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FACTORS INFLUENCING FARMERS' DECISIONS OF WHETHER OR NOT TO HEDGE

B.I. Shapiro and B. Wade Brorsen*

Commodity exchanges, extension agents, and academic researchers have spent much effort educating farmers about the advantages of hedging, yet use of this marketing strategy by farmers is still limited. Patrick, et al. found farmers ranked hedging as the least important of five alternative marketing responses to risk. The traditional theory of hedging argues producers will hedge in order to reduce risk. But some researchers such as Working, Hieronymus, and Ikerd have argued that farmers hedge to profit from favorable changes in basis or some other form of speculation.

Most empirical work addressing farmer hedging has been normative. This research typically makes assumptions about producer's preference functions and then attempts to answer the question of whether a farmer with the assumed preferences would want to hedge. Peck, Johnson, and Stein used portfolio theory to support the risk reduction hypothesis. The portfolio approach has not answered why individual farmers do or do not hedge. Holt and Brandt list numerous studies that show hedging can reduce risk. This set of research suggests that if farmers are sufficiently risk averse then they should hedge even if hedging may lower average prices. Research into selective hedging strategies (e.g., technical analysis) have found some cases where producers could both reduce risk and increase income. This research seems to conflict with the reality that farmers hedge very little (Helmuth). To better direct future research and education on futures markets we need a better understanding of the factors determining whether a producer hedges or not. This paper seeks to meet this need.

Commodity traders, researchers and educators, as well as policy makers want to know why futures market have failed to attract greater farmer participation. Many reasons have been suggested to explain why farmers hedge so little. For example, Frazier (p. 29) cited lack of understanding, fear of margin calls, and basis risk. Education has been suggested as one way of increasing farmer participation, but extensive efforts have been going on for a long time. Newbery and Stiglitz suggest that producer use of the futures market may be influenced by exposure to risk, farmer beliefs regarding a downward bias in futures prices, transactions costs, size of operation, whether or not their commodities are continuously stocked, and the cost of information. Newbery and Stiglitz (p. 192) also argue that producers may use futures markets very little because they are concerned about medium run instabilities and futures markets are only effective in stabilizing incomes over a short period of time.

Alternative methods of reducing marketing and production risk are also available. These include forward contracting, price support programs, crop insurance, off-farm income, spreading the timing of cash sales, and credit reserves. Thus farmers have several alternative ways of reducing risk. Forward contracting can overcome problems with lumpiness, marking-to-market and basis, but it is not a perfect substitute for hedging. Nelson (p. 15) argues that under certain market conditions, futures and forward contracts can be complementary rather than interchangeable.

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This study uses the results of a survey of Indiana corn and soybean farmers to determine the factors influencing whether these farmers participate in futures markets. The hedging decision can be viewed as a technology adoption decision. The technology adoption model suggests a Tobit regression model as the empirical model.

The Model

The decision to hedge on the futures market can be analyzed with an adoption model. Just and Zilberman suggest that an appropriate technology adoption model should incorporate both the discrete decision whether or not to adopt (hedge) and the continuous decision of how much of total resources (measured here as percentage of total crop acreage) to allocate to the adopted activity. The model used here is a reduced form model since it does not include any of the alternative risk reduction methods which can be chosen simultaneously:

(1) PERCENT = f(FACTORS)

where PERCENT is the percent of expected output hedged, and FACTORS is a vector of variables that should influence the decision to hedge.

The first set of variables come from subjective expected utility (Dillon; Anderson, Dillon, and Hardaker). This theorem states that agents seek to maximize their subjectively determined utility taking into account profit, risk, risk preference, and other factors. Therefore, FACTORS includes subjective measures of the effects of hedging on profit and risk as well as measures of risk aversion. Hedging is expected to be positively related to the change in expected returns and inversely related to the change in the variance of returns. We would expect hedging to increase with increases in risk aversion.

The second set of variables are personal and farm characteristics that the technology adoption literature suggests are important. Age, experience, education, and management ability are variables which may affect the decision of how much to hedge. Human capital theory suggests that farmers become less risk averse as they gain in experience and education (Welch; Schultz). However, empirical studies have found the opposite result as well (Luzar, Kramer, and Turner).

Farmers' subjective confidence in themselves and their business may also be an important variable affecting technology adoption. Therefore we include subjective assessment of confidence in management ability.

The third set of variables are those suggested in the introduction which we could adequately measured. Frazier argued that farmers do not hedge because of lack of understanding regarding hedging or bad experiences with hedging. Attending classes or seminars that explain hedging should be positively related to this decision and bad experiences inversely related to hedging. Farm size, should be positively related to hedging since there may be some economies of size and large farmers will be less concerned about the lumpiness of futures contracts.

Farmers with a favorable debt position may have no need to hedge. A low leveraged farmer would have little risk of bankruptcy even if crop prices plummeted sharply, particularly since government programs were in place in this time period. Also, banks may require highly leveraged borrower to hedge part of their crop.

Alternative methods of marketing and risk management are available. These include forward contracting, participation in commodity programs, use of crop insurance, and reliance on off-farm income. These methods can be substitutes or complements in the mix of strategies followed by farmers. Information about these was obtained in the questionnaire, but they are not included in the equation because they are simultaneously related to the decision to hedge and this is a reduced form model.[1]

Method

Since the dependent variable (Y), the percent of output hedged, cannot take on values below zero and many farmers in the sample did not hedge, it has a truncated normal distribution and Tobit Maximum Likelihood estimation is required (Tobin; Amemiya; McDonald and Moffitt). The dependent variable in this case also has an upper limit of 100, but no observations were observed at this limit. Adopting the notation of McDonald and Moffitt we can represent the model as:

$$(2) \quad Y = X\beta + e \text{ if } X\beta + e > 0$$
$$0 \text{ if } X\beta + e \leq 0$$

The vector X of explanatory variables (FACTORS) contains the factors hypothesized to affect the adoption decision, β is a vector of coefficients to be estimated, and e is the independently distributed normal random error term with mean zero and variance σ^2.

The total change in Y (PERCENT) associated with a change in X_i can be decomposed into the change in the probability of Y being above zero and the change in the value of Y, if it is above zero. This corresponds to the discrete choice whether or not to hedge, and the percentage hedged by those who decide to hedge. Elasticities, useful in comparing the relative magnitude of effects of significant variables on the total change in Y were calculated using the following derivations outlined in McDonald and Moffitt.

McDonald and Moffitt showed that the expected value of all observations of the dependent variable (EY) is equal to the expected value conditional upon being above zero (EY^*) and the probability of being above zero (F(z)):

$$(3) \quad EY = F(z)\, EY^*$$

They decompose the effect of a change in the i^{th} variable of X on the expected value of Y as follows:

$$(4) \quad \partial EY/\partial X_i = F(z)(\partial EY^*/\partial X_i) + EY^*(\partial F(z)/\partial X_i).$$

Thus, the total change in EY is made up of two components: (1) the change in the expected value of Y for those observations above the limit zero, weighted by the probability of being above the limit; and (2) the change in the

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[1] If information is included in the empirical model about these four factors, the coefficients and standard errors on the other variables change little and only the coefficient for off-farm income is statistically significant.

probability of being above zero, weighted by the expected value of Y, if above zero.

The effect of a change in X_i on E(Y) is not equal to β. Simplifying equation (4), it can be shown to be:

$$(5) \quad \partial EY/\partial X_i = F(z)\beta_i$$

where $z = X\beta/\sigma$.

We are also interested in the fraction of the mean total change in PERCENT that would be expected due to marginal changes by those who are already hedging and the fraction that would be generated by a change in the probability of adopting, i.e., the effect due to the likelihood of new adoption. McDonald and Moffitt show the first effect to be:

$$(6) \quad [1 - zf(z)/F(z) - f(z)^2/F(z)^2]$$

This is the fraction by which the β coefficients must be adjusted to obtain correct effects for observations above the limit. The second fraction is obtained by subtracting the result obtained from equation (6) from one.

Data

Each year the Top Farmer Crop Workshop is held at Purdue University. Participants are introduced to innovative technologies and management practices to help them improve the profitability of their farm business. Voluntary participation in such a workshop distinguishes them as highly motivated to improve their management expertise and be innovative. A questionnaire was administered at the August 1985 workshop to 42 farmers.

The questionnaire elicited the following objective and subjective measures of personal and farm characteristics:

ACRHED - average crop acreage hedged over the last five years

EXPER - years managing a farm (this variable is highly correlated with age and therefore age is not included)

EDUC - years of formal education

ACRE - total acreage farmed

MGTRATE - self-rating of managerial ability (1 = average, 2 = good, 3 = excellent)

DEBTPOS - self-assessment of debt position (1 = greater than 75% debt to asset ratio, 2 = 50-75%, 3 = 30-50%, 4 = 15-30%, 5 = 15% or less)

Three alternative measures of risk preferences were elicited since past research has shown this variable to be difficult to measure. Since these all attempt to measure the same thing only one was included in the final model. The three measures are:

RISKATT - how they feel about taking business risks (1 = dislike, 2 = indifferent, 3 = like)

GAMBATT - whether they like to gamble (1 = yes, 2 = no)

RISKAVR - a Pratt-Arrow risk aversion measure elicited with a King-Robison type risk interval questionnaire and transformed from a range to an ordered qualitative variable.

To measure the perception of farmers regarding the effect of hedging on profit and risk (whether or not they hedge), the following variables were measured:

DINCHED - expected percent change in farm income from hedging

INCSTAB - to what degree they believe hedging leads to income stability (1 = strongly disagree, 2 = disagree, 3 = not sure, 4 = agree, 5 = strongly agree)

They were also asked the expected percent change in farm income variability, but some apparently did not understand this question so the alternative measure, INCSTAB, is used in the empirical model.

To measure the effect of education and experience with the futures market on hedging, the following variables were measured:

CLASS - whether they had attended a class or a seminar on futures

BADEXP - whether they have had or knew anyone who has had a bad experience with the futures market.

The next section reports the results of the survey and the statistical analysis.

RESULTS

Sample Characteristics

Of the 41 farmers in the sample[2], 26 or 63% hedged at least some of their expected crop (corn, wheat, and soybeans) during the previous five years. The mean percent hedged (measured as percent of total acreage) for all farmers in the sample was 11.4%. Average total acreage farmed was 1365 acres.

Use of alternative risk management strategies was greater than hedging. The mean percent forward contracted over the same five year period was 20.5%. Ninety-three percent (93%) participated in government commodity programs the year of the questionnaire (1985) and 24% had crop insurance at the time. Thirty-two percent (32%) indicated that their family had a significant source of off-farm income.

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[2] Originally the sample included 42 observations but one respondent was a corporate farm manager who managed 12,000 acres. He was judged sufficiently unlike the rest of the sample to warrant deletion. Doing so, substantially affected the results only for the coefficient on the acreage variable.

This group of farmers is highly educated and experienced and indicated a high degree of self-confidence in their ability as farm managers. Almost all (90%) rated themselves as good or excellent managers. The mean age for the sample was 41.5 years (standard deviation (s.d.) = 13.1), average years managing a farm was 18.1 (s.d. = 12.0), and average years of formal education was 14.2 (s.d. = 3.4). The farmers sampled were relatively knowledgeable about futures. Ninety-three percent (93%) had attended a class or seminar on futures and 71% either had or knew someone who had a bad experience with the futures market. This is clearly a sample of likely innovators who can provide insight into the behavior of innovative farmers under risky conditions.

These farmers believe that hedging both increases income and decreases risk, but does both only slightly. The average change in income expected from hedging (for both hedgers and non-hedgers) was an increase of 3.5% (s.d. = 10.7), while the mean change in income variability expected from hedging was a decrease of 3.0% (s.d. = 8.4).

The debt-wealth position of 73% of the sample was either moderately (30-50% debt to assets) or highly (50-75% debt to assets) leveraged. Pratt-Arrow risk aversion ranges elicited using the King-Robison risk interval method are measures of risk preference. Fifty-one percent (51%) are in the two most risk averse ranges and 70% are on the risk averse side of the distribution.

Tobit Regression Results

Column 1 of Table 1 presents the estimated coefficients from the model to explain hedging on the futures market. These results were obtained with the maximum likelihood estimator of the Tobit regression model. The model has a high degree of explanatory power as shown by the R^2 of .83.

Significant factors related to hedging for this sample include years of experience managing a farm (EXPER), years of formal education (EDUC), self-rating of farm management ability (MGTRATE), self-perceived debt position (DEBTPOS), farm size (ACRE), a positive perceived change in income (DINCHED), and income stability (INCSTAB) due to hedging. The relative importance of these factors is made apparent by considering the elasticities in column 5. Caution should be taken in the case of the variables that were measured as dummy variables and it may be more meaningful to interpret them by considering the derivatives given in column 4.

The most important factor related to hedging for this sample of Indiana farmers is whether hedging is perceived to increase income stability (ϵ = 5.54). Although a significant variable, the elasticity associated with belief in hedging's ability to bring about increased income is only .41. These farmers perceive hedging to both increase income and income stability slightly, but place emphasis on the risk reduction aspect of hedging. They do not hedge all of their crop. They may be seeking risk reduction through diversification in the timing of marketing.

Next to income stability, the most important variable related to the hedging decision is debt position (ϵ = -2.65). The more highly leveraged farmers consider themselves, the more likely they are to hedge and the more they hedge if they do. Farmers who have a favorable debt position may not need to reduce their risk. Also, producers with high debt loads may be required to hedge in order to obtain financing.

Table 1. Estimated Tobit Model, Total Change Derivatives and Elasticities, and Above-the-Limit Change Derivatives and Elasticities to Explain Hedging on the Futures Market.[a]

Independent Variable	Estimate	t-value	Mean	Total Change		Change Above the Mean	
				Derivative[b]	ϵ[d]	Derivative[c]	ϵ*[bd]
Intercept	-34.89	-1.28					
EXPER	-0.53**	-2.44	18.10	-0.33	-0.97	-0.23	-0.42
EDUC	-1.81**	-3.01	14.20	-1.14	-2.61	-0.80	-1.14
MGTRATE	8.55*	1.91	2.00	5.35	1.73	3.76	0.76
RISKATT	-0.44	-0.10	1.05	-0.29	-0.05	-0.19	-0.02
DEBTPOS	-8.77**	-3.84	2.98	5.50	-2.65	-3.86	-1.16
BADEXP	4.18	0.75	0.71	2.62	0.30	1.84	0.13
ACRE (1,000)	7.30*	1.70	1.37	4.56	1.01	3.21	0.44
DINCHED	1.15**	2.54	3.51	0.73	0.41	0.51	0.18
INCSTAB	14.91**	3.55	3.66	9.37	5.54	6.56	2.44
CLASS	12.47	1.02	.93	7.79	1.17	5.49	0.51
R^2	.83						

[a] One asterisk denotes significance at the 10% level and two asterisks denotes significance at the 5% level using a two-tailed test.

[b] $\partial E(Y)/\partial \bar{X}_i$ [b] $=\beta_i F(z)$

$E(Y) = 6.189$

$E(Y^*) = 9.955$

$F(Z) = P(Z \leq .31) = .6217$

[c] $\partial E(Y^*)/\partial \bar{X}_i = \beta_i [1 - Zf(Z)/F(Z) - f(Z)^2/F(Z)^2] = .44$; $f(Z) = .3802$

[d] Elasticities evaluated at the mean

[e] Measured as 0-1 dummy variables

Education specific to hedging through having attended a class or seminar on futures is not significant for this sample. Thus the belief of people in the trade that increased producer education would have a positive effect on the rate of hedging is not supported for this sample. Education might be important for other groups, but this group should have understood futures markets since 93% had attended a class or a seminar on futures. Knowing someone else or having had a bad experience with futures oneself was also not significantly related to the decision to hedge.

Another interesting result is the sign and significance of experience and formal education in explaining hedging. Both of these are inversely related to hedging and could lead to the disturbing conclusion that a more educated or experienced farmer is less likely to hedge. This result, however, may be peculiar to this highly educated and experienced sample which is not intended to be representative of all Indiana farmers, but rather be indicative of highly innovative and entrepreneurial farmers. These farmers use diverse marketing and risk reduction strategies. This result is consistent with the proposition of human capital theory that risk aversion decreases with increases in education and experience. This may lead in this case to less participation in what is primarily perceived to be a risk reducing strategy. Another possibility is that the more experienced and educated farmers hedge less and rely on alternative activities to reduce risk.

Self-confidence, measured as perception of their own management ability is positively related to hedging. Hedging is a marketing tool that is difficult to understand and use successfully. The higher the self-confidence in one's management ability the more hedging is used.

Size of farm, measured in acres, is positively related to hedging. This provides a qualification to the findings of Gonzalez, Rhodes, and Grimes that large livestock production units hedge very little. At least in the case of corn and soybean producers, size is of consequence. This could result either from economies of size in hedging or from problems with the lumpiness of futures contracts for smaller producers.

Risk preference was specified three ways in the questionnaire. None of the three measures were significant and the other results were not affected by which measure was used. The business risk variable (RISKATT) is the only one reported here. Both risk preference and risk perception are difficult to measure and other variables such as debt position and experience may be capturing these effects in this model.

Also included in Table 1 are the derivatives and elasticities that measure the effects on the expected rate of hedging due to marginal changes by those currently hedging positive amounts. The computation of these effects involves multiplying the estimated Tobit coefficients by the correction factor given in equation (6). This correction factor, which is .44, indicates that 44% of the total change in hedging from a change in the independent variables would come from marginal changes by those already hedging. Fifty-six percent (56%) would come from changes in the probability of hedging by those not currently doing so. Thus, education efforts should be directed at both those already hedging and those not currently doing so.

Conclusions

This study sought to gain a better understanding of the factors that determine whether or not a producer hedges. Hedging by the farmers in this

sample is done on a limited basis, averaging only 11.5% of expected output over the previous five years. Differences in the level of hedging are most affected by differences in beliefs about the ability of futures markets to provide income stability. Even though these farmers expected hedging to increase profits, their beliefs about the effects on profits was not significantly related to their decisions. Thus, any farmer beliefs about a downward bias in futures are of minor importance. Both the expected change in profits and risk are small, 3.5 and 3.0 percent, respectively.

Nearly all the farmers in this sample participate in government commodity programs and nearly three-fourths are risk averse. If they are highly leveraged, they are more likely to hedge. This suggests that research into optimal hedging strategies for producers which does not consider leverage ratios is inappropriate. They forward contracted twice as much expected production as they hedged over the same period. It would appear that hedging, even as a risk reduction strategy, is a minor activity in the mix of risk management strategies used by these farmers.

The results indicate that education specific to the futures market, such as classes or seminars is not significantly related to hedging. Exposure to futures through classes or seminars was also high, 93%. Thus, lack of understanding of futures may not explain much of the reasons for the limited use of hedging by these farmers. Seventy-one percent (71%) of the sample had or knew someone who had a bad experience with futures. But, bad experiences with futures was not significantly related to hedging.

Differences in individual perceptions about the effects of futures markets on the variability of income were more important than the effects of the futures markets on the level of income. Thus, efforts to increase farmer hedging are more likely to be successful if they are directed at changing farmers perceptions of the ability of futures markets to reduce income variability rather than their ability to increase income. One way of increasing hedging may come from educating officers of financial institutions since the results show that producers with high debt loads are more likely to hedge. Producers who are in a solid financial position do not need to reduce risks through the futures market.

In conclusion, hedging appears to be a secondary risk management strategy for large Indiana corn and soybean producers like those sampled. It appears to hold this position because, although it is seen by farmers to decrease risk and increase profits, the magnitude of these effects is small and alternative means of responding to risk are available.

REFERENCES

Anderson, J.R., J.L. Dillon, and B. Hardaker, Agricultural Decision Analysis, Ames: Iowa State University Press, 1980.

Amemiya, T., "Regression Analysis When the Dependent Variable is Truncated Normal," Econometrica, 41(1973):991-1116.

Arcia, G., S.R. Johnson, and J.H. Sanders. Risk, Perceptions of Price, and Yield Uncertainty, and New Technology in a Small Farm Setting.

Dillon, John L., "Bernoullian Decision Theory: Outline and Problems," Chapter 2 in J.A. Roumasset, J.M. Boussard, and I. Singh (eds.), Risk, Uncertainty, and Agricultural Development, New York: Agricultural Development Council, 1985.

Frazier, John H., Jr., "Commentary," Review of Research in Futures Markets, 4(1)(1984):29-30.

Gonzalez, J., V.J. Rhodes, and G. Grimes. U.S. Hog Producers Size Comparisons, University of Missouri Agricultural Experiment Station Bulletin SR299, 1983.

Hieronymus, T.A., "Farmer Use of the Market," in A.E. Peck (ed.), Views From the Trade, Chicago Board of Trade, 1978.

Halter, A.N. and R. Mason, "Utility Measurement for Those Who Need to Know," Western Journal of Agricultural Economics, 3(1978):99-109.

Helmuth, John W., "Grain Pricing," Commodity Futures Trading Commission Economic Bulletin No. 1, September 1977.

Holt, Matthew T. and Jon A. Brandt, "Combining Price Forecasting with Hedging of Hogs: An Evaluation Using Alternative Measures of Risk," The Journal of Futures Markets, 5(Fall 1985):297-309.

Ikerd, John E., "Forward Pricing for Maximum Producer Profits," Futures Trading Seminar Proceedings, Volume 4, pp. 1-10, Chicago: Board of Trade of the City of Chicago, 1978.

Johnson, Leland L., "The Theory of Hedging and Speculation in Commodity Futures," Review of Economic Studies, 27(1959-60):139-51.

Just, Richard and D. Zilberman, "The Role of Risk in Adoption Behavior," in Peter Barry (ed.), Risk Analysis for Agricultural Production Farms, Iowa Press, 1984.

King, R.P. and L.J. Robinson, "Implementation of the Interval Approach to the Measurement of Decision-Maker Preference," AJAE, 63(3):510-20.

McDonald, J.F. and R.A. Moffitt, "The Use of Tobit Analysis," The Review of Economics and Statistics, 62(1980):318-21.

Nelson, Ray, "Forward and Futures Contracts as Preharvest Commodity Marketing Instruments," AJAE, 67(1985):15-23.

Newbery, David M.G. and Joseph Stiglitz, The Theory of Commodity Price Stabilization, Chapters 12 and 13, Oxford: Clarendon Press, 1981.

Patrick, G.F., "Risk and Variability in Indiana Agriculture," Indiana Agricultural Experiment Station Bulletin, Purdue University, No. 234, 1979.

Patrick, G.F., P.N. Wilson, P.J. Barry, W.G. Boggess, and D.L. Young. "Risk Perceptions and Management Responses: Producer Generated Hypotheses for Risk Modeling," S.J. Agr. Econ., 17(1985):231-38.

Peck, Anne E., "Hedging and Income Stability: Concepts, Implications, and An Example," AJAE, 57(1975):410-19.

Pratt, J., "Risk Aversion in the Small and in the Large," Econometrica, 26(January 1958):24-36.

Schultz, Theodore W., "The Value of the Ability to Deal with Disequilibrium," Journal of Economic Literature, 13(1975):827-46.

Stein, Jerome L., "The Simultaneous Determination of Spot and Future Prices," American Economics Review, 51(1961):1012-25.

Tobin, James, "Estimation of Relationships for Limited Dependent Variables," Econometrica, 26(January 1958):24-36.

Welch, Finis, "Education in Production," Journal of Political Economy, 78(1970):35-39.

Wilson, P.N. and V.R. Eidman, "An Empirical Test of the Interval Approach for Estimating Risk Preferences," Western Journal of Agricultural Economics, 8(2):170-82.

Working, Holbrook, "New Concepts Concerning Futures Markets and Prices," American Economics Review, 51(1961):431-59.

Young, D.L., "Risk Preferences of Agricultural Producers: Their Use in Extension and Research," AJAE, 61(1979):1063-70.