PRODUCTION RISK MANAGEMENT UNDER ARKANSAS SOYBEAN RENTAL ARRANGEMENTS FROM THE TENANT'S AND LANDLORD'S PERSPECTIVE

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Abstract

Potential of alternative production practices and rental arrangements for risk management of both landlord and tenant, individually and jointly, is examined. Mathematical programming and simulation is used to study a hypothetical Arkansas soybean producer. Results indicate importance of lease types and risk in choice of optimal farm plans.

Subject areas: Farm/Risk Management and Production Economics

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INTRODUCTION

The growing importance of agricultural land leasing is one of the significant developments in US agriculture in the past several decades. While the farmland share of full-owner operators declined from about 53% in 1910 to 31% in 1992, census data show a corresponding increase for part-owners from 15% to about 56% during the same period (USDA). Leasing of agricultural land is especially common in states with many commercial operators and/or where crop receipts are a significant portion of farm income such as Illinois, Arkansas, Iowa, California and Louisiana (Bierlen and Parsch).

Several farm leasing studies have appeared in the literature in response to the increasing relevance of this component of agricultural land tenure. However, many of these studies have ignored the landlord preferences in evaluating lease terms on tenant's incentive conditions (Bierlen and Parsch; Heady; Reiss). The few studies that considered landlord preferences (Apland, Barnes and Justus; Blank; Sutinen) suggest that risk attitudes influence lease terms and there are considerable trade-offs between tenant and landlord preferences as the degree of risk aversion changes. Further empirical elucidation of these conclusions is now appropriate considering the renewed opportunities and challenges embodied in the recent FAIR (Federal Agricultural Improvement and Reform) act. Consequently, the objective of this study is to provide further insights into the potential of alternative production practices and rental arrangements for reducing production risk while improving both the tenant and landlord preferences. The hypothesis to be tested is whether risk attitudes of the agents influence their preferences for lease types and optimal farm plans.

In the sections that follow, the analytical procedure and estimation methods are first presented. Following this, the results of the analyses are discussed. Finally, the summary and conclusions of the study will be presented .

MODEL AND ESTIMATION

A case study approach of a hypothetical soybean producer in Arkansas was adopted for this study. Soybeans account for more cultivated acreage in Arkansas than any other crop (Arkansas Agricultural Statistics Service) while about 677 acres or 77% of the average size of commercial crop farms in the state is rented (Webb).

A mathematical programming model was employed to embody the decision-making framework facing a hypothetical Arkansas soybean producer on a loamy soil in Keiser, located in the Mississippi Delta region of Arkansas. The Delta region is a major soybean producing area of the state. The focus of the study was on non-irrigated soybeans which account for the bulk of soybean acreage in Arkansas. Crop rental arrangement for both the landlord and the tenant in the Delta region of Arkansas is considered for three rental strategies: straight share, cost share, and cash.

Biophysical simulation model was utilized to generate yield data and suitable field days. Average soybean prices, average input prices and representative input requirements were obtained from Arkansas Agricultural Statistics Service and Cooperative Extension Service publications. Rental returns for a hypothetical landlord in the Delta region of Arkansas owning dryland soybean and dryland grain sorghum acreage were then calculated for the straight share, cost share, and base plus bonus rental arrangements. The straight share landlord rental returns were calculated by taking 25% of total value of production. Under this common rental agreement in the Delta region, no operating expense is borne by the landlord. The cost share rental returns were based on one-third of the total value of production as is commonly used in the Delta region. In addition, the landlord shares one-third of fertilizer, seed, chemical, hauling, and drying expenses. Finally, a base cash rental agreement was investigated using 20% of the average value of dryland soybean produced from 1992-1996. Under the assumption that soybean price averaged $6.39/bushel in these years, the base cash rent amounted to $37.74/acre.

A quadratic programming model was employed within a expected value-variance (E-V) framework to incorporate profit and risk considerations for various lease types. The sufficiency conditions under which the use of E-V is consistent with expected utility theory include one of the following: (1) normal distribution (Freund), (2) if the distributions of net returns associated with the decision variable differ only by location and scale (Meyer) or (3) if the utility can be approximated by a quadratic function (Markowitz). For this study, yield is the only random component of net returns; therefore normality of yields is expected to be sufficient condition for normality of returns. Testing with Kolmogorov-Smirnov statistics failed to reject the normality assumption at the 5% level of significance for these yields. Therefore, E-V was considered to be an appropriate method.

The general specification of the E-V model is:

$$MAX\ \overline{Y} - \Phi\sigma^2{}_y$$

subject to:

(1) $\sum_R \sum_M \sum_P \sum_S X_{R,M,P,S} \leq 400$

(2) $\sum_R \sum_M \sum_P \sum_S SOYLAB_{P,S,WK} X_{R,M,P,S} \leq FLDDAY_{WK} \qquad \forall WK$

(3) $\sum_M \sum_P \sum_S EXPYLD_{R,M,P,S,YR} X_{R,M,P,S} - SALES_{R,YR} = 0 \qquad \forall R,YR$

(4) $\sum_R \sum_M \sum_P \sum_S REQ_{I,P*} X_{R,M,P,S} - PURCH_I = 0 \qquad \forall I$

(5) $\sum_I IP_I \, PURCH_I - \sum_R P_R * SALES_{R,YR} + Y_{YR} = 0 \qquad \forall \, YR$

(6) $\sum_{YR} \frac{1}{N} Y_{YR} - \overline{Y} = 0$

where

activities include:

$\overline{Y}$	= expected net returns above variable cost (mean across years)
Y_{YR}	= net returns above variable cost by year (net returns)
$X_{R.M,P,S}$	= production by rental arrangement R of maturity group M with a plant population P under sowing date S in acres
$SALES_{R,YR}$	= bushels of soybeans sold by rental arrangement and year
$PURCH_I$	= purchases of input I

constraints include:

(1) Land resource limitation

(2) Labor resource limitations by week

(3) Sales balance by rental arrangement and year

(4) Input purchases by input

(5) Profit balance by year

(6) Expected profit balance

coefficients include:

Φ	= Pratt risk-aversion coefficient
P_R	= Price of crop in dollars less dependent costs (hauling) if dictated by rental strategy R
IP_I	= Price of input I
$EXPYLD_{R,M,P,S}$	= Expected yield of maturity group M planted in row and plant spacing P planted on sowing date S in bushels per acre

$REQ_{I,P}$ =Requirement of input I for production in row and plant spacing P in units per acre adjusted by rental strategy R

$SOYLAB_{P,S,WK}$ = Soybean labor requirements for production of soybeans planted in row and plant spacing P planted on sowing date S in week WK in hours per acre

$FLDDAY_{WK}$ = Available field days per week at the 75% level of certainity

indices include:

R = Rental arrangement (base cash rent, crop share, cost share)

M = Maturity group (MG V = maturity group 5, MG VI = maturity group 6)

P = Plant population (nine inch rows with two and three plants per foot; nineteen inch rows with four and six plants per foot; thirty eight inch rows with eight and twelve plants per foot)

S = Sowing date (nine dates in weekly intervals beginning May 10 and ending July 5)

I = Input

WK = Week

YR = Year

The objective function maximizes the certainty equivalent of net returns which is net returns above variable costs (hereafter referred to as simply net returns) less the product of Pratt risk-aversion function coefficient and the variance of net returns (o^2_y). The Pratt risk-aversion function coefficient is a measure of a hypothetical producer's aversion to risk. This coefficient is calculated using the method described by McCarl and Bessler, wherein a producer is said to maximize the lower limit from a confidence interval of normally distributed net returns. The resultant general formula for calculating the risk aversion parameter is:

$$\Phi = 2 Z_{\alpha} / S_y$$

where Φ = risk-aversion coefficient, Z_{α} = the standardized normal Z value of α level of significance and S_y = the relevant standard deviation the risk-neutral profit maximizing base case for each.

The data required to specify the production decision model are: 1) available land, 2) available field days, 3) labor requirements, 4) input requirements and prices, 5) soybean price and 6) yields. The hypothetical farm is assumed to be a commercial size operation with 400 acres which is close to the 1992-1996 average number of soybean acres harvested per commercial farm in Mississippi County where Keiser is located (Arkansas Agricultural Statistics Service).

The number of suitable field days available per week was estimated using historical weather data and soil water simulation under a modified procedure discussed by Dillon, Mjelde and McCarl. A 50% likelihood of a given number of field days occurring in any particular week was then specified as the labor constraint. Available field time is calculated by multiplying the average number of workable field days per week by 12 working hours per day for 1 person. The weekly number of days the tractor could work was calculated using a field days criteria function.[1] The vector of the field days available appeared as the weekly right hand side values in the mathematical programming model; the average weekly days available for Keiser was 4.3.

The labor requirements per week and input costs and requirements per acre were generated using budget data from the Mississippi State Budget Generator (MSBG) (Spurlock). Sample budgets were constructed for all eight row/plant spacing combinations using standard production practices in the area (Windham and Brown; Keisling). The input prices used by this budget generator were the 1996 estimates of prices by the Arkansas Cooperative Extension Service. The price for soybeans is the 1992-1996 average season Arkansas of $6.39/bushel (Arkansas Agricultural Statistics Service) less the hauling charge (Windham and Brown).

SOYGRO (Wilkerson et al.) was used to generate the soybean yield data for two maturity groups, eight row and plant spacing combinations and nine planting dates. Two maturity groups, group five (MG V) and group six (MG VI). The eight different row and plant spacing combinations consist of nine inch rows with two and three plants per foot, 19 inch rows with four and six plants per foot, 30 inch rows with six and nine plants per foot, and 38 inch rows with eight and twelve plants per foot. Nine planting dates in weekly intervals beginning May 10 and ending July 5 were used as the possible planting dates. These production alternatives were chosen because they represent a reasonable span of production practices that are commonly encountered in the Arkansas Delta region (Keisling).

RESULTS AND DISCUSSION

The base case scenario was analyzed for four situations including both the tenant and the landlord and under risk neutral and risk averse scenarios. The risk aversion parameter based on McCarl and Bessler approach was selected by increasing the Z score from 50% for the risk neutral situation in 5% increments until the optimal solution changed. This resulted in the use of a 60% probability level for the risk averse tenant and a 55% level for the risk averse landlord. The standard deviations from the optimal solution for the risk neutral tenant and landlord were utilized as the representative standard deviations in the McCarl and Bessler formula.

The results for net returns and production strategy selected are shown in Table 1. The risk neutral tenant optimal solution provided mean net returns of $20,758 for the tenant and $14,119 for the landlord. Risk was also relatively high with a tenant coefficient of variation (cv) of net returns of 133.70. The production strategies selected were 171 acres planted on June 28th and 229 acres planted on July 5th, all of maturity group VI on 9 inch rows and 2 plants per foot spacing. The rental strategy selected for all acreage was the one third cost share. The landlord's expected net returns are about 84% of the optimal solution for the risk neutral landlord which displayed mean net returns of

$16,873. While the production strategies remain identical, the rental strategy preferred by the landlord is for the quarter crop share rent. The landlord has only a 59% cv in this scenario while the tenant has a cv of 177% on a mean net returns of $17,543.

Interestingly, risk management was only possible for the tenant producer by reducing the acres planted. The risk averse tenant lowered risk by reducing the June 28th planting of soybeans from 171 to 59 acres. Consequently, mean net returns dropped to $15,124 with only a slight reduction in the cv to a level of 132%. This inability of the tenant to further reduce risk can be seen in a relative comparison. Moving from risk neutral to risk averse for the tenant results in a 27% decrease in expected net returns for an almost negligible decrease in cv from 134% to 132%. The 28% decline in acreage would lead to this expected result, with mean net return falling comparably given the similar production practices. Greater concentration in the preferred July 5th planting results in only a slightly improved cv, as a relative measure of risk. The preferences of risk averse landlord shifted from quarter crop share rent to a cash rent strategy as would be expected. Specifically, while 151 acres remained in the July 5th planting of crop share rent, cash rent included the 171 acres planted June 25th and the remaining 78 acres planted July 5th. This enabled a substantial reduction in risk to a 21% cv in net returns with the accompanying approximate $1,000 decrease in expected net returns to a level of $15,848. Nonetheless, the tenant under this scenario has the greatest level of risk with a 200 % cv and achieved expected net returns of $18,837. Consequently, the results display the predetermined ability of cash rent to decrease the landlord's risk while increasing the risk of the tenant.

Following Apland, Barnes and Justus, a joint objective function analysis was conducted by utilizing, under equal weights, the summation of the landlord's and the tenant's objective function. Four joint objective functions were examined. Specifically, all combinations of risk neutral and risk averse tenant and landlord were investigated. Interestingly, three of the four situations result in strategies identical to that of the singular risk neutral tenant optimal strategy (Table 2). In the case of the risk neutral tenant combined with a risk neutral tenant, the total value associated with the tenant predominated, giving rise to a solution identical to that of considering the risk neutral tenant alone. The risk averse tenant combined with landlord solutions seemingly represent a compromise between the tenant's risk management strategy of acreage reduction which unacceptably lowers the landlord's net returns and the dissimilar rental strategy preferences of the landlord. Specifically, while the tenant prefers a third cost share rent, the risk neutral landlord prefers a quarter straight hare rent and the risk averse landlord prefers a cash rent. Renting all 400 acres under a third crop share agreement represents an intermediate strategy between reduced acreage for the risk averse tenant and alternative rental strategies for the landlord.

The notable difference in the optimal solution of the joint objective function experiment was a risk neutral tenant combined with a risk averse landlord. This solution resulted in the predominance of acreage to be rented under the cash method with only 11 of the 400 acres being rented on a third cost share strategy. With a 209% cv for the tenant, this solution displayed the greatest level of risk borne by the tenant and the least borne by the landlord who enjoyed a 2% cv. The tenant's expected net returns were approximately 95% of the risk neutral profit maximizing level and the landlord's expected net returns were approximately 89% of expected profit maximizing risk neutral singular objective function solution value. These results demonstrate that even though the tenant may be risk averse, consideration of the landlord may prohibit the tenant from utilizing rental strategies to reduce risk. Furthermore, the use of a cash rent may be especially important for risk averse landlords and would, of course, be potentially more acceptable to a risk neutral tenant as opposed to a risk averse tenant.

CONCLUSIONS

The study supports the expectation that cash rent is a mechanism for reducing the risk borne by the landlord while increasing the risk borne by the tenant. The quarter share of crop rental strategy was preferred by risk neutral landlords while a cash rent was preferred by risk averse landlords. The tenant displayed a desire for the third cost share rent regardless of whether he/she is risk neutral or risk averse. In this study, there was a preference by both parties for the use of rental strategies in reducing risk as opposed to utilizing production practices such as planting date, maturity group, row spacing and plant spacing. Analysis of joint objective functions between the two parties indicated that the optimal solution for a risk neutral tenant dominated most situations. This was the optimal solution for the joint risk neutral tenant and risk neutral landlord scenario but also seemed to be the compromise solution for risk averse tenant's desire to reduce acreage and the risk averse landlord's desire for a cash rent when both are considered jointly. This compromise solution holds true even if a risk averse tenant is partnered with a risk neutral landlord who prefers a quarter share rent. However, for a risk averse landlord and a risk neutral tenant, the preferences of the risk averse landlord dominate with a heavy shift to cash rent for the majority of acreage.

Several limitations of the study provide the grounds for further research. Specifically, a further evaluation with lease type constraints might lead to more meaningful results. Also, the use of a single crop as opposed to diversification across multiple crops in a whole farm scenario may also impact the findings. Finally, the joint objective functions between the two parties assigned equal weights, but tradeoffs between landlords and tenants can be better illustrated by changing these weights parametrically.

END NOTES

1. The criteria used to identify a nonworking day are 1) if it rained three consecutive days, the third day along with the following day is not considered a field day, 2) if the soil moisture of the top 11.8 inches (30cm) is 70 percent or greater of water storage capacity on a given day, then that day is not considered a field day, and 3) if it rained 0.15 inches (0.38 cm) or more on a given day, then that day is not considered a field day. The soil moisture portion of the biophysical model is used to derive soil moisture.

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Table 1. Base Case Net Returns and Production Strategy Results by Party and Risk Attitude

Section 1. Net Returns above Specified Costs

	Optimal Strategy For:			
	Risk Neutral		Risk Averse	
Component	Tenant	Landlord	Tenant	Landlord
	Tenant			
Mean($)	20,757.80	17,542.53	15,123.70	18,836.78
Std. Dev. ($)	27,754.12	31,026.33	19,988.84	37,625.58
C.V. (%)	133.70	176.86	132.17	199.75
Min. ($)	-14,951.83	-22,377.27	-10,708.11	-29,515.40
Max. ($)	78,517.88	82,112.53	56,739.98	97,109.83
Percent of Profit Max (%)	100.00	84.51	72.86	90.75
	Landlord			
Mean ($)	14,118.74	16,873.37	10,246.68	15,848.38
Std. Dev. ($)	13,877.06	10,342.11	9,994.42	3,928.92
C.V. (%)	66.85	58.95	66.08	20.86
Min. ($)	-3,736.06	3,566.77	-2,669.23	10,762.02
Max. ($)	42,998.79	38,396.71	31,054.82	24,013.40
Percent of Profit Max (%)	83.67	100.00	60.73	93.93

Section II. Production Strategies Results in Acres (All Maturity Group 6; 9 inch rows, 2 plants/foot)

		Optimal Strategy For:			
Planting		Risk Neutral		Risk Averse	
Date	Rent[1]	Tenant	Landlord	Tenant	Landlord
June 28	Third	171.42	0.00	58.58	0.00
July 5	Third	228.58	0.00	228.58	0.00
June 28	Quarter	0.00	171.42	0.00	0.00
July 5	Quarter	0.00	228.58	0.00	150.70
June 28	Cash	0.00	0.00	0.00	171.42
July 5	Cash	0.00	0.00	0.00	77.88
Mean Yield (bu/ac)		27.22	27.22	27.40	27.22

[1]Rental Strategy = Cash for cash rent, Quarter for quarter crop share, Third for one third cost share

Table 2. Joint Objective Function Net Returns and Production Strategy Results

Section I. Net Returns above Specified Cost

	Risk Neutral Tenant and Landlord is:		Risk Averse Tenant and Landlord is:	
Component	Risk Neutral	Risk Averse	Risk Neutral	Risk Averse
	— — — — — — — — — — — — — —	Tenant	— — — — — — — — — — — — — —	
Mean($)	20,757.80	19,788.46	20,757.80	20,757.80
Std. Dev. ($)	27,754.12	41,262.55	27,754.12	27,754.12
C.V. (%)	133.70	208.52	133.70	133.70
Min. ($)	-14,951.83	-33,305.71	-14,951.83	-14,951.83
Max. ($)	78,517.88	105,663.33	78,517.88	78,517.88
Percent of Profit Max (%)	100.00	95.33	100.00	100.00
	— — — — — — — — — — — — — —	Landlord	— — — — — — — — — — — — — —	
Mean ($)	14,118.74	15,063.56	14,118.74	14,118.74
Std. Dev. ($)	13,877.06	15,837.24	13,877.06	13,877.06
C.V. (%)	66.85	1.89	66.85	66.85
Min. ($)	-3,736.06	14,588.08	-3,736.06	-3,736.06
Max. ($)	42,998.79	15,837.24	42,998.79	42,998.79
Percent of Profit Max (%)	83.67	89.27	83.67	83.67

Section II. Production Strategies Results in Acres (All Maturity Group 6; 9 inch rows, 2 plants/foot)

Planting		Risk Neutral Tenant and Landlord is:		Risk Averse Tenant and Landlord is:	
Date	Rent[1]	Risk Neutral	Risk Averse	Risk Neutral	Risk Averse
June 28	Third	171.42	8.17	171.42	171.42
July 5	Third	228.58	2.60	228.58	228.58
June 28	Cash	0.00	163.25	0.00	0.00
July 5	Cash	0.00	225.98	0.00	0.00
Mean Yield (bu/ac)		27.22	27.22	27.22	27.22

[1]Rental Strategy = Cash for cash rent, Quarter for quarter crop share, Third for one third cost share