REGIONAL CROP ENTERPRISE AND FARM PROGRAM SELECTION ON WHOLE FARM NET RETURNS UNDER RISK

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Abstract

This economic analysis incorporates stochastic efficiency with respect to a function (SERF) to rank alternative crop selection and farm program alternatives on representative farms in central and northeastern regions of Louisiana. This farm-level returns model provides a cardinal measure of a producer's conviction for crop choice and farm program preferences among alternative enterprise and farm program choice across varying risk aversion levels. By interpreting the differences between certainty equivalent (CE) values as risk premiums, representative farm analysis is applied to document the effectiveness enterprise selection and farm program choice have on mitigating net return risk among corn, cotton, rice, and soybean enterprises on leading Louisiana farms.

Introduction

The Mississippi River Delta Region of northeastern Louisiana is perhaps one of the more diverse areas of the state in terms of agricultural crop production. Corn, cotton, rice, and soybeans are commonly grown on farms in the region as these crops are suited for the soil type and pair well with growers' ability to produce these enterprises under irrigation. The economic efficacy of different production systems has been investigated using both partial budget and whole-farm analyses by Deliberto 2015. Simulation analysis provides a basis for evaluating the variability associated with production systems in the Mississippi River delta region. Three representative rice and soybean farms and six corn, cotton, and soybean farms were modeled in an effort of accurately projecting the five-year net returns resulting from price and yield risk as well as to evaluate optimal alternative farm program and crop insurance selection options. The financial performance of these farms was then measured for varying levels of risk using stochastic efficiency criterion. Results are presented for multiple combinations for both the Agriculture Risk Coverage (ARC) and Price Loss Coverage (PLC) programs of the commodity title safety net program. For each farm and each location, an estimate to the net present value of the cumulative net returns above variable costs to the producer for the five-year life of the farm bill is provided. Results from different farming operations suggest the preferred pairing of farm programs and crop insurance policies does vary across locale and crop.

The objective of this study is to evaluate the profitability and risk efficiency of alternative crop enterprise selection and farm program choice (ARC or PLC) on representative farms in Louisiana from the grower's perspective. Stochastic crop yield and price distributions are simulated for a diverse multi-crop rotation using reported field yields sourced from the LSU Agricultural Center and secondary price data obtained from the USDA National Agriculture Statistics Service (NASS). Grower net return distributions are constructed for those crops most widely cultivated in central and northeastern Louisiana, and risk efficient crop selection and farm program choice are then subsequently identified for growers in the region using SERF for each farm location, respectively.

Materials and Methods

Simulation analysis utilizes both farm level and aggregate data in analyzing various sectors of the U.S. agricultural economy. Stochastic analysis provides inferences about the drivers behind commodity production selection and their relationships along with any correlations amongst relevant variables (Flanders, 2008). Stochastic simulation models permit variations in variables and are interpreted as representing the random occurrences that correspond to risks associated with decision-making (Flanders and Wailes, 2010) while providing graphical inferences caused by relevant variables and correlations among the variables (Flanders, 2008). A multivariate empirical (MVE) distribution accounts for interrelationships occurring in the data and prevents the application of a specific distribution on the variables (Flanders and Wailes, 2010). Alternatively stated, an MVE distribution is viewed as being able to simulate random values from a frequency distribution composed of actual historical data and is considered a proper means of appropriately correlating random variables upon the basis of their historical correlation (Richardson et al., 2000).

By utilizing an MVE simulation, simulated random variables that are generated are bounded by the historical minimums and maximums of the original data, rather than, in the case of normal distributions, where random variables that generated may fall outside of historical bounds (Flanders, 2008). MVE distribution simulations engage in the use of non-normal distributions and an intra-temporal distribution across different commodities and an inter-temporal distribution across a time correlation matrix in order to generate correlated stochastic error terms that can be applied to any forecasted mean (Richardson et al., 2000). Using an MVE distribution is valuable when simulating commodity prices and yields because the distribution includes a correlation matrix that generates correlated stochastic variables (Richardson et al., 2000). Simulated stochastic commodity prices and yields involve the use of MVE distributions for generating random prices and yields, which, in turn, are then employed as a means of deriving net returns that account for stochastic relationships extant amongst production systems. Therefore, implementing a simulation analysis with stochastic variables and assuming a baseline cost of production will provide the sufficient results needed in comparing levels of farm net returns as market conditions change (Flanders, 2008).

SERF uses the concept of certainty equivalents (CEs) to evaluate the risky alternatives for a specified range of upper and lower bound absolute risk aversion coefficients (Hardaker et al., 2004). SERF contains a stronger discriminating power over other conventional stochastic dominance techniques because it utilizes the concept of CEs for each alternative rather than the conventional approach of cumulative distribution functions (CDFs) (Fathelrahman et al., 2011). CEs enable SERF to rank a set of risk-efficient alternatives instead of a subset of dominated alternatives (Hardaker et al., 2004). The risk alternatives are partitioned in terms of CEs for a specified range of attitudes to risk. Each alternative is simultaneously compared with the others, rather than a pairwise comparison of risky alternatives (Hardaker et al., 2004). The CE of a risky alterative is the dollar amount at which the producer is indifferent between the certain dollar value and the risky alternative (Fathelrahman et al., 2011, 2014; Williams et al., 2012). When calculating CEs, various types of utility functions can be applied to the individual's level of risk aversion, defined by the corresponding ranges of absolute, relative, or partial risk aversion coefficients (Hardaker et al., 2004). Thus, the decision criteria analysis of the economic measures for SERF is to rank risky alternatives from the highest valued (i.e., highest CEs at specified levels of risk aversion) to the lowest valued (i.e., lowest CEs at the specified levels of risk aversion) (Fathelrahman et al., 2011, 2014).

Watkins et al. 2008 applies SERF analysis to ranked preferable rice rental arrangements for landlords and tenants according to risk attitudes using stochastic efficiency with respect to a function (SERF). The SERF method is a variant of stochastic dominance with respect to a function (SDRF) that orders a set of risky alternatives in terms of certainty equivalents (CE) calculated for specified ranges of risk attitudes (Hardaker et al., 2004). A certainty equivalent (CE) is equal to the amount of certain payoff an individual would require to be indifferent between that payoff and a risky investment. The CE is typically less than the expected (mean) monetary value and greater than or equal to the minimum monetary value of a stream of monetary outcomes (Hardaker et al. 2004). The SERF method allows for simultaneous rather than pairwise comparison of risky alternatives and can in some instances produce a smaller efficient set than conventional stochastic dominance with respect to a function (SDRF) (Hardaker et al. 2004). Graphical presentation of SERF results facilitates the presentation of ordinal rankings for decision makers with different risk attitudes and provides a cardinal measure of a decision maker's conviction for preferences among risky alternatives at each risk aversion level by interpreting differences in CE values for a given risk aversion level as risk premiums (Hardaker et al. 2004).

The SERF method calls for calculating CE values over a range of absolute risk aversion coefficients (ARACs). The ARAC represents a decision maker's degree of risk aversion. Decision makers are risk averse if ARAC > 0; risk neutral if ARAC = 0, and risk preferring if ARAC < 0. The range of ARAC values used in this analysis was from 0 (risk neutral) to 0.035 (strongly risk averse). The latter value was calculated using the formula proposed by Hardaker et al. of $ARAC_w = r_r(w)/w$, with $ARAC_w$ defined as a producer's absolute risk aversion with respect to a specified level of wealth (w) and $r_r(w)$ defined as a producer's relative risk aversion with respect to w.

Following the methodology outlined above, corn, cotton, rice, and soybean yield distributions for Rapides Parish (central region) and Tensas Parish (northeastern region) were simulated using ten years of historical yield data (2010-2019) from annual production statistics published by the LSU Agricultural Center. Historical yields were detrended using linear regression, and residuals from trend were used to estimate the parameters for the MVE yield distributions for 1,000 iterations. These mean yield values were used as average yield values for the MVE yield distributions. Commodity price distributions were simulated using season average Louisiana price data and national

marketing year average price data from the USDA NASS for the ten-year period. These simulated price data were then utilized to determine if any farm payment(s) would have occurred. The simulated pricing data was used to determine gross farm revenues before accounting for simulated production costs.

We then simulated per acre variable production costs for corn, cotton, rice, and soybeans along with the per acre nitrogen and diesel costs associated with the irrigated production of those commodities for the same ten-year period as these direct costs account for the majority of the cost of production. Irrigated production systems were chosen for the representative farm locations based on personal communication with grower cooperators. We then used these simulated variable production costs to calculate net returns to the grower by way of crop receipts and farm program payments given the simulated yield and pricing data for each iteration. An 80/20 rental arrangement was chosen as the proxy for land cost, with the grower receiving 80 percent of revenues and the landlord receiving 20 percent, as this was felt the most representative land tenure arrangement extant in the areas of interest (Tensas and Rapides parishes). Having simulated yield, price, and direct cost data for our representative farms, we then were able to calculate net returns which were then, in turn, employed to measure grower's attitude to risk at multiple risk coefficients that were calculated in SIMETAR©.

Results and Discussion

Net returns were analyzed the basis of three possible crop diversification production options: 1.) rice, soybeans, and corn; 2.) corn, soybeans, and cotton; and, 3.) cotton, corn, and rice for both representative farm locations. Table 1. Net returns per acre for each alternative production scheme was expressed as one-third of a farm acre.

Table 1. Crop mix composition (evenly distributed acreage) imposed on two representative Louisiana farms.

Crop Mix Composition (33.3% each)	Option Identifier No.
Rice/Soybean/Corn	1
Corn/Soybean/Cotton	2
Cotton/Corn/Rice	3

In order to estimate the net return effect that farm program choice has on the aforementioned covered commodities, PLC and ARC-CO participation was incorporated into the grower's share of mean net returns per iteration which were then varied over risk. However, in attempting to capture this farm program income effect, a pairwise comparison among the two representative farms was modeled for each crop mix option. Table 2. In the absence of farm program payments to each representative farm, the highest net returns were associated with option 2 (corn/soybean/cotton) rotation for both farms, followed by option 3 (cotton/corn/rice) and option 1 (rice/soybean/corn). One notable observation is that the difference in mean net returns across risk, suggest that the difference between options 3 and 1 for the Rapides farm is less significant that for the Tensas farm. Figure 1 and 2.

Table 2. Mean Net Returns per acre for imposed crop mixes on a representative Louisiana farm with no farm program enrollment.

Rep. Farm Location	Option 1	Option 2	Option 3
Rapides Parish	$116.78	$132.88	$117.41
Tensas Parish	$180.99	$215.24	$203.64

Results in Figure 1 for the Rapides parish farm indicate that as the level of risk increases via the increase in risk aversion coefficients, the rice/soybean/corn crop option (option 1) dominates or increases the grower's share of net returns as compared to the cotton/corn/rice crop option (option 3). However, both of these options are less than the corn/soybean/cotton (option 2). Results in Figure 2 for the Tensas parish farm indicate that the corn/soybean/cotton (option 2) dominates all other alternatives across all levels of implied risk.

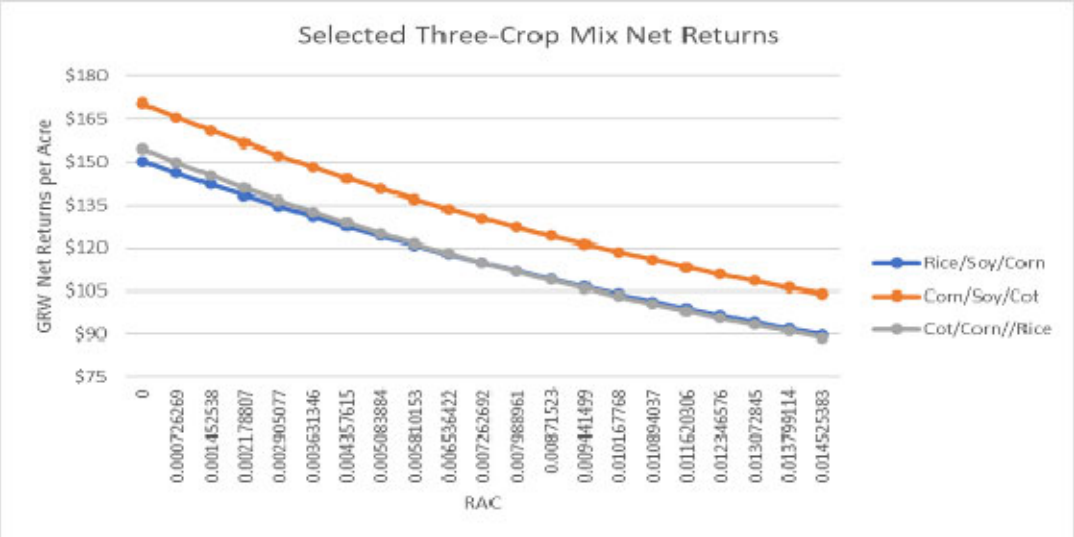

Figure 1. Mean net returns per acre on a representative central Louisiana farm (Rapides Parish).

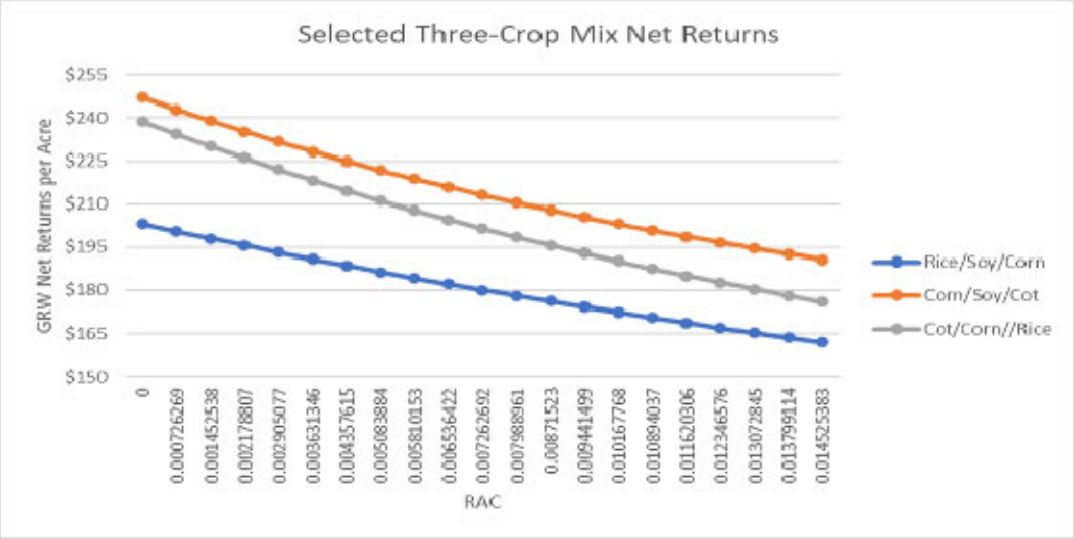

Figure 2. Mean net returns per acre on a representative northeastern Louisiana farm (Tensas Parish).

In order to impose the performance measure of farm program selection on grower net returns, the ARC-CO and PLC programs were incorporated into the analysis. Table 3 imposes the ARC-CO program choice among all covered commodities on the farm. Similar to the results in Table 1, the corn/soybean/cotton crop option (option 2) maximizes the grower's share of net returns per acre for both farms ($144.82 and $229.21 per acre respectively).

Table 3. Mean Net Returns per acre for imposed crop mixes on a representative Louisiana farm with ARC-CO farm program enrollment (all crops).

Rep. Farm Location	Option 1	Option 2	Option 3
Rapides Parish	$125.84	$144.82	$134.06
Tensas Parish	$194.47	$229.21	$228.99

In Figure 3, the corn/soybean/cotton crop option (options 2) dominates all alternatives across all levels of risk.

However, results from Figure 4 suggest that for the Tensas parish farm, grower net returns between options 2 and 3 are less than one dollar per acre. When comparing the impact of farm program choice, the ARC-CO producers a difference of approximately $12 per acre between cropping options 2 and 3 (Table 2). Therefore, the interpretation can be summarized that the ARC-CO program payments for seed cotton and rice can offset perhaps lower returns across risk in the absence of farm program participation.

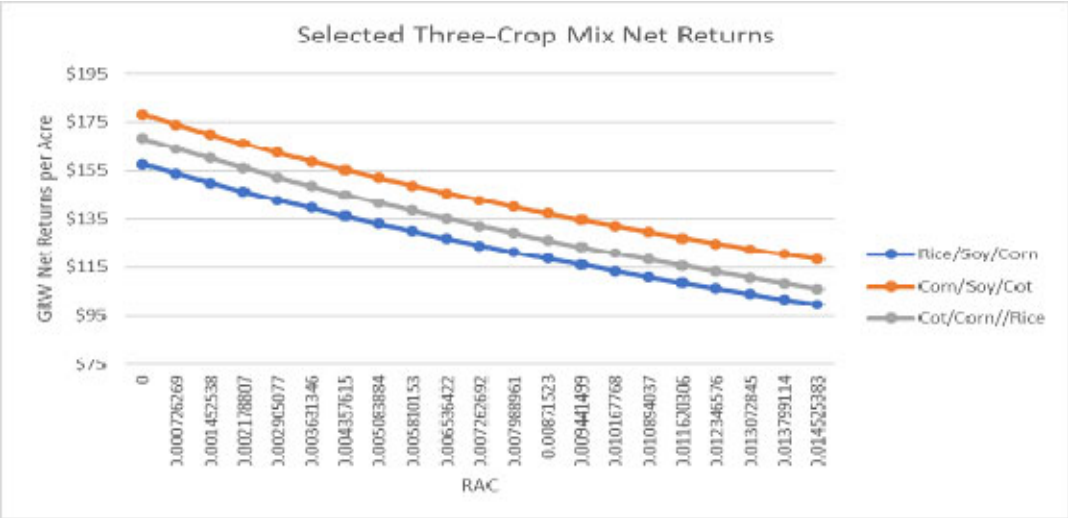

Figure 3. Mean net returns per acre on a representative central Louisiana farm (Rapides Parish), ARC-CO farm program selection across all covered commodities.

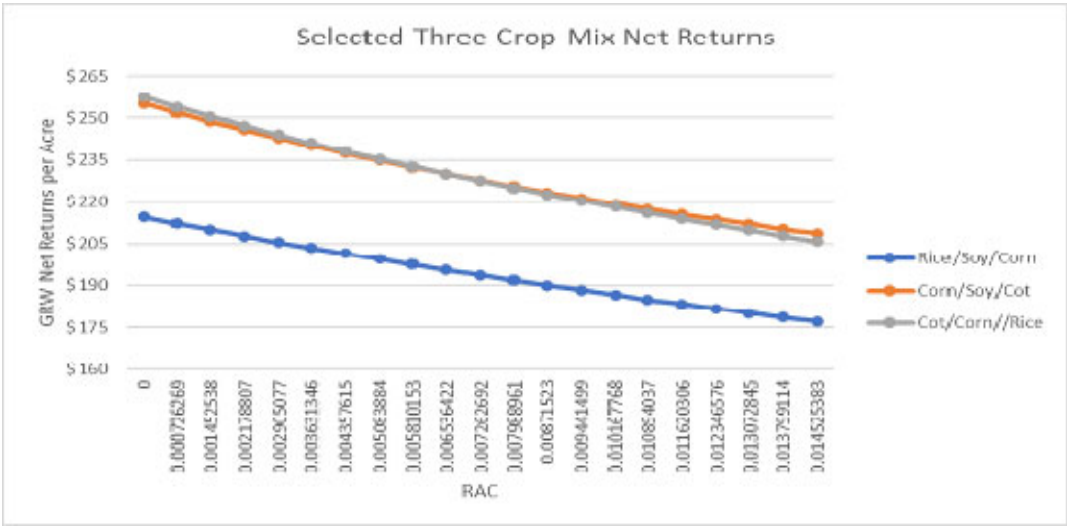

Figure 4. Mean net returns per acre on a representative northeastern Louisiana farm (Tensas Parish), ARC-CO farm program selection across all covered commodities.

Table 4 imposes the PLC program choice among covered commodities on each representative farm location. Results indicate that the cotton/corn/rice crop option (option 3) generates the highest level of net returns per acre for both farming locations. For the Rapides parish farm, the difference between options 2 and 3 is approximately one dollar per acre. Hence, participation in the PLC farm program makes option 3 more appealing as compared to the corn/soybean/cotton (option 2) under the assumption of no government program participation listed in Table 2. Alternative stated, the $15 premium in option 2 over option 3 is eroded when PLC program payments are considered. As such, option 3 is the preferred crop choice. Figure 5. For the Tensas parish farm the cotton/corn/rice

crop option (option 3) dominates all alternatives across all levels of risk appearing in Figure 6.

Table 4. Mean Net Returns per acre for imposed crop mixes on a representative Louisiana farm with PLC farm program enrollment (all crops).

Rep. Farm Location	Option 1	Option 2	Option 3
Rapides Parish	$140.52	$153.32	$154.93
Tensas Parish	$204.07	$237.29	$247.72

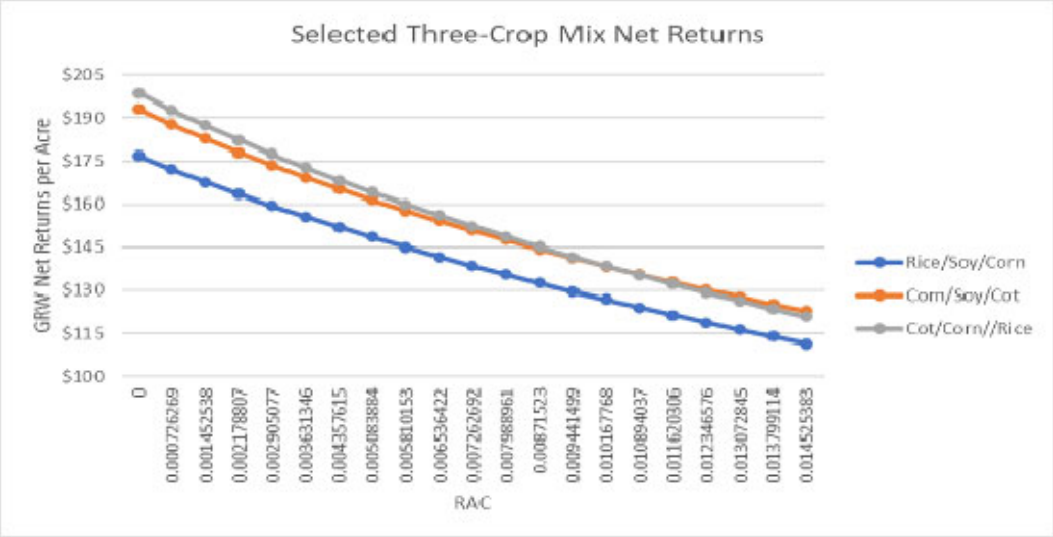

Figure 5. Mean net returns per acre on a representative central Louisiana farm (Rapides Parish), PLC farm program selection across all covered commodities.

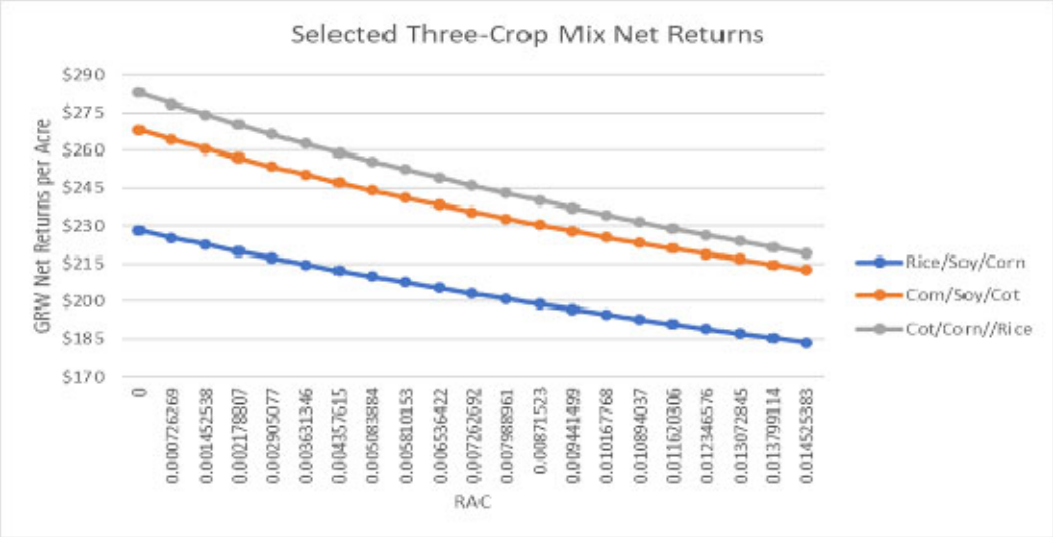

Figure 6. Mean net returns per acre on a representative northeastern Louisiana farm (Tensas Parish), PLC farm program selection across all covered commodities.

Table 5 imposes the PLC program choice among corn, seed cotton, and rice and ARC-CO for soybeans on each representative farm location. Results indicate that the cotton/corn/rice crop option (option 3) generates the higher

grower net returns for both the Rapides and Tensas parish farms at $154.98 and $247.80 per acre respectively. Similarly, for the Rapides parish farm graphical analysis, as presented in Figure 7, coincided with the results in Figure 5, albeit at a slightly higher average grower return level ($154.98 compared to $154.93 per acre). This implies that the selection of ARC-CO for soybeans (in lieu of PLC) has a null effect on grower whole farm net returns. Results in Figure 8 for the Tensas parish farm indicate the same conclusion as the selection of ARC-CO for soybeans in lieu of PLC has a null effect (247.80 compared to $247.72 per acre).

Table 5. Mean Net Returns per acre for imposed crop mixes on a representative Louisiana farm with ARC-CO and PLC farm program enrollment (PLC choice for corn, seed cotton, and rice and ARC-CO for soybeans).

Rep. Farm Location	Option 1	Option 2	Option 3
Rapides Parish	$141.48	$154.29	$154.98
Tensas Parish	$206.13	$239.36	$247.80

At a risk aversion coefficient of 0 (risk neutral) the grower net returns (CE) for production option 1 are $177.16 per acre, option 2 are $193.46 per acre, and option 3 are $198.52 per acre. This implies greater returns for option 3 are preferred to options 2 and 1 in that order. Figure 7. Alternatively stated, returns from the cotton/corn/rice rotation are preferred for Rapides parish. Albeit the level of variability mirrors that of Tensas parish for the same cropping options, the range of variability is narrower. As we start to increase the level of risk, options 3 and 2 approach parity and then diverge from one another as option 2 becomes the preferred production scheme at higher levels of risk. At higher levels of risk, soybeans will be substituted for rice in enterprise selection for Rapides parish as soybeans have a propensity to contribute more to net returns than rice does.

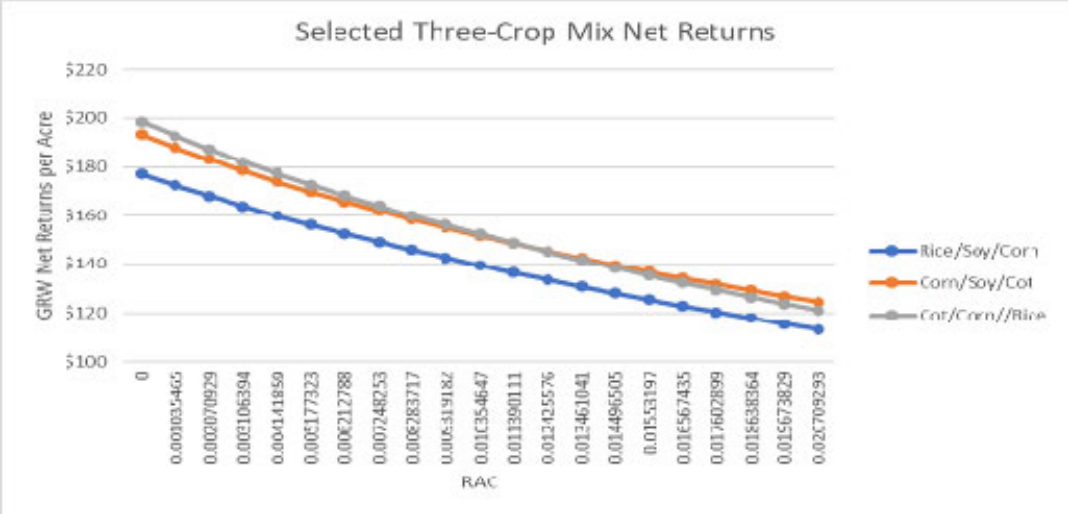

Figure 7. Mean net returns per acre on a representative central Louisiana farm (Rapides Parish) PLC farm program selection for corn, seed cotton and rice with ARC-CO selection for soybeans.

Results in Figure 8 suggest that at a risk aversion coefficient of 0 (risk neutral) the grower net returns (CE) for production option 1 are $228.27 per acre, option 2 are $268.24 per acre, and option 3 are $282.70 per acre. This implies greater returns for option 3 are preferred to options 2 and 1 in that order. Alternatively stated, returns from the cotton/corn/rice rotation are preferred for Tensas parish. Across increasing levels of risk aversion, option 3 dominates but as risk aversion increases option 3 approaches option 2 denoting a reduction in the risk premium between the production options. Figure 8. This can be viewed as the level of risk aversion is increased, the tradeoff between production scheme adoption decreases between options 3 and 2. Those cropping options are synonymous to Tensas parish as the agronomic production environment and managerial efficiency is directed towards the economically efficient production of cotton and corn. As both cotton and corn are produced under irrigation, yield variability is diminished based on reported historical yield data for the ten-year observation period.

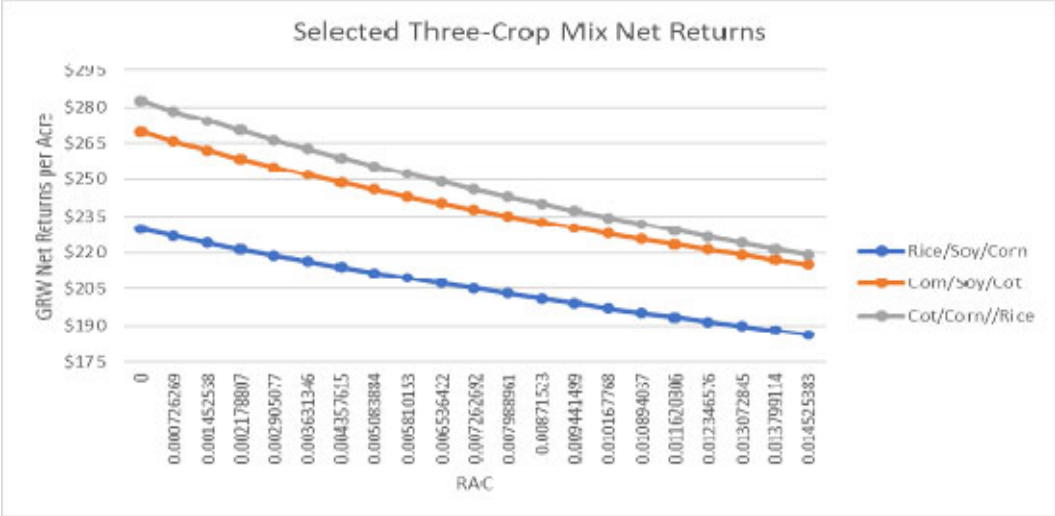

Figure 8. Mean net returns per acre on a representative northeastern Louisiana farm (Tensas Parish) PLC farm program selection for corn, seed cotton and rice with ARC-CO selection for soybeans.

Summary

This analysis evaluated the profitability and risk efficiency of alternative crop selection and farm program selection for two representative farms in Louisiana using simulation and stochastic efficiency with respect to a function (SERF). Risk premiums are presented in Table 6 as compared to no farm program selection for each representative farm. The premiums are interpreted as the average increase in grower share of net returns across varying levels of risk subject to farm program selection and crop mix.

Table. 6. Difference in mean net return per acre for imposed crop mixes on a representative Louisiana farm with ARC-CO and PLC farm program enrollment (PLC choice for corn, seed cotton, and rice and ARC-CO for soybeans).

	All ARC-CO			*All PLC*			*All PLC but ARC-CO SY*		
Farm Location	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Rapides Parish	$9.06	$28.04	$17.29	$23.74	$36.54	$38.16	$24.71	$37.51	$38.21
Tensas Parish	$13.48	$48.22	$48.00	$23.08	$56.30	$66.73	$25.14	$58.37	$66.81

In Rapides parish, under a Rice/Soybean/Corn rotation (Option1), Corn/Soybean/Cotton rotation (Option 2), and a Cotton/Corn/Rice rotation (Option 3), optimal mean net returns per acre would come under Option 3 with an All PLC exc. ARC-CO for soybeans program election. For Option 1, program election translates into a potential difference of $15.65 mean net returns per acre, $9.47 mean net returns per acre under Option 2, and a difference of $20.92 mean net returns per acre under Option 3 by choosing All PLC but ARC-CO for soybeans program election vs a program election of All ARC-CO, respectively.

In Tensas parish, under a Rice/Soybean/Corn rotation (Option1), Corn/Soybean/Cotton rotation (Option 2), and a Cotton/Corn/Rice rotation (Option 3), optimal mean net returns per acre would come under Option 3 with an All PLC exc. ARC-CO for soybeans program election. Between program elections, under Option 1, there is a potential difference of $11.66 mean net returns per acre, $10.15 mean net returns per acre under Option 2, and a difference of $18.81 mean net returns per acre under Option 3 by choosing an All PLC but ARC-CO for soybeans program election vs a program election of All ARC-CO, respectively.

From these results, one may conclude that crop production choice and program election have a very important place in the farm management decision. This is especially true for the 2021 crop year in which growers can make annual farm program elections.

Acknowledgements

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