An Economic Risk Analysis of No-Till Rice Management from the Landlord's Perspective

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Abstract

Rice production generally involves intensive cultivation. The profitability of no-till rice has been investigated but solely from the producer's perspective. Most farmed cropland is owned by someone else. This study evaluates the risk efficiency of no-till rice from the landlord's perspective using stochastic efficiency with respect to a function (SERF).

Introduction

Arkansas is the top rice producing state in the U.S. and accounts for over 48% of total U.S. rice production (USDA ERS 2006). Nearly all rice production occurs in the eastern part of the state in the Mississippi Alluvial Valley. Surface water quality in this region is significantly influenced by geography, climate, and agriculture. The area has little topographic relief, and soils are predominantly composed of dense alluvial clay sub-soils that limit water infiltration (Kleiss et al.). Surface soils contain little organic matter and are comprised of silt and clay particles that are readily transported by runoff from tilled fields during heavy rainfall events (Huitink et al.). Sediment is the primary pollutant identified for most eastern Arkansas waterways (ADEQ; Huitink et al.), and conservation practices like no-till are commonly recommended as remedial mechanisms (Huitink et al.).

The economics of no-till rice have been investigated using both partial budget analysis (Pearce et al.; Smith and Baltazar; Watkins, Anders, and Windham) and whole-farm analysis (Watkins et al.). However, these studies evaluate no-till profitability from the prospective of the producer only. Most farmland under cultivation in eastern Arkansas is owned by someone other than the producer (Table 1). In 2002, tenants accounted for 28 percent of farmland acres, while part owners (farmers who own and rent farmland) accounted for 48 percent of farmland acres in eastern Arkansas. Moreover, 70 percent of eastern Arkansas farmland acres operated by part owners were rented in 2002. These statistics implicitly highlight the influence of landlords in eastern Arkansas agriculture. Studies investigating the landlord's role in environmental decision making on rented land indicate landlord participation may be based more on economic rather than environmental concerns (Constance, Rikoon, and Ma.; Rogers and Vandeman). Therefore, any profitability analysis of no-till rice in eastern Arkansas should also include the landlord's perspective.

The objective of this study is to evaluate the profitability and risk efficiency of no-till management in Arkansas rice production from the perspective of the landlord. Stochastic crop yield and price distributions are simulated for a typical two-year rice-soybean rotation using field experiment data from a long-term rice based cropping systems study near Stuttgart, Arkansas and secondary price data from the USDA. Landlord net return distributions are constructed for popular rental arrangements in Arkansas rice production, and risk efficient rental arrangements are identified for landlords using stochastic efficiency with respect to a function.

Data and Methods

Rental Arrangements. Rental arrangements in eastern Arkansas can be grouped into three classifications: 1) crop share arrangements; 2) cost share arrangements; and 3) fixed cash arrangements (Bierlen and Parsch; Rainey et al.). Most rental arrangements in Arkansas rice production are crop share arrangements in which the landlord receives a share of the crop and government payments, and the tenant pays nearly all expenses related to crop production (Parsch and Danforth). The only expense items shared in crop share arrangements are drying and irrigation expenses. Drying expenses are shared in the same proportion as the crop. Irrigation expenses are split into above and below ground expenses, with the tenant paying all above ground expenses associated with the irrigation power unit and the landlord paying all below ground expenses associated with the well, pump, and gearhead. The typical split for crop share arrangements is 75/25, with the landlord receiving 25% of the crop and government payments. However, 80/20 crop share arrangements also exist in Arkansas rice production.

Cost share arrangements are common in Arkansas rice production, although less frequent than crop share arrangements. The typical split for these arrangements is 50/50 (Parsch and Danforth). The landlord receives 50% of the rice crop and government payments in exchange for sharing 50% of seed, pesticide, and fertilizer variable expenses. The landlord also pays 100% of all irrigation expenses with the exception of irrigation labor, which is supplied by the tenant. Cost share arrangements are less frequent for soybeans than for rice. Thus cost share arrangements in this analysis are modeled for the rice portion of the rotation only, with crop share arrangements modeled for soybeans.

Fixed cash arrangements are less common than crop share arrangements in Arkansas rice production (Parsch and Danforth). In a fixed cash arrangement, the tenant pays the landlord a fixed rate for the use of the land and is responsible for all other production expenses except those associated with below ground irrigation. The tenant receives 100% of the crop and government payments. Rice and soybean cash rents used in the analysis were obtained from 2001 average rents reported in Hill et al. Cash rents were adjusted to 2006 dollars using the Producer Price Index. The resulting cash rents were $117 per acre for rice and $80 per acre for irrigated soybeans.

The rental arrangements modeled for this analysis are as follows:

1. 75/25 Crop share (R75S75)
2. 80/20 Crop share (R80S80)
3. 50/50 Rice Cost Share - 75/25 Soybean Crop Share - (R50S75)
4. 50/50 Rice Cost Share - 80/20 Soybean Crop Share - (R50S80)
5. Fixed Cash (CASH)

where R = rice; and S = Soybean.

Simulated net returns. Landlord rice-soybean rotation net returns were simulated by iteration, tillage treatment, and rental arrangement using the following equation:

$$(1)\ \ LNR_{ijk} = 0.5 \cdot \sum_{l=1}^{2} S_{kl} \cdot [Y_{ijl} \cdot (P_{il} + LDP_{il} - D_l) + DP_l + CCP_{il}] + C_l - LVE_{kl} - LFE_{kl}$$

where i = 1 to 500 iterations; j = 1 to 2 tillage treatments (no-till, conventional till); k = 1 to 5 rental arrangements as defined above; l = 1 to 2 crops (rice, soybean); S_{kl} is the landlord's share of the crop and government payments for rental arrangement k and crop l; Y_{ijl} is the simulated yield of crop l for tillage treatment j and iteration i (bushels per acre); P_{il} is the simulated farm price for crop l and iteration i ($ per bushel); LDP_{il} is the loan deficiency payment for crop l and iteration i ($ per bushel); D_l is the drying charge for crop l ($ per bushel); DP_l is the direct payment for crop l ($ per acre); CCP_{il} is the counter-cyclical payment for crop l and iteration i ($ per acre); LVE_{kl} is the landlord's variable expenses for rental arrangement k and crop l ($ per acre); LFE_{kl} is the landlord's fixed expenses for rental arrangement k and crop l ($ per acre); and C_l is the fixed cash rent for crop l ($ per acre).

Government payments. Government payments for the study were calculated assuming the continuation of the Farm Security and Rural Investment Act of 2002 (hereafter referred to as the 2002 Farm Bill). Simulated loan deficiency payments for rice and soybean are calculated as follows:

(2) $LDP_{il} = Max[(LR_l - \tilde{P}_{il}),0]$

where LR_l equals the loan rate for crop l ($ per bushel) and $\tilde{P}_{il}$ equals either the simulated world market rough rice price or the simulated season average Arkansas soybean price ($ per bushel), depending on the crop of interest. The LR_l used for rice and soybeans, respectively was $2.93 and $5.00 per bushel as per the 2002 Farm Bill.

Direct payments (DP_l) are calculated for each crop as follows:

(3) $DP_l = 0.85 \cdot DPY_l \cdot DPR_l$

where DPR_l and DPY_l are the direct payment rate ($ per bushel) and the direct payment yield (bushels per acre) for crop l. The DPR_l used for rice and soybean, respectively, was $1.06 and $0.44 per bushel as per the 2002 Farm Bill. The DPY_l used for rice and soybean, respectively, was 108.9 and 25.7 bushels per acre. Direct payment yields for rice and soybeans represent averages obtained from six Arkansas representative panel farms growing both rice and irrigated soybeans (Hignight).

Simulated counter-cyclical payments (CCP_{il}) were calculated as follows:

(4) $CCP_{il} = 0.85 \cdot CCPY_l \cdot Max[TP_l - (DPR_l + Max\{SAFP_{il}, LR_l\},0]$

where TP_l is the target price for crop l ($ per bushel), $SAFP_{il}$ is the simulated national season average farm price for iteration i and crop l ($ per bushel), $CCPY_l$ is the counter cyclical payment yield for crop l (bushels per acre), and DPR_l is as defined above. The TP_l used for rice and soybean, respectively was $4.73 and $5.80 bushels per acre as per the 2002 Farm Bill. The $CCPY_l$ used for rice and soybean, respectively, was 122.6 and 33.2 bushels per acre, and represent averages obtained from six Arkansas representative panel farms growing both rice and irrigated soybeans (Hignight).

Simulated yields and prices. SIMETAR, developed by Richardson et al. was used to simulate yield and price distributions in the study. Multivariate empirical distributions (MVEs) were used to simulate 500 iterations of yields and prices. A MVE distribution simulates random values from a frequency distribution made up of actual historical data and has been shown to appropriately correlate random variables based on their historical correlation (Richardson, Klose, and Gray). Parameters for the MVE include the means, deviations from the mean or trend expressed as a fraction of each variable, and the correlation among variables. The MVE distribution is used in instances where data observations are too few to estimate parameters for another distribution (Pendell et al.).

Rice and soybean yield distributions under conventional till (CT) and no-till (NT) were simulated using seven years of historical yield data from a long term rice-based cropping systems study at Stuttgart, AR for the period 2000-2006 (Anders et al.). The historical crop yields represent yields obtained in a two-year rice-soybean rotation. Historical yields were detrended using linear regression, and residuals from the trend were used to estimate the parameters for the MVE yield distributions. The mean yield values over the 7-year period were used as the average yields for the MVE yield distributions. Summary statistics for the simulated yields are presented in Table 2.

Price distributions were simulated using season average Arkansas rice and soybean price data (USDA NASS 2006), world market rice price data (USDA ERS 2006), and national average rice and soybean price data (USDA, ERS 2006, 2007) for the period 2000-2006. The season average world market rice price for each year was determined by averaging observations from August 15 through October 31 of each year. Historical prices were detrended using linear regression, and residuals from the trend were used to estimate the parameters of the MVE price distributions. Mean prices for the period 2004-2006 rather than historical means were used as average prices for the MVE price distributions. Prices for the latter three years of the 7-yr period better represent current farmer price expectations. The MVE approach has been shown to reproduce the historical correlation matrix and maintain the historical coefficient of variation from the original historical data series even when using means different from the historical mean (Ribera et al.). Summary statistics for simulated prices are presented in Table 2.

Risk analysis. Rental arrangements are ranked 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.). 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.). 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 SDRF (Hardaker et al.). 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.).

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 $r_a(w) = r_r(w)/w$, where $r_a(w)$ = absolute risk aversion with respect to wealth (w), and $r_r(w)$ = relative risk aversion with respect to wealth. In this analysis, $r_r(w)$ was set to 4 (very risk averse) as proposed by Anderson and Dillon, and w equals the landlord's average net return across alternative rental arrangements in Table 3 of $114/acre (Hardaker et al.).

The SERF procedure in SIMETAR was used to calculate CE values by rental arrangement for the landlord ARAC ranges specified above. A negative exponential utility function was used to calculate CE values for each ARAC range (Hardaker et al.). Landlord NT risk premiums were calculated for each rental arrangement by subtracting conventional till CE values from no-till CE values at given ARAC values, and a landlord CE graph was constructed to display ordinal rankings of rental arrangements across each specified range of ARAC values.

Results and Discussion

Summary statistics of simulated landlord net returns by rental arrangement and tillage method are presented in Table 3. Average returns to the landlord are approximately equal for no-till relative to conventional till management for every rental arrangement analyzed in the study. Therefore, risk-neutral landlords desiring to maximize expected returns would be indifferent as to whether the tenant used NT or CT on rented land. The NTR50S75 and CTR50S75 arrangements have the largest average net return for the landlord ($135 and $136 per acre, respectively), while the CASH arrangement produces the smallest average net return for the landlord ($85 per acre). Landlord return variability is slightly smaller for NT than for CT for all rental arrangements evaluated with the exception of CASH. The NTR80S80 and CTR80S80 arrangements are the least desirable for the landlord relative to the other rental arrangements evaluated. Both arrangements result in the largest probabilities of receiving a net return lower than cash rent (33 percent for NTR80S80; 38 percent for CTR80S80).

Landlord certainty equivalents (CEs) and no-till risk premiums are presented by rental arrangement for various absolute risk aversion coefficients (ARAC) in Table 4. Certainty equivalents are equal to mean (expected) net returns when ARAC = 0 but decline slightly as ARACs become larger (e.g., as risk aversion increases) for the landlord. Certainty equivalent values are slightly larger for NT than for CT for ARAC values greater than 0. Thus, landlords receive positive risk premiums for NT management as risk aversion increases, but the risk premiums are relatively small, implying small monetary benefits to NT for risk averse landlords.

Landlord SERF results are presented across the ARAC range of 0 (risk neutral) to 0.035 (strong risk aversion) in Figure 1. Strategies that are risk preferred in Figure 1 have the locus of points of highest CE values (Hardaker et al.). The NTR50S75 arrangement is the preferred strategy for the landlord for most ARAC values greater than 0, followed closely by the CTR75S25 arrangement. These arrangements allow the landlord to receive a larger share of the rice crop and rice government payments relative to the other rental arrangements evaluated. The CASH arrangement is the least preferred for the landlord, followed by the CTR80S80 and the NRTR80S80 arrangements. Rental arrangements using NT management dominate rental arrangements using CT management at most ARAC values greater than 0. Thus the landlord's preference for NT increases slightly with increasing levels of risk aversion for all rental arrangements examined.

Summary and Conclusions

This analysis evaluated the profitability and risk efficiency of no-till management in Arkansas rice production from the prospective if the landlord using simulation and stochastic efficiency with respect to a function (SERF). Crop yields and prices were simulated for a typical two-year rice-soybean rotation using multivariate empirical distributions (MVEs). Landlord net return distributions were constructed for popular rental arrangements used in Arkansas rice production. The landlord's perspective was evaluated because the majority of cropland farmed in eastern Arkansas is owned by someone other than the producer.

Landlord preferences for no-till management depend on risk attitude. Risk neutral landlords would be indifferent between no-till or conventional till, because expected (mean) returns to the landlord are essentially equal for both tillage methods across all rental arrangements examined. Risk-averse landlords would have a slight preference for no-till, since no-till risk premiums are positive with increasing levels of risk aversion across all rental arrangements examined with the exception of fixed cash arrangements. However, no-till risk premiums are relatively modest. Thus monetary benefits to no-till management appear to be small for risk-averse landlords, implying these landlords may be largely indifferent as to whether no-till or conventional till is used on rented cropland.

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Table 1. Land Tenure Data by Type of Operator, Eastern Arkansas, 2002

Operator	Acres	Percent
Full Owner	1,805,073	24%
Part Owner	3,589,388	48%
Tenant	2,066,404	28%
Total	7,460,865	100%
Part Owner	**Acres**	**Percent**
Owned	1,087,431	30%
Rented	2,501,957	70%
Total	3,589,388	100%

Source: U.S. Department of Agriculture-National Agricultural Statistics Service. 2002 Census of Agriculture: Arkansas State and County Data.

Table 2. Summary Statistics of Simulated Yields and Prices.

Variable	Mean [a]	SD	CV [b]	Minimum	Maximum
NT Rice Yield (bu/acre) [c]	177.02	15.54	8.78	160.46	204.76
CT Rice Yield (bu/acre)	183.50	15.89	8.66	152.53	201.28
NT Soybean Yield (bu/acre)	48.90	5.06	10.35	40.42	55.53
CT Soybean Yield (bu/acre)	45.15	17.39	38.52	14.65	69.03
Arkansas Rice Farm Price ($/bu)	3.55	0.47	13.17	2.86	4.18
Arkansas Soybean Farm Price ($/bu)	6.10	0.60	9.82	5.35	7.47
Rice World Market Price ($/bu)	2.79	0.27	9.53	2.45	3.21
National Rice Farm Price ($/bu)	3.71	0.45	12.12	3.05	4.31
National Soybean Farm Price ($/bu)	5.87	0.70	11.98	5.17	7.58

[a] Summary statistics calculated from 500 simulated iterations.

[b] Coefficient of Variation (CV) is a unitless measure of relative risk and is equal to the standard deviation (SD) divided by the mean.

[c] NT = No-Till; CT = Conventional till.

Table 3. Summary Statistics of Simulated Landlord Net Returns by Rental Arrangement and Tillage Method.

Arrangement	Mean [a]	SD	CV [b]	Minimum	Maximum	Prob. NR < C [c]
	-----------$/acre-----------			------------$/acre------------		
NTR75S75[d]	116	12	10.6	91	158	0%
CTR75S75	116	19	16.5	70	171	4%
NTR80S80	91	10	10.9	70	124	33%
CTR80S80	90	15	16.9	53	134	38%
NTR50S75	135	21	15.7	91	208	0%
CTR50S75	136	27	20.1	67	215	2%
NTR50S80	128	21	16.2	85	198	0%
CTR50S80	128	25	19.8	64	202	3%
CASH	85	0	0.0	85	85	0%

[a] Summary statistics calculated from 500 simulated iterations.

[b] Coefficient of Variation (CV) is a unitless measure of relative risk and is equal to the standard deviation (SD) divided by the mean.

[c] Probability of receiving a net return less than cash rent.

[d] NT = No-Till; CT = Conventional Till; R = Rice portion of rotation; S = Soybean portion of rotation; 75, 80, 50 = tenant's share of the crop in crop/cost share arrangement; CASH = fixed cash arrangement.

Table 4. Landlord Certainty Equivalents and No-Till Risk Premiums by Rental Arrangement for Various Absolute Risk Aversion Coefficients.

Arrangement	Absolute Risk Aversion Coefficients (ARAC)				
	0.000	0.009	0.018	0.026	0.035
	Certainty Equivalents ($/acre)				
NTR75S75 [a]	116	116	115	115	114
CTR75S75	116	115	113	112	110
NTR80S80	91	90	90	89	89
CTR80S80	90	89	88	87	86
NTR50S75	135	134	132	130	128
CTR50S75	136	132	129	126	123
NTR50S80	128	126	124	123	121
CTR50S80	128	126	123	120	118
CASH	85	85	85	85	85
	No-Till Risk Premiums ($/acre)				
R75S75	0	1	2	3	4
R80S80	0	1	1	2	3
R50S75	0	1	3	4	5
R50S80	-1	0	1	2	3
CASH	0	0	0	0	0

[a] NT = No-Till; CT = Conventional Till; R = Rice portion of rotation; S = Soybean portion of rotation; 75, 80, 50 = tenant’s share of the crop in crop/cost share arrangement; CASH = fixed cash arrangement.

Figure 2. Landlord SERF Results Over Absolute Risk Aversion Range of 0.000-0.035, Assuming Negative Exponential Utility Function