Journal of Agricultural and Resource Economics 22(2):264–280

Farmers' Preferences for Crop Contracts

Kaouthar Lajili, Peter J. Barry, Steven T. Sonka, and Joseph T. Mahoney

An empirical approach combining elements of principal-agent theory and transaction cost economics is used to determine farmers' preferences for contract terms in crop production. The approach is tested by asking grain farmers to rank contract choices and specify price premiums in simulated case situations. The statistical results indicate that farmers' preferences for rates of cost sharing, price premiums, and financing arrangements are significantly influenced by asset specialization and uncertainty associated with the case situations, and by selected business and personal characteristics.

Key words: contracting, finance, principal-agent, transaction costs

Introduction

Contract production and vertical integration are common with livestock, broilers, turkeys, fruits, vegetables, and dairy in the U.S., but vertical coordination in grain production is limited (Barkema, Drabenstott, and Welch; Barry, Sonka, and Lajili; Sporleder). The most common form of vertical coordination in grain is forward contracting of prices (Hambleton and Bullen). Grain farmers in the U.S. formerly "contracted" with the federal government in order to participate in price and income support programs along with related acreage set-aside requirements. The decoupling between price protection and production reflected in the 1996 farm bill, along with increasing processor interest in specific input characteristics, will likely lead to more extensive vertical coordination in crop production (Coaldrake and Sonka 1995).

Some of the new contracting alternatives may require farmers to invest in specialized equipment. This increase in the complexity of decision making suggests the need for new information about the effects of transaction and producer characteristics on preferred contract terms and financing arrangements. Principal-agent theory, transaction cost economics, and game theory provide (individually or combined) sound theoretical frameworks for addressing contractual and vertical coordination decisions. In particular, principal-agent theory (Jensen and Meckling) and transaction cost economics (Williamson) suggest that an asset's degree of specialization (asset specificity) and uncertainty may strongly influence vertical coordination decisions (Mahoney), although little is known about their influence on crop contracts (Frank and Henderson). Both contractors and farmers must consider the risk-return trade-offs of each potential crop contract. Farmers' choices may also depend on their risk attitudes and financial positions. Thus, contractors and farmers have both expressed the need for new information to assist in contract evaluation and decision making (Coaldrake and Sonka 1993).

Kaouthar Lajili is a former graduate student; Peter J. Barry is a professor; Steven T. Sonka is a professor, Department of Agricultural and Consumer Economics, University of Illinois; and Joseph T. Mahoney is an associate professor, Department of Business Administration, University of Illinois.

This article uses a principal-agent and transaction cost approach to specify the risk and decision elements of new contract choices in crop production and tests the approach based on rankings by grain farmers of contract choices that differ in terms of required investments in specialized assets, riskiness of returns, and farmer/contractor sharing arrangements for production and financial costs. Historic data cannot be used to analyze new contracts which have not previously been offered. Therefore, this analysis generates the needed data by surveying farmers about their preferred contract choices in case decision situations. Doing so is consistent with Williamson's (p. 27) recognition of the need to "... develop primary, micro-analytic data" for this purpose. The grain farmers reside in Central Illinois, although the approach and findings will apply to a much wider range of crop producers.

Model Development

Transaction cost and principal-agent concepts will be jointly used to develop hypotheses about the anticipated effects of asset specificity, uncertainty, and firm characteristics on vertical coordination and financing decisions by crop producers.[1] Asset specificity represents the degree to which an investment's assets are specialized to particular uses. More specialized assets are less easily liquidated or adapted to other uses. As shown by Riordan and Williamson, highly specialized assets can create potential hold-up problems and opportunistic pursuit of quasi-rents by the contracting parties.[2] Uncertainty includes the range of possible production levels and prices, and unanticipated behavioral responses by the contracting parties—called bounded rationality and opportunistic behavior by Williamson. Financing arrangements also are important, based on Williamson's contention that highly specific assets will have greater equity financing, while less specific assets involve greater debt financing.

The crop contracting relationship can be modeled as a principal-agent problem where the agent (farmer) is growing a specialty crop that will be owned and exclusively used by the principal (processor). Asymmetric information reflects the processor's uncertainty about the farmer's efforts and performance under the contract. The "real" ex post contract costs are private information to the farmer who can truthfully disclose them to the principal or not. The processor cannot completely observe the managerial effort spent by the farmer on the contracted activity and the care taken to reach the desired crop quality. He also cannot observe consistently whether the specific asset was used appropriately and exclusively to the contract (i.e., moral hazard problems). Monitoring costs are assumed to be relatively high and quality measurement techniques are either costly or imperfect. As a result, the contract terms should be set so that the incentives and efficiency considerations are consistent with the risk-bearing capacities of the agent.

The effects of these factors on contract choice, along with the farmer's personal and

[1] A game theory approach is also appropriate for modeling contract design and negotiation questions (e.g., Tirole). However, such an approach is more valid when the parties have equal or close bargaining power and the contract terms are set competitively through repeated negotiations and/or bargaining. Crop contracting farmers usually have contract opportunities with only a few large agribusinesses (e.g., Frito-Lay and Pioneer). Vulnerability in bargaining positions with contractors was a consistent concern expressed by the farmers in this study.

[2] Quasi-rents are usually defined as the nonsalvageable value of specific assets—that is, the difference between the first-best and the second-best use values of those assets (Klein, Crawford, and Alchian). The importance of quasi-rents reflects the sunk costs and, thus, the degree of asset specificity.

business characteristics (e.g., risk attitudes, leverage, and farm size), can be approximated by his or her choice of cost- and risk-sharing rates with contractors, pricing options, contract length, financing arrangements, and other contracting terms, as expressed in the following theoretical model.[3] The model represents an extension of Weitzman's efficient incentive contracts in a principal-agent framework to include an asset specificity variable and related financing costs. The extension yields analytical expressions and testable hypotheses for optimal cost- and risk-sharing rates and fixed contract fees as a function of asset specificity, uncertainty, and personal and business characteristics.

The farmer's profit function, π, and associated contracting terms are represented as

$$\pi = (p + r)Y - \alpha X - \beta A + \phi, \tag{1}$$

where $(p + r)$ is a fixed fee per bushel including a market price p and a premium r for meeting quality specifications and accepting greater production and investment risks; Y is the contracted crop's yield; α is the farmer's share of production costs; X is the production cost for meeting the processor's quality specifications; β is the farmer's share of financial costs for the specific asset; and A is the annualized financial cost of the investment in the specific assets. For a highly specific asset, A represents quasi-rents because the asset's next-best value would be close to zero. Variable ϕ is net profits from the farmer's other activities.

In this framework, the degree of vertical coordination is represented by the levels of the shares for production costs and financial costs. A cost-plus contract implies $\alpha = 0$, where the processor vertically integrates into agricultural production and bears all production risk. A fixed-price contract implies $\alpha = 1.0$, where a spot market prevails and the farmer bears all the production risk. Values of α between 0 and 1 imply different degrees of vertical coordination between the extremes of integration and spot market transactions. Similarly, financing specific assets by the processor implies $\beta = 0$, and high vertical coordination. Specific asset financing by the farmer implies $\beta = 1.0$, and low vertical coordination.

The farmer's income from other activities, ϕ, is essential in delineating potential moral hazard problems characterizing the principal-agent relationship. This variable is assumed to be positively correlated with the contract production and investment costs; externalities might exist between these costs and the farmer's profits from other activities. For example, some production inputs and overhead costs, as well as experimentation and development costs and the expenses of specific assets dedicated to the contract, might be inflated to increase the farmer's long-run profits in other activities. In this sense, and considering that monitoring costs are high, the farmer (agent) might allow the contract costs to increase (knowing the processor will cover part of the increase) to raise profits outside the contract relationship. This situation reflects the asymmetric information and incentive aspects of the study's agency model.

Production cost uncertainty is represented by different states of the world θ.[4] Once set, the contractual terms cannot be renegotiated; however, after θ is known and the cost

[3] Vertical coordination may have multiple dimensions. For example, the location of asset control and decision making, and the degree of information sharing and learning are other possible dimensions of vertical coordination.

[4] Uncertainty in this model reflects production risk and potential hold-up and lock-in problems arising from the farmer/processor contracting relationship. Although production costs are usually known a priori for crop production, the production cost per bushel (ex post) depends on external factors such as weather conditions, diseases, insects, and pest infestations.

uncertainty is resolved, the farmer will use appropriate "discretionary actions" to maximize total revenues, given the negotiated terms (Weitzman).

The linkage between the farmer's income in other activities and the ex post contract costs is expressed by the following state-dependent function g_θ. In state of the world θ, let

$$\phi = g_\theta (X, A) \tag{2}$$

be the farmer's maximum attainable net profits in other activities, given the values of X and A. The farmer's profit-maximizing equilibrium for X, A, and ϕ in state θ is derived from

$$\max g_\theta (X, A) - \alpha X - \beta A. \tag{3}$$

The first-order conditions with respect to decision variables X and A are

$$g'_{X\theta} = \alpha, \quad \text{and} \tag{4}$$

$$g'_{A\theta} = \beta. \tag{5}$$

Equations (4) and (5) represent the incentive compatibility constraints in this agency formulation. They illustrate the trade-off between the farmer's incentive efficiency and risk bearing. The lower the optimal cost-sharing rate, the higher this inefficiency because the farmer has little incentive to reduce and control costs carried by the processor. However, the risk-bearing cost is also lower. Conversely, the higher the farmer's cost shares, the greater his incentive to control costs and thus align his goals with those of the processor. Subject to his degree of risk aversion, the farmer will demand a high fee to compensate for the greater share of costs and risks. However, competing farmers who might bid less to receive the contract will limit the risk-return trade-off.

Let U and V denote the farmer's and the processor's utility functions, respectively, where the farmer is more risk averse than the processor. The assumption that the farmer is more risk averse than the processor is needed to show the effects of different risk attitudes on the contract terms and reward structure. The difference in risk attitudes will affect the optimal sharing rates through the weighted average cost ratios for X and A, defined below. Higher costs are associated with lower income for both parties. Thus, X_θ (A_θ) is positively correlated with marginal utilities U' and V'. No empirical evidence is available about the risk attitudes of processors relative to farmers (Young). Assuming the farmer is more risk averse than the processor is plausible, however, in specialty crop contracting where the processor usually is a large agribusiness such as Pioneer or Frito-Lay. If the processor were the more risk averse, his sharing rates would be lower or he would demand higher fixed fees as a risk premium.

The processor's utility is maximized when the contracted payments to the farmer are minimized. The optimal contract maximizes the processor's expected utility with the farmer's expected utility fixed at reservation level U_0 and with respect to the incentive compatibility constraints [equations (4) and (5)] in order to induce the farmer to reduce costs and/or reach the quality specifications at minimum cost. The agency problem could also reflect the farmer's point of view. However, the focus is on the processor here, because he or she usually sets the contract terms and then offers the contract to the farmer.

The optimal contract ($(p + r)^*$, α^*, β^*) thus solves the following problem:

(6) $$\max Ev_{\alpha,\beta}\{-(p + r)Y_\theta - (1 - \alpha)X_\theta(\alpha) - (1 - \beta)(A_\theta(\beta))\}$$

s.t.

(7) $$EU\{(p + r)Y_\theta - X_\theta(\alpha) - \beta(A_\theta(\beta)) + \phi_\theta(\alpha, \beta)\} = U_0,$$

(8) $$g'_{X\theta} = \alpha,$$

and

(9) $$g'_{A\theta} = \beta.$$

Following Weitzman, this principal-agent problem is solved analytically to derive expressions for the optimal shares as a function of uncertainty, asset specificity, and risk attitudes. Given the optimal shares, the optimal fixed fee is determined residually from (7). The optimal shares are expressed as (derivations are available upon request):

(10) $$\alpha^* = e_\alpha/(e_\alpha - 1 + X_u/X_v), \quad \text{and}$$

(11) $$\beta^* = e_\beta/(e_\beta - 1 + A_u/A_v),$$

where e_α and e_β are elasticity-like measures for the responsiveness of contract production costs and asset specific investment costs, respectively, to changes in the sharing rates. $X_u = EXU'/EYU'$ ($X_v = EXV'/EYV'$) is defined as weighted average production cost where the weights are the farmer's (processor's) weighted marginal utilities of income in various states of the world times their probability of occurrence. Similarly, A_u/A_v is a ratio of weighted average specific asset costs.

Comparative static results can be found if additional assumptions are made about the utility and cost functions and the probability distribution. The main results of such a comparative static analysis are linked to the above average weighted cost ratios X_u/X_v and A_u/A_v. Indeed, higher costs are associated with lower income for both the farmer and processor. X_θ is positively correlated with marginal utilities U'_θ and V'_θ. Thus, if the farmer's risk aversion is increased (relative to the processor's), then X_u/X_v is larger. The result would be a lower cost sharing for the farmer, given (10). In particular, if the farmer is more risk averse than the processor, this relationship would lead to the condition $X_u/X_v > 1$. This result is especially true if the farmer is risk averse and the processor is risk neutral (Weitzman). A decrease in cost uncertainty (i.e., costs less spread out) would tend to lower X_u/X_v and thus increase a farmer's cost-sharing rate. The same analysis is valid for the cost, A, of the specific asset.

Based on these analytical results and model assumptions, the study's testable hypotheses can be formulated, as in the following section. Furthermore, a numerical simulation is followed to set the contract options and terms in the survey's simulated decision situations.

Testable Hypotheses

The analytical and comparative static results derived from the theoretical framework allow formulations of testable hypotheses H_1 and H_4, while H_2 and H_3 are variations of Williamson's transaction cost hypotheses. The first hypothesis considers how asset specificity and uncertainty individually affect the degree of vertical coordination.

H_1: Under high (low) asset specificity and production uncertainty, the contracting parties will prefer a higher (lower) degree of vertical coordination, in terms of cost and risk sharing.

The second hypothesis considers how the interaction of asset specificity and uncertainty affects vertical coordination.

H_2: Under high (low) asset specificity and low (high) uncertainty, the contracting parties prefer an intermediate level of vertical coordination in terms of sharing production and investment costs.

The third hypothesis considers how asset specificity affects preferences for financial assistance between the contracting parties.

H_3: The higher the required investment in specific assets, the greater the preference for financial assistance from the processor in order to overcome anticipated debt constraints.

The fourth hypothesis considers the relationship between farmer characteristics and the preferred degree of vertical coordination.

H_4: More risk averse and highly leveraged farmers have a greater preference for cost and risk sharing (i.e., greater vertical coordination).

Data Generation

Experimental Approach

Without historical data on the relationship of emerging crop contracts to transaction and producer characteristics, data are generated using a farmer survey based on simulated contract situations and farmers' preferred choices. The experimental approach has been widely used in economics, business management, and other social sciences, especially when secondary data are unavailable and when new issues and approaches (e.g., food safety, environmental policy, institutional innovation, new governance structures) are expected to have greater importance in the future. Examples in economics include contingent valuation techniques in recreation analysis (Boyle and Bishop); elicitation of subjective utility functions and probability distributions under risk (Anderson, Dillon, and Hardaker); elicitation of time attitudes (Thaler); valuation of food safety (Eom); investment analysis (Gustafson, Barry, and Sonka); and measurement of lenders' credit responses to business characteristics and management practices in agriculture (Baker; Barry, Baker, and Sanint).

The experimental approach tries to approximate actual decision situations. Experiments allow for precisely controlling key parameters of the decision situation and thus enhance the precision of hypotheses testing. These survey methods may be subject to arbitrariness, potential interviewer bias, lack of realism in the elicitation setting, inadequate decision time, and compounding of errors in the elicitation process. However, analysts have committed substantial resources to refining, extending, and generalizing the various elicitation approaches so that the results will be valid indicators of true values.

Producer Survey

The farmers who participated in the survey were selected from 77 Illinois farmers who were experienced with crop contracting and who had responded to a previous mail survey conducted by the University of Illinois (Coaldrake and Sonka 1993). Each farmer was contacted by phone and invited to participate in the survey. Twenty-five farmers responded favorably and were interviewed on their farms during the July to September 1994 period.[5] The power approach for selecting sample sizes in experiments (Neter, Wasserman, and Kutner) by controlling the magnitudes of type I and type II errors was followed to evaluate the sample size for this experiment. Although the sample size (25) is relatively small, it is sufficiently large and adequately set to detect statistically significant differences with relatively high precision using the power approach. Moreover, the experimental approach uses considerable resources and appropriate statistical tools, and it helps to generate consistent responses across the participants.

The personal interviews ensured effective communication and better control of the experimental setting, although the higher costs of personal rather than mail or phone surveys limited the number of participants. The farmers first responded to questions about their personal and business characteristics.[6] The experimental portion of the survey contained a cover page and an illustration to describe the cost- and risk-sharing arrangements, followed by three sets of questions. In the first set of questions, the farmers ranked four contract options for crop production defined over four case situations. The contract options differed in terms of contract price, contract length, and sharing rates for production and investment costs (see the row labels in table 1). The case situations included high and low levels of production and demand uncertainty and asset specificity (see the column headings in table 1). High uncertainty was characterized by variable yields and a relatively new, hybrid crop variety with little market experience; low uncertainty exhibited the opposite characteristics. High asset specificity required investing in a nonredeployable irrigation system, while low asset specificity required investing in conventional harvesting equipment. Consistent with hypothesis H_1, the farmers were anticipated to associate a contract having greater sharing rates and length with greater asset specificity and uncertainty.

In the second set of questions, the farmers were told that the processor was negotiating production contracts with five other producers and would award contracts to two of the six candidates. Each farmer considered a range of premium bids for contract participation with or without cost sharing and was asked to compete for the contract by selecting the premium bid he would accept. Higher bids were anticipated under the high asset specificity and high uncertainty situations.

In the third question, the farmers were asked to rate their preferences on a seven-point scale for each of five financial arrangements provided by the processor. Included were assistance with arrangement of financing at a local bank, a loan guarantee, direct financ-

[5] The experiment questionnaire was pretested with two agricultural economists, three graduate students, and four farmers who were seed crop experts.

[6] Risk attitudes were inferred from farmers' bids for playing a heads-or-tails lottery game cast in a farm risk situation. Another proxy for risk aversion was the farmers' assessment of risk attitude using a seven-point scale. The proxies were positively correlated with each other.

Table 1. Summary Statistics for Contract Ranking and Premium Bidding

Case Studies	Case 1 HAS, HU		Case 2 HAS, LU		Case 3 LAS, HU		Case 4 LAS, LU	
Contract Options	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Contract A Rank • 1-year contract • 0% production cost sharing • 0% investment cost sharing	2.80	1.32	2.84	1.24	2.08	1.15	1.84	1.10
Contract B Rank • 3-year contract • 10% production cost sharing[a] • 16% investment cost sharing	2.32	0.98	2.28	1.06	2.48	0.87	2.56	0.87
Contract C Rank • 2-year contract • 20% production cost sharing • 8% investment cost sharing	2.44	0.65	2.2	0.64	2.28	0.84	2.24	0.87
Contract D Rank • 5-year contract • 30% production cost sharing • 23% investment cost sharing	2.44	1.38	2.68	1.34	3.16	1.31	3.36	1.00
No cost-sharing premium bid	0.90	0.06	0.86	0.08	0.50	0.05	0.46	0.07
With cost-sharing premium bid	0.59	0.06	0.62	0.08	0.28	0.04	0.28	0.08

Note: HAS refers to "high asset specificity" and LAS to "low asset specificity"; whereas HU refers to "high uncertainty" and LU to "low uncertainty."
[a] The cost-sharing levels were based on numerical simulations using the derived relationship between optimal cost sharing rates and fixed fees (see Lajili).

ing, leasing, and co-ownership. Consistent with hypothesis three, processor assistance with financing was anticipated to be more attractive under high asset specificity and uncertainty.

During the interview, short breaks were taken after each set of questions to reduce "carry-over" effects. Randomization in the order of the cases was employed to eliminate "practice" effects. The average time to complete the interview was approximately 50 minutes. At the end, the farmers were asked if they had any comments about the experiment and contracting in general. They indicated that participation in the experiment was straightforward and readily understandable, and that the contract situations clearly resemble those beginning to emerge in actual decision situations.

Farmer Profiles

Participating farmers operate large farms averaging 1,671 acres. They are relatively young (43.4 years on average), but also experienced (22 years on average), and their experiences with contracting range from 6 to 15 years. They are moderately risk averse and not highly leveraged (68% had debt to equity ratios less than 0.40). The most widely contracted crops are white food-grade corn, seed soybeans, and seed corn. The farmers expressed satisfaction with their contracting experiences, although vulnerability in bargaining positions with contractors was a consistent concern. They also expressed interest in a tournament compensation scheme with rewards relative to peer performance (Knoeber). Higher profits and quality incentives were rated as the most important motivations for contracting.

Summary Statistics

Summary results for the contract preferences and premium bids are reported in table 1. Both sets of responses are consistent with the testable hypotheses. Ranks of 1 and 4 are assigned to the most and least preferred contracts, respectively. Contracts A and D were most preferred (mean ranks of 1.84 and 2.44, respectively) under the low asset specificity/low uncertainty and the high asset specificity/high uncertainty cases, respectively. Contracts B and C (called hybrid contracts) were most preferred under combinations of high and low asset specificity and uncertainty. Hybrid contract C had the lowest average mean rank (2.29) and, thus, was most preferred on average, consistent with results of other incentive contracting studies.[7] Premium bids also are consistent with the testable hypotheses in that farmers' mean bids were highest and lowest under high asset specificity and uncertainty, and low asset specificity and uncertainty, respectively. The bids are less variable than the rankings of cases and are concentrated around the prior year's premium given in the survey.

Responses to the financing alternatives (table 2) indicate that the most preferred option is "the processor provides direct financing" to acquire the required equipment, followed by the leasing option. In general, the farmers preferred relatively high involvement in financing by the processor whether asset specificity is high or low.

ANOVA Analysis

Experimental Design

The survey employed a repeated-measures experiment in which each participant responds to all cases (treatments) in a randomized order. A repeated-measures design requires fewer subjects, is more sensitive in detecting treatment effects, has lower experimental error, and controls effectively for subject heterogeneity. Problems related to potential changes in the behavior of subjects during repeated administration of the treatment con-

[7] Previous work in agency/contracting theory showed that incentive contracts, where $0 < \alpha < 1$ and $0 < \beta < 1$, are Pareto superior to either cost-plus or fixed-price contracts under general assumptions about uncertainty and risk attitudes (Weitzman; Samuelson).

Table 2. Descriptive Statistics and ANOVA Results: Financing Arrangement Preferences

Financing Option Description	Significance of *F* (One-Way ANOVA)	High Asset Specificity		Low Asset Specificity	
		Mean	SD	Mean	SD
Processor arranges financing at a local bank	0.62	3.12	1.92	3.28	2.07
Loan guarantees by processor	0.08*	3.68	2.05	3.84	2.05
Processor provides the loan (direct financing)	0.42	5.12	1.96	5.48	1.89
Lease equipment from processor	0.38	4.40	1.82	4.60	1.65
Processor co-owns equipment with producer	0.69	2.68	1.93	2.60	1.73

Note: Asterisk means statistically significant differences between the high and low asset specificity cases at the 10% level.

ditions (i.e., carry-over and practice effects) were minimized by the random ordering of cases.

A two-factor repeated-measures design is modeled as

$$Y_{ijk} = \mu + \rho_i + \alpha_j + \beta_k + (\alpha\beta)_{jk} + \epsilon_{ijk}, \tag{12}$$

where μ is a constant, ρ_i are independent $N(0,\sigma^2)$; α_j and β_j are constants subject to $\Sigma_{\alpha j} = 0$ and $\Sigma_{\beta j} = 0$; $(\alpha\beta)_{jk}$ are constants subject to $\Sigma_j(\alpha\beta)_{jk} = 0$ for all k and $\Sigma_k(\alpha\beta)_{jk} = 0$ for all j; ϵ_{ijk} are independent $N(0,\sigma^2)$ independent of ρ_i; $i = 1, \ldots n$ is the number of participants; $j = 1, \ldots a$ denotes the level of asset specificity; and $k = 1, \ldots b$ denotes the level of uncertainty. In the two-factor repeated-measures model (12), it is assumed that the observations Y_{ijk} have constant variance, constant covariance, and that any two observations from different subjects (prior to the random trials) are independent. Also, all observations are assumed to be normally distributed and all the treatment observations for a given subject are assumed to be independent.

The two-factor repeated-measures design (where asset specificity and uncertainty are the factors) characterizes this study's survey because the farmers' responses likely are affected by their personal characteristics as well as by the treatment conditions (and their interactions) based on transaction attributes as hypothesized above. Moreover, with four treatment combinations and 25 subjects, the observations totaled 100.

The research hypotheses are tested using the experiment data and the repeated analysis of variance (ANOVA) procedures. Multiple linear and logistic regressions are also used to test the link between farmer characteristics and transaction attributes in explaining contract preferences. ANOVA techniques are widely used in experiment response analysis to test single and interaction treatment effects based on factor level-mean differences, if the model assumptions are satisfied (Keppel; Neter, Wasserman, and Kutner). Because the experiment data (especially the rankings) may violate normality, nonparametric tests also are conducted.

Table 3. Significance of Asset Specificity and Uncertainty in Contract Rankings

Dependent Variable	Source of Variation	Significance of F
Contract A		
• 1-year contract	Asset specificity	0.002**
• 0% PCS	Uncertainty	0.579
• 0% ICS	Asset specificity by uncertainty interaction	0.258
Contract B		
• 3-year contract	Asset specificity	0.331
• 10% PCS	Uncertainty	0.882
• 16% ICS	Asset specificity by uncertainty interaction	0.743
Contract C		
• 2-year contract	Asset specificity	0.772
• 20% PCS	Uncertainty	0.295
• 8% ICS	Asset specificity by uncertainty interaction	0.495
Contract D		
• 5-year contract	Asset specificity	0.009**
• 30% PCS	Uncertainty	0.278
• 23% ICS	Asset specificity by uncertainty interaction	0.919

Note: Double asterisks mean significant at the 5% level.

Contract Type

Table 3 reports the univariate ANOVA results for the contract rankings. A univariate analysis considers each contract response as a separate dependent variable; a multivariate approach considers the contract type as an additional within-subjects variable similar to the asset specificity and uncertainty variables.

The univariate ANOVA results indicate that asset specificity is significant at the 5% level for extreme case contracts A and D; however, neither asset specificity nor uncertainty are significant for the hybrid contracts B and C. The insignificance of the interactions effects is consistent with previous transaction cost economics work (Anderson and Schmittlein). The multivariate results (not reported here; see Lajili) further confirm the dominant effect of asset specificity on the farmers' contracting preferences. The asset specificity and contract "main effects" are significant, as well as their interaction. This result implies that contract preferences differ for each asset specificity level. The direction of asset specificity significance is consistent with hypothesis H_1; the farmers shift their preferences from contract A to contract D as asset specificity increases. The nonparametric results are consistent with the ANOVA results (Lajili). Thus, the transaction cost hypotheses are supported.

Premium Bids

The premium bids reflect the farmers' preferences between a reference contract with no cost-sharing by the processor and a cost-sharing contract. Only the multivariate results for

Table 4. Significance of Contract Characteristics in Premium Bids

	Significance of *F*	
Treatment Effect	Absolute Bids	Relative Bids
	(*p*-value)	
Asset specificity	0.000**	0.109
Uncertainty	0.829	0.000**
Cost sharing	0.000**	0.708
Asset specificity by uncertainty interaction	0.258	0.006**
Asset specificity by cost-sharing interaction	0.000**	0.255
Uncertainty by cost-sharing interaction	0.000**	0.001**
Asset specificity by uncertainty by cost-sharing interaction	0.094*	0.125

Note: Double and single asterisks mean significant at the 5% and 10% levels, respectively.

absolute and relative bids are reported in table 4.[8] Absolute premium bids are the actual bids, while relative bids are deviations between actual bids and last year's reference premium.

Farmer bids and thus the implicit choice between these contracts are significantly influenced by asset specificity and uncertainty, consistent with the testable hypotheses. Moreover, in contrast with the contract choice results, the effects on the premium bids of uncertainty and the interaction between asset specificity and uncertainty are significant. This consistency with hypothesis H_2 suggests that the interaction between the two transaction cost variables significantly influences the various contracting terms.

The observed differences between the ANOVA results for the absolute and relative premium bids also reflect a reversal in the significance of asset specificity and uncertainty. The farmers' absolute bids are significantly affected by asset specificity while the relative bids depend more on uncertainty. This contrast could reflect ambiguity and anchoring in decision making where individuals rely more heavily on anchor points when decision situations are ambiguous (Kahneman, Slovic, and Tversky).

Financing Arrangements

The one-way ANOVA results for financing preferences were shown in table 2. Asset specificity is not significant for most of the financing arrangements (further supported by the multivariate and nonparametric results). The farmers may have considered the required equipment investment as another contract risk and thus preferred relatively high financial assistance from the processor, regardless of the asset specificity level. Only the most preferred option (processor provides direct financing) was significant at the 10% level. These results could imply the role of financial hostages and risk sharing needed

[8] The univariate and multivariate ANOVA results are consistent.

to reduce agency costs and foster a stable contractual relationship (Jensen and Meckling). When both parties are required to invest in the specific asset, the adverse selection problems are reduced since this investment share requirement will act as an ex ante screening tool to differentiate among potential agents. In addition, the financial hostage (equipment) acts as a bond whose costs are born by both contracting parties to increase their cooperation and commitment, especially if long-term relationships are sought.

Regression Analysis

Regression analysis is used to determine the relationship between the farmers' contracting preferences and their personal and business characteristics (farm size, leverage, age, risk attitude). Logistic regression is used for the rank measures and ordinary least squares (OLS) is used for the premium bid and financing preferences. The rankings were recorded as binary variables by assigning a rank of one to the farmers' preferred contract. The logistic results for contracts A through D are reported in table 5. Contracts A and B experience better fit than C and D in terms of the log-likelihood and model chi-squared statistic. The chi-squared statistic is significant at 10% for contract A and at 5% for contract B. In particular, the asset specificity variable is significant at the 5% level for both A and B. Higher asset specificity significantly decreases the likelihood of preferring contract A and increases the likelihood of preferring contract B, as predicted by the theory and consistent with the ANOVA results.[9]

Although not statistically significant, the results for contracts C and D are consistent with the anticipated relationships; greater asset specificity decreases the odds of choosing the hybrid contract C, while increasing the odds of preferring contract D with the greatest risk sharing and duration. Among the farm characteristics, only the leverage variable significantly influences contract preferences in the case of contract B. A one-unit increase in leverage significantly increases the odds of choosing contract B by a factor of 13,585, while it decreases the odds of choosing contract A by a factor of 0.05. Similarly, greater leverage increases the odds of choosing C and decreases the odds of choosing D. These results imply that highly leveraged farmers are more likely to prefer hybrid contracts B and C, with some risk sharing and average duration, over the extreme alternatives A and D.

The overall prediction accuracy rates indicate the logistic model's performance in predicting group membership based on the selected covariates in the model and the estimated probabilities. This approach is especially useful for grouping respondents based on the personal characteristics and the contract or transaction attributes. The prediction accuracy rates for each contract regression are relatively high (78.3% for A and 91.3% for B), implying that the personal information and contract attributes help considerably to explain contract preferences. Moreover, the farmers' postexperiment comments indicated that the contract-menu approach followed in the experiment would offer greater flexibility in contract analysis and enhance their bargaining power.

The OLS results for the premium bids with and without cost sharing are reported in table 6. The asset specificity and risk variables are significant at the 5% level when absolute bids are regressed on farmer and contract characteristics. The relative bids also

[9] The exp (*B*) column in table 5 represents the change in the odds of preferring the contract of interest following a unit change in the corresponding independent variable. The odds of an event are the ratio of probability of that event occurring to the probability that it will not occur. For example, an increase in asset specificity decreases the odds of preferring A by a factor of 0.26, while it increases the odds of preferring *B* by a factor of 40.93.

Table 5. Significance of Contract, Business, and Personal Characteristics in Contract Rankings

Variable	Contract Type	Estimated Coefficient	Wald Statistic	Significance	exp (*B*)
Asset Specificity	A	−3.63	5.14	0.02**	0.026
	B	3.71	3.98	0.04**	40.93
	C	−0.28	0.03	0.85	0.75
	D	6.29	1.90	0.16	0.75
Uncertainty	A	0.54	0.17	0.67	1.71
	B	−2.47	2.35	0.12	0.08
	C	11.01	0.02	0.87	61013
	D	−0.28	0.01	0.89	0.75
Size	A	−0.001	2.29	0.13	0.99
	B	0.0008	0.73	0.39	1.00
	C	−0.0003	0.07	0.78	0.99
	D	0.003	1.94	0.16	1.00
Leverage	A	−2.92	0.89	0.34	0.05
	B	9.51	3.16	0.07*	13585
	C	3.39	0.16	0.20	29.75
	D	−22.84	1.64	0.20	0.00
Lottery (risk aversion)	A	0.22	0.75	0.38	1.24
	B	−0.302	0.65	0.42	0.73
	C	−0.52	0.86	0.35	0.59
	D	1.12	1.90	0.16	3.08
Age	A	0.05	0.47	0.49	1.05
	B	−0.11	1.04	0.31	0.89
	C	−0.05	0.53	0.46	0.94
	D	0.34	1.41	0.23	1.40
Constant	A	0.52	0.02	0.9	
	B	−0.302	0.002	0.95	
	C	−7.80	0.01	0.91	
	D	−26.51	1.84	0.17	

	Contract A	Contract B	Contract C	Contract D
−2 Log-likelihood	16.99	15.67	12.61	12.02
Good of fit	15.45	49.06	10.79	9.86
Overall prediction accuracy	78.26%	91.30%	86.96%	82.61%

	Chi-Squared	df	Significance
Model chi-squared			
Contract A	11.28	6	0.08*
Contract B	14.04	6	0.02**
Contract C	8.64	6	0.19
Contract D	9.22	6	0.16

Note: Double and single asterisks mean significant at the 5% and 10% levels, respectively.

Table 6. Multiple Regression Results for Absolute and Relative Premium Bids

Variable	Cost Sharing	Estimated Coefficient: Absolute Bids	Estimated Coefficient: Relative Bids	Significance of t-Statistic: Absolute Bids	Significance of t-Statistic: Relative Bids
Asset specificity	Without	0.38	0.02	0.00**	0.34
	With	0.34	0.05	0.00**	0.11
Uncertainty	Without	0.03	−0.04	0.4	0.17
	With	−0.06	−0.10	0.07*	0.004**
Size	Without	0.00	0.00	0.64	0.19
	With	0.00	0.00	0.17	0.09*
Leverage	Without	−0.006	−0.03	0.93	0.64
	With	−0.001	−0.01	0.98	0.81
Lottery (risk aversion)	Without	−0.016	−0.01	0.019**	0.01**
	With	−0.018	−0.01	0.01**	0.01**
Age	Without	−0.002	−0.001	0.22	0.28
	With	−0.001	0.00	−0.57	0.79
Constant	Without	0.63	0.17	0.00**	0.08*
	With	0.37	0.11	0.00**	0.32

	Without	With
F-statistic	34.33 (2.21)	24.43 (3.52)
Significance of F	0.00** (0.09*)	0.00** (0.02**)
R^2	0.93 (0.46)	0.09 (0.56)
Sample Size	$N = 22$	$N = 23$

Note: The numbers in parentheses represent the relative bid statistics results.

indicate a significant risk attitude effect. Higher risk aversion is associated with a lower deviation between the actual bid and the reference premium, perhaps reflecting an anchoring effect as well. Only the uncertainty variable is significant and negatively related to the relative bids; the higher is uncertainty, the greater the reliance on the reference premium, consistent with the ANOVA results.

OLS results for the financing preferences (table 7) are also consistent with the ANOVA results relative to the nonsignificance of asset specificity. An exception is the positive and significant relationship between asset specificity and co-ownership. Among farmer characteristics, leverage is positively and significantly related to preferences in three of the five financing options: processor arranges financing, guarantees loans, and co-owns the equipment. This result could imply farmers' perceptions of credit rationing due to high risks. Finally, as farm size increases, the lease option was preferred less than the other financing arrangements.

Concluding Comments

The market-oriented 1996 farm bill may encourage greater use of contract crop production. This article used simulated decision and preference-ordering techniques within a

Table 7. Regression Results for Financing Preferences

Variable	Financing Option	Estimated Coefficient	Significance of t
Asset specificity	F1	0.69	0.38
	F2	0.46	0.57
	F3	0.05	0.95
	F4	0.95	0.23
	F5	1.67	0.02**
Size	F1	0.00	0.43
	F2	0.00	0.56
	F3	0.00	0.29
	F4	−0.001	0.02**
	F5	0.00	0.47
Leverage	F1	5.35	0.00**
	F2	5.71	0.00**
	F3	0.59	0.77
	F4	−0.05	0.97
	F5	3.48	0.04**
Lottery (risk aversion)	F1	−0.13	0.42
	F2	−0.006	0.96
	F3	0.28	0.13
	F4	0.04	0.79
	F5	0.05	0.72
Age	F1	−0.07	0.12
	F2	−0.08	0.12
	F3	0.01	0.85
	F4	0.008	0.85
	F5	−0.005	0.89

Note: F1: "Processor arranges financing at a local bank"
F2: "Processor provides loan guarantees"
F3: "Processor provides direct financing"
F4: "Processor provides a lease option"
F5: "Processor co-owns equipment with the producer"

principal-agent and transaction cost framework to determine crop farmers' preferences for new vertical coordination alternatives. The statistical results support the testable hypotheses about the anticipated relationships between contract choice, pricing behavior, financing arrangements, asset specificity, and uncertainty. The degree of asset specificity significantly influences farmers' choices of contractual arrangements, whereas uncertainty and the interaction between asset specificity and uncertainty play a significant role in pricing behavior and the choice of hybrid contracts. Among the farmer characteristics, risk aversion and leverage significantly affect bidding behavior and financing choice, respectively. The results also confirm the need to jointly consider transaction attributes and personal and business characteristics to explain vertical coordination decisions. Moreover, the commitment and bonding effects arising from required equipment investments are plausible explanations for the observed financing preferences.

[*Received August 1996; final revision received June 1997.*]

References

Anderson, E., and D. C. Schmittlein. "Integration of the Sales Force: An Empirical Examination." *Rand J. Econ.* 15(1984):385–95.

Anderson, J. R., J. Dillon, and B. H. Hardaker. *Agricultural Decision Analysis.* Ames IA: Iowa State University Press, 1977.

Baker, C. B. "Credit in the Production Organization of the Firm." *Amer. J. Agr. Econ.* 49(1968):507–21.

Barkema, A., M. Drabenstott, and K. Welch. "The Quiet Revolution in the U.S. Food Market." *Econ. Rev.* 76(1991):43–57.

Barry, P. J., C. B. Baker, and L. R. Sanint. "Farmers' Credit Risks and Liquidity Management." *Amer. J. Agr. Econ.* 63(1981):216–27.

Barry, P. J., S. T. Sonka, and K. Lajili. "Vertical Coordination, Financial Structure and the Changing Theory of the Firm." *Amer. J. Agr. Econ.* 74(1992):1219–225.

Boyle, K. J., and R. C. Bishop. "Welfare Measurements Using Contingent Valuation: A Comparison of Techniques." *Amer. J. Agr. Econ.* 70(1988):20–28.

Coaldrake, K., and S. T. Sonka. "Contractual Arrangements in the Production of High Value Crops." *J. Amer. Soc. Farm Mgrs. Rur. Appr.* 57(1993):70–75.

———, eds. *New Industries and Strategic Alliances in Agriculture.* Champaign IL: Stipes Publishing, 1995.

Eom, Y. S. "Pesticide Residue Risk and Food Safety Valuation: A Random Utility Approach." *Amer. J. Agr. Econ.* 76(1994):760–71.

Frank, S. D., and D. R. Henderson. "Transaction Costs as Determinants of Vertical Coordination in the U.S. Food Industries." *Amer. J. Agr. Econ.* 74(1992):941–50.

Gustafson, C. R., P. J. Barry, and S. T. Sonka. "Machinery Investment Decisions: A Simulated Analysis for Cash Grain Farms." *West. J. Agr. Econ.* 13(1988):244–53.

Hambleton, R., and G. Bullen. *Illinois Grain Marketing Tools, Survey 1994.* Dept. of Agr. Econ., Coop. Ext. Serv., University of Illinois, 1995.

Jensen, M., and W. Meckling. "Theory of the Firm: Managerial Behavior, Agency Costs, and Ownership Structure." *J. Finan. Econ.* 3(1976):305–60.

Joskow, P. "Asset Specificity and the Structure of Vertical Relationships: Empirical Evidence." *J. Law, Econ. Org.* 4(1988):95–117.

Kahneman, D., P. Slovic, and A. Tversky. *Judgement under Uncertainty: Heuristics and Biases.* Cambridge: Cambridge University Press, 1982.

Keppel, G. *Design and Analysis: A Researcher's Handbook,* 2nd ed. Englewood NJ: Prentice Hall, 1982.

Klein, B., R. Crawford, and A. Alchian. "Vertical Integration, Appropriable Rents and the Competitive Contracting Process." *J. Law and Econ.* 21(1978):297–326.

Knoeber, C. R. "A Real Game of Chicken: Contracts, Tournaments, and the Production of Broilers." *J. Law, Econ. Org.* 5(1989):271–92.

Lajili, K. "An Agency/Transactions-Costs Approach and Application to Vertical Coordination Arrangements in Food and Agricultural Markets." Unpub. Ph.D. diss., University of Illinois, Urbana-Champaign, 1995.

Mahoney, J. T. "The Choice of Organizational Form: Vertical Financial Ownership versus Other Methods of Vertical Integration." *Strat. Manage. J.* 13(1992):559–84.

Neter, J., W. Wasserman, and M. H. Kutner. *Applied Linear Statistical Models,* 3rd ed. Homewood IL: Richard Irwin, 1990.

Riordan, M. H., and O. Williamson. "Asset Specificity and Economic Organization." *Internat. J. Ind. Org.* 3(1985):365–78.

Samuelson, W. "Bidding for Contracts." *Manage. Sci.* 32(1986):1533–550.

Sporleder, T. L. "Managerial Economics of Vertically Coordinated Agricultural Firms." *Amer. J. Agr. Econ.* 74(1992):1226–231.

Thaler, R. "Some Empirical Evidence on Dynamic Inconsistency." *Econ. Letters* 8(1981):201–7.

Tirole, J. *The Theory of Industrial Organization.* Cambridge MA: The MIT Press, 1988.

Weitzman, M. L. "Efficient Incentive Contracts." *Quart. J. Econ.* 94(1980):719–29.

Williamson, O. E. *The Mechanisms of Governance.* New York: The Free Press, 1996.

Young, D. L. "Risk Preferences of Agricultural Producers: Their Use in Extension and Research." *Amer. J. Agr. Econ.* 61(1979):1063–70.