Empirical Analysis of the Determinants of Marketing Contract Structures

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The proportion of U.S. crop production sold under contract is becoming increasingly large. In 2003, 39% of the value of U.S. production was sold under contract compared to 11% in 1999 and 10% in 2001 (ERS; NASS). Numerous explanations for the increased use of contracting have been proposed, including supply-chain organization, more discriminating consumers, more efficient relationships between buyers and sellers, information asymmetries, quality control, procurement considerations specific to the dynamics of agricultural decision making, declining commodity prices, and the decoupling of farm support outlined in the 1996 farm bill.

A contract can be characterized by its allocation of value, risk, and decision-making rights among the contractor(s) and contractee(s) (Sykuta and Parcell). That contracts are structured to efficiently allocate risk between the parties is an assumption based in traditional contract theory. Two very general (and related) hypotheses stemming from contract theory include 1) higher levels of risk should imply contracts with a higher level of risk-sharing between the contracting parties, and 2) farmers with higher levels of risk-aversion will prefer contract structures that shift more of the risk to the contractor. Conceptually, one would expect the preferences and characteristics of the contractor and contractee, as well as the characteristics of the commodity being contracted, to determine the attributes of the optimal contract.

While the theoretical literature on contracts has been an important and relatively recent development in the field of economics, there has been surprisingly little empirical work done in the area to test the underlying theoretical assumptions. In the area of

contracts for agricultural production, experimental approaches have provided some support for the relationship between the risk attitudes of the producer and contract attributes in both crop and livestock contract examples (Lajili et al.; Roe, Sporleder, and Belleville). However, results based on survey responses or those from experimental laboratory settings do not provide a reflection of actual contracts being used in practice.

Moreoever, true empirical studies of contract design have produced more mixed results. Allen and Lueck provided an empirical analysis of the role of risk in contract choice using a large data set of land rental agreements between landlords and farmers in North America. Using a simple OLS framework, they find little support for the hypothesis that risk-sharing is an important determinant in shaping rental agreement contracts. Fraser analyzed data on contracts for wine grapes in Australia, finding that producer characteristics do not have a significant effect on contract design in the Australian grape industry.

Other authors have focused on the impacts of contractor characteristics on contract design. Sykuta and Cook outlined a theoretical framework that suggests differences in the attributes of contracts offered through producer and investor owned firms motivated by trust of the organization. An analysis by James and Sykuta of crop producers in Missouri provided evidence of a producer preference for marketing to cooperatives over private or investor-owned firms due to a higher level of trust for cooperative organizations.

Ackerberg and Botticini built and improved upon previous work using a much older data set on crop-sharing agreements in Italy from the 1400s. They proposed a model which recognized the potential for endogenous matching of the contracting parties

based on their preferences/characteristics as well as the characteristics of the commodity being produced. Using an estimation method which controls for this endogenous matching, Ackerberg and Botticini found evidence of risk-sharing motivations in their data set which would not have been evident had the enogeneity not been accounted for.

In the present study, we further investigate the determinants of contract design by applying the methodology outlined by Ackerberg and Botticini to data from the Agricultural Resource and Management Survey (ARMS). The ARMS data lends itself well to this purpose, as the ARMS is administered to thousands of producers every year by the National Agricultural Statistics Service (NASS) and is designed to provide an accurate reflection of the agricultural sector in the U.S. The survey contains a section devoted to marketing and production contracts which includes questions regarding the structure of each contract, as well as characteristics of the contractor. Furthermore, financial accounting data is available for each producer included in the survey.

We construct and estimate several models to analyze the effects of producer and contractor characteristics on the decision to produce under contract and the types of contract structures that arise in practice, while controlling for the potential for endogenous matching between the parties. Our results indicate that while producer characteristics have a significant effect on the decision to produce corn or soybeans under contract (regardless of the specific design of the contract), we do not find any significant effects of the same producer characteristics on the attributes of the contracts themselves.

Our results seem to be consistent with the previous findings of Allen and Lueck and the hypotheses of Sykuta and Cook in that other factors will play a larger role in determining the structure of agricultural contracts. However, our results should be

interpreted with care due to certain data limitations. Furthermore, the lack of data on the value derived from the specific contracts that is comparable across observations makes it difficult to separate the effects of compensation from those of producer and contractor characteristics.

If our results prove to be both accurate and robust, there could be wide implications in the areas of both contract theory and agricultural contract design. For example, if producer and contractor characteristics are not determining factors in the design of contracts, advancement in the theoretical literature on other types of incentives and transaction cost motivations warrants further investigation.

Methodology and Data

Following Ackerberg and Botticini, we start by supposing there exists a general relation where contract choice *y* is determined by characteristics of the principal (*p*) and the agent (*a*).

(1) $$y = \alpha_0 + \alpha_1 p + \alpha_2 a + \varepsilon$$

Direct estimation of equation 1 could lead to biased coefficient estimates if the contracting parties are matched with each other endogenously (i.e. if there exists incentives for certain types of farmers to "match" with certain types of contractors). To control for this potential endogeneity bias, Ackerberg and Botticini proposed that an instrumental variables approach be used where the actual values of the potentially endogenous principal and agent variables in equation 1 be replaced by their fitted values estimated from a "matching equation."

Data were obtained from the Agricultural Resource Management Survey (ARMS) which is conducted annually by the U.S. Department of Agriculture. The ARMS data

include detailed information on marketing contracts used by farmers to sell their commodities. Farmers identified the price, quantity, and value for each commodity sold with marketing contracts. The main version of the survey also includes more detailed questions about the specifications of the marketing contracts such as the quantity and pricing mechanisms, and characteristics of the contractors.

Due to data availability of the contracting survey questions, the analyses are conducted with ARMS data from the main version of the survey for 2003-2005. The ARMS data also include survey weights indicating the number of farms in the U.S. that each farm in the survey sample represents. All estimations are weighted using the jackknife approach[2] so that the results are representative of all marketing contracts used by U.S. corn and soybean producers.

The variables used in the analysis are described below in table 1. Farm characteristics included proxies for size (VP), risk aversion (*HHNW, OFI, D/A*), and other characteristics (*Age, Edu, Hobby*, θ_i). Farmers with greater net wealth and off farm income levels were assumed to be less risk averse. Operations with higher debt-to-asset ratios could imply a less risk averse producer (i.e. a willingness to take on more risk through higher leverage levels) or a more risk averse producer (i.e. higher leverage levels require the operator to take on less risky activities relative to similar operations with less leverage). Additional variables were defined at the contract level to describe the organizational structure of the contractor (*Coop*) and the commodity being contracted (*Crop*).

[2] Please refer to Dubman for more details on the jackknife approach and its implementation in analysis of the ARMS data.

Table 1. Description of variables.

Variable	Description
Crop	Binary variable which equals one if the contract is for corn and equals zero for soybeans.
Coop	Binary variable which equals one if the contractor is a cooperative and equal to zero otherwise.
θ_i	Proportion of value of production from crop *i* (*i* = corn or soybeans)
HHNW	Net wealth of the farm household.
VP	Value of the farm's total production.
OFI	Total income earned off the farm.
D/A	Debt-to-asset ratio for the farm operation
Hobby	Binary variable which equals one if the operation is defined as a hobby farm and equal to zero otherwise.
Age	Age, in years, of the farm operator.
Edu	Education level, in years, of the farm operator.

We approached the contracting decision at two different levels. First, the decision of whether to enter into a formal marketing contract was examined by estimating how the contracting decision is impacted by farm characteristics and proxies for the risk preferences of the producer. The structure of the contracting decision relationship is given in equation 1 where $y = 1$ if the farmer chooses to enter into a marketing contract for crop *i* and the right hand side variables are defined in table 1. Match equation 2 was estimated by state to control for difference across geographical regions.

$$(2) \quad \begin{aligned} y_i = {} & \alpha_0 + \alpha_1\theta_i + \beta_1 HHNW + \beta_2 VP + \beta_3 OFI + \beta_4 D/A + \\ & \beta_5 Hobby + \beta_6 Age + \beta_7 Edu + \delta_1 StDum + \delta_2 TimeDum + \varepsilon \end{aligned}$$

The farm type variable θ_i describes the relative intensity of the farm's production of the commodity which is being contract, which is assumed to be and endogenous choice of the farm operator. This endogeneity is controlled for through the estimation of a single matching equation for the farm type variable[3], outlined in equation 3.

$$\theta_i = \gamma + \varphi_1 HHNW + \varphi_2 VP + \varphi_3 OFI + \varphi_4 D/A + \varphi_5 Hobby + \varphi_6 Age + \varphi_7 Edu + \delta TimeDum + \eta \quad (3)$$

Second, we moved to the contract level to examine the impacts of farm characteristics and operator preferences, contractor type, and commodity type on specific attributes of the contract. This relationship is outlined in equation 4. The specific contract attributes analyzed include pricing mechanisms and whether or not the contract outlines a specific quantity of the commodity.

$$y = \alpha_0 + \alpha_1 crop + \alpha_2 coop + \beta_1 HHNW + \beta_2 VP + \beta_3 OFI + \beta_4 D/A + \beta_5 Hobby + \beta_6 Age + \beta_7 Edu + \delta_1 StDum + \delta_2 TimeDum + \varepsilon \quad (4)$$

Endogeneity of the contractor and crop type variables is controlled for through matching equations 5 and 6, under the assumption that farmers optimally choose which crop and with what type of organization to contract. The matching equations are estimated by state to control for geographical differences.

$$crop = \gamma + \varphi_1 HHNW + \varphi_2 VP + \varphi_3 OFI + \varphi_4 D/A + \varphi_5 Hobby + \varphi_6 Age + \varphi_7 Edu + \delta TimeDum + \eta \quad (5)$$

$$coop = \pi + \phi_1 HHNW + \phi_2 VP + \phi_3 OFI + \phi_4 D/A + \phi_5 Hobby + \phi_6 Age + \phi_7 Edu + \delta TimeDum + \mu \quad (6)$$

[3] A matching equation for contractor type is not included for the contracting decision relation because information about the contractor is only included for those farms who chose to contract.

Results

Table 2 reports the results on the producer's decision to produce corn under a marketing contract. The naïve[4] results of the logit model estimation imply that more intensive corn operations will be more likely to enter into market contracts for corn. However, after adjusting for endogeneity, the effect of the farm type was found to be insignificant. The decision to produce corn under contract was estimated to be positively influenced by the debt-to-asset ratio of the operation. One possible explanation for this result is that more highly leveraged farms use marketing contracts as mechanisms for market coordination to reduce overall risk.

The age of the farm operator was found to have a negative effect on the decision to enter into marketing contracts for corn production. Age is often used as a proxy for risk aversion, with older operators assumed to be less risk averse because of more established operations and higher levels of experience. Hobby farms are estimated to be less likely to enter into marketing contracts for corn. Since hobby farms are small in size and contribute a relatively minor contribution to total income, the use of contracts to add value and coordinate markets may be rather limited.

Qualitatively similar results were estimated for the producers' decisions to grow soybeans under a marketing contract and are reported in Table 3. The intensity of soybean production is estimated to have a significant and positive effect on the decision to contract soybeans, but is found to be insignificant after adjusting for endogeneity. Operations with greater debt-to-asset ratios are more likely to grow soybeans under

[4] Following Ackerberg and Botticini, naïve estimates refer to those which were estimated without instrumenting to correct for potential endogeneity.

contract while older operators and hobby farms are less likely to enter into marketing contracts for soybeans.

Note that the impact of the farm type variable was found to be positive and significant for both corn and soybean contract decisions prior to the adjustment for endogeneity. However, once the matching equation is included and the estimates in the contracting decision equation are adjusted the effect of the farm type variable is found to be insignificant. At the very least, this implies that endogeneity may be a concern and not adjusting for this effect could lead to biased results and inaccurate conclusions related to the effect of farm type on the decision to produce corn or soybeans under contract.

Table 2. Logit Estimation Results
Dependent Variable = 1 if the farm produces corn under contract

Variable	Parameter Estimates Naïve	Adjusted
Intercept	-3.907* (-5.764)	-3.210* (-4.754)
θ_{Corn}	**2.910*** **(5.108)**	**1.957** **(1.399)**
HHNW	1.506e-07 (0.907)	1.484e-07 (0.939)
VP	5.589e-07 (1.525)	4.768e-07 (1.582)
OFI	3.767e-06 (0.980)	3.412e-06 (1.116)
D/A	1.486* (3.043)	1.339* (2.662)
Hobby	-1.211* (-3.625)	-1.017* (-2.829)
Age	-0.017* (-2.253)	-0.017* (-2.372)
Edu	0.079 (0.420)	0.077 (0.465)
IL dummy	1.057* (2.281)	1.016* (2.662)
IN dummy	1.446* (4.122)	1.293* (3.958)
IA dummy	0.934* (2.601)	0.868* (2.498)
OH dummy	1.188* (3.086)	0.927* (2.725)
2004 dummy	0.865* (3.163)	0.756* (3.641)
2005 dummy	0.882* (2.263)	0.786* (2.189)

*Significant at 5%
t-statistics are reported in parentheses
N = 1763

Table 3. Logit Estimation Results
Dependent Variable = 1 if farm produces soybeans under contract

Variable	Parameter Estimates Naïve	Adjusted
Intercept	-2.648* (-6.656)	-2.875* (-5.196)
Θ_{Soy}	**1.488*** **(2.931)**	**2.491** **(1.482)**
HHNW	1.162e-07 (0.716)	1.063e-07 (0.661)
VP	6.967e-07 (1.863)	7.250e-07* (2.239)
OFI	5.325e-07 (0.378)	2.098e-07 (0.137)
D/A	1.453* (2.399)	1.625* (2.385)
Hobby	-0.958* (-3.474)	-0.934* (-3.384)
Age	-0.019* (-3.009)	-0.019* (-2.629)
Edu	0.0006 (0.004)	-0.021 (-0.139)
IL dummy	0.967* (3.123)	0.897* (3.074)
IN dummy	1.526* (4.454)	1.380* (4.710)
IA dummy	0.557 (1.934)	0.578* (1.973)
OH dummy	1.286* (3.120)	1.156* (2.992)
2004 dummy	0.323 (1.254)	0.202 (1.135)
2005 dummy	0.893* (2.684)	0.828* (2.674)

*Significant at 5%
t-statistics are reported in parentheses
N = 1763

Tables 4-6 report the parameter estimates for specific contract attributes defined by equations 4-6. Neither producer characteristics nor the organizational structure of the contractor were found to have significant effects on the specific design of the marketing contract. Table 4 reports the parameter estimates that determine whether the price received under the contract is determine by a formula. The use of a formula implies a larger degree of price uncertainty relative to a contract which outlines a single deterministic price. Therefore, one would expect more risk averse producer to prefer contracts that outline a single price. Similarly more risk averse producers would be expected to be more willing to accept contracts with formula prices (more price risk) with a cooperative organization that garners greater levels of trust.

Table 5 reports the naïve and adjusted logit estimates of the effects of producer and contractor characteristics on whether the price received under the contract is conditional on quality attributes of the contracted commodity. Tying price to some quality attribute of the commodity may expose the farmer to more price risk driven by quality uncertainty, implying more risk averse producers would tend to enter into contracts where price was independent of quality attributes. However, we find no evidence of this in the ARMS data.

Finally, Table 6 reports both the naïve and adjusted logit estimates where the dependent variable is whether or not the contract outlines a specific quantity to be delivered by the producer. Specifying a quantity exposes the producer to a greater share of the production risk of the commodity, so one would expect more risk average producers to be associated with contractual arrangements that do not specify a quantity to

be delivered to the contractor. Again, we find no evidence of producer or contract characteristics having any significant effect on this specific contract attribute.

Table 4. Logit Estimation Results
Dependent Variable = 1 if the price received is determined by a formula

	Parameter Estimates	
Variable	Naïve	Adjusted
Intercept	-3.8908	-5.3781
Crop	-0.3003	-0.2958
Coop	-0.0216	1.6060
HHNW	2.274e-07	2.639e-07
V of P	1.138e-07	1.566e-07
OFI	-4.96e-06	-4.1e-06
D/A	-1.1414	-1.4715
Hobby	0.4575	0.5088
Age	0.0229	0.0318
Edu	0.0395	0.0237
IL dummy	0.2815	0.6754
IN dummy	0.4658	1.3449
IA dummy	-0.00463	0.0517
OH dummy	-0.1686	-0.2637
04 dummy	0.7200	0.4878
05 dummy	0.7214	0.6067

*Significant at 5%

Table 5. Logit Estimation Results
Dependent Variable = 1 if the price received is based on quality attributes

	Parameter Estimates	
Variable	Naïve	Adjusted
Intercept	-5.5856*	-5.5642*
Crop	-0.0553	-0.0854
Coop	0.5934	0.7121
HHNW	3.18e-07	3.171e-07
V of P	-6.49e-07	-6.25e-07
OFI	2.328e-06	2.254e-06
D/A	-0.4171	-0.3924
Hobby	0.7877	0.7979
Age	0.0219	0.0212
Edu	0.1808	0.1742
IL dummy	-1.0227	-0.9599
IN dummy	0.1442	0.2103
IA dummy	0.4308	0.4395
OH dummy	0.4302	0.4452
04 dummy	-0.1295	-0.1487
05 dummy	3.3301*	3.2883*

*significant at 5%

Table 6. Logit Estimation Results
Dependent Variable = 1 if the contract is for a specific quantity of corn/soybeans

	Parameter Estimates	
Variable	Naïve	Adjusted
Intercept	1.3315	2.0490
Crop	-0.2821	-0.2502
Coop	-0.4653	-1.3571
HHNW	-7.3e-08	-9.76e-08
V of P	-2.26e-07	-2.38e-07
OFI	-3.78e-06	-3.9e-06
D/A	0.1299	0.1506
Hobby	-0.4015	-0.4484
Age	-0.0290	-0.0355
Edu	0.8690*	0.9091*
IL dummy	-0.1018	-0.2306
IN dummy	0.0265	-0.4146
IA dummy	-0.4575	-0.4470
OH dummy	0.5126	0.5130
04 dummy	-0.2135	-0.0568
05 dummy	0.4995	0.6331

*Significant at 5%

Discussion and Conclusions

While contract theory implies that there exists a link between the characteristics of the principal and agent and the resulting contract between the parties, there seems to be a lack of support for this relationship in the limited empirical literature devoted to contracts in agriculture. We add to the empirical literature on agricultural contracts by applying an econometric method which allows for endogenous matching between contracting parties. The estimation of the contracting equation is done using an instrumental variables approach to correct for this potential endogeneity.

Applying this method to ARMS survey data for corn and soybean producers in five Midwestern states from 2003-2005, this paper examines the effect of producer and contractor characteristics on contract design while controlling for potential endogeneity in the matching of farmers and contractors. We find evidence of producer characteristics impacting the decision to grow corn or soybeans under a formal marketing contract agreement. However, we do not find any evidence of producer or contractor characteristics impacting the specific attributes of the marketing arrangements at the contract level (i.e. pricing or quantity specifications within the contract).

These results are surprising and, if accurate, suggest that further work in the area of agricultural contracts is needed to identify the determinants of specific contract design. However, the results should be interpreted with care for a number of reasons. Most principal and agent characteristics that are postulated to effect contract choice and design are unobserved (i.e. risk preference) and therefore observed proxy measures are used in place of the unobserved variables. The explanative power of our models are limited by how well the observed variables proxy the true unobserved characteristics.

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