for each strategy within a run was 192. The cash market strategy was used to evaluate the accuracy of the model. The simulated mean and standard deviation of net revenues for the cash strategy were \$97,626 and \$37,717, respectively. The actual mean and standard deviation of net revenues from the 1988 through 1994 data series for Obion County were \$96,676 and \$31,521. Hence, the calculated degree of simulation accuracy using equation (7) and averaged across 20 simulation runs is \$5,335. Consequently, the average 95 percent confidence interval for the cash market strategy is $\$92,291 \leq H(0) \leq \$102,961$. The simulated cash strategy net revenue of \$97,626 falls within this interval suggesting the model is accurate at the 95 percent confidence level.

To evaluate the futures hedging strategy performance in the model, the simulated basis was compared with the actual basis for the 1984 to 1994 period. The difference between the November futures and northwest Tennessee cash price averaged \$0.057/bushel across twenty simulation runs. The simulated basis is similar to the \$0.064/bushel for the original data points. The standard deviation of the simulated basis is \$0.15/bushel, which is twice the standard deviation of \$0.07/bushel in the original data points. The actual basis and the simulated basis were more variable than cash market

prices for the period. The coefficient of variation for cash price was 10.07 compared with 102.46 for the actual basis and 234.38 for the simulated basis. The high variability in the basis for this period may cause the hedging strategy to not perform well as a risk reduction strategy in the simulation.

Net Revenue Evaluation

The top five strategies in order of descending mean net revenues are: (1) futures hedge on 100 percent of the historical yield average, (2) futures hedge on 50 percent of the historical yield average, (3) combination of the 100 percent futures hedge and multiple peril crop insurance (MPCI) with 65 percent yield coverage at \$2.45/bushel, (4) cash market, and (5) combination of the 100 percent futures hedge and MPCI with 70 percent coverage at \$2.45/ bushel. The futures hedge on 100 percent of the historical yield average produced mean net revenue of \$101,501, compared with \$97,626 for the cash market strategy. However, the standard deviation of net revenue for the futures hedging strategy was \$67,289, nearly double the \$37,717 standard deviation of the cash market strategy. A textbook futures hedge involves a tradeoff of lower expected net revenue for a smaller variance of net revenue for a risk averse decision maker. The reasons for the higher mean and standard deviation of net revenues for the futures hedge in the model are as follows. First, the amount of total production hedged may be too high for a producer interested in reducing price risk. Second, the basis relation in the model is more variable than cash market prices causing more variability in net revenues from

futures hedges. Because both yields and prices are stochastic in the model, the hedging strategy in some years is speculative when simulated production is less than the 120,000 bushel amount hedged on the futures market. For example, yield that is two standard deviations below the mean of 116 bushels/acre is 72 bushels/acre and results in a 48,000 bushel production shortfall under this hedging scenario. If the cost of buying back the corn in November is greater than what it has sold for in February on the futures market, the farmer takes a direct loss on the 48,000 bushel shortfall. On the other hand, if production is above average, and if the cost of buying corn on the futures market is less in November than in February, the profit from hedging is higher than in the cash market. Farmers who are risk neutral would prefer the futures hedge on 100 percent of the historical yield average over all other income protection strategies under the price and yield scenario modeled. Farmers who are risk averse are interested in strategies involving tradeoffs of mean net revenue for lower variance of net revenues. Producers who are extremely risk averse prefer strategies that maximize the minimum revenue (maximin strategy). The top five strategies in minimizing variance of net revenues were alternative crop insurance strategies: (1) CRC, 75 percent coverage; (2)MPCI, 75 percent yield coverage at \$2.45/bushel; (3) MPCI, 75 percent yield coverage at \$2.13/bushel; (4) CRC, 65 percent coverage; and (5) MPCI, 70 percent coverage at \$2.45/bushel. For CRC with 75 percent coverage, mean net revenue of \$72,512 was reduced 26 percent less than the cash market strategy while the \$35,511 standard deviation of net revenue was only 6 percent lower than the cash strategy. In terms of relative risk as measured by the coefficient of variation, the cash strategy was less risky ($CV=38.6$) than the CRC strategy

(CV=48.9). In general, none of the crop insurance or hedging strategies markedly reduced variability of net revenue and relative riskiness when compared with the cash strategy.

The top five strategies that maximized the minimum net revenue (maximin criterion) are: (1) Revenue Assurance, 75% coverage, (2) Revenue Assurance, 70% coverage, (3) cash market prices, (4) Revenue Assurance 65% coverage, (5) Crop Revenue Coverage 75% coverage. The actual yield and price data used to make the simulation model operational did not contain extremely low values. This may partially explain the appearance of the cash market strategy in the above. Revenue Assurance strategies were the most effective at setting a floor on net revenues with minimum values ranging from \$18,118 to \$24,338 for 75 percent coverage. These minimum net revenues compare with \$9,964 for the cash market strategy. As a result, Revenue Assurance products may perform well for extremely risk averse producers. However, RA strategies did not significantly lower the standard deviation of net revenues, but did lower mean net revenues by three to 15 percent depending on the coverage and premium level. Consequently, the relative riskiness of RA strategies was higher than the cash strategy with coefficient of variations ranging from 41.5 to 44.6 depending on the coverage and premium level.

The probabilities of achieving alternative rates of return above variable and fixed cost and the specified return to land and equipment are in Table 5. At the zero percent rate of return level, RA, CRC, and MPCCI strategies did not affect the probability of covering the variable and fixed costs of production. Combining futures hedging with

MPCI reduced the probability of covering variable and fixed costs from one to eight percent when compared with the cash market strategy. The cash market and futures hedge on 50% of the historical yield average provided the highest probability of 73 percent in achieving at least a five percent rate of return on investment. At the ten percent rate of return level, the 100 percent futures hedge on the historical yield average provided the highest probability of 31 percent in achieving that return. MPCFI combined with futures hedging also provided a high probability of achieving a 10 percent rate of return, ranging from a 11 to 26 percent probability. The options strategies modeled performed worst. One reason for this is that option prices for a \$2.30 put were very “in the money” during many years from the original data.

Summary and Conclusions

This study evaluated the expected value and variability of net revenues for alternative income protection strategies for a large corn enterprise located in Northwest Tennessee. A simulation model was developed to generate the randomly correlated draws from which net revenues were then calculated for each strategy. The following criteria were used to evaluate net revenues: the expected value of net revenues, the variance of net revenues, the minimum value of net revenues, and the rates of return and investment in land, buildings, and equipment for corn production.

The top five strategies in order of descending mean net revenue were: (1) futures hedge on 100 percent of the historical yield average, (2) futures hedge on 50 percent of

the historical yield average (3) combination of the 100 percent futures hedge and MPCl with 65% yield coverage at \$2.45/bushel, (4) no crop insurance or futures hedging (cash market), and (5) combination of 100 percent futures hedge and MPCl with 70 percent coverage at \$2.45/bushel. Producers interested in maximizing profit would not use crop insurance. In general, none of the crop insurance or hedging strategies were very effective in reducing the variability of net revenues and the relative riskiness when compared with not using any yield or price protection. However, RA at the 75 percent coverage level was the most effective strategy in setting a floor on the minimum value of net revenue. Moreover, the cash market, RA, CRC, and MPCl strategies were the most likely to cover all of the variable and fixed costs of production in the simulation.

Further research should be conducted in the area of analyzing multiple crops (e.g. corn and soybeans) for West Tennessee farms. Due to inherent correlations among price and yield with a multiple crop study, the results would be more applicable to those same farmers. Also, the Group Risk Plan (GRP) is now widely available and should be studied in conjunction with other strategies.

References

References

- Boehlje, M.D., and V.R. Eidman. *Farm Management*. John Wiley & Sons, New York, 1984.
- Campbell, J.Y., A.W. Lo, and C. MacKinlay. *The Econometrics of Financial Markets*. Princeton University Press, 1997. pp. 384.
- Chicago Board of Trade. Chicago Board of Trade Monthly Average, 1988-1996. Chicago, Illinois.
- Clements, A.M., H.P. Mapp, and V.R. Eidman. "A Procedure for Correlating Events in Farm Firm Simulation Models." Oklahoma State University Agricultural Experiment Station Technical Bulletin T-131, August 1971. pp. 5-9.
- Dhuyvetter, K.C., and T.L. Kastens. "Crop Insurance and Forward Pricing Linkages: Effects on Mean Income and Variance." *In Proceeding of the NCR-134 Conference*. Chicago, Illinois, 1997, pp. 94-111.
- Fishman, G.S. *Concepts and Methods in Discrete Event Digital Simulation*. John Wiley, New York, 1973.
- Gerloff, D.C., and L. Maxey. "Field Crop Budgets for 1997: A supplement to the Guide to Farm Planning." University of Tennessee Agric. Econ. and Rur. Devel. Info. Section 36., January 1997.
- Gray, A., J. Richardson, and J. McClaskey. "Farm Level Impacts of Revenue Assurance." *Rev. of Agr. Econ.* 17(1995): 171-183.

- Grub, A.H. "Participation in Farm Commodity Programs: A Stochastic Dominance Analysis: Comment." *Amer. J. Agr. Econ.* 68 (1986): 185-188
- Harwood, J., D. Heifner, K. Coble, and J. Perry. "Strategies for a New Risk Management Environment." *Agricultural Outlook*. Volume 234 (October 1996): 24-30.
- Heifner, R., and K. Coble. "Optimizing Farmers' Joint Use of Forward Pricing and Crop Insurance by Comparing Revenue Distributions Estimated with Numerical Integration." *In Proceedings of the NCR-134 Conference*, Chicago, Illinois 1997.
- King, R.P., and L.J. Robinson. "Risk Efficiency Models." *Risk Management in Agriculture*, ed P.I. Barry, Ames, Iowa: Iowa State University Press, 1984. pp. 68-81.
- National Futures Association, "Understanding Opportunities and Risks in Futures Trading", Chicago, IL. 1986. pp.14.
- Tennessee Department of Agriculture. *Tennessee Agriculture*, 1988-97 Annual Issues. Tennessee Agricultural Statistics Service, Nashville, TN.
- Tennessee, Agricultural Extension Service. *Tennessee Market Highlights*. November 1988-1994, Issues.
- Trapp, J. "Simulation and Systems Modeling". In *Agricultural Policy Analysis Tools for Economic Development*. ed L. Tweeten. Westview Press, Boulder, Colo. 1989.
- United States Department of Commerce, Bureau of Census, *1992 Census of Agriculture*, Washington D.C.

Young, E., and D.A. Shields. "1996 FAIR Act Frames Farm Policy for Seven Years",
Agricultural Outlook. Supplement, U.S. Department of Agriculture, Economic
Research Service, (April 1996): 1-21

Appendix

Table 1. Obion County corn yields and market prices used to estimate expected values and the variance-covariance coefficients for the simulation model

Year	Corn yield ^a (lb/acre)	November Northwest Tennessee cash market price ^b (\$/bushel)	November futures price on the December corn contract ^c (\$/bushel)	February futures Price on the December corn contract ^c (\$/bushel)
1988	110	2.57	2.69	2.17
1989	128	2.40	2.38	2.71
1990	111	2.29	2.26	2.47
1991	90	2.39	2.43	2.59
1992	147	1.96	2.12	2.70
1993	91	2.66	2.74	2.40
1994	136	2.06	2.16	2.68
1995	147	3.26	3.28	2.57
1996	134	2.66	2.68	3.08
Average, 1988-94	116	2.33	2.40	2.53

Sources: ^a Tennessee Department of Agriculture. *Tennessee Agriculture*. 1988-96 Annual Issues. Tennessee Agricultural Statistics Service, Nashville, TN; ^b Agricultural Extension Service. *Tennessee Market Highlights*. November 1988-96 monthly issues; ^cChicago Board of Trade, Chicago, Illinois 1988-96.

Table 2. The estimated variance-covariance coefficients for the simulation model

Item	Corn yield	Northwest Tennessee cash price	November futures	February futures	February options
Corn yield ^a	477.8	-3.86898 (-0.8138) ^d	-17327 (-0.7548)	10569 (0.5622)	-1.4842 (-0.5278)
Cash price ^b		0.06439	255.98 (0.96065)	-155.65 (-0.7132)	0.023086 (0.70722)
November futures ^c			1500954	-827060 (-0.7849)	109.57 (0.69525)
February futures ^c				1006821	-13.259 (-0.1027)
Option price ^c					0.0271

Sources: ^a Tennessee Department of Agriculture. *Tennessee Agriculture*. 1988-96 Annual Issues. Tennessee Agricultural Statistics Service, Nashville, TN; ^b Agricultural Extension Service. *Tennessee Market Highlights*. November 1988-96 monthly issues; ^c Chicago Board of Trade, Chicago, Illinois 1988-96.

^d The correlation coefficient is in parenthesis

Table 3. Alternative income protection strategies simulated in the analysis

Strategy	Cost /Acre (Dollars)
Cash Market	0.00
Revenue Assurance	
65% coverage	4.45 ($\times 75\% = 3.34$, $\times 125\% = 5.56$)
70% coverage	8.25 ($\times 75\% = 6.19$, $\times 125\% = 10.31$)
75% coverage	12.44 ($\times 75\% = 9.33$, $\times 125\% = 15.55$)
Crop Revenue Coverage,	
65% coverage	12.93
70% coverage	18.52
75% coverage	26.69
Multiple Peril Crop Insurance (MPCI),	
75% Yield coverage at \$2.13/ bu	17.27 ^a
75% yield coverage at \$2.45 / bu	20.83 ^a
70% yield coverage at \$2.28 / bu	12.37 ^a
70% yield coverage at \$2.45 / bu	13.78 ^a
65% yield coverage at \$2.45 / bu	8.89 ^a
50% Futures hedge and MPCI	
75% yield coverage at \$2.13 / bu	17.27 ^a + \$0.62/acre ^b + margin
75% yield coverage at \$2.45 / bu	20.83 ^a + \$0.62/acre ^b + margin
70% yield coverage at \$2.28 / bu	12.37 ^a + \$0.62/acre ^b + margin
70% yield coverage at \$2.45 / bu	13.78 ^a + \$0.62/acre ^b + margin
65% yield coverage at \$2.45 / bu	8.89 ^a + \$0.62/acre ^b + margin
100% Futures hedge and MPCI	
75% yield coverage at \$2.13 / bu	17.27 ^a + \$1.24/acre ^b + margin
75% yield coverage at \$2.45 / bu	20.83 ^a + \$1.24/acre ^b + margin
70% yield coverage at \$2.28 / bu	12.37 ^a + \$1.24/acre ^b + margin
70% yield coverage at \$2.45 / bu	13.78 ^a + \$1.24/acre ^b + margin
65% yield coverage at \$2.45 / bu	8.89 ^a + \$1.24/acre ^b + margin
100% Futures hedge on the historical yield average	\$1.24/acre ^b + margin
50% Futures hedge on the historical yield average	\$0.62/acre ^b + margin
100% options hedge on the historical yield average	\$1.24/acre ^b
50% options hedge on the historical yield average	\$0.62/acre ^b

^a Includes \$10 service charge prorated over 1,000 acres

^b Commissions and tax of \$51.72 per contract times the number of contracts purchased divided by 1,000 acres. The number of contracts purchased for 100 and 50 percent of the historical yield average were 24 and 12, respectively.

Table 4. Simulated net revenue statistics averaged over 20 simulations (Dollars)

Strategy	Means	Standard deviation	Maximum	Minimum	Skewness
Cash Market	97626	37717	210155	9964	0.27
Revenue Assurance, 65% coverage	93186	37702	205705	7376	0.27
65% coverage at 75% of premium	94296	37702	206815	8486	0.27
65% coverage at 125% of premium	92076	37702	204595	6266	0.27
Revenue Assurance, 70% coverage	89466	37437	201905	12500	0.30
70% coverage at 75% of premium	91526	37437	203965	14560	0.30
70% coverage at 125% of premium	87406	37437	199845	10440	0.30
Revenue Assurance, 75% coverage	86054	37008	197715	21228	0.37
75% coverage at 75% of premium	89164	37008	200825	24338	0.37
75% coverage at 125% of premium	82944	37008	194605	18118	0.37
Crop Revenue Coverage, 65% coverage	84865	37411	197225	3976	0.31
70% coverage	79686	36779	191635	4347	0.38
75% coverage	72512	35511	183465	6126	0.49
Multiple Peril Crop Insurance (MPCI) 75% yield coverage at \$2.13/ bu	81428	36247	184935	2234	0.41
75% yield coverage at \$2.45 / bu	78030	36075	189325	-891	0.42
70% yield coverage at \$2.28 / bu	85708	37015	197785	4440	0.35
70% yield coverage at \$2.45 / bu	84331	36971	196375	3204	0.35
65% yield coverage at \$2.45 / bu	88865	56551	201265	3867	0.30
50% Futures hedge and MPCI 75% yield coverage at \$2.13/ bu	87748	46911	217965	-8894	0.28
75% yield coverage at \$2.45 / bu	84348	46668	214405	-10601	0.30
70% yield coverage at \$2.28 / bu	92026	47907	222865	-12543	0.20
70% yield coverage at \$2.45 / bu	90649	47849	221445	-13243	0.20
65% yield coverage at \$2.45 / bu	95183	48499	226345	-17333	0.14
100% Futures hedge and MPCI 75% yield coverage at \$2.13/ bu	94065	65425	272904	-62684	0.14
75% yield coverage at \$2.45 / bu	90666	65171	269344	-63552	0.15
70% yield coverage at \$2.28 / bu	98344	66430	277804	-66981	0.08
70% yield coverage at \$2.45 / bu	96968	66370	276394	-67606	0.09
65% yield coverage at \$2.45 / bu	101501	67015	281284	-70532	0.05
100% Futures hedge on the historical yield	110262	67289	290174	-67471	0.03
50% Futures hedge on the historical yield	103944	48775	235235	-16661	0.11
100% options hedge on the historical yield	-32909	134619	146613	-821754	-2.57
50% options hedge on the historical yield	32359	77398	175143	-379754	-1.86

Table 5. Probability of achieving alternative rates of return on investment in corn production*

Strategy	0 percent	5 percent	10 percent
Cash Market	100	73	11
Revenue Assurance,			
65% coverage	100	68	9
70% coverage	100	65	8
75% coverage	100	61	6
Crop Revenue Coverage,			
65% coverage	100	61	6
70% coverage	100	55	5
75% coverage	100	47	3
Multiple Peril Crop Insurance (MPCI),			
75% Yield Coverage at \$2.13/ bu	100	57	5
75% yield coverage at \$2.45 / bu	100	53	4
70% yield coverage at \$2.28 / bu	100	62	6
70% yield coverage at \$2.45 / bu	100	60	5
65% yield coverage at \$2.45 / bu	100	65	8
50% Futures hedge and MPCI			
75% yield coverage at \$2.13 / bu	99	61	12
75% yield coverage at \$2.45 / bu	98	58	11
70% yield coverage at \$2.28 / bu	98	65	14
70% yield coverage at \$2.45 / bu	98	64	14
65% yield coverage at \$2.45 / bu	98	68	16
100% Futures hedge and MPCI			
75% yield coverage at \$2.13 / bu	92	62	22
75% yield coverage at \$2.45 / bu	92	60	21
70% yield coverage at \$2.28 / bu	93	66	25
70% yield coverage at \$2.45 / bu	92	64	24
65% yield coverage at \$2.45 / bu	93	67	26
100% Futures hedge on the historical yield average	95	72	31
50% Futures hedge on the historical yield average	99	73	20
100% options hedge on the historical yield average	52	10	0
50% options hedge on the historical yield average	77	30	2

* Above variable and fixed costs of production and the specified return to land and equipment of 0, 5, or 10 percent.

**Part 3: Stochastic Dominance Analysis of Net Revenues for Alternative
Protection Strategies**

Introduction

The revenues that Tennessee farmers receive from the production of field crops are risky due to uncertain weather impacts on yields and uncertain market impacts on prices. Historically, producers have relied on the federal government to manage income risk through a price support program. Under the government program, farmers would receive a deficiency payment during periods when the market price fell below a specified target price. These payments would help farmers manage the downside income risk associated with adverse price movements. Producers were required under the program to restrict acreage grown in order to receive the deficiency payment. With the passage of the Federal Agricultural Improvement and Reform (FAIR) Act of 1996, deficiency payments for many crops were replaced by contract payments, and acreage reduction programs were eliminated. Contract payments were set for fixed amounts through the year 2002 and are not expected to change regardless of future prices and yields (Young and Shields, 1996). Now that these restrictions have been eliminated, farmers can grow what they think will be the most profitable crop given their expectations of price and yield at planting time.

A related development affecting farmers is lower global stocks for the major grains. Increased domestic consumption, higher exports from the United States due to changes in government policy, and less forfeiture of crops into government stocks, caused global stocks-to-use ratios for corn and wheat in 1995-1996 to fall to the lowest level since USDA began tracking stocks in 1960 (Harwood *et al.*, 1996). With lower stocks of grain to help buffer yearly supply and demand shocks, many analysts believe there will be

increased price volatility in the future. The implications of increased planting flexibility and recent global trends will most likely increase future income volatility for farmers unless a risk management strategy is used in conjunction with market signals.

The FAIR Act and previous farm bill legislation have encouraged the development of alternative income protection strategies for farmers. These risk management products were designed to help farmers manage yield and price volatility in the absence of price support programs and acreage controls being phased out under the FAIR Act. These insurance products are offered through private insurance companies and are reinsured through the Federal Government. Some of these products are currently available in Tennessee and others are expected to be available in the future. The effectiveness of these insurance products in managing risk as measured by the expected value and variability of net revenues has not been evaluated for Tennessee farmers. Information about the net revenue trade offs among traditional hedging strategies using futures and options, existing crop insurance programs, and new income protection programs would be useful for farm planning and decision making.

Because these products are designed to reduce variability of income, a farmer's risk attitude is an important factor that may explain whether or not a specific income protection product is used. Farmers with alternative risk attitudes may prefer different income protection products based on the tradeoffs in expected value and variability of net revenues. The objective of this study was to identify from the traditional and new income protection alternatives, the risk-preferred strategies for a representative row crop for different levels of farmer risk aversion behavior.

Representative Farm Situation

For the purpose of this analysis, the farm modeled in this study was a large, commercial operation that obtains all of its income from farming activities. The specific field crop scenario modeled is a 1,000 acre corn enterprise in Obion County, Tennessee. Obion County is in northwest Tennessee and is located near the southern edge of the U.S. Corn Belt. Approximately 10 percent of the 697 farms in Obion County had a farm size of more than 1,000 acres in 1992 (U.S. Department of Commerce, Bureaus of the Census). The reasons for using a corn production scenario to analyze net revenues for alternative income protection strategies are as follows. First, corn is an important enterprise alternative for farmers in northwest Tennessee. In 1997, Obion County was ranked number one in corn production in Tennessee with 69,000 acres planted (Tennessee Department of Agriculture, 1998). In addition, corn is grown in nearly every County in Tennessee. Finally, a single commodity was evaluated to facilitate the modeling of alternative income protection strategies. Potential correlations among alternative crops and commodity prices were not considered in this analysis. Indeed, crop diversification is a risk reduction strategy upon which crop insurance can be purchased at a lower cost per acre than assumed in this analysis. By modeling only a single commodity, the actual risk incurred is representative of the worst case scenario for a producer.

Review of Literature

Several researchers have evaluated the effectiveness of alternative income protection strategies in mitigating risk in a post FAIR Act environment. Harwood, *et al.* (1996) compared Crop Revenue Coverage (CRC), Income Protection (IP), Multiple Peril Crop Insurance (MPCI), and forward contracting risk management strategies for corn producers in Illinois, Iowa, North Carolina, and South Dakota. They ranked the risk management alternatives based on the probability of revenue falling below 70 percent of an expected preplanting level. The results, from best to worst were IP and CRC followed by a combination of crop insurance and forward contracting, crop insurance alone, and forward contracting alone. However, premiums were not included in the revenue assessment and no weight was given to strategies that would have resulted in higher probabilities of revenue above projected levels. Harwood, *et al.* also analyzed data from the 1993 Farm Costs and Returns Survey and found that producers with higher farm sales were less likely to obtain insurance and more likely to hedge production.

Dhuyvetter and Kastens (1997) compared net revenues from no crop insurance versus using CAT, MPCI, and CRC coverage options for a dryland Kansas wheat farm. They also examined pre-harvest hedging strategies in conjunction with using insurance. CRC produced the highest minimum net revenue value (maxi-min criterion) among the alternatives analyzed. The maxi-min strategy is preferred by decision makers who are extremely risk averse (Grub, 1986). The MPCI plan maximized expected net revenue among the alternatives. The strategy that maximizes expected net revenue is preferred by

risk neutral decision makers. Furthermore, Dhuyvetter and Kastens observed that although the variability of revenues is generally lower with CRC than with MPCl, the advantage of CRC over MPCl decreases as the amount of production hedged increases.

Heifner and Coble (1997) used numerical integration to find the optimal price futures and options hedge ratios in conjunction with crop insurance and forward contracting for corn producers in Dewitt County, Illinois. The crop insurance strategies that they evaluated were: 1) MPCl, 2) MPCl with replacement coverage, 3) IP, and 4) CRC. Their model accounted for differences in yield-price correlation and yield variability in order to apply their results over areas without a 'natural hedge' and/or high yield variability. Furthermore, the gains in hedging effectiveness were normalized under four different levels of risk aversion. Without forward pricing of production, IP and CRC were found to be superior to MPCl in reducing risk over four combinations of yield-price correlation and yield variability. With forward pricing of production, IP and CRC also outperformed MPCl and provided protection to a producer who has overcommitted production through forward contracting. Gray et al. (1995) have shown that incomes could be stabilized and that payments to producers would be substantially less under Revenue Assurance (RA) than under the former price support programs.

Methods and Data

Monte Carlo simulation and stochastic dominance methods were used to achieve the objectives of this study. Compared to other procedures, Monte Carlo simulation is

numerically efficient when there are several variables. This is because the time taken to carry out a Monte Carlo simulation increases approximately linearly with the number of variables, whereas the time taken for most other procedures increases exponentially with the number of variables. Stochastic dominance procedures facilitate the evaluation of tradeoffs in the expected value and variability of net revenues among income protection strategies for risk averse farmers. The first part of this section presents the simulation model followed by the yield, price, and cost data used in the model. Next, is a presentation of the hedging and insurance strategies simulated with the model. The final part of this section is a description of stochastic dominance methods used to analyze the simulated net revenues.

Simulation Model

The farm decision maker was assumed to make planting hedging and crop insurance decisions in February. The corn crop was assumed to be harvested and sold in November. For the futures hedge, the producer was assumed to sell a December corn futures contract in February and buy back the December futures contract in November. For the put option strategy, the producer was assumed to purchase a put option on the December corn contract in February and not exercise the option contract until the corn was sold in November. If the option premium did not have a positive value at harvest it was allowed to expire. Indemnity payments from crop insurance strategies were determined in November after the crop was harvested and sold. Net revenue (NR) for a

farmer producing corn, hedging with futures and options, and purchasing crop insurance can be written as:

$$(1) \quad NR = P \times Y + HR - HC + ID - IC - OC,$$

where P is the cash price for corn (\$/bushel), Y is the yield of corn (lb/acre); HR is the revenue from pre-harvest hedging activities with futures or options (\$/acre); ID is the indemnity payment received from crop insurance activities (\$/acre); HC is the cost of hedging activities; IC is the premiums paid for crop insurance coverage (\$/acre); and OC is the estimated variable expenses, fixed equipment and labor costs, and overhead expenses that do not change with the hedging or insurance strategies (\$/acre). This residual (NR) is the estimated return to a farmer for land, management and risk (Boehlje and Eidman, 1984). HR for the futures strategy was determined by the difference between futures contract prices in February and November and the basis, or the difference between the November futures and cash prices. This difference was multiplied by the bushels of production hedged. For the options strategy, HR was determined by multiplying the bushels of production hedged by the premium value of the option in November. HC for the futures hedge included commission expenses and taxes and interest costs on initial margin. ID is the payout made by the insurance company for a specified corn yield and/or corn price selection or for a specified level of gross revenue coverage.

To calculate stochastic NR 's for the production, hedging, and crop insurance activities represented in equation (1), the five random values simulated were: 1) harvested corn yield, 2) the November cash corn price for Obion County, 3) the February futures

price for the Chicago Board of Trade (CBOT) December corn contract, 4) the February put option premiums for the CBOT December Corn contract, and 5) the December futures price for the Chicago Board of Trade (CBOT) December corn contract. The five random correlated variates were generated as follows:

$$(2) \quad \mathbf{D} = \mathbf{E} + \mathbf{A}^* \mathbf{R},$$

where $\mathbf{D}$ is a 5×1 vector of random values, $\mathbf{E}$ is a 5×1 vector of expected values, $\mathbf{A}^*$ is a 5×5 matrix of coefficients, and $\mathbf{R}$ is a 5×1 vector of lognormally distributed random deviates. A lognormal distribution was assumed to preclude negative yields or commodity prices. $\mathbf{A}^*$ in equation (2) is an upper triangular matrix of coefficients derived from the estimated variance-covariance matrix of the five yield and price random variables (Clements, Mapp, and Eidman; Fishman).

Yield and price data reported in Table 1 were used to estimate expected (mean) values and variance-covariance coefficients for the simulation model. Obion County corn yields (1988-1996) were from *Tennessee Agriculture* (Tennessee Department of Agriculture). Northwest Tennessee November average cash market prices used to represent Obion county prices were from *Tennessee Market Highlights* (Tennessee Department of Agriculture). February and November averages for the December Corn contract were computed using data from the Chicago Board of Trade. Evaluations of the data for an inflationary trend in prices and upward trends in yields due to changes in technology were found to not be statistically significant at the 90% confidence level. The 1995 cash price of \$3.26/bushel was deemed to be an outlier that would bias upward the probability of a high corn price received by farmers and may overstate variability of net

revenue experienced by farmers. Consequently, the 1988-94 portion of the time-series in Table 1 was used to estimate coefficients for this simulation model. Removing the 1995-96 years reduced the variability in gross revenue by approximately 50 percent.

To develop put option premiums for the simulation model, the November average futures price on the December contract was regressed on the February average futures price on the December contract:

$$(3) \quad FP_{NOV} = \alpha_0 + (\alpha_1 \times FP_{FEB}) + \varepsilon_i ,$$

where FP_{NOV} and FP_{FEB} are the November and February futures prices for the CBOT December corn contract, α_0 and α_1 are the estimated regression coefficients, and ε_i is the regression residuals. The residuals were used to calculate σ_ε^2 for inclusion as a stochastic variable in the Cholesky decomposition in A^* . The residuals and November futures price from the random variants were used to infer a futures price in February by solving equation (3) for the February futures price as follows:

$$(4) \quad \text{Inferred } FP_{FEB} = 1/\alpha_1 \times FP_{NOV} - \alpha_0 - \varepsilon_i .$$

Finally, the option price of the December contract at the end of February was derived by regressing the price of the option (OP) on the inferred February futures price.

$$(5) \quad OP = \beta_0 + (\beta_1 \times \text{Inferred } FP_{FEB}) + \omega_i .$$

The \$2.30 strike price and the 1984-94 time period were chosen due to data availability. The data from the CBOT lists final daily settlements for strike prices of \$2.10 and \$2.30 for each of the years in the 1988-1994 time series. One limitation of this method is that option prices for the \$2.30 strike were extremely “in the money” for many years of the time series. The result of which is expensive option premiums for the purchaser. Another

assumption of the options strategy is that the producer purchases the option on March 1 and holds it until the end of November without using the early exercise feature characteristic of American options. This assumption of the options strategy fails to account for the value of the early exercise feature that is built into the option premium. The estimated variance-covariance coefficients for the simulation model are presented in Table 2.

Strategies Simulated

The 26 hedging and insurance strategies simulated with the model are outlined in Table 3. The per acre costs for each income protection strategy simulated are also in Table 3. The cash market strategy assumes that the farmer does not hedge against price risk, does not purchase insurance, and sells production on the cash market. The coverage levels for Revenue Assurance (RA), CRC, and MPCCI insurance products modeled were 65, 70, and 75 percent coverage.

Currently, RA is not available in Tennessee. Consequently, premiums for RA in Obion County were determined in the following manner. Market quotes for RA and CRC products in Clay County, Iowa were obtained from the Deanna Orwig Agency (Personal communication with Deanna Orwig, Insurance Agent, Spencer, IA, February, 1998). County-level yields for 1977 to 1997 were compared between Obion County TN and Clay County IA (Tennessee Department of Agriculture; Iowa Department of Agriculture). The coefficient of variation (CV) was calculated to estimate relative yield variability for each of

the two counties.¹ The CV for Obion County was 23.1 compared with 17.3 for Clay County. It was assumed that the higher costs of the CRC products in Tennessee compared with Iowa are due to the higher yield variability as opposed to higher administrative costs for selling a product to a smaller customer base in Tennessee than in Iowa. Therefore, RA premiums were determined using a relative as opposed to an absolute difference in premiums for CRC and RA products. For each level of coverage, the Obion County RA premium was determined by dividing the RA premium by the CRC premium for Clay County, IA, and multiplying the resulting ratio by the Obion County CRC premiums quoted from the Jarmon Insurance Agency (Personal communication with Jerry Jarmon, Insurance agent, Alexandria, IN, September, 1997)². Although the aforementioned procedure calculates a close approximation for West Tennessee RA premiums, it is by no means exact. Therefore, RA premiums were also modeled at 75 and 125 percent of the previously determined RA premiums for each level of coverage.³

MPCI strategies modeled were 65, 70, and 75 percent of the 5-year average of Obion county corn yields. MPCI policies can be purchased at varying indemnity rates for the 70 and 75% yield selections. MPCI policies were modeled at the five levels of subsidized yield coverage and indemnity payment rates: 65 percent of yield at \$2.60 per

¹ Coefficient of variation = standard deviation ÷ mean × 100.

² RA, 65 percent level = \$2.92/acre ÷ \$8.49/acre × \$12.93/acre = \$4.45/acre
RA, 70 percent level = \$5.45/acre ÷ \$12.45/acre × \$18.52/acre = \$8.25/acre
RA, 70 percent level = \$8.42/acre ÷ \$18.07/acre × \$26.69/acre = \$12.44/acre

³ RA, 65 percent level = \$4.45/acre × .75 = \$3.34/acre; \$4.45/acre × 1.25 = \$5.56/acre
RA, 70 percent level = \$8.25/acre × .75 = \$6.19/acre; \$8.25/acre × 1.25 = \$10.31/acre
RA, 75 percent level = \$12.44/acre × .75 = \$9.33/acre; \$12.44/acre × 1.25 = \$15.55/acre

bushel, 70 percent at \$2.60 per bushel, 70 percent at \$2.42 per bushel, 75 percent at \$2.60 per bushel, 75 percent at \$2.26 per bushel, respectively. An administrative fee of \$10 per policy was prorated over the 1,000 acre enterprise in addition to premium amounts.

MPCI premiums were also quoted from the Jarmon Insurance Agency (Personal communication with Jerry Jarmon, Insurance agent, Alexandria, IN, September, 1997).

The management alternatives involving the use of options contracts were limited to two routine hedging strategies on 100 percent (100% options) and 50 percent (50% options) of the historical average yield of 116 bushels per acre via the purchase of a \$2.30 put option. Round turn commissions and taxes of \$50.00 and \$1.72, respectively were also subtracted from gross income for each option and future contract purchased (Personal communication with Charlie Crawford, senior broker, Parker Grain Brokerage, Knoxville, TN, December 1997).

Hedging with futures contracts was considered both alone and in combination with MPCI. Future hedges were placed on 100 percent (100% futures hedge) and 50 percent (50% futures hedge) of the historical average yield. Interest on margin deposits was calculated at an 11 percent annual rate for eight months of the year. This interest was applied to 5 percent of the initial February futures price times the number of contracts purchased (National Futures Association). Interest charges on margin calls due to fluctuations in the futures price before harvest were ignored in the analysis.

The other costs of production in equation (1) that were subtracted from revenues when estimating net revenues were from Gerloff and Maxey (1997). These costs include machinery, labor, and materials expenses to produce an acre of corn using 8-row

equipment. The total variable expenses, fixed equipment and labor costs, and overhead expenses used in the simulation totaled \$170.40 per acre.

Stochastic Dominance Analysis

The stochastic dominance procedure is based on the theory of expected utility and involves a pair-wise comparison of expected utilities derived by decision makers from a set of risky net revenues (King and Robison, 1984). For example, take a person who displays utility for income (x) defined by the monotonically increasing function $u(x)$. This person must decide between two risky sets of net revenues, A_1 and A_2 , with cumulative outcome probability distribution functions (CDFs) represented by $G(x)$, and $F(x)$, respectively. When the expected utility of $F(x)$ is greater than the expected utility of $G(x)$, then A_2 stochastically dominates A_1 and is preferred by that person. Using this pair-wise comparison procedure, stochastic dominance provides an ordering of choices by placing them into two mutually exclusive sets: the risk efficient set and the risk inefficient set. Alternatives in the efficient set will always provide higher expected utilities than ones in the inefficient set regardless of one's attitude towards risk.

Farmer's risk attitudes that can be modeled using alternative stochastic dominance criteria fall into three general categories: risk averse, risk neutral, and risk seeking behaviors (King and Robison, 1984). For risk averse farmers, their utility increases with net revenue but at a decreasing rate, i.e., $u'(x) > 0$ and $u''(x) < 0$. By definition, a risk averter would be willing to accept a slightly lower mean net revenue in exchange for a

significantly less variable (risky) distribution of net revenues. If $u'(x) > 0$ and $u''(x) = 0$, utility increases at a constant rate as net revenue increases and the individual is said to be risk neutral. These persons will only consider expected (mean) net revenue when ranking alternatives. For risk seeking behavior, $u'(x) > 0$ and $u''(x) > 0$, utility increases at an increasing rate as net revenue increases. A risk seeker could be willing to accept lower mean net revenue in exchange for a riskier distribution of net revenue-especially distributions that have one or more very large net revenue values.

The two stochastic dominance criteria used to examine the net revenues for alternative income protection strategies are first-degree stochastic dominance (FSD) and second-degree stochastic dominance (SSD). FSD imposes the single restriction, $u'(x) > 0$, on decision maker preferences regardless of one's risk attitude. At all levels of cumulative probability, a strategy in the FSD set produces net revenue equal to or greater than net revenue from a strategy in the inefficient set. In graphical terms, the two cumulative outcome probability distribution functions (CDFs) represented by $G(x)$, and $F(x)$ for the two risky sets of net revenues A_1 and A_2 , respectively could never cross. However, in empirical analysis many distributions will cross each other and cannot be ranked using the FSD criterion. It is therefore necessary to seek a more restrictive concept of efficiency so that one can judge between risky prospects any time there is a chance that one alternative is not 100 percent sure to be superior. This problem is addressed by second degree stochastic dominance (SSD).

The SSD criterion was developed by Hadar and Russell (1969) and Hanoch and Levy (1969) as a means of predicting a decision maker's choice between given pairs of

risky alternatives without having any knowledge of a decision maker's utility function other than it is monotonically increasing and strictly concave (the decision maker is risk averse). In graphical terms, the two cumulative outcome probability distribution functions (CDFs) represented by $G(x)$, and $F(x)$ for the two risky sets of net revenues A_1 and A_2 , respectively can cross and still be ranked using the SSD criterion. Like FSD, SSD will include the maximin and expected net revenue maximizing strategies. In this study, a computer program by Cochran and Raskin was used to evaluate strategies for 20 simulation runs based on FSD and SSD criterion.

Results and Discussion

Net revenue statistics for the 26 strategies simulated are presented in table 4. The top five strategies in order of descending mean net revenues are: (1) futures hedge on 100 percent of the historical yield average, (2) futures hedge on 50 percent of the historical yield average, (3) combination of the 100 percent futures hedge and multiple peril crop insurance (MPCI) with 65 percent yield coverage at \$2.45/bushel, (4) cash market, and (5) combination of the 100 percent futures hedge and MPCI with 70 percent coverage at \$2.45/ bushel. The futures hedge on 100 percent of the historical yield average produced mean net revenue of \$101,501, compared with \$97,626 for the cash market strategy. However, the standard deviation of net revenue for the futures hedging strategy was \$67,289, nearly double the \$37,717 standard deviation of the cash market strategy. A textbook futures hedge usually involves a tradeoff of lower expected net revenue for a

smaller variance of net revenue for a risk averse decision maker. The possible reasons for the higher mean and standard deviation of net revenues for the futures hedge in the model are as follows. First, the amount of total production hedged may be too high for a producer interested in reducing price risk. Second, the simulated basis in the model is more variable than cash prices, which may make the hedging strategies not effective in reducing income variability for this analysis. Because both yields and prices are stochastic in the model, the hedging strategy in some years is speculative when simulated production is less than the 120,000 bushel amount hedged on the futures market. For example, yield that is two standard deviations below the mean of 116 bushels/acre is 72 bushels/acre and results in a 48,000 bushel production shortfall under this hedging scenario. If the cost of buying back the corn in November is greater than what it has sold for in February, on the futures market, the farmer takes a direct loss on the 48,000 bushel shortfall. On the other hand, if production is above average, and if the cost of buying corn on the futures market is less in November than in February, the profit from hedging is higher than in the cash market.

The top five strategies in minimizing variance of net revenues were alternative crop insurance strategies: (1) CRC, 75 percent coverage; (2) MPCI, 75 percent yield coverage at \$2.45/bushel; (3) MPCI, 75 percent yield coverage at \$2.13/bushel; (4) CRC, 65 percent coverage; and (5) MPCI, 70 percent coverage at \$2.45/bushel. For CRC with 75 percent coverage, mean net revenue of \$72,512 was 26 percent less than the cash market strategy while the \$35,511 standard deviation of net revenue was only 6 percent lower than the cash strategy. In terms of relative risk as measured by the coefficient of variation,

the cash strategy was less risky ($CV=38.6$) than the CRC strategy ($CV=48.9$). In general, none of the crop insurance or hedging strategies markedly reduced variability of net revenue and relative riskiness when compared with the cash strategy.

The top five strategies that maximized the minimum net revenue (maximin criterion) are: (1) Revenue Assurance, 75 percent coverage, (2) Revenue Assurance, 70 percent coverage, (3) cash market, (4) Revenue Assurance 65 percent coverage, (5) Crop Revenue Coverage 75 percent coverage. The actual yield and price data used to make the simulation model operational did not contain extremely low values. This may partially explain the appearance of the cash market strategy in the above. Revenue Assurance strategies were the most effective at setting a floor on net revenues with minimum values ranging from \$18,118 to \$24,338 for 75 percent coverage. These minimum net revenues compare with \$9,964 for the cash market strategy. As a result, Revenue Assurance products may perform well for extremely risk averse producers. This is because RA strategies provided the largest minimum net revenues in the simulation. However, RA strategies did not significantly lower the standard deviation of net revenues, but did lower mean net revenues by three to 15 percent depending on the coverage and premium level. Consequently, the relative riskiness of RA strategies was higher than the cash strategy with coefficient of variations ranging from 41.5 to 44.6 depending on the coverage and premium level.

The stochastic dominance results are listed in Table 5. Three strategies were in the risk efficient set for both the first- and second-degree stochastic dominance criteria on all 20 simulation runs: (1) cash market, (2) 100 percent futures hedge, and (3) 50 percent

futures hedge. These three strategies would be preferred by decision makers who are risk averse. However, in terms of the level of risk aversion, it is likely that the futures hedging strategies would be preferred by individuals who are risk neutral or slightly risk averse. The cash market strategy would likely be preferred by individuals who have a higher degree of risk averse behavior. The next best strategies in terms of the number of times that they appeared in the FSD efficient set were: (1) a combination of the 100 percent futures hedge and multiple peril crop insurance (MPCI) with 75 percent yield coverage at \$2.13/bushel and (2) Revenue Assurance, 75 percent coverage at 75 percent of premium. Each of these strategies appeared in the FSD efficient set in 13 out of the 20 simulation runs. Under the second-degree stochastic dominance criterion, the next best strategies in terms of the number of times that they appeared in the SSD efficient set were: (1) Revenue Assurance, 75 percent coverage at 75 percent of premium and (2) Revenue Assurance, 75 percent coverage at 100 percent of the premium. These two RA strategies appeared in the SSD efficient 13 and seven times, respectively, out of 20 simulations.

Besides the top three strategies of Cash Market and Futures hedges, only the Revenue Assurance strategies appeared in the SSD efficient set more than once out of 20 simulations. Furthermore, the Revenue Assurance strategies were in the second-degree stochastic dominance efficient set in every trial for which they also appeared in the first-degree stochastic dominance efficient set. This result was far different than the case for strategies using a combination of futures hedges with MPCI at 75 percent coverage at \$2.13/ bu and 70 percent yield coverage at \$2.28/ bu. These strategies appeared in the first-degree stochastic dominance efficient set more than any other strategies but failed to

appear in the second-degree stochastic dominance efficient set. Among the crop insurance strategies evaluated, RA appears to have the greatest potential to be a risk preferred strategy for decision makers who have a higher degree of risk averse behavior. RA produced the highest minimum net revenues in the simulation but did not markedly affect the variance of net revenues. Finally, the in the money put options strategy simulated in this analysis was not risk efficient for any class of decision makers.

Summary and Conclusions

This study evaluated the problem of selecting risk efficient income protection strategies for a large corn enterprise located in Northwest Tennessee. A simulation model was developed to generate the randomly correlated draws from which net revenues were then calculated for alternative crop insurance and price hedging strategies. First-degree stochastic dominance and second-degree stochastic dominance criteria were used to evaluate net revenues simulated for each alternative.

In the simulation, the traditional hedge of a short futures position maximized expected net revenue but also increased the variability of net revenues. The unstable futures basis relation in the data used in the simulation model and the large amount of production hedged may have contributed to increased variability of net revenues. Consequently, the futures hedging strategies were risk efficient for risk neutral and slightly risk averse decision makers. For a decision maker with a higher degree of risk averse behavior, the cash market and Revenue Assurance strategies may be the dominant

strategies. Revenue Assurance at the 70 and 75 percent coverage levels were superior in setting a floor on minimum net revenues. As a result, Revenue Assurance may be preferred by extremely risk averse decision makers. While the Revenue Assurance strategies were able to maximize-minimum net revenue, they did not appreciably lower the variability of net revenues in the simulation.

Further research should be conducted in the area of analyzing multiple crops (e.g. corn and soybeans) for West Tennessee farms. Due to inherent correlations among price and yield with a multiple crop study, the results would be more applicable to those same farmers. Also, the Group Risk Plan (GRP) is now widely available and should be studied in conjunction with other strategies.

References

References

- Boehlje, M.D., and V.R. Eidman. *Farm Management*. John Wiley & Sons, New York, 1984.
- Chicago Board of Trade. Chicago Board of Trade monthly average, 1988-1994. Chicago, Illinois.
- Clements, A.M., H.P. Mapp, and V.R. Eidman. "A Procedure for Correlating Events in Farm Firm Simulation Models." Oklahoma State University Agricultural Experiment Station Technical Bulletin T-131, August 1971. pp. 5-9.
- Dhuyvetter, K.C., and T.L. Kastens. "Crop Insurance and Forward Pricing Linkages: Effects on Mean Income and Variance." *In Proceeding of the NCR-134 Conference*. Chicago, Illinois , 1997, pp. 94-111.
- Fishman, G.S. *Concepts and Methods in Discrete Event Digital Simulation*. John Wiley, New York, 1973.
- Gerloff, D.C., and L. Maxey. "Field Crop Budgets for 1997: A Supplement to the Guide to Farm Planning." University of Tennessee Agric. Econ. and Rur. Devel. Info Series 36. January 1997.
- Gray, A., J. Richardson, and J. McClaskey. "Farm Level Impacts of Revenue Assurance." *Rev. Agr. Econ.* 17(1995): 171-183.
- Grub, A.H. "Participation in Farm Commodity Programs: A Stochastic Dominance Analysis: Comment." *Amer. J- Agr. Econ.* 68 (1986): 185-188.

- Hadar, J. and Russel. W. R. "Rules for Ordering Uncertain Prospects", *Amer. J. Econ. Rev.* 59 (1969): 25-34
- Hanoch, G., and H. Levy. "Efficiency Analysis of Choices Involving Risk." *Rev. Econ. Stud.* 36 (1969): 335-345.
- Harwood, J., D. Heifner, K. Coble, and J. Perry, "Strategies for a New Risk Management Environment." *Agricultural Outlook.* 234 (October 1996): 24-30.
- Heifner, R., and K. Coble. "Optimizing Farmers' Joint Use of Forward Pricing and Crop Insurance by Comparing Revenue Distributions Estimated with Numerical Integration." *In Proceedings of the NCR-134 Conference*, Chicago, Illinois 1997.
- King, R.P., and L.J. Robinson. "Risk Efficiency Models." In Risk Management in Agriculture. ed P.I. Barry, Ames, Iowa: Iowa State University Press, 1984. 68-81.
- National Futures Association, "Understanding Opportunities and Risks in Futures Trading", Chicago, IL. 1986. pp.14.
- Tennessee Department of Agriculture. *Tennessee Agriculture*, 1988-97 Annual Issues. Tennessee Agricultural Statistics Service, Nashville, TN.
- Tennessee, Agricultural Extension Service., *Tennessee Market Highlights*. November 1988-1994, Issues.
- United States Department of Commerce, Bureau of Census, *1992 Census of Agriculture*, Washington D.C.
- Young, E., and D.A. Shields. "1996 FAIR Act Frames Farm Policy for Seven Years", *Agricultural Outlook.* Supplement, U.S. Department of Agriculture, Economic Research Service, (April 1996): 1-21.

Appendix

Table 1. Obion County corn yields and market prices used to estimate expected values and the variance-covariance coefficients for the simulation model

Year	Corn yield ^a (lb/acre)	November Northwest Tennessee cash market price ^b (\$/bushel)	November futures price on the December corn contract ^c (\$/bushel)	February futures Price on the December corn contract ^c (\$/bushel)
1988	110	2.57	2.69	2.17
1989	128	2.40	2.38	2.71
1990	111	2.29	2.26	2.47
1991	90	2.39	2.43	2.59
1992	147	1.96	2.12	2.70
1993	91	2.66	2.74	2.40
1994	136	2.06	2.16	2.68
1995	147	3.26	3.28	2.57
1996	134	2.66	2.68	3.08
Average, 1988-94	116	2.33	2.40	2.53

Sources: ^a Tennessee Department of Agriculture. *Tennessee Agriculture*. 1988-96 Annual Issues. Tennessee Agricultural Statistics Service, Nashville, TN; ^b Agricultural Extension Service. *Tennessee Market Highlights*. November 1988-96 monthly issues; ^c Chicago Board of Trade, Chicago, Illinois 1988-96.

Table 2. The estimated variance-covariance coefficients for the simulation model

Item	Corn yield	Northwest Tennessee cash price	November futures	February futures	February options
Corn yield ^a	477.8	-3.86898 (-0.8138) ^d	-17327 (-0.7548)	10569 (0.5622)	-1.4842 (-0.5278)
Cash price ^b		0.06439	255.98 (0.96065)	-155.65 (-0.7132)	0.023086 (0.70722)
November futures ^c			1500954	-827060 (-0.7849)	109.57 (0.69525)
February futures ^c				1006821	-13.259 (-0.1027)
Option price ^c					0.0271

Sources: ^a Tennessee Department of Agriculture. *Tennessee Agriculture*. 1988-96 Annual Issues. Tennessee Agricultural Statistics Service, Nashville, TN; ^b Agricultural Extension Service. *Tennessee Market Highlights*. November 1988-96 monthly issues; ^c Chicago Board of Trade, Chicago, Illinois 1988-96.

^d The correlation coefficient is in parenthesis

Table 3. Alternative income protection strategies simulated in the analysis

Strategy	Cost /Acre (Dollars)
Cash Market	0.00
Revenue Assurance	
65% coverage	4.45 (× 75% = 3.34, × 125% = 5.56)
70% coverage	8.25 (× 75% = 6.19, × 125% = 10.31)
75% coverage	12.44 (× 75% = 9.33, × 125% = 15.55)
Crop Revenue Coverage,	
65% coverage	12.93
70% coverage	18.52
75% coverage	26.69
Multiple Peril Crop Insurance (MPCI),	
75% Yield coverage at \$2.13 / bu	17.27 ^a
75% yield coverage at \$2.45 / bu	20.83 ^a
70% yield coverage at \$2.28 / bu	12.37 ^a
70% yield coverage at \$2.45 / bu	13.78 ^a
65% yield coverage at \$2.45 / bu	8.89 ^a
50% Futures hedge and MPCI	
75% yield coverage at \$2.13 / bu	17.27 ^a + \$0.62/acre ^b + margin
75% yield coverage at \$2.45 / bu	20.83 ^a + \$0.62/acre ^b + margin
70% yield coverage at \$2.28 / bu	12.37 ^a + \$0.62/acre ^b + margin
70% yield coverage at \$2.45 / bu	13.78 ^a + \$0.62/acre ^b + margin
65% yield coverage at \$2.45 / bu	8.89 ^a + \$0.62/acre ^b + margin
100% Futures hedge and MPCI	
75% yield coverage at \$2.13 / bu	17.27 ^a + \$1.24/acre ^b + margin
75% yield coverage at \$2.45 / bu	20.83 ^a + \$1.24/acre ^b + margin
70% yield coverage at \$2.28 / bu	12.37 ^a + \$1.24/acre ^b + margin
70% yield coverage at \$2.45 / bu	13.78 ^a + \$1.24/acre ^b + margin
65% yield coverage at \$2.45 / bu	8.89 ^a + \$1.24/acre ^b + margin
100% Futures hedge on the historical yield average	\$1.24/acre ^b + margin
50% Futures hedge on the historical yield average	\$0.62/acre ^b + margin
100% options hedge on the historical yield average	\$1.24/acre ^b
50% options hedge on the historical yield average	\$0.62/acre ^b

^a Includes \$10 service charge prorated over 1,000 acres

^b Commissions and tax of \$51.72 per contract times the number of contracts purchased divided by 1,000 acres. The number of contracts purchased for 100 and 50 percent of the historical yield average were 24 and 12, respectively.

Table 4. Simulated net revenue statistics averaged over 20 simulations (Dollars)

Strategy	Means	Standard deviation	Maximum	Minimum	Skewness
Cash Market	97626	37717	210155	9964	0.27
Revenue Assurance, 65% coverage	93186	37702	205705	7376	0.27
65% coverage at 75% of premium	94296	37702	206815	8486	0.27
65% coverage at 125% of premium	92076	37702	204595	6266	0.27
Revenue Assurance, 70% coverage	89466	37437	201905	12500	0.30
70% coverage at 75% of premium	91526	37437	203965	14560	0.30
70% coverage at 125% of premium	87406	37437	199845	10440	0.30
Revenue Assurance, 75% coverage	86054	37008	197715	21228	0.37
75% coverage at 75% of premium	89164	37008	200825	24338	0.37
75% coverage at 125% of premium	82944	37008	194605	18118	0.37
Crop Revenue Coverage, 65% coverage	84865	37411	197225	3976	0.31
70% coverage	79686	36779	191635	4347	0.38
75% coverage	72512	35511	183465	6126	0.49
Multiple Peril Crop Insurance (MPCI) 75% yield coverage at \$2.13/ bu	81428	36247	184935	2234	0.41
75% yield coverage at \$2.45 / bu	78030	36075	189325	-891	0.42
70% yield coverage at \$2.28 / bu	85708	37015	197785	4440	0.35
70% yield coverage at \$2.45 / bu	84331	36971	196375	3204	0.35
65% yield coverage at \$2.45 / bu	88865	56551	201265	3867	0.30
50% Futures hedge and MPCI 75% yield coverage at \$2.13/ bu	87748	46911	217965	-8894	0.28
75% yield coverage at \$2.45 / bu	84348	46668	214405	-10601	0.30
70% yield coverage at \$2.28 / bu	92026	47907	222865	-12543	0.20
70% yield coverage at \$2.45 / bu	90649	47849	221445	-13243	0.20
65% yield coverage at \$2.45 / bu	95183	48499	226345	-17333	0.14
100% Futures hedge and MPCI 75% yield coverage at \$2.13/ bu	94065	65425	272904	-62684	0.14
75% yield coverage at \$2.45 / bu	90666	65171	269344	-63552	0.15
70% yield coverage at \$2.28 / bu	98344	66430	277804	-66981	0.08
70% yield coverage at \$2.45 / bu	96968	66370	276394	-67606	0.09
65% yield coverage at \$2.45 / bu	101501	67015	281284	-70532	0.05
100% Futures hedge on the historical yield	110262	67289	290174	-67471	0.03
50% Futures hedge on the historical yield	103944	48775	235235	-16661	0.11
100% options hedge on the historical yield	-32909	134619	146613	-821754	-2.57
50% options hedge on the historical yield	32359	77398	175143	-379754	-1.86

Table 5. Number of times strategies appeared in efficient sets out of twenty simulations

Strategy	First Degree Stochastic Dominance	Second Degree Stochastic Dominance
Cash Market	20	20
Revenue Assurance, 65 percent coverage	1	1
65% coverage at 75% of premium	1	1
65% coverage at 125% of premium	1	1
Revenue Assurance, 70% coverage	5	5
70% coverage at 75% of premium	5	5
70% coverage at 125% of premium	4	4
Revenue Assurance, 75% coverage	7	7
75% coverage at 75% of premium	13	13
75% coverage at 125% of premium	4	4
Crop Revenue Coverage, 65% coverage	0	0
70% coverage	0	0
75% coverage	0	0
Multiple Peril Crop Insurance (MPCI) 75% yield Coverage at \$2.13/ bu	0	0
75% yield coverage at \$2.45 / bu	0	0
70% yield coverage at \$2.28 / bu	1	1
70% yield coverage at \$2.45 / bu	0	0
65% yield coverage at \$2.45 / bu	0	0
50% Futures hedge and MPCI 75% yield Coverage at \$2.13/ bu	12	0
75% yield coverage at \$2.45 / bu	1	0
70% yield coverage at \$2.28 / bu	11	0
70% yield coverage at \$2.45 / bu	1	0
65% yield coverage at \$2.45 / bu	6	1
100% Futures hedge and MPCI 75% yield Coverage at \$2.13/ bu	13	0
75% yield coverage at \$2.45 / bu	5	0
70% yield coverage at \$2.28 / bu	11	0
70% yield coverage at \$2.45 / bu	5	0
65% yield coverage at \$2.45 / bu	7	1
100% Futures hedge on the historical yield average	20	20
50% Futures hedge on the historical yield average	20	20
100% options hedge on the historical yield average	0	0
50% options hedge on the historical yield average	0	0

Part 4: Summary

Summary

Among the crop insurance and hedging strategies simulated, the top five strategies in order of descending mean net revenue were: (1) futures hedge on 100 percent of the historical yield average, (2) futures hedge on 50 percent of the historical yield average (3) combination of the 100 percent futures hedge and MPCCI with 65% yield coverage at \$2.45/bushel, (4) no crop insurance or futures hedging (cash market), and (5) combination of 100 percent futures hedge and MPCCI with 70 percent coverage at \$2.45/bushel.

Producers interested in maximizing profit would not use crop insurance. In general, none of the crop insurance or hedging strategies were very effective in reducing the variability of net revenues and the relative riskiness when compared with not using any yield or price protection. However, RA at the 75 percent coverage level was the most effective strategy in setting a floor on the minimum value of net revenue. As a consequence, extremely risk averse producers may prefer a RA strategy as a way to manage income risk. Moreover, the cash market, RA, CRC, and MPCCI strategies were the most likely to cover all of the variable and fixed costs of production in the simulation. The strategies most likely to be in the second-degree stochastic dominance efficient set were: (1) the cash market strategy, (2) RA at the 75 percent coverage level, (3) 100 percent futures hedge on average production, and (4) 50 percent futures hedge on average production. These strategies are risk efficient for risk neutral and risk averse decision makers.

Vita

Walter Ray Philpot was born in Gainesville, Florida, on May 30, 1970 to Laurie and Margret Philpot. He has two sisters, Lynn Bledsoe and Dana Sawyer. Walter attended high school in the public system of Alachua County, Florida, where he graduated in May of 1988.

In August of 1988, he enrolled at David Lipscomb University in Nashville, Tennessee. In December of 1992, he received his Bachelor of Science degree with a major in Finance/Economics and a minor in Psychology. From that point he worked various executive and miscellaneous jobs. In January 1996, he entered the Master's program in the Agricultural Economics and Rural Sociology Department at The University of Tennessee, Knoxville. Walter received his Master of Science degree in Agricultural Economics officially in August, 1998 while completing the requirements in August, 1998. He is employed by the National Agricultural Statistics Service in the U.S. Department of Agriculture, Sacramento, California.

04-29-99
MRB
1739 5801 16
INFORMATION
CONTAINED HEREIN IS UNCLASSIFIED