

**TESTING FOR COOPERATIVE BEHAVIOR: AN EMPIRICAL STUDY OF LAND
TENURE CONTRACTS IN TEXAS**

by

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Abstract

Non-cooperative behavior in land lease contracts under production uncertainty and information asymmetry results in input application and wealth distribution inefficiencies which can be mitigated by self-enforcing, long-term cooperative contracts. This paper investigates cooperative and non-cooperative behavior in land lease contract data from the southern high plains of Texas by developing and analyzing an empirical model of private information sharing. The paper also obtains empirical evidence supporting the classical conclusion that information asymmetry can be reduced and cooperation promoted in repeated contracts.

TESTING FOR COOPERATIVE BEHAVIOR: AN EMPIRICAL STUDY OF LAND TENURE CONTRACTS IN TEXAS

Share lease contracts are a common form of land tenure arrangement in the United States and elsewhere. U. S. census data indicate that in 1992, 43% of arable land was farmed by tenants (USDA, 1995). This study investigates cooperative behavior between landlords and tenants and evidence of opportunistic use of agricultural resources.

Central to the economics of these contracts are clauses relating to resource allocation and wealth sharing between landlords and tenants. Negotiation of these clauses between landlords and tenants is often affected by income uncertainty (due to uncertain production and prices) and information asymmetry (due to absentee landlords who usually do not observe the production activities of tenants) (Stiglitz). This often precludes costless enforcement of the tenant's actions, affording the opportunity for tenants to adjust input levels to maximize their own payoffs, usually to the detriment of the landlord (i.e., moral hazard) (Shavell). As a result, such contracts are often viewed as being negotiated with each party optimizing their own payoffs, assuming similar behavior from the other party. A contract based on such a strategy is said to be non-cooperative.

If both parties have full knowledge of each other's actions, they may choose to cooperate because the consequent payoffs are usually Pareto superior to non-cooperative payoffs (Radner; Dasgupta, Knight and Love). However cooperation, which often involves both parties undertaking to maximize a joint payoff, can only be sustained in equilibrium provided neither party has incentive to defect when the other party cooperates, as in the familiar 'Prisoner's Dilemma' game (Kreps). Holmstrom shows in a more general setting that an imperfect signal observed in every iteration of a repeated game under information asymmetry provides perfect information asymptotically. Therefore, the information asymmetry in a contract can be mitigated

by sufficient repetition, provided the landlord observes the output during every repetition. In this context Dasgupta et al. has shown that a cooperative equilibrium is feasible in a repeated contract where the landlord initiates cooperation and credibly threatens the tenant with non-cooperation if the observed output, averaged over sufficiently many time periods, falls below a threshold level.

The goal of this paper is to obtain evidence of information asymmetry and cooperation in repeated land lease contracts. Specific objectives are to find evidence of tenant-moral hazard, private-information exchange in repeated contracts and associate cooperative behavior with tenant-monitoring activities of landlords. The next section outlines the theoretical model. This is followed by a section describing the data and a section specifying the empirical model and estimation results. The concluding section interprets the results and discusses implications of our findings.

Theoretical Model

We consider a land lease contract that is negotiated between one landlord and one tenant for multiple time periods where both parties act according to pre-specified strategies. For expositional clarity, the landlord is referred by the pronoun ‘she’, and the tenant by ‘he.’ Throughout, we assume that the tenant makes input application decisions and the landlord makes wealth distribution decisions.

Non-cooperation is characterized by each party optimizing their own-payoffs, assuming that the other party does the same. Thus, the landlord’s and tenant’s non-cooperative objectives are given by (1) where both parties maximize their expected utility of income.

$$(1) \quad \begin{aligned} & \text{Landlord: } \text{Max}_{\alpha, \beta} \text{EU}_L [\text{income}_L = (1 - \alpha)Y(x, l, u) - (1 - \beta)r x] \\ & \text{Tenant: } \text{Max}_{x, l} \text{EU}_T [\text{income}_T = \alpha Y(x, l, u) - \beta r x - w l] \end{aligned}$$

Here, x and l represent a cost-shared input and labor (with per-unit prices of r and w),

respectively, u is a stochastic input (random state of nature) and Y is the output (per acre). The tenant's share of the output and costs of input x are denoted by α and β , respectively. Assuming that the first-order conditions from the landlord's and tenant's objectives can be simultaneously solved, the landlord's solution functions ($\alpha^*(Z | x, l)$, $\beta^*(Z | x, l)$) and tenant's solution functions ($x^*(Z | \alpha, \beta)$, $l^*(Z | \alpha, \beta)$) are the best response of each party (which are dependent on a set of exogenous variables Z , which include w and r) to the expected best response of the other party. Hence, non-cooperative behavior results in a Nash equilibrium. We denote the non-cooperative payoffs of the landlord's and tenant's as L^* and T^* , respectively.

Cooperation between the landlord and tenant is defined by both parties simultaneously choosing input levels and wealth sharing terms to optimize a joint objective:

$$(2) \quad \text{Max}_{x, l, a, b} [EU_L(\text{income}_L) - L^*][EU_T(\text{income}_T) - T^*]$$

The cooperative objective in (2) is a Nash product where both parties receive payoffs that are Pareto-superior to their non-cooperative payoffs (Nash, Harsanyi). This objective represents a static axiomatic solution to a dynamic Nash bargaining problem where parties revert to non-cooperation in the event of a disagreement (Binmore, Rubinstein, and Wolinsky). Assuming that a solution to (2) exists, the cooperative level of the landlord's and tenant's decision variables are denoted as $(\hat{\alpha}, \hat{\beta})$ and (\hat{x}, \hat{l}) and payoffs are denoted by \hat{L} and \hat{T} , respectively.

If the landlord announces her intention to cooperate, the tenant has incentive to adjust his labor input (unobserved by the landlord) according to the following objective:

$$(3) \quad \text{Max}_x EU_T(\text{income}_T | \{\hat{x}, \hat{\alpha}, \hat{\beta}\})$$

Here, $\hat{\alpha}$ and $\hat{\beta}$ are the tenant's cooperative output and input cost shares, respectively, and \hat{x} indicates that the tenant applies the cooperative level of x , since information on the cost-shared input is assumed observable to the landlord. The objective in (3) gives payoffs L^{**} and T^{**} for the

landlord and tenant in which the tenant is better off ($T^{**} > \hat{T}$) and the landlord is worse off ($L^{**} < \hat{L}$) than when the tenant cooperates. Hence, for a single-period contract, if a landlord cooperates, a rational tenant is better off cheating. As a result, a cooperative Nash equilibrium is precluded in a single-period contract.

However, a cooperative Nash equilibrium is feasible if the contract is repeated over time. This is done by designing a contract according to strategies outlined in Dasgupta et al. which are adopted from Radner's 'review strategies.' The landlord's strategy consists of initiating cooperation for R consecutive periods followed by comparing the average output to her expected cooperative output level (a review phase). If the average output exceeds this minimum threshold, another review phase begins; otherwise, the landlord initiates an M -period non-cooperation (or punishment) phase which is followed by the next review phase. A tenant acts according to his best response to the landlord's strategy and non-cooperates (for M' periods) if the landlord deviates from the cooperative wealth sharing rule. Dasgupta et al. show that both parties cooperate in a Nash equilibrium if R is large enough and (M, M') are appropriately bounded, provided the payoff discount factors of both parties are close enough to one. Details of the derivations are not presented for sake of brevity, but are available upon request.

Differences between cooperative and non-cooperative decision making can be associated with the nature of information sharing between the two parties. Non-cooperating parties are interested only in maximizing their own payoff and have no incentive to share private information with the other party. Under cooperation, since optimal input and wealth distribution variable choices are jointly made to maximize a combined payoff (2), both parties benefit from sharing private information with one another. This is illustrated in (1) and (2). We observe in (1) that the landlord requires no information on the tenant's marginal factor cost of labor (w) in order to

determine her optimal non-cooperative responses α^* and β^* . Correspondingly, in (2), the tenant must share information about w with the landlord for optimal decision making.

Data

The data used in this study come from a survey of 2000 cotton producing tenants operating in the southern high plains of Texas. The producers were questioned on their production-related activities and land lease contract terms for the 1995 crop year. We also inquired about the landlord-tenant contractual relation and obtained information on tenant demographics, capital equipment and crop insurance. We received 278 useful responses.

Econometric Model

Cooperative / non-cooperative behavior in the data is determined by the interdependence on landlord and tenant decisions. Specifically, a tenant's labor application intensity and a landlord's per-acre output sharing decisions are considered. The landlord's decision variable (q_L) is the expected number of pounds of cotton (per acre) given to the tenant.

$$(4) \quad q_L = (1-\alpha) Y^E$$

Here, Y^E is the expected yield per acre and is derived from the fitted values in a linear regression of the actual yield per acre on input levels, land quality indicator variables, planting pattern, etc.

The tenant's decision variable (q_T) is the total hours of paid and unpaid labor employed per acre of the land.

$$(5) \quad q_T = \frac{1}{\text{Land Area}} \left[\frac{\text{Cost of Paid Labor}}{\text{Wage Rate}} + \text{Unpaid Labor Hours} \right]$$

The econometric model is summarized by (6) and (7).

$$(6) \quad \begin{aligned} \text{Landlord's Equation: } & q_L = \eta_1 \cdot Z + u_L \\ \text{Tenant's Equation: } & q_T = \eta_2 \cdot Z + u_T \end{aligned}$$

$$(7) \quad \begin{aligned} \text{Landlord's Equation: } & q_L = \lambda_1 \cdot \hat{u}_T^c + \lambda_2 \cdot \hat{u}_T^{nc} + \theta_1 \cdot Z + \varepsilon_L \\ \text{Tenant's Equation: } & q_T = \tau_1 \cdot \hat{u}_L^c + \tau_2 \cdot \hat{u}_L^{nc} + \theta_2 \cdot Z + \varepsilon_T \end{aligned}$$

In (6) we regress q_L and q_T on the same set of independent variables (Z) and obtain residuals \hat{u}_L and \hat{u}_T . Here, Z is a set of independent variables that are observed by both parties. Therefore, if a landlord and tenant base their decisions on variables not known to the other party (i.e., private information), effects of these variables are captured by the residuals \hat{u}_L and \hat{u}_T , respectively. We partition the residuals according to the potentially non-cooperative and cooperative contracts obtaining \hat{u}_i^{nc} , $i \in \{L, T\}$ and \hat{u}_i^c , $i \in \{L, T\}$, respectively. In (7), we regress each party's decision variable on the partitioned residuals of the other party and Z . The estimated coefficients of Z from (6) (i.e., $\hat{\eta}_1$ and $\hat{\eta}_2$) are equal to the corresponding estimated coefficients of Z from (7) (i.e., $\hat{\theta}_1$ and $\hat{\theta}_2$) (Greene p. 179).

We test for interdependence of landlord and tenant decisions by regressing q_L and q_T on the partitioned residuals of the other party and Z , as shown in (7), and interpreting the statistical significance of the estimated coefficients. If the coefficients of \hat{u}_i^c are significantly different from zero it indicates that, in potentially cooperative contracts, each party conditions their decisions on the private information of the other party. For potentially non-cooperative contracts, if coefficients of \hat{u}_i^{nc} are not significantly different from zero, each party makes decisions without taking private information of the other party into account. Hence, one can conclude that a party's decision is dependent (independent) of the other party's private information in potentially cooperative (non-cooperative) contracts.

Results

The empirical model is analyzed by first estimating (6) and using the residuals to estimate (7). These residuals are partitioned according to potentially cooperative and non-cooperative contracts on the basis of the number of years (prior to 1995) since the last change in contracts terms. In the first partition, potentially non-cooperative contracts are those where the contract

terms changed one year prior to 1995. Considering the remaining contracts to be potentially cooperative, this partition is called the 1-year partition. Similarly a 2-year and 3-year partition of the residuals are also obtained. Results from regressing (7) for the three partitions appear in tables 1 and 2 for the landlord and tenant, respectively. The independent variables in Z were chosen from a list of variables, commonly observable to both parties, that significantly influence their decisions (q_L and q_T).

Since the effects of the independent variables in Z are fairly uniform across the three partitions, we discuss them simultaneously. Considering the effect of Z on q_L , the following variables exert significant influence: landlord's ownership of the irrigation delivery system, fertilizer and insecticide expenditure, landlord's share of fertilizer costs, irrigation dummy variable, cost of irrigation delivery system and the percentage of tenant-income from off-farm sources. A landlord gives more output (per acre) to a tenant if there is an increase in fertilizer/insecticide expenditure, the land is irrigated, there is an increase of investment in the irrigation delivery system or if the land is of better quality (i.e., farm-program yield of the land is higher). This is plausible because in each of these cases, a landlord could expect an increase in the output per acre. Since fertilizer and insecticide are cost-shared inputs, a landlord has full information of their application levels, which prevents their opportunistic use by tenants. Hence, the landlord tends to give a greater amount of output (per acre) to tenants if there is evidence of more intensive use of cost-shared inputs. On the contrary, if a tenant uses a landlord-supplied quasi-fixed input, moral-hazard incentives will induce him to substitute lesser use of tenant-supplied variable inputs for greater use of the quasi-fixed input in an effort to increase his own payoff. Consistent with this theory, the results indicate that a landlord gives less output (per acre) to a tenant, if she supplies the irrigation delivery system. Similarly, if the tenant's income is less

output-dependent, he has greater moral hazard incentives. Table 1 indicates that a landlord gives less output to a tenant if the tenant's income is more dependent on off-farm sources, which further supports the theory of moral hazard under asymmetric information.

The effects of Z on q_T indicate that a tenant increases his labor intensity if the land is irrigated, the irrigation delivery system is more expensive or if the landlord shares more of the fertilizer costs. The data indicate that 81.65% of tenants bear 75% of fertilizer costs and 16.46% of tenants bear 100% of fertilizer costs. Hence, if a tenant increases his share of fertilizer costs, it is likely that fertilizer is becoming a tenant-supplied input and not a cost-shared input. In this context if the tenant is bearing 100% of the fertilizer expenses, the landlord will not have information on fertilizer and labor use. Thus, moral hazard incentives would induce a tenant to adjust the two input levels in order to minimize his own costs. Hence, if the tenant absorbs all of the fertilizer costs, *ceteris paribus*, his labor intensity should decrease. This is clearly supported by the above results.

The effect of the residuals on q_L and q_T are not symmetric across the three partitions. For potentially non-cooperative contracts in the 1-year partition, decisions of either party are not significantly influenced by residuals of the other party. Conversely, both party's decisions are significantly influenced by the residuals of the other party in the potentially cooperative contracts. For the 2- and 3-year partitions, in either contract type, decisions of each party are significantly influenced by residuals of the other party. Since the data indicate asymmetric information due to absentee landlords, the residuals contain the effect of private information for each party. Hence, a significant (insignificant) impact on a party's decision of private information of the other party implies information sharing (non-sharing). This indicate private-information sharing for all contract types except the potentially non-cooperative contracts in the 1-year partition. Since

equilibrium cooperation under information asymmetry requires contract repetition, the evidence that cooperative exchange of information occurs in contracts that have been repeated for at least two years support the theory of cooperation (Radner, Holmstrom).

Since the data indicate that in some contracts a landlord monitors her tenant, which is captured in the number of times that she confers with the tenant on some aspect of farming, we investigate the effect of such activities on private-information sharing. Contracts involving monitoring are designated as those in which the landlord and tenant interacted at least twice during the crop year. Hence, following the above analysis, the residuals from (6) are partitioned into \hat{u}_i^m and \hat{u}_i^{nm} , $i \in \{L, T\}$, for contracts with and without monitoring activities, respectively. By substituting these residuals for \hat{u}_i^c and \hat{u}_i^{nc} , $i \in \{L, T\}$, in (7), we can determine the association between monitoring activities and cooperative information sharing. Results from regressing (7) give the following coefficient estimates (t-ratios): from the landlord's equation, $\hat{\lambda}_1$ and $\hat{\lambda}_2$ are 0.024 (1.076) and 0.095 (2.856), respectively, and from the tenant's equation, $\hat{\tau}_1$ and $\hat{\tau}_2$ are 0.396 (1.141) and 1.421 (1.787), respectively. Clearly, only $\hat{\lambda}_2$ and $\hat{\tau}_2$ are significantly different from zero, which indicates that private-information sharing is predominant only in contracts without monitoring activities. A cooperative equilibrium exists due to self-enforcing strategies and not due to monitoring activities (Radner). However, monitoring activities, used to reduce information asymmetry, are more prevalent in models of non-cooperative contracts (Lucas; Stiglitz, 1975). Hence, our results are consistent with models of cooperative and non-cooperative contracts.

Conclusions

The findings of this study suggest the existence of information asymmetry and cooperation in the Texas lands lease contracts. This is borne out from the evidence of tenant moral hazard and

cooperative exchange of information between landlords and tenants. A tenant's tendency to decrease labor use if the landlord stops sharing fertilizer costs and a landlord's propensity of giving less output to a tenant if she supplies the irrigation delivery system indicate tenant moral hazard. The dependence of the actions of each party on private information of the other party in contracts that have existed without alteration for at least two years indicate cooperative behavior. This is so because, given information asymmetry, private-information exchange is mutually beneficial only under cooperation (Kreps, Radner). Further, the results indicate that monitoring activities of landlords are associated with no private- information exchange between the two parties, i.e., non-cooperative contracts. Therefore, the empirical results of this study support theoretical models of cooperative and non-cooperative land lease contracts under information asymmetry and income uncertainty.

Table 1. Results from Landlord's Equation in (7) by Partitioning the Residuals in 1, 2 and 3-year Contracts

Regressor	Coefficient Estimate (t-ratio)		
	1-Year	2-Year	3-Year
\hat{u}_T^c :Tenant's residual (potentially cooperative contract)	.043 (1.962 ^b)	.038 (1.698 ^a)	.038 (1.654 ^a)
\hat{u}_T^{nc} :Tenant's residual (potentially non-cooperative contract)	.097 (.815)	.123 (2.485 ^b)	.123 (2.503 ^b)
Intercept	.103 (1.216)	.101 (1.213)	.102 (1.221)
Distance of landlord's residence from the farm	-.0003 (-.005)	.001 (.011)	-.0004(-.008)
Dummy var.: 1 if landlord owns irrigation delivery system	-.081 (-1.695 ^a)	-.081(-1.71 ^a)	-.081(-1.76 ^b)
Dummy var.: 1 if tenant owns irrigation delivery system	.009 (.259)	.005 (.152)	.006 (.175)
Fertilizer expenditure per acre	.051 (2.058 ^b)	.048 (1.924 ^a)	.047 (1.880 ^a)
Percentage of fertilizer costs paid by the landlord	.112 (4.223 ^b)	.111 (4.184 ^b)	.111 (4.211 ^a)
Herbicide expenditure per acre	-.022 (-.959)	-.020 (-.920)	-.020 (-.891)
Insecticide expenditure per acre	.036 (4.459 ^b)	.036 (4.548 ^b)	.036 (4.55 ^b)
Dummy var: 1 if land is irrigated	.550 (12.85 ^b)	.555 (12.92 ^b)	.553 (13.13 ^b)
Cost of the irrigation delivery system	.085 (6.270 ^b)	.084 (6.229 ^b)	.084 (6.24 ^b)
Farm program yield of cotton per acre	.414 (9.780 ^b)	.414 (9.908 ^b)	.417 (10.01 ^b)
Size of leased tract in acres	-.007 (-.592)	-.007 (-.598)	-.007 (-.631)
Age of tenant	.019 (.306)	.024 (.384)	.021 (.334)
Dummy var.: 1 if tenant chooses to cover more than 50% of approved yield by Fed Crop Insurance	.013 (.422)	.013 (.420)	.013 (.426)
Percentage of net tenant-income from non-farm sources	-.011 (-1.94 ^a)	-.012(-2.13 ^b)	-.012(-2.14 ^b)

Notes: R^2 (adjusted R^2) for the 1-year, 2-year and 3-year partitions are .926 (.918), .927 (.918) and .927 (.918), respectively. F-statistic for the significance of the landlord's equation for the 1-year, 2-year and 3-year partitions are 595.990, 599.568 and 600.198, respectively, i.e., null hypothesis is rejected for the three partitions. Durbin-Watson test statistics of the landlord's equation for the 1-year, 2-year and 3-year partition are 2.347, 2.348 and 2.346, respectively, i.e., serial correlation is indeterminate.

^a Coefficient Estimate is significant at the 10% level (statistic for the 2-tailed t-test =1.645.)

^b Coefficient Estimate is significant at the 5% level (statistic for the 2-tailed t-test =1.960.)

Table 2. Results from Tenant's Equation in (7) by Partitioning the Residuals in 1, 2 and 3-year Contracts

Regressor	Coefficient Estimate (t-ratio)		
	1-Year	2-Year	3-Year
\hat{u}_L^c :Landlord's residual (potentially cooperative contract)	.703 (1.951 ^a)	.610 (1.748 ^a)	.604 (1.712 ^a)
\hat{u}_L^{nc} :Landlord's residual (potentially non-cooperative contract)	.721 (1.045)	2.285 (2.07 ^b)	1.990 (2.15 ^b)
Intercept	.200 (.704)	.198 (.693)	.196 (.686)
Distance of landlord's residence from the farm	-.001 (-.054)	-.001 (-.004)	-.0002(-.001)
Dummy var.: 1 if landlord owns irrigation delivery system	-.110 (-.503)	-.117 (-.536)	-.128 (-.580)
Dummy var.: 1 if tenant owns irrigation delivery system	-.192 (-1.23)	-.214 (-1.38)	-.215 (-1.38)
Fertilizer expenditure per acre	.004 (.047)	.003 (.002)	.002 (.032)
Percentage of fertilizer costs paid by the landlord	.184 (1.779 ^a)	.175 (1.686 ^a)	.177 (1.722 ^a)
Herbicide expenditure per acre	.022 (.314)	.022 (.323)	.025 (.356)
Insecticide expenditure per acre	.003 (.097)	.005 (.157)	.002 (.073)
Dummy var: 1 if land is irrigated	.381 (2.293 ^b)	.411 (2.468 ^b)	.397 (2.420 ^b)
Cost of the irrigation delivery system	.188 (2.042 ^b)	.182 (1.986 ^b)	.184 (1.995 ^b)
Farm program yield of cotton per acre	.104 (.628)	.090 (.549)	.107 (.657)
Size of leased tract in acres	-.056 (-1.19)	-.053 (-1.15)	-.054 (-1.16)
Age of tenant	.286 (1.439)	.307 (1.562)	.294 (1.514)
Dummy var.: 1 if tenant chooses to cover more than 50% of approved yield by Fed Crop Insurance	.381 (.470)	.068 (.460)	.066 (.451)
Percentage of net tenant-income from non-farm sources	-.016 (-.739)	-.019 (-.979)	-.018 (-.910)

Notes: R^2 (adjusted R^2) for the 1-year, 2-year and 3-year partitions are .285 (.203), .291 (.210) and .290 (.210), respectively. F-statistic for the significance of the tenant's equation for the 1-year, 2-year and 3-year partitions are 34.010, 34.392 and 34.344, respectively, i.e., null hypothesis is rejected for the three partitions. Durbin-Watson test statistics of the tenant's equation for the 1-year, 2-year and 3-year partition are 1.633, 1.594 and 1.597, respectively, i.e., serial correlation is indeterminate.

^a Coefficient Estimate is significant at the 10% level (statistic for the 2-tailed t-test =1.645.)

^b Coefficient Estimate is significant at the 5% level (statistic for the 2-tailed t-test =1.960.)

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