Economic Analysis of Crop Insurance Alternatives Under Surface Water Curtailment Uncertainty

Authors:

Lawrence L. Falconer
Extension Professor and Agricultural Economist
Mississippi State University Extension Service
Delta Research and Extension Center
PO Box 197
Stoneville, MS 38776
Phone: 662-686-3238
Fax: 662-686-7336
falconer@ext.msstate.edu

and

James W. Richardson
Regents Professor and Senior Faculty Fellow
Texas A&M University
351C AGLS, 2124 TAMU
College Station, TX 77843-2124
Phone: (979) 845-5913
Fax: (979) 845-3140
jwrichardson@tamu.edu

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Introduction

The objective of this paper is to report an analysis to help rice landlords in the Upper Coastal Bend of Texas evaluate alternative crop insurance combinations of yield loss and prevented planting coverage levels given uncertainty related to the availability of surface irrigation water.

Background

The drought that occurred in Texas during 2011 has resulted in an unprecedented curtailment of surface water supplies to rice farmers served by the Lower Colorado River Authority (LCRA) for the 2012 crop year. Current projections of water supplies and utilization by LCRA indicate that curtailments of surface water supplies will exist in 2013 and most likely increase in occurrence during the future.

Data and Methods

There has been an increased use of Monte Carlo simulation (Richardson et al. (2007), Winston (1996), and Vose (2000)) over the past several years to address investment analysis problems. The wide spread use of Excel and the availability of simulation add-ins for Excel has made this methodology practical for both extension and business applications. Monte Carlo simulation provides an economical means of conducting risk-based economic feasibility studies for new investments which is applicable to analysis of alternative risk management strategies based on crop insurance.

Ignoring risk only provides a point estimate for key output variables (KOVs) instead of probability distributions that show the risks of success and failure (Pouliquen (1970), Reutlinger (1970), and Hardaker, et al. (2004)). Following the examples of Richardson and Mapp (1976), Pouliquen (1970), Reutlinger (1970), and Richardson et al. (2007), a stochastic simulation model of a proposed investment in a supplemental rice irrigation system is developed and applied to demonstrate the benefits of Monte Carlo simulation for advising agricultural managers involved in rice production in the Upper Gulf Coast Region of Texas.

Richardson (2005) outlines the steps for developing a production-based investment feasibility simulation model. First, probability distributions for all risky variables need to be defined, parameterized, simulated, and validated. Secondly, the stochastic values from the probability distributions are linked to the capital budgeting relationships needed to calculate receipts, costs, and cash flows for the risk management alterntives. Stochastic values sampled from the probability distributions thus make the capital budgeting variables stochastic. By stochastically sampling the probability distributions many times (say, 500 iterations) the model generates an empirical estimate of the probability distributions for unobservable KOVs such as the net present value and annual ending cash flows, so investors can evaluate the probability of success for the proposed risk management alternative over time.

Due to the annual nature of rice production, the Monte Carlo feasibility model is an annual model. In addition to the stochastic part of the model, the feasibility model has all of the accounting equations for calculating annual cash flows. The parts of the model are described in the following sections.

The model assumptions are summarized in this section in terms of cost per acre of rice produced. The cost share structure assumed was a 50% cost-share on custom spraying, fertilizer, chemicals, consulting fees and canal repairs. The landlord paid for 100% of the water lifting costs and rice seed in this analysis. In addition, the landlord paid for 50% of crop insurance and marketing costs.

For 2012, the assumed landlord cost share was $26.58/acre for custom spraying, $81.80/ acre for fertilizer, $59.10/acre for chemicals, $10.00/acre for consulting fees, $6.07/acre for canal repairs and $4.00 to survey levees.

The model described in this section was programmed in Microsoft© Excel using standard accounting identities and equations. The financial model was made stochastic using Simetar©, an add-in for Excel

(Richardson, Schumann and Feldman, 2006). Simetar© was used to estimate the parameters for the multivariate empirical probability distribution, and Simetar© simulated the model using a Latin hypercube sampling procedure for sampling random variables.

The assumptions related to the probability of curtailment of irrigation water are based on information from an LCRA working paper (Gertson). Three levels of risk associated with surface water availability received for irrigation are modeled. The baseline probabilities used are from LCRA model results for projected demand compared with historic supplies over the 1940-2009 time period. Baseline assumptions are that there is a 77% probability that there will be no curtailment of water for the main crop and a 67% probability of full water availability for the ratoon crop. The high curtailment assumptions are based on model results for the drought-of record period that occurred from June 1945 through May 1957. High curtailment assumptions are a 25% probability that no curtailment of water for main crop will occur and a 25% probability of no curtailment of water for the ratoon crop. The low risk scenario assumes limited growth in future water demand. The low risk scenario assumes a 100% probability of no curtailment of main crop water supplies, and an 83% probability of no curtailment of ratoon crop water supplies. The state of nature related to water curtailment is modeled as a Bernoulli distribution for each scenario.

Certified rice yields were obtained from Duncan Brothers Ranch for the 2001 through 2011 time period, and used to calculate actual production history for crop insurance premiums. Nine crop insurance alternatives were analyzed based on yield protection levels of 65%, 70% and 75% with prevented planting coverage levels of 45%, 50% and 55% for each of the three curtailment states of nature.

Table 1. Premium Rates per Acre for Alternative Yield Protection and Prevented Planting Coverage Levels (USDA-RMA).

	Yield Protection Level		
Prevented Planting	65%	70%	75%
45%	$ 7.81	$ 10.22	$ 14.73
50%	$ 10.69	$ 13.99	$ 20.16
55%	$ 11.11	$ 14.52	$ 20.93

The stochastic rice yield and price variables were simulated using the linear copula for a multivariate empirical distribution to account for the correlation and dependency among rice yields and prices. Expected share rents over a 10 year are discounted by 5% and alternatives are ranked using stochastic efficiency with respect to a function (SERF). SERF partitions alternatives in terms of certainty equivalents as a selected measure of risk aversion is varied over a defined range. The SERF method does not attempt to pinpoint risk aversion levels elicited by experimentation or estimation to categorize alternatives. Rather, it takes risk aversion levels as given and presents rankings of risky alternatives based on categories or classes of decision makers within ranges of risk aversion (Hardaker, et al.).

Results and Discussion

SERF results for the base case are shown in Figure 1. These results are derived using a power utility function for a range of relative risk aversion coefficients from 0 to 4.0 and an initial wealth parameter set at $25,000. The 65% yield coverage and 55% prevented planting coverage level has the largest certainty equivalent across the entire range of risk aversion coefficients. These SERF results indicate that the landlord in the base case would prefer the 65% yield coverage and 55% prevented planting coverage for the baseline surface water availability scenario. The results related to the selection of yield protection levels are consistent with coverage levels selected by the majority of rice producers in the area, as the perceived probability of a yield loss large enough to trigger an indemnity is low, and producers and landlords often opt for minimal levels of coverage. However, prior to the curtailment, producers did not opt to "Buy-up" prevented planting coverage.

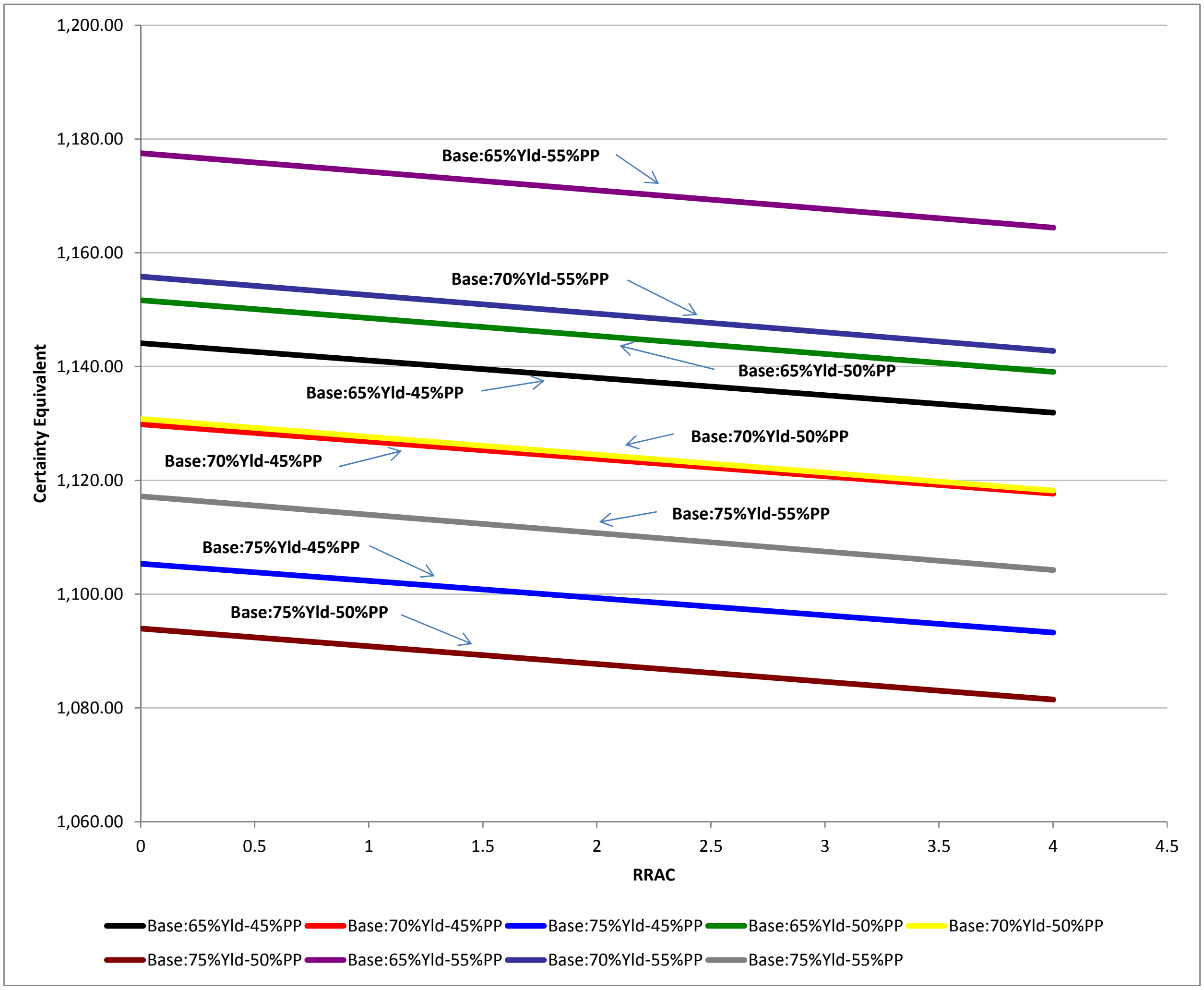

Figure 1. Stochastic Efficiency With Respect to a Function Under a Power Utility Function Results for the Base Irrigation Water Availability Case.

SERF results for the low curtailment probability case are shown in Figure 2, using a power utility function for a range of relative risk aversion coefficients from 0 to 4.0 and an initial wealth parameter set at $25,000. The 65% yield coverage and 45% prevented planting coverage level has the largest certainty equivalent across the entire range of risk aversion coefficients and would be preferred by the landlord. The selection of yield protection level and the prevented planting protection level in the low curtailment probability case are consistent with coverage levels currently selected by the majority of rice producers in the area.

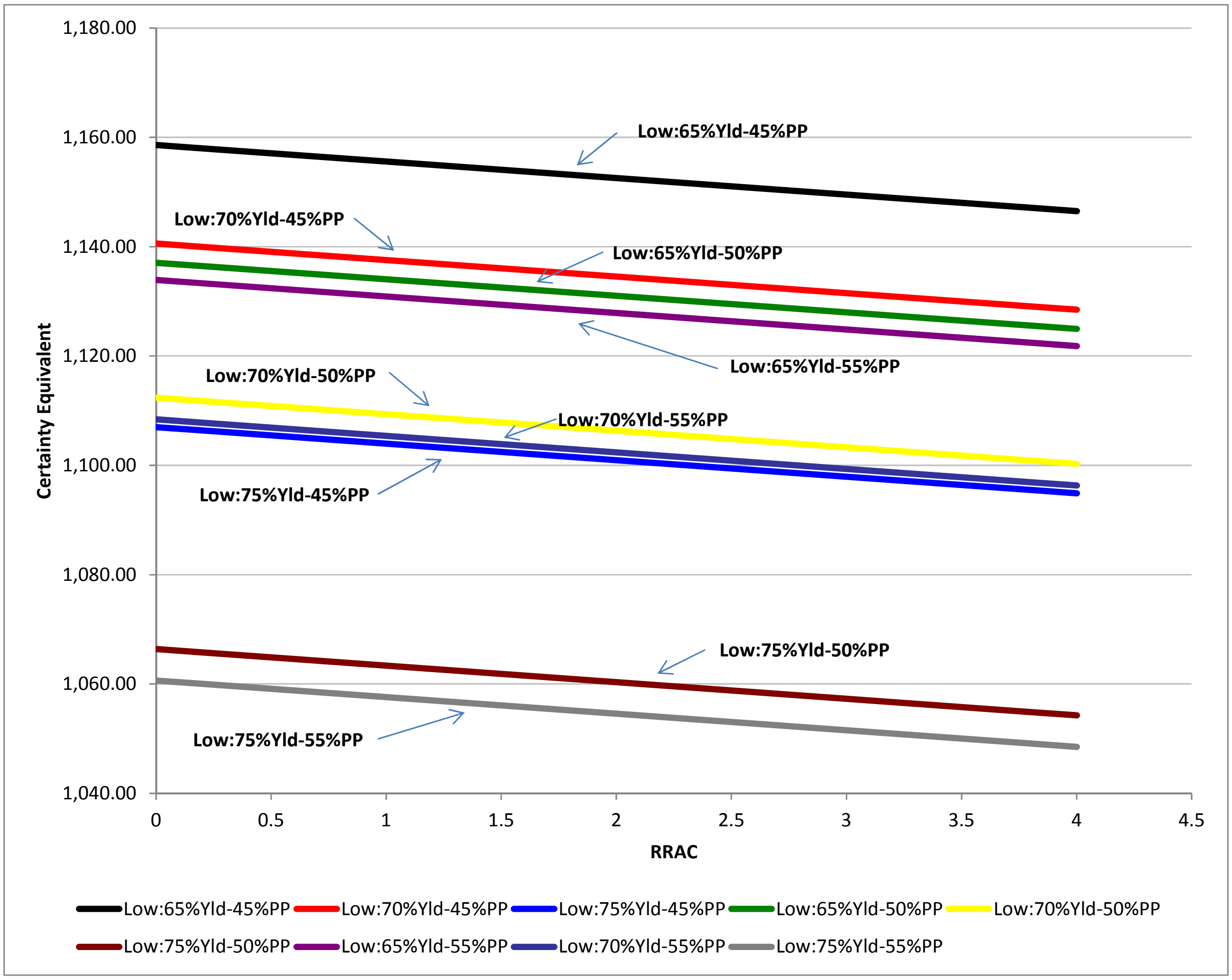

Figure 2. Stochastic Efficiency With Respect to a Function Under a Power Utility Function Results for the Low Probability of Irrigation Water Curtailment Case.

SERF results for the high curtailment probability case are shown in Figure 3, using a power utility function for a range of relative risk aversion coefficients from 0 to 4.0 and an initial wealth parameter set at $25,000. The 65% yield coverage and 55% prevented planting coverage level has the largest certainty equivalent across the entire range of risk aversion coefficients and would be preferred by the landlord. The selection of yield protection level and the prevented planting protection level in the high curtailment probability case are consistent with coverage levels currently selected in the base case.

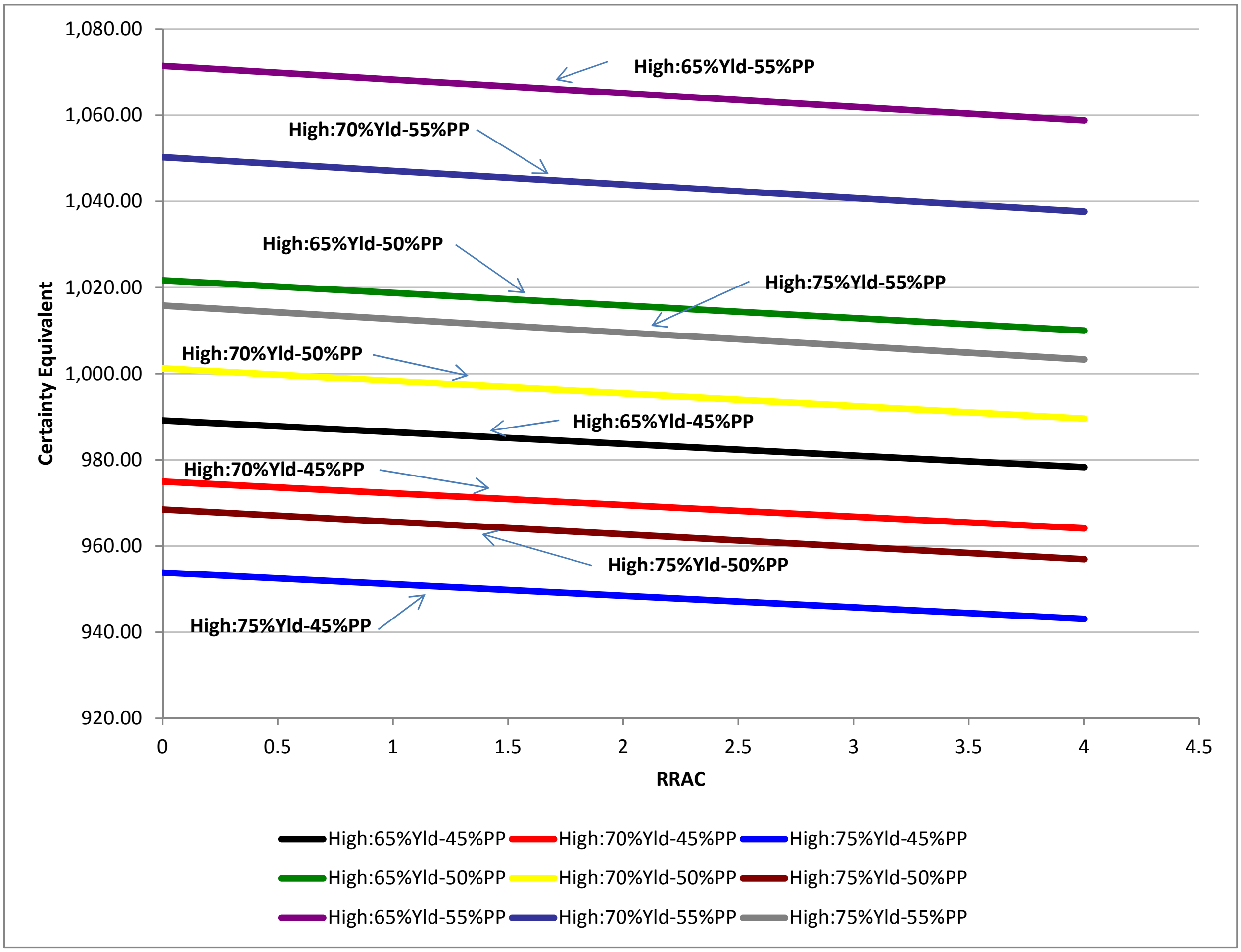

Figure 3. Stochastic Efficiency With Respect to a Function Under a Power Utility Function Results for the High Probability of Irrigation Water Curtailment Case.

Summary

The results related to the selection of yield protection levels across the base, high and low probability of curtailment scenarios are consistent with coverage levels selected by the majority of rice producers in the area, as the perceived probability of a yield loss large enough to trigger an indemnity is low, and producers and landlords often opt for minimal levels of yield coverage.

However, the introduction of base and high levels of surface water curtailment risk leads to preferred prevented planted coverage levels that are “bought-up” in the base and high curtailment probability scenarios.

The model results are graphically presented and relatively easy to interpret, making the model a tool that can be tailored to analyze specific situations using readily available spreadsheet technology for Extension work. In addition, the analysis of prevented planting insurance alternatives is extremely important to landlords currently dependent on surface water for irrigation as it would serve as a baseline for comparison to potential investments in development of ground water resources for rice irrigation.

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