Forward Contracting of Inputs:
A Farm-Level Analysis

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Forward contracting of inputs in production agriculture is becoming increasingly important as more farmers attempt to manage risk. Using a logit model and farm-level data, this analysis estimates the effect of factors on the probability of a producer using forward input contracting. Results suggest that use of contracting in selling of crops and livestock, technology, farm size, geographic location, participation in government commodity programs, and use of extension services are important factors affecting the choice to forward contract inputs.

Key Words: forward contracting, inputs, risk

Since the 1930s, farm programs have helped stabilize farm income through various price and income support policies. In contrast, the Federal Agricultural Improvement and Reform (FAIR) Act of 1996 transfers income risk from the government to farmers.[1] To manage this shift in risk, individual farmers will develop risk manage-ment strategies best suited for their farms. Farmers manage risk by altering their production plans through diversification or by leasing land instead of purchasing. Some farmers will expand their use of futures and options contracts. Others will alter their marketing practices either by increasing storage to take advantage of high prices during the marketing year or by contracting in advance for the sale of their commodities. Farmers have yet another way to mitigate the effects of risk—forward contracting in input markets. Forward contracting of inputs could aid planning and allow farmers to diversify purchases over time (Haydu, Myers, and Thompson).

Forward contracting of factors of production is a growing activity between the suppliers of inputs and the farmers who use them (Ryan, Peacock, and Perry). As farm firms become more market oriented, and as government intervention simul-taneously diminishes, reducing risk and uncertainty in the supply of inputs becomes

[1] However, as one reviewer noted, in the presence of marketing loans and subsidized crop insurance programs, FAIR does not completely transfer all income risk to farmers.

more and more important. The U.S. Department of Agriculture (USDA) estimates that in 1994, approximately 42% of U.S. farms reported using forward input contracting as a farm management strategy. Forward contracting of inputs also guarantees farmers an assured supply of inputs at a specified price. Furthermore, terms in a contract may specify quality, quantity, and time of delivery. Given these certainties, the operator may be able to secure better pricing of those inputs, and ultimately to increase profits.

While much of the agricultural economics literature is focused on contracting (both production and marketing), our review of current literature found no empirical study on recent farm-level adoption of forward contracting of inputs. Therefore, the objective of this research is to investigate the factors influencing farmers' use of forward input contracting. The analysis includes factors suggested by previous studies in output contracting, and focuses on farmers' use of alternative marketing strategies, information, technology, and risk management strategies. Our analysis is conducted on a national level, with the unique feature of a larger sample than previously reported, comprising farms of different economic sizes and in different regions of the United States.

In the section below, we give an overview of the economic reasoning behind the use of input contracting. Proceeding this background information is the presentation of a conceptual model and literature review. The data are then discussed, followed by a description of the empirical framework and econometric procedure used to analyze the model. Next, we offer a detailed discussion of the empirical results of our analysis, and end the article with a summary of our conclusions.

Background

Almost every business must stock goods that are inputs to the production process. Having inputs in stock ensures smooth and efficient running of the business operation (Taha). The manager must consider the appropriate lot size, quality, and purchase price, as well as setup or preparation costs and storage or handling costs. Purchase price is of special interest when quantity discounts and price breaks can be secured. Decisions regarding the quantity and time at which the inputs are ordered are based on the minimization of an appropriate cost function which balances total costs resulting from over- or understocking of the inputs. The biological nature of agriculture makes timing of input supplies paramount.

Farmers choose to forward contract their factors of production for two basic reasons. First, they are seeking to obtain price discounts and "lock in" a certain price for the inputs. This reduces the input price risk. Second, contracting of inputs ensures quality and timeliness of input deliveries (Perry and Johnson). In addition to input quality, contracting may also assure quantity of inputs, and facilitate coordination among individuals (Sonka and Patrick). The farmer can arrange for a supply of inputs when they are needed, rather than having to overstock to ensure supply. For example, crop producers may forward price fertilizer and other chemicals to

reduce price variability. Feedlot operators may contract with cow-calf operators to supply feeder calves, reducing price variability for both parties. Acquiring assets through contracting offers the farmer a number of advantages, including possible supplier-provided financing to purchase the inputs. In addition to financial assistance, the farmer may receive production or managerial assistance such as fertilizer recommendations, custom-blend feed, high-quality seed varieties, and other services not available without the contract.

Under forward contracting, the risk of price changes is shared by the farmer and the supplier. While farmers are assured of a supply at a known price and are protected against input price increases, the most obvious disadvantage is the loss of managerial control—i.e., if prices for inputs go down, the operator is unable to take advantage of those lower prices, and if prices for outputs go down, the farmer still has a fixed obligation to purchase inputs at a known price.

Past research in agricultural production risk has focused mainly on the output side when considering futures markets and forward contracts (McKinnon; Chavas and Pope; Anderson and Danthine). Only limited attention has been given to input price risk, however. Batra and Ullah show that output price uncertainty, assuming all inputs are chosen before the output price is observed, leads to changes in output level, but leaves relative input quantities unchanged. Other research supports Batra and Ullah's argument (Leland; Baron; and Sandmo). Using a constant elasticity of substitution (CES) production function and relaxing the assumption that all inputs are chosen before the output price is observed, Hartman concludes that reducing output due to uncertainty reduces factor demand. Holthausen finds that, in a perfectly competitive market, quantity (output) is controlled ex ante, and the firm selects the optimal input combination as it would if there were no uncertainty. However, the opposite is true with price-setting firms. Robison and Barry note that even though risk modifies the output level, leaving relative input ratios unaltered, production still occurs on the line of least-cost combination.

A Conceptual Model

Consider a representative farmer who produces a single commodity using a single input. Assume that two different input-buying techniques are available to the producer: (*a*) buying in a forward market, or (*b*) buying in a spot/cash market. Input can be divided such that a proportion λ (where $0 \le \lambda \le 1$) will be purchased in the forward market, and the remaining $1 - \lambda$ will be purchased in the spot/cash market. The producer will choose λ that maximizes his expected utility of profits:

$$(1) \qquad \pi_i = pq_i - f\lambda x_i - r(1 - \lambda)x_i - v_i - \alpha_i - m_i\lambda x_i,$$

where f is the forward input price, r is the spot/cash price, x_i is input, v_i is total fixed production costs, α_i is a fixed cost component associated with forward pricing, and m_i is a variable cost component associated with forward pricing. Costs associated

with adopting forward pricing of inputs include information-gathering expenses, commissions, and brokerage fees.

A Taylor's series expansion of the utility-of-profits function[2] [equation (1)] about the means of profits yields an expected utility-of-profits function with mean (μ), variance (σ^2), and higher products (σ^k) of profits as arguments:

$$(2) \qquad\qquad EU(\pi_i) = f_i(\mu, \sigma^2, \ldots, \sigma^k).$$

Now, if we assume that producers are risk averse and that risk attitudes may be represented by each producer's risk-aversion coefficient (θ_i), the expected utility function is:

$$(3) \qquad\qquad EU(\pi_i) = f_i(\mu, \sigma^2, \ldots, \sigma^k, \theta_i).$$

Production, marketing activities, and constraints—including those reflecting the availability and adoption of forward input contracting—determine the mean, variance, and higher moments of the profit distribution. Maximization of the expected utility of profits yields an expression relating a producer's adoption of forward contracting of inputs, represented by λ_i, to a set of observable farm and operator characteristics ($\mathbf{X}_i$):

$$(4) \qquad\qquad \lambda_i = g(\mathbf{X}_i\boldsymbol{\beta}) + \varepsilon_i,$$

where $\boldsymbol{\beta}$ is a parameter vector, and ε_i represents unmeasured factors related to adoption. Because λ_i is unobservable, we work with an estimable discrete choice version of this model:

$$(5) \qquad\qquad Y_i = \mathbf{X}_i\boldsymbol{\beta} + \psi_i,$$

where Y_i is one if $\lambda_i > 0$, and is zero otherwise, and ψ_i is a residual error.

Review of Literature

Using a logit model for a sample of Iowa farmers, Edelman, Schiesing, and Olsen found that forward pricing and gross farm sales were significant factors influencing the use of futures and options. In their investigation of producers' attitudes toward electronic marketing, Turner, Epperson, and Fletcher identified the factors of age, business expansion intentions, on-farm storage, and producers' perception regarding the fairness of farm prices as most significant. Their study showed age to be negatively related to attitudes toward innovative marketing alternatives. Further, using experience as a proxy for age, Shapiro and Brorsen found this factor to be

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[2] Because output and prices are random, profits are stochastic.

inversely related to the level of hedging. Employing a Tobit model, they concluded that debt position, education level, farm management experience, and perception that hedging contributed to income stabilization significantly affected the hedging decisions of 42 Indiana farm operators. In assessing Illinois producers' decisions regarding the purchase of a grain dryer, Hill and Kau reported that farmers' decisions varied significantly by their age, type of farm, and size of farm.

Fu et al. found that number of enterprises (measure of diversification), debt/asset ratio, education, and location were significantly related to producers' attitudes toward alternative peanut marketing. Calvin, using a logit model to study the participation of U.S. farmers in crop insurance programs, concluded that farmers who participated in federal commodity programs were more likely to buy crop insurance. Pointing to a possible explanation for this finding, Calvin notes that farmers who participate in the commodity programs may be more risk averse than other farmers.

In a survey of 353 Ohio crop farms, Asplund, Forster, and Stout found that forward contracting is significantly related to age, attendance at farm organization meetings, use of computers or consultants, gross receipts, and leverage. Hedging activity, however, was affected only by computer or consultant use and by gross receipts. Finally, in a study of hedging, Makus et al. observed that hedging activity was influenced by marketing club membership, education, gross sales, and producer's geographic region.

Data

Data for this analysis are derived from the USDA's 1994 "Agricultural Resource Management Study" (ARMS), formerly known as the "Farm Costs and Return Survey" (FCRS). The ARMS, conducted annually by the Economic Research Service and the National Agricultural Statistics Service, is a multi-frame stratified survey, with the sample being drawn from both a list and an area frame. The survey collects data to measure the financial condition (farm income, expenses, assets, and debts) and operating characteristics of farm businesses, the cost of producing agricultural commodities, and the well-being of farm operator households. The survey design of the ARMS allows each sampled farm to represent a number of farms that are similar, the exact number of which is determined by a survey expansion factor. This expansion factor (or weight), in turn, is defined as the inverse of the probability of the surveyed farm being selected. Consequently, these expansion factors are used to expand the data to derive estimates for the population of all farms in the U.S. (for technical documentation, see Morehart, Johnson, and Banker).

The ARMS consists of several versions that can be used separately to analyze a particular issue, or together to examine national whole-farm issues. In addition to collecting basic financial data, the Farm Operator Resource (FOR) version is dedicated to the collection of special data on farm and farm operator households. In 1994, the FOR collected information on business contacts by farm operators,

management decisions, sources of information, use of technology, management strategies, and off-farm employment. The 1994 ARMS also collected information on the importance of the financial condition of the farm. Farm financial condition is determined by asking respondents about the importance of such factors as expanding the business, reducing the debt, reducing the costs, moderating fluctuation of prices received for products, and keeping records for financial analysis.

The sample size of the ARMS survey was 7,225 farms and ranches.[3] The target population consists of those operators associated with farm businesses representing agricultural production across the United States. A farm is defined as an establishment that sold or normally would have sold at least $1,000 of agricultural products during the year. Farms can be organized as proprietorships, partnerships, family corporations, nonfamily corporations, or cooperatives. Data are collected from one operator per farm, the primary farm operator. The primary farm operator is the individual who makes most of the day-to-day management decisions.

The 1994 FOR version of the ARMS survey provides information on farmers' use of various marketing, production, and financial strategies (risk management strategies). In addition to questions about the use of certain marketing and production contracts, farmers were given a list of 15 strategies and asked to identify their uses of these strategies.[4] About 40% of all farm operators indicated that they employed at least one financial strategy.[5] About the same proportion of farm operators also used some marketing strategy.[6] Use of marketing strategies also varied by commodity specialization and by size of farm. Over 46% of farms specializing in corn production used contracted sales of their crop. In contrast, only a third of producers or ranchers raising beef, sheep, and other livestock reported using any marketing strategies. However, nearly 77% of producers reported using the marketing strategy of spreading their sales over the year. Hedging was infrequently used by producers; only 5% hedged a portion of their production. Cash grain was hedged more frequently (11.8%), followed by dairy (4%), and other crops (2.7%). Approximately 30% of operators of small farms indicated use of one of the risk management strategies.

About 55% of all farm operators reported that they used at least one production strategy.[7] Use of production strategies differed by type of commodity specialization. As expected, producers specializing in the production of cash grains were heavy users of government programs. Cash grain farmers also were the most frequent users of insurance and share rent land. Dairy farms were most likely to use leased land,

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[3] Although the original sample size was 11,499, the actual usable sample size was 7,225, yielding a final response rate of approximately 63%.

[4] Response choices included: (*a*) have used, will use again; (*b*) have used, probably won't use again; (*c*) have not used; and (*d*) does not apply.

[5] Financial strategies included: (*a*) maintaining an open line of credit, (*b*) keeping cash on hand, (*c*) renegotiating loans, and (*d*) matching loan maturity terms with sales of products.

[6] Examples of marketing strategies included: (*a*) hedging or use of futures, (*b*) contracting the sale of farm products, and (*c*) spreading sales over the year.

[7] Production strategy examples included: (*a*) diversification; (*b*) insurance (crop and livestock); (*c*) leasing land, machinery, or equipment; (*d*) use of custom work; (*e*) government programs; and (*f*) forward contracting of inputs.

followed by participation in government programs. Over 25% of producers reported they used farm diversification as a production strategy. More than 35% of cash grain farmers employed diversification as a means to minimize risk, followed by producers of other livestock (28%), and dairy (23%).

Empirical Framework and Econometric Procedure

Qualitative response models, which are strongly linked to utility theory, have been widely used in economics to investigate factors affecting an individual's choice from among two or more alternatives (Amemiya; Greene). Maximum-likelihood logistic regression (logit) was employed to analyze the use of forward input contracting rather than ordinary least squares (OLS) because the dependent variable is binary $(0, 1)$ (see Pindyck and Rubinfeld). Our dependent variable, *FORWARD* (Y_i), takes a value of one if the farmer/farm reported using, and will use in the future, the strategy "forward contracting of inputs," and assumes a value of zero otherwise. Specifically, the logit is defined as the natural logarithmic value of the odds in favor of a positive response (in this case, forward input contracting), i.e.:

(6) $$Y_i = \begin{cases} 1 \text{ if producer participates in } FORWARD, \\ 0 \text{ otherwise.} \end{cases}$$

An empirical representation of the forward input contracting (Y_i) model by producer *I* to observable explanatory variables is given by:

(7) $$Y_i = \mathbf{X}_i\boldsymbol{\beta} + \psi_i,$$

where $\mathbf{X}_i$ is a vector of explanatory variables relevant to producer *I*'s use of forward contacting of input alternatives, $\boldsymbol{\beta}$ is a vector of unknown parameters, and ψ_i is a residual error assumed normally distributed with a zero mean and constant variance. In a binary logit model, the marginal effect of a variable X_j on the response probability is:

(8) $$\frac{\partial P_i}{\partial X_j} = f(\mathbf{X}_i\boldsymbol{\beta})\beta_j,$$

where $f(\cdot)$ is the normal marginal density function. For dummy variables, the marginal effect with respect to variable X_j is found by taking the difference in the predicted probabilities calculated at $X_j = 1$ and $X_j = 0$, holding other variables constant at their means.

Table 1 gives the definitions and mean values of the explanatory variables and of the binary dependent variable *FORWARD*. Not all responses included complete sets of variables for financial and farm characteristics, resulting in a usable sample of 4,713 respondents. Regional dummy variables are included to account for factors

Table 1. Definitions and Mean Values of Variables Used in the Logit Analysis, 1994 ARMS Survey

Variable Name	Variable Description	Mean
Dependent Variable:		
FORWARD	1 if operator uses forward contracting of inputs; 0 otherwise	0.32
Explanatory Variables:		
AGE	Age of the farm operator (years)	53.14
DEBTAST	Ratio of total debts to total assets	0.16
CONTRACT	1 if operator participated in contract sales of crops and livestock; 0 otherwise	0.23
OFF-FARM	1 if operator participated in off-farm work; 0 otherwise	0.45
GOVTPGM	1 if operator participated in government commodity program; 0 otherwise	0.42
DIVERSIF	Entropy measure of farm diversification	0.11
COMPBOOK	1 if farm operator uses computerized bookkeeping/financial analysis; 0 otherwise	0.16
EXTENSION	1 if operator used extension/county agent service as a source of information; 0 otherwise	0.58
MIDSIZE	1 if farm's gross income is $100,000 to $249,999; 0 otherwise	0.13
LARGE	1 if farm's gross income is $250,000 to $499,999; 0 otherwise	0.05
SLARGE	1 if farm's gross income is $500,000 or more; 0 otherwise	0.03
NORTHEAST	1 if farm is located in Northeast; 0 otherwise	0.06
MIDWEST	1 if farm is located in Midwest; 0 otherwise	0.41
WEST	1 if farm is located in West; 0 otherwise	0.13
RENTLAND	1 if operator leased/rented land; 0 otherwise	0.50
CGRAIN	1 if classified as cash grain farm; 0 otherwise	0.23
OGRAIN	1 if classified as other grain farm; 0 otherwise	0.20
BEEF	1 if classified as beef, hog, or sheep farm; 0 otherwise	0.44
POULTRY	1 if classified as poultry farm; 0 otherwise	0.02

Source: USDA, Agricultural Resource Management Study (ARMS), Farm Operator Resource version, 1994.

such as soil and climate variables, transportation, and other infrastructures that may impact the choice of forward contracting. In particular, three regional dummy variables (*NORTHEAST*, *WEST*, and *MIDWEST*) are included in the regression model.

Another factor that may influence use of forward input contacting is the size of farm. We divided farms into four major groups: (*a*) small farms (*SMALL*), with gross farm income of less than $100,000; (*b*) medium-sized farms (*MIDSIZE*), with gross farm income between $100,000 and $249,999; (*c*) large farms (*LARGE*), with gross income between $250,000 and $499,999; and (*d*) super-large farms (*SLARGE*), with gross farm income of $500,000 or more. Small farms (*SMALL*) is used as the base group.

The identification of variables expected to be associated with farm operators' decision to use forward contracting of inputs is based on the literature dealing with futures and options markets (Shapiro and Brorsen; Knight et al.; Makus et al.; and Calvin), and the literature addressing adoption and diffusion processes for innovations (Rahm and Huffman; Rogers; Robertson). Other variables included were: contract sales of crops and livestock (serving as an outlet for the commodities produced, as suggested by Paul, Heifner, and Gordon); several risk factors, such as participation in a government commodity program (often considered as the primary risk-reducing mechanism—see Kramer and Pope, and Musser and Stamoulis); and off-farm work (it is believed that off-farm income reduces the instability in total household income—see Mishra and Goodwin).

Further, farm diversification (*DIVERSIF*), measured by an entropy index (i.e., the proportion of revenue from each enterprise in total value of farm production), is included as a possible determinant of forward input contracting. The index[8] takes a value of one when a farm is completely diversified, and zero when a farm is specialized (Theil). Specifically, the entropy measure of farm diversification considers the number of enterprises in which a farm participates and the relative importance of each enterprise to the farm. An operation with many enterprises, but with one predominant enterprise, would have a lower number on the diversification index. Higher index numbers go to the operations that distribute their production more equally across several enterprises. It is hypothesized that farms which are diversified would be more inclined to forward contact.

Finally, technology is included in the analysis via a variable (*COMPBOOK*) describing computer use on the farm. The *COMPBOOK* variable is expected to be positively associated with forward contracting of inputs. This hypothesis is based on the premise that farms employing computerized bookkeeping are more efficient, and are more likely to be the first to try new methods in production agriculture. This variable may also reflect the educational attainment of the farm operator.

Empirical Results

The logit model depicted in equation (7) was estimated using maximum-likelihood methods in PC-CARP[9] (Fuller et al.), a statistical package suitable for analyzing data with complex survey design. Estimated model parameters are presented in table 2. Summary statistics show that the hypothesized forward input contracting model

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[8] The entropy index (*EI*) used for measuring farm diversification is calculated as:

$$EI = \sum_{i-1}^{N} \frac{(\% \text{ production from enterprise } i) \times \ln(\% \text{ production from enterprise } i)}{\ln(\text{number of possible enterprises})},$$

where *i* refers to each of the *N* possible enterprises.

[9] PC-CARP is a statistical software program for the analysis of survey data. The program is designed for multistage stratified samples, and finite correction terms can be introduced at two stages. An example of a multistage stratified survey is an area sample, where the strata are geographic subdivisions of the country, the clusters are area sampling units, and the observation units are individual farmers. Further, PC-CARP is a specialized statistical package designed specifically for probability-based data (as in the ARMS).

Table 2. Maximum-Likelihood Estimates for the Logit Model of Forward Contracting of Inputs by Producers in the 1994 ARMS Survey

Variable	Parameter Estimate	Δ in Probability	Variable	Parameter Estimate	Δ in Probability
Intercept	4.190** (0.525)		*LARGE*	0.543* (0.271)	0.1357
AGE	−0.008 (0.007)	−0.0019	*SLARGE*	1.364** (0.224)	0.3409
CONTRACT	2.057** (0.193)	0.4865	*NORTHEAST*	0.498 (0.327)	0.1245
DIVERSIF	1.009 (0.730)	0.2515	*MIDWEST*	0.776* (0.218)	0.1892
DEBTAST	0.001 (0.001)	0.0002	*WEST*	0.008 (0.232)	0.0020
OFF-FARM	0.045 (0.195)	0.0112	*RENTLAND*	−0.012 (0.209)	−0.0030
GOVTPGM	1.097** (0.219)	0.2602	*CGRAIN*	0.632* (0.309)	0.1572
COMPBOOK	0.536** (0.198)	0.1338	*OGRAIN*	0.252 (0.029)	0.0630
EXTENSION	0.719** (0.196)	0.1722	*BEEF*	0.115 (0.289)	0.0287
MIDSIZE	0.570** (0.206)	0.1423	*POULTRY*	0.047 (0.598)	0.0117

McFadden R^2 = 0.397
F-Statistic / (d.f.) = 27.148** / (19)
Correct prediction = 83%
Sample   = 4,713

Notes: Single and double asterisks (*) denote significance at the 5% and 1% levels, respectively. Values in parentheses are standard errors.

provided acceptable "fit" to the data. The McFadden R^2 value of 0.397 is acceptably high, particularly for logit models where evidence of goodness of fit points to a range of 0.20 to 0.40 (Sonka, Hornbaker, and Hudson; Harper et al.). The regression's *F*-statistic (27.148, with 19 degrees of freedom), which tests the overall significance of the model, is significant at the 1% level. Because the coefficients of the logit model themselves are difficult to interpret, marginal effects (changes in probability) are reported in table 2.

As found in previous studies, the estimated parameter for age (*AGE*) is negative; however, it was not significant in our model. Diversification (*DIVERSIF*) is not significantly related to the adoption of forward input contracting. Our analysis confirms

that use of contracted sales of crops and livestock (*CONTRACT*) increases use of forward input contracting. *CONTRACT*'s relatively large marginal effect (0.4865) indicates that producers who have contracted sales of their crops and livestock are more likely to use forward input contracts, ceteris paribus.[10] One explanation for this result may be that by contracting their crop and livestock sales, producers are essentially assuring an outlet for their produce at a given price (Paul, Heifner, and Gordon). By also setting input price through forward input contracting, and with output prices established in advance, producers are thereby locking in their margin.

Government programs are intended to decrease agricultural producers' risks (Goodwin and Schroeder), i.e., price support programs help reduce producers' price risk by assuring a guaranteed return. The estimated parameter for participation in a government commodity program (*GOVTPGM*) is positive and significantly different from zero. As reported in the literature, government commodity programs have often been identified as the primary risk-reducing mechanism for many farmers, especially those producing cash grains (Calvin; Kramer and Pope; Musser and Stamoulis; Asplund, Forster, and Stout). However, as noted by Baxter et al., farmers may participate in government programs to increase profits. The marginal effect for *GOVTPGM* (0.2602) indicates that producers who participate in government programs are much more likely to use forward input contracting than those who do not participate, ceteris paribus.

The parameter estimate for use of computers in bookkeeping and other financial analysis (*COMPBOOK*) is significant at the 1% level. Results show that the likelihood of using forward contracting of inputs is positively related to the use of computerized bookkeeping and financial analysis. However, the marginal effect value for this variable (0.1338) is the lowest among all the significant variables. One can argue that early adopters of new methods such as use of computers likely have greater management capabilities and perhaps greater risk-bearing capacity. Both Robertson and Rogers identify other characteristics shared by early adopters: they are willing and able to take risk, and they possess the willingness to change. Moreover, other research shows that producers who are early users of new technology achieve a higher level of education, and that better educated producers seek greater access to information on new technology (Makus et al.; Fu et al.; and Putler and Zilberman).

The coefficient for use of agricultural extension services (*EXTENSION*) is positive and statistically significant at the 1% level, confirming the importance of this source of information. A marginal effect of 0.1722 suggests that producers who seek information from agricultural extension sources are more likely to use forward input contracting than others. Both Hurd and Huffman, in their respective studies, report that visits to the Agricultural Extension Service may allow farmers to increase their allocative efficiency, which appears to increase the likelihood of using forward

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[10] As noted by one reviewer, simultaneity across *CONTRACT*, *GOVTPGM*, *COMPBOOK*, and *EXTENSION* is possible. Such simultaneity is an important topic to be considered in future research. Therefore, results in the present study should be interpreted with caution.

contracting in input markets. Producers who regard the extension service as an important source of market information are considered active in seeking information to increase relative returns to farm inputs, including their time spent farming. Likewise, they are expected to have favorable attitudes toward forward contracting of inputs as a means to reduce both production and input risks. These results are consistent with the findings of other studies (El-Osta and Perry; Fu et al.; Turner, Epperson, and Fletcher; Makus et al.; Asplund, Forster, and Stout; and Goodwin and Schroeder).

Parameter estimates for the impact of farm size were all significant. The variable for the smallest group of farms (<$100,000 in gross sales) was omitted for estimation purposes. The three remaining farm size groups (*MIDSIZE*, *LARGE*, and *SLARGE*) all have a positive impact on the likelihood of using forward input contracting. Results show that compared to small farms, *MIDSIZE*, *LARGE*, and *SLARGE* farms are more likely to use forward input contracting. The coefficients on *MIDSIZE* (0.570) and *LARGE* (0.543) differ slightly, but they are essentially the same in terms of the marginal impact—0.1423 and 0.1357, respectively. Similar results were obtained by Makus et al. and by Goodwin and Schroeder. By comparison, super-large farms (*SLARGE*) are even more likely (relative to small farms) to use forward contracting than their mid-sized and large-sized farm counterparts. The significant coefficient on *SLARGE* (1.364) implies that the marginal probability of input contracting increases by 34% for this farm size group.

Geographic location of farms determines cropping patterns, rainfall amounts, and soil productivity. As noted earlier, we used four regional dummies to denote farm location. However, only the coefficient for *MIDWEST* was statistically significant. Results indicate that compared to farms in the South (the benchmark), Midwestern farms are more likely to use forward input contracting. This finding is not surprising because farms in the Midwest tend to specialize in cash grain, a typically high-risk crop. This result is consistent with the findings of Makus et al. El-Osta and Perry found a similar result in their study of farmers' participation in crop insurance and hedging markets.

Finally, the coefficient on cash grain (*CGRAIN*) is positive and statistically significant at the 5% level, indicating that farms specializing in cash grain are more likely to use forward input contracts compared to farms specializing in dairy (our benchmark group). The significant coefficient on *CGRAIN* implies that the marginal probability of input contracting increases by 15.7%.

Conclusions

Forward contracting of inputs allows farmers to reduce cost and risk. Our study uses national farm-level data with great diversity regarding farm size, location, commodities produced, and risk management strategies. A logit model was developed to identify the factors influencing the likelihood that a farmer used forward input contracting during the 1994 production season.

Model results suggest that use of contracted sales of crops and livestock, use of new technology, managerial ability, and participation in government commodity programs are significant factors affecting the likelihood of using forward input contracts. Size of farm operation (as measured by gross farm sales) also played an important role. Farms with gross sales of $100,000 or more (medium, large, and super-large) are more likely to participate in forward contracting relative to smaller farms. Geographic region was also an important variable, with farmers in the Midwest more likely to use forward input contracting relative to farmers in the South. Finally, farms specializing in cash grain production are more likely to use forward input contracting than farms specializing in dairy.

Other variables, such as age, off-farm work by farm operators, and leasing or renting of land by farmers, were not statistically significant in explaining the use of forward contracting of inputs. The decoupling of government payments from planting decisions allows farmers to respond more closely to market conditions. In the absence of government programs, farmers can use input contracting (in addition to other strategies) to lower their costs and maximize their profits.

References

Amemiya, T. (1981). "Qualitative response models: A survey." *Journal of Economic Literature* 19, 1483–1536.

Anderson, R. W., and J. Danthine. (1983). "The time pattern of hedging and the volatility of futures prices." *Review of Economic Studies* 50, 249–266.

Asplund, N. M., D. L. Forster, and T. T. Stout. (1989, July). "Participation by farmers in forward contracting and hedging." Paper presented at the annual meetings of the American Agricultural Economics Association, Baton Rouge, LA.

Baron, D. (1970, October). "Price uncertainty, utility, and industry equilibrium in pure competition." *International Economic Review* 11, 463–480.

Batra, R. N., and A. Ullah. (1974). "Competitive firm and the theory of input demand under price uncertainty." *Journal of Political Economy* 82, 537–548.

Baxter, S., C. Zulauf, G. Schnitkey, and L. Forster. (1996). "Corn program participation and farm program opinions." *Review of Agricultural Economics* 18, 43–51.

Calvin, L. (1992). "Participation in the U.S. Federal Crop Insurance Program." Technical Bulletin No. 1800, U.S. Department of Agriculture, Economic Research Service, Washington, DC.

Chavas, J. P., and R. D. Pope. (1982). "Hedging and production decisions under a linear mean-variance preference function." *Western Journal of Agricultural Economics* 7, 99–110.

Edelman, M. A., B. H. Schiesing, and D. R. Olsen. (1990). "Use of selected marketing alternatives by Iowa farmers." *Agribusiness: An International Journal* 6, 121–132.

El-Osta, H. S., and J. E. Perry. (1997). "Use of hedging and insurance by U.S. farmers." Working paper, U.S. Department of Agriculture, Economic Research Service, Washington, DC.

Fu, T., J. E. Epperson, J. V. Terza, and S. M. Fletcher. (1988). "Producer attitudes toward peanut market alternatives: An application of multivariate probit joint estimation." *American Journal of Agricultural Economics* 70, 910–918.

Fuller, W. A., W. Kennedy, D. Schnell, G. Sullivan, and H. J. Park. (1986). "PC-CARP." Statistical software program, Statistical Laboratory, Iowa State University, Ames.

Goodwin, B. K., and T. C. Schroeder. (1994). "Human capital, producer education programs, and the adoption of forward pricing methods." *American Journal of Agricultural Economics* 76, 936–947.

Greene, W. H. (1993). *Econometric Analysis*, 2nd edition. New York: Macmillan Publishing Co., Inc.

Harper, J. K., M. E. Rister, J. W. Mjelde, B. M. Drees, and M. O. Way. (1990). "Factors influencing the adoption of insect management technology." *American Journal of Agricultural Economics* 72, 997–1005.

Hartman, R. (1975). "Competitive firm and the theory of input demand under price uncertainty: Comment." *Journal of Political Economy* 83, 1289–1290.

Haydu, J. J., R. J. Myers, and S. R. Thompson. (1992). "Why do farmers forward contract in factor markets?" *Southern Journal of Agricultural Economics* 24(1), 145–151.

Hill, L., and P. Kau. (1973). "Application of multivariate probit to a threshold model of grain dryer purchasing decision." *American Journal of Agricultural Economics* 55, 19–27.

Holthausen, D. M. (1976). "Input choices and uncertain demand." *American Economic Review* 66, 94–103.

Huffman, W. E. (1977). "Allocative efficiency: The role of human capital." *Quarterly Journal of Economics* 9, 59–79.

Hurd, B. H. (1994). "Yield response and production risk: An analysis of integrated pest management in cotton." *Journal of Agricultural and Resource Economics* 19(2), 313–326.

Knight, T. O., A. C. Lovell, M. E. Rister, and K. H. Coble. (1989). "An analysis of lenders' influence on agricultural producers' risk management decisions." *Southern Journal of Agricultural Economics* 21(1), 21–33.

Kramer, R. A., and R. D. Pope. (1981). "Participation in farm commodity programs: A stochastic dominance analysis." *American Journal of Agricultural Economics* 63, 119–128.

Leland, H. E. (1972). "Theory of the firm facing uncertain demand." *American Economic Review* 62, 278–291.

Makus, L. D., B. H. Lin, J. Carlson, and R. K. Prather. (1990). "Factors influencing farm-level use of futures and options in commodity marketing." *Agribusiness: An International Journal* 6, 621–631.

McKinnon, R. T. (1967). "Futures markets, buffer stocks, and income stability for primary producers." *Journal of Political Economy* 75, 844–861.

Mishra, A. K., and B. K. Goodwin. (1997, August). "Farm income variability and the supply of off-farm labor." *American Journal of Agricultural Economics* 79, 880–887.

Morehart, M. J., J. D. Johnson, and D. E. Banker. (1986, August). "Financial performance of U.S. farm businesses, 1987–1990." Pub. No. AER-66, Economic Research Service, U.S. Department of Agriculture, Washington, DC.

Musser, W. N., and G. Stamoulis. (1981). "Evaluating the Food and Agricultural Act of 1977 with firm quadratic programming." *American Journal of Agricultural Economics* 63, 447–456.

Paul, A. B., R. G. Heifner, and J. D. Gordon. (1985). "Farmers' use of cash forward contracts, futures contracts, and commodity options." Pub. No. AER-533, U.S. Department of Agriculture, Economic Research Service, Washington, DC.

Perry, J. E., and J. D. Johnson. (1997, July 28–31). "Farm financial outlook in a changing environment." Paper presented at the annual meetings of the American Agricultural Economics Association, Toronto, Canada.

Pindyck, R. S., and D. L. Rubinfeld. (1991). *Econometric Models and Economic Forecasts*, 3rd edition. New York: McGraw-Hill Book Co.

Putler, D. S., and D. Zilberman. (1988). "Computer use in agriculture: Evidence from Tulare County, California." *American Journal of Agricultural Economics* 70, 790–802.

Rahm, M. A., and W. E. Huffman. (1984). "The adoption of reduced tillage: The role of human capital and other variables." *American Journal of Agricultural Economics* 66, 405–413.

Robertson, T. S. (1971). *Innovative Behavior and Communication.* New York: Holt, Rinehart, and Winston.

Robison, L. J., and P. J. Barry. (1987). *Competitive Firm's Response to Risk.* New York: Macmillan Publishing Co., Inc.

Rogers, E. M. (1983). *Diffusion of Innovations.* New York: Free Press.

Ryan, J. T., D. L. Peacock, and J. E. Perry. (1998). "Financial prospects, business organization, and management: Farm business challenges." Paper presented at the Agricultural Outlook Forum '98, Washington, DC.

Sandmo, A. (1971). "On the theory of the competitive firm under price uncertainty." *American Economic Review* 61, 65–73.

Shapiro, B. I., and B. W. Brorsen. (1988). "Factors affecting farmers' hedging decisions." *North Central Journal of Agricultural Economics* 10, 145–153.

Sonka, S. T., R. H. Hornbaker, and M. A. Hudson. (1989). "Managerial performance and income variability for a sample of Illinois cash grain producers." *North Central Journal of Agricultural Economics* 11, 39–47.

Sonka, S. T., and G. F. Patrick. (1984). "Risk management and decision making in agricultural firms." In P. J. Barry (ed.), *Risk Management in Agriculture* (pp. 95–115). Ames, IA: Iowa State University Press.

Taha, H. A. (1976). *Operations Research: An Introduction*, 2nd edition. New York: Macmillan Publishing Co., Inc.

Theil, H. (1972). *Statistical Decomposition Analysis.* Amsterdam: North-Holland.

Turner, S. C., J. E. Epperson, and S. M. Fletcher. (1983). "Producers' attitudes toward multi-commodity electronic marketing." *American Journal of Agricultural Economics* 65, 818–822.

U.S. Department of Agriculture. (1994). "Agricultural Resource Management Study" (ARMS), Farm Operator Resource (FOR) version. Annual farm survey, jointly conducted by Economic Research Service and National Agricultural Statistics Service, USDA, Washington, DC.