Optimal Hedging Levels for Corn Producers with Differing Objective Functions

by

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Agricultural economists often recommend that farmers hedge crop production decisions. These recommendations have been supported by empirical simulations of alternative marketing strategies that use futures markets. Such simulations typically have assumed that the farmer is fully hedged (the sale of futures exactly equals the quantity to be sold in the spot market). But individual farmers face basis and yield risks. Consequently, a 100 percent hedge may not be "optimal" and the appropriate hedging strategy may differ across farms.

This paper derives optimal hedging levels for various objective functions using data that incorporate basis and yield risks that might be faced by individual farmers. Emphasis is placed on county-level and farm-level observations in Western New York, but these results are compared with those for individual farms in Central Illinois. The sensitivity of results to different dates for placing and lifting hedges is also investigated.

The production of corn for grain in New York State expanded from 27.7 million bushels in 1973 to 67.2 million bushels in 1982. Production is concentrated in a 10 county area in western New York, delineated as the state's surplus feed-grain area, which produced 55 percent of the state's

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corn output in 1982. Given the historically small levels of production in Western New York, the marketing infrastructure is not well-developed relative to the central corn belt, and basis risk may negate much of the theoretical risk reduction potential of hedging. Basis risk should be smaller in Illinois than in New York, but as we shall show, yield risk is larger in Illinois. Thus, it is likely that the optimal hedge for farmers in both locations will be less than 100 percent of expected production.

The first section of the paper reviews the objective functions and data used in the analysis. Two subsequent sections summarize the empirical results, and finally the results are appraised.

Hedging Objective Functions and Their Implementation

The theory of hedging has changed dramatically since its inception 60 years ago. Three main theories have been used to explain an individual's incentive to hedge. The first and oldest concept is that individuals hedge to reduce income variability (Keynes; Hicks; Kaldor). The second theory is that individuals hedge to maximize profits taking into account expected changes in prices (Working). The third and most recent concept is that producers hedge to maximize income subject to a given level of risk or alternatively, maximize the level of utility derived from the activities being considered (Markowitz).

The third concept is used in this paper since the first two are special cases of the third when either risk or return is extremely important to a producer. Five different risk-return or utility objective functions are analyzed: mean-variance, mean-semivariance, mean-target deviation, maximization of logarithmic utility, and minimization of variance. The first three procedures involve the maximization of expected return subject to a risk measure. Mean-variance analysis is consistent with the expected utility theorem when returns are normally distributed or the decision-maker has a quadratic utility function. Mean-variance results may also be acceptable if higher moments than the second are small or relatively unimportant to the decision maker. However, since returns from crop production may be skewed, semivariance measured below the expected value is perhaps an appropriate measure of risk; the lower semivariance provides a measure of the risk of below average returns.

Farmers also may strive for target prices. They wish to sell at the highest price, but are concerned about selling below a target price, which may be necessary to cover their cost of production or cash-flow needs. Thus, deviations below a target is a third measure of risk. It has been shown that mean-target deviations results are a subset of second-degree stochastic dominant solutions (Tauer). All three techniques are appropriate for a risk averse farmer, but mean-variance is the only procedure that can also be utilized by a risk preferer, where variance is maximized subject to some level of expected return.

The logarithmic function is chosen for direct maximization of expected utility since it displays decreasing aversion to risk as returns increase. The quadratic utility function, which may be implied in the mean-variance results, displays increasing aversion to risk. The last criterion, minimization of variance, can be obtained from mean-variance analysis. Our analysis, however, uses the bivariate minimum-variance hedging model derived by Heifner, since it allows yield and basis risk effects on hedging levels to be separated.

These functions are used to analyze growing season hedges for corn by farmers in Western New York and Central Illinois. A hedge can be placed on either April 15, May 1, June 1, July 1, August 1, or September 1, and can be offset on either October 1, October 15, November 1, or November 15. The six placement dates and four offset dates are combined to form 24 decision periods over which hedging returns are calculated.

Data were obtained for the 10 years, 1973 to 1982. Cash prices for number 2 yellow corn were obtained from a grain elevator in Batavia, New York for each of the 4 offset days. On average, the cash price tended to fall as harvest proceeded, and the annual variability (standard deviation) of prices also was smaller as harvest progressed. Futures prices for the 1973-82 sample period were the closing prices for the CBT December corn contract found on, or most closely preceeding, the placement and offset dates. Futures and cash prices are not detrended nor deflated.

Corn production data were obtained from four farms producing corn for grain in Western New York who had participated for 10 years in the Cornell Farm Management Business Summary. Farms with highest and lowest mean squared errors of yields were selected, along with two farms that represented a division between high and low yield mean squared errors. Average corn yield was used as the expected yield. Yield and price data were also obtained for three farms in Logan County, Illinois for the same 1972-83 period. (These data were provided by Darrel Good, Department of Agricultural Economics, University of Illinois.)

Hedging costs such as commissions, cost of funds for margin deposits, and cost of managing the hedging program are ignored in estimating returns. Only one round-turn transaction is made per decision period. This simplifies the computations; of course, actual returns would be somewhat lower than those reported. Querin found that total hedging cost for a Western New York producer performing a routine hedge averaged $.03 per bushel between 1972 and 1980.

For the three risk-return functions, twenty-three different hedging percentages were evaluated ranging from a minus 110 percent of expected production to a positive 110 percent of the expected yield in 10 percentage point increments. The return was computed for each hedging percentage by multiplying the actual yield by the actual cash price and subtracting or adding the loss or gain on the percentage of expected yield that was hedged. This procedure implicitly assumes that the farmer does not know the actual production until the corn is harvested and thus is not able to adjust the futures position accordingly. The annual returns over 10 years are used to compute the expected return, the variance, and semivariance for the 23 alternative hedging percentages for each of the farmers. The target return was based on the cost of production.

Then, the optimal hedging ratio was calculated for the farmers for each of the 24 decision periods under each of the objectives. The three risk-return objectives required risk coefficients to determine which of the 23 hedging percentages maximized the utility function: utility = expected return - risk coefficient x risk measure. Six risk coefficients were used: 1, .1, .01, .001, .0001, and .00001. The larger the number the more risk averse the farmer. In addition a value of -.1 was used when risk was measured by variance to simulate risk preferring behavior.

The minimum variance and logarithmic utility objectives generate only one optimal solution for each farmer for each decision period. The logarithmic utility function, E(u) = Eln(R), is representative of a risk averse producer with decreasing risk aversion as income increases (Rolfo), while variance minimization assumes, of course, that the farmer is highly risk averse.

The hedging ratio that minimizes the variance of returns is calculated from

$$X^*/u_Q = (\rho_{p,f} \cdot \frac{\sigma_p}{\sigma_f}) + (\rho_{Q,f} \frac{\sigma_Q/\mu_Q}{\sigma_f/\mu_p}) .$$

The minimum-variance hedging ratio, $\frac{X^*}{\mu_Q}$, is the level of futures contracts, X*, to hold relative to expected output, μ_Q, to minimize the variance of expected returns. By assuming that prices and yields are bivariate normally distributed, the levels of yield risk and basis risk affecting the minimum-risk hedging ratios can be separated and quantified (Heifner). The basis risk effect, represented by the difference between the first term on the RHS of the bivariate model and unity, is the percentage that the minimum-risk hedging level falls below 100 percent due to basis uncertainty. The second term represents the effect of yield risk. In theory, if there was no basis risk and no yield uncertainty present, the minimum-variance hedging ratio would be 100 percent.

The basis risk term, $\rho_{p,f} \frac{\sigma_p}{\sigma_f}$, is composed of the correlation between harvesttime cash price deviations from expectations and futures price movements, $\rho_{p,f}$, the ratio of the standard deviation of harvesttime cash prices, σ_p, and the standard deviation of the futures price change over the decision period, σ_f. The yield risk factor, $\rho_{Q,f} \frac{\sigma_Q/\mu_Q}{\sigma_f/\mu_p}$, is composed of the correlation between yield deviations from expectations and futures price movements, $\rho_{Q,f}$, the ratio of the coefficient of variation of yield, σ_Q/μ_Q, and the coefficient of variation of prices, σ_f/μ_p.

The model assumes a fixed structure of price and yield behavior, and the results for all of the objective functions depend on the estimates of the parameters from the 1973-1982 sample. Thus, even if the objective functions are reasonable representations of farmers' behavior, the results can be in error either because of sampling error in estimating the parameters or because of structural change (i.e., the historical estimates are not representative of current yield and price behavior). In this context, a key issue is whether or not the expected change in futures prices over the hedging interval is zero or not. If the current futures quote is an unbiased estimate of the harvesttime price, then the expected price change is zero, and the optimal hedge from mean-variance analysis reduces to the minimum variance hedge (Kahl). Another possibility is to measure expected price change by the difference between the current futures quote and some forecast of the forthcoming harvesttime price, which might be derived by econometric, time series, or judgmental means. Clearly the expected price change, in this case, could vary from one year to the next. For our analyses, expected price changes are estimated by the averages from the sample period for each hedging interval. Hence, as the length of time the hedge is held changes, the estimated average change in futures prices also changes. This, in part, explains why the estimated optimal hedge can vary as the length of time the hedge is held changes.

Empirical Results for Mean-Risk Functions

To illustrate the effects of price and basis risk on hedging levels, Cayuga County, New York aggregate yields are used to ensure a relatively low yield risk effect on hedging. The large number of placement and offset date combinations (24) allow capturing changes in basis and price risk over the growing season. Selected mean-variance results are shown in Table 1.

At the extreme risk averse solutions ($\lambda = 1$), a shorter hedging period increases the percentage of the expected crop hedged since basis risk is reduced. This can be seen by comparing the 20 and 30 percent hedge during April with the 40 and 50 percent hedge during June. The minus 20 and plus 60 percent ratios for placing a hedge in September is due to a few years out of ten where prices increased through September and then decreased. This is the problem of measuring expected price change, mentioned earlier, and these results probably should be disregarded.

At the low risk averse solutions ($\lambda = .001$), there is no clear pattern to hedging behavior. At this level of risk aversion, variance is relatively unimportant, so price movement over the hedging period can radically alter the percentage of the expected crop hedged.

Table 1: Optimal Hedging Levels Using Mean-Variance Analysis
Cayuga County, New York

Placement Date	Offset Date	Risk Parameter a/	Hedging Percentage	Expected Return per Acre	Variance per Acre
4/15	10/1	1	30	$215.07	$2,033
4/15	11/15	1	20	200.76	1,468
5/1	10/1	1	30	214.26	2,038
6/1	10/15	1	50	207.27	1,659
6/1	11/1	1	40	202.78	1,562
7/1	10/1	1	40	214.47	2,079
8/1	10/15	1	20	211.66	2,295
9/1	10/1	1	-20	216.65	2,355
9/1	11/15	1	60	202.64	1,503
4/15	10/1	.001	-30	217.91	3,370
4/15	11/15	.001	10	200.87	1,538
5/1	10/1	.001	-70	221.58	5,555
6/1	10/15	.001	-50	213.51	4,594
6/1	11/1	.001	0	203.84	2,195
7/1	10/1	.001	-90	220.91	5,340
8/1	10/15	.001	110	217.02	2,625
9/1	10/1	.001	-110	217.50	2,514
9/1	11/15	.001	110	204.02	1,606

a/ Risk parameter is λ in the objective function $u = E(R) - \lambda var(R)$, where R is return and E is the expectation operator.

The effects of yield risk are demonstrated in Table 2. These results are based on the May 1 to November 1 hedging interval (actual production obviously is not known on May 1) and on two levels of risk aversion for the mean-variance objective function. The mean and variance of returns are also shown for zero and 100 percent hedges. All farmers face the same futures prices, while one cash price series is used for New York and another for Illinois. Thus, the different results within each state are related to differing yield behavior among farms, while the differences between Illinois and New York farms is partly explained by differing yield behavior.

Table 2: Optimal Hedging Levels Using Mean-Variance Analysis
Hedge Held from May 1 to November 1

Risk Parameter a/	Farm Number	Hedging Percentage	Expected Return ($ per Acre)	Variance per Acre
		----------New York Farms----------		
1	County	30	202.89	1,814
1	1	40	224.87	2,268
1	2	30	231.07	4,330
1	3	10	211.43	1,086
1	4	50	197.25	4,541
.001	County	-10	204.15	2,469
.001	1	0	266.07	2,808
.001	2	10	231.41	4,493
.001	3	0	211.45	1,095
.001	4	-20	200.49	6,093
-- b/	County	0	203.84	2,195
--	1	0	226.07	2,808
--	2	0	231.58	4,726
--	3	0	211.45	1,095
--	4	0	199.56	5,285
--	County	100	200.68	3,506
--	1	100	223.07	4,082
--	2	100	229.87	6,928
--	3	100	211.23	4,227
--	4	100	194.95	5,617
		----------Illinois Farms----------		
1	1	10	315.87	2,396
1	2	10	348.25	2,152
1	3	0	349.43	1,872
.001	1	10	315.87	2,396
.001	2	10	348.25	2,152
.001	3	10	349.65	2,020
-- b/	1	0	315.84	2,410
--	2	0	348.36	2,342
--	3	0	349.43	1,872
--	1	100	316.08	9,471
--	2	100	347.30	8,997
--	3	100	351.57	12,036

a/Risk parameter is λ in the objective function $u = E(R) - \lambda \, var(R)$, where R is return and E is the expectation operator.

b/Risk parameter not applicable. Results shown for arbitrary levels of hedging, zero and 100 percent.

For moderate to high levels of risk aversion (risk parameter λ = .01 or larger, λ = 1 shown), New York farms 1, 2, and 4 and Cayuga County, New York all have similar optimal hedges of 30, 40 or 50 percent of expected production. New York farm 3 and the three Illinois farms have smaller optimal hedges (zero to 10 percent) at high risk coefficients, and these small optimal hedges persist when the risk parameter declines to .001.

Yield risk for the Illinois farms as measured from the 1973-82 data is large, with yields dropping by one-half in 1974 and 1980 from the prior year. (The drought of 1983 is not included in the sample, but it illustrates that the yield risk in Illinois probably is not exaggerated by our data.) Yield variability is typically smaller on Western New York farms than on Illinois farms, but for whatever reason, New York farm 3 had a yield pattern similar to those of the Illinois farms. As risk becomes less important (λ gets smaller), the optimal hedging ratios change sharply for all farms. In general, reverse (Texas) hedging is optimal, but the consequence is to raise expected return only slightly while the variance increases dramatically (not shown in Table 2).

The results in Table 2 demonstrate that a 100 percent hedge is sub-optimal since expected returns change very little while the variance of returns is much larger than at the optimum. Under the mean-variance criterion for this hedge interval, corn growers are better off not to hedge than to be fully hedged. If, however, New York growers are risk averse, hedging 30 to 40 percent of the expected crop reduces the variance of returns relative to not hedging at all.

The hedging ratio also depends upon the objective function used. Results for functions using three different measures of risk--variance

(EV), semivariance (ESV) and deviations from a target (ET)--are shown in Table 3. When the risk parameter equals one in each function (extreme risk aversion), the smallest hedging level for farms 1 and 2 is for the semivariance measure; these farms have relatively small yield variability. The semivariance measures less risk than the variance; how much less depends upon the skewness of the return distribution. The size of the optimal hedge varies little for farm 4, a farm with highly variable yields. In other words, given farm 4's pattern of yield variability and given risk averse behavior by the farmer, the optimal hedge is relatively large regardless of how risk is measured.

Farm 3 also has variable yields, but the pattern is different than for farm 4. Farm 3, like the Illinois farms, had small yields in the drought years of 1974 and 1980, and consequently these yields tended to be correlated with high prices. In this case, the largest hedge is associated with the variance and semivariance measures of risk; the deviation from target measure of risk implies that farmer 3 should take a negative hedge position. Farm 3 has relatively low returns, while the target return, which is the cost of production, is relatively high. By hedging, this producer would "lock in" returns that are lower than the cost of production. Only speculation provides the possibility of reducing the deviations from target. This model can explain the apparent speculative behavior of farmers when it appears that they are not meeting their cost of production.

When the risk parameter is .001 (risk relatively unimportant to the farmer), the only positive optimal hedge is for farm 2 using the variance as a measure of risk. Typically, the optimal hedges are zero or

Table 3. Optimal Hedging Levels of Three Risk-Return Techniques Hedge Held from May 1 to November 1, Western New York

Model a/	Risk Parameter b/	Farm	Hedging Percentage	Expected Return ($ per Acre)	Risk per Acre
EV	1	1	40	$224.87	2268
ESV	1	1	0	226.08	1078
ET	1	1	40	224.88	66.32
EV	1	2	30	231.07	4330
ESV	1	2	-20	231.93	1988
ET	1	2	30	231.07	65.54
EV	1	3	10	211.43	1086
ESV	1	3	20	211.41	737
ET	1	3	-50	211.57	81.12
EV	1	4	50	197.25	4541
ESV	1	4	50	197.25	2215
ET	1	4	60	196.80	97.95
EV	.001	1	0	226.07	2808
ESV	.001	1	-70	228.18	2074
ET	.001	1	-110	229.38	90.61
EV	.001	2	10	231.41	4493
ESV	.001	2	-60	232.61	2304
ET	.001	2	-110	233.46	92.55
EV	.001	3	0	211.45	1095
ESV	.001	3	0	211.46	760
ET	.001	3	-110	211.70	89.57
EV	.001	4	-20	200.49	6093
ESV	.001	4	-110	204.65	4700
ET	.001	4	-110	204.65	113.65

a/ EV = mean-variance, ESV = mean-semivariance, and ET = mean-target deviation.

b/ Each objective function is of the form $u = E(R) - \lambda(\text{Risk})$. Three different measures of risk are used (note a). Results are shown for two levels of the risk paramters, λ .

negative. The hedging level is -110 percent for the estimates based on deviations from a target return. The increase in average returns from this risky practice, however, is small.

Logarithmic Utility and Minimum Variance Results

Unlike the previous risk-return models, the logarithmic utility function computes only one hedging ratio. For a hedge placed on May 1 and lifted on November 1, the optimal hedging ratio is estimated to be 10 percent for average Cayuga County conditions and for farms 1 and 2, which have had relatively low yield variability. The recommended ratio is -10 for farm 3 and 40 for farm 4. In general, if the hedge was placed before August and lifted in November, the optimal hedge ranged from zero to 30 percent of expected production. The recommended ratio was consistently 110 percent for hedges placed on August 1 or later and lifted in November. Hedges lifted in October, however, often gave perverse (negative hedge) results. The price increases in futures--hence a loss for short positions--were always larger for those hedges terminated in October than for those terminated in November for this particular 10 year sample. This behavior has influenced all of the comparisons of hedging intervals.

The basis risk effects, yield risk effects, and the minimum-variance hedging ratios are presented in Table 4 for a hedge held from May 1 until November 1. Since the sample farms within a state face the same prices, the basis risk effect is constant among farms within each state (-50 for New York and -49 for Illinois). The yield risk effect is not constant and the minimum-risk hedging ratios are highly variable among farms.

The magnitude of the yield risk effect is dependent on the correlation of yield deviations from expectations with futures price movements, and the ratio of the coefficient of variation of yield and prices. The size and sign of the correlation between prices and yields is dependent on the experiences of the specific farm over the 1973-82 sample period. New York farms 1, 2 and 3 and the Illinois farms have negative yield-price correlations. A decrease in yield is usually a regional phenomenon, resulting in a price rise. In some instances, however, a farm may have isolated yield difficulties such as New York farm 4. This farm had a high coefficient of variation of yield, .23, but a low level of yield-price correlation, -.06. Since the output fluctuations of farm 4 have been only slightly negatively correlated with futures price movements, the yield risk effect is a low -5 percent.

A large level of relative yield variability increases the yield risk effect on hedging. For example, the Illinois farms had relatively high, negative yield-price correlations and high coefficients of variation of yield, and interestingly New York farm 3 had similar coefficients. Therefore, the yield risk effect present during 1973-82 was a high (-31 to -43 percent) in these cases.

For the New York farms, the yield risk effects on a hedge placed on May 1 and offset on November 1, vary from -33 to -5 percent. Basis and yield risk significantly decrease the effectiveness of hedging in Western New York corn. The large risks present tend to diminish, but not eliminate, the use of futures markets for hedging during the growing season to reduce income variability. Basis uncertainty decreases hedg-

Table 4. Minimum-Risk Optimal Hedging Levels
Hedge Held from May 1 to November 1
Western New York vs. Illinois

	New York Farms				Illinois Farms		
	1	2	3	4	1	2	3
Correlation between Cash and Futures Prices ($\rho_{p,f}$):	.70	.70	.70	.70	.71	.71	.71
Standard Deviation of cash price at harvest (σ_p) \$/bu:	.51	.51	.51	.51	.51	.51	.51
Standard Deviation of futures price movement (σ_f) \$:	.71	.71	.71	.71	.71	.71	.71
Basis risk effect:	-.50	-.50	-.50	-.50	-.49	-.49	-.49
Correlation between yields and futures price movements ($\rho_{Q,f}$):	-.50	-.42	-.61	-.06	-.59	-.59	-.68
Standard Deviation of yield (σ_Q) bu/ac.:	9.71	16.79	14.50	18.51	23.93	27.57	27.36
Mean yield (μ_Q) bu/ac.:	92.96	94.67	88.53	80.50	132.90	147.60	148.10
C.V. of yield (σ_Q/μ_Q):	.10	.18	.16	.23	.18	.19	.18
Mean harvesttime price, cash price (μ_p) \$/bu:	2.43	2.43	2.43	2.43	2.43	2.43	2.43
C.V. of price (σ_f/μ_p):	.29	.29	.29	.29	.29	.29	.29
Yield risk effect:	-.18	-.26	-.33	-.05	-.36	-.31	-.43
Optimal hedging levels %:	.32	.24	.17	.45	.15	.20	.08

ing effectiveness on the individual farms more than yield risk does. The size of the basis and yield risk effect appears to be more sensitive to changes in the farm analyzed than to alterations in the dates the hedge is placed and lifted.

The basis risk effect found in South Central Illinois is slightly smaller than the effect present in Western New York as the correlation of cash price deviations and futures price movements in Illinois is minutely higher than the price correlation found in New York. Since the difference in the basis risk effect is small, differences in the minimum-variance hedging levels between regions are due to variations in yield risk. Differences in yield risk are caused by variations in the combination of the coefficient of variation of yield and the correlation between the deviation in yields from expectations and futures price movements. As indicated above, the combination of relatively large coefficients of variations of yields, and large negative correlations of yields and futures prices, force the yield risk effects for Illinois farms generally to be above the yield risk effects present on the individual farms in New York. The large yield risk effects typically decrease hedging potential on Illinois farms below the hedging potential of the New York sample farms. Because of the large yield risk effects found in Illinois over the 1973-82 period, the minimum-variance hedging levels are generally smaller than those calculated for the New York farmers.

Appraisal of Results

These estimates of hedging returns are affected by sampling error, and the results are sensitive to changes in the years from which the distributions of hedging returns are simulated. If 1974-82 had been used as the sample period rather than 1973-82, the minimum-variance hedging ratio, for a hedge placed on May 1 and offset on November 1, by an average Cayuga County producer, would have been 40 instead of 30 percent. Thus, the effectiveness of the optimal hedging ratios in obtaining the hedger's objective in the future is dependent on how well the sample distributions of returns for 1973-82 represent the future distributions of returns.

In assessing the quality of the estimates, the sampling error related to intrayear variability of futures prices can be explored. If the length of the hedging interval is held constant for a given farmer with a given risk parameter, then logically the optimal hedging ratios should be the same for any such interval, such as from August 1 to October 1 or from September 1 to November 1. This assumes that the population distribution of returns is the same for any interval of the same length. Although this may not be true, differences in distributions should be minimal, and thus, any large difference in empirical results should be more due to sampling error than to population differences. Differences in the estimated ratios for given conditions are, therefore, a measure of sampling error related to intrayear price changes. In Figure 1, optimal hedging ratios are plotted against the length of time the hedge is held for New York farm 1, for the mean-variance analysis assuming a risk parameter of .01. These data suggest that the sampling error is large for hedges held for short periods of time, i.e., from one to three and one-half months, since typically the range of results is rather wide for the shorter intervals. In contrast, the ratios for hedges held for four months and longer had much less variability.

Logic also suggests that the size of the optimal hedging ratio should decrease as the length that the hedge is held increases, because the longer the hedging interval, the larger the variance of the change in futures prices. The figure seems consistent with this logic, although given the wide variability of the ratios at the shorter lengths, the inverse relationship is not as clear as one might like.

This type of analysis can be used to make the following statement. If price and yield behavior on farm 1 continues in the future as it did in 1973-82, if mean-variance analysis with a risk parameter of .01 is appropriate for this farmer, and if the hedge is held for four months or more, then a hedging ratio of 30 to 40 percent appears appropriate. If, however, the hedge is held for shorter intervals (near harvest) the optimal ratio probably is larger than 40 percent, but the precise optimum is much more difficult to ascertain.

Moreover, the structure which generated the sample of cash and futures prices may change in the future. For example, government involvement in the corn market in 1983 greatly altered the probability distributions of prospective returns. This would make the historical estimates inappropriate to current conditions, requiring either a modification of the historical sample or a different estimation technique.

The usefulness of the optimal hedging ratios is also dependent on the correctness of the utility function utilized. The estimated optimal hedging levels are altered by different utility functions. Therefore, the applicability of the optimal hedging ratio to a particular producer necessitates the elicitation of the correct objective function.

Another factor in using the various objective functions is how the expected change in futures price is handled. The results reported in this paper use average changes from the sample period, but an individual hedger might have an alternative measure. If, for example, the prospective hedger expected futures prices to decline from planting to harvest time in a particular year, then the optimal hedge could be near 100 percent rather than the averages reported in this paper. On the other hand, if no reason exists for forecasting a price change, i.e. if the expected price change is zero, then the estimates based on the risk minimizing function could be used.

The optimal hedging ratios also do not incorporate the fact that yield uncertainty would decrease as the growing season progresses. The effectiveness of hedging to minimize the variability of returns would then increase.

Given all of the caveats associated with this type of analysis, simple rules of thumb about optimal hedges are difficult, if not impossible, to give. Our analysis seems to suggest, however, that planting-time hedges should not exceed 20 percent of expected production in Illinois or 30 percent in New York and perhaps should be less. As the growing season progresses and yields become more certain, the size of the optimal hedge probably grows, and hedges of 60 percent or more of expected production could be optimal. But, we cannot emphasize too strongly that these results are tenuous. Indeed, the analyses reported in this paper imply that advice to farmers to hedge, at least on a routine basis, may not be wise.

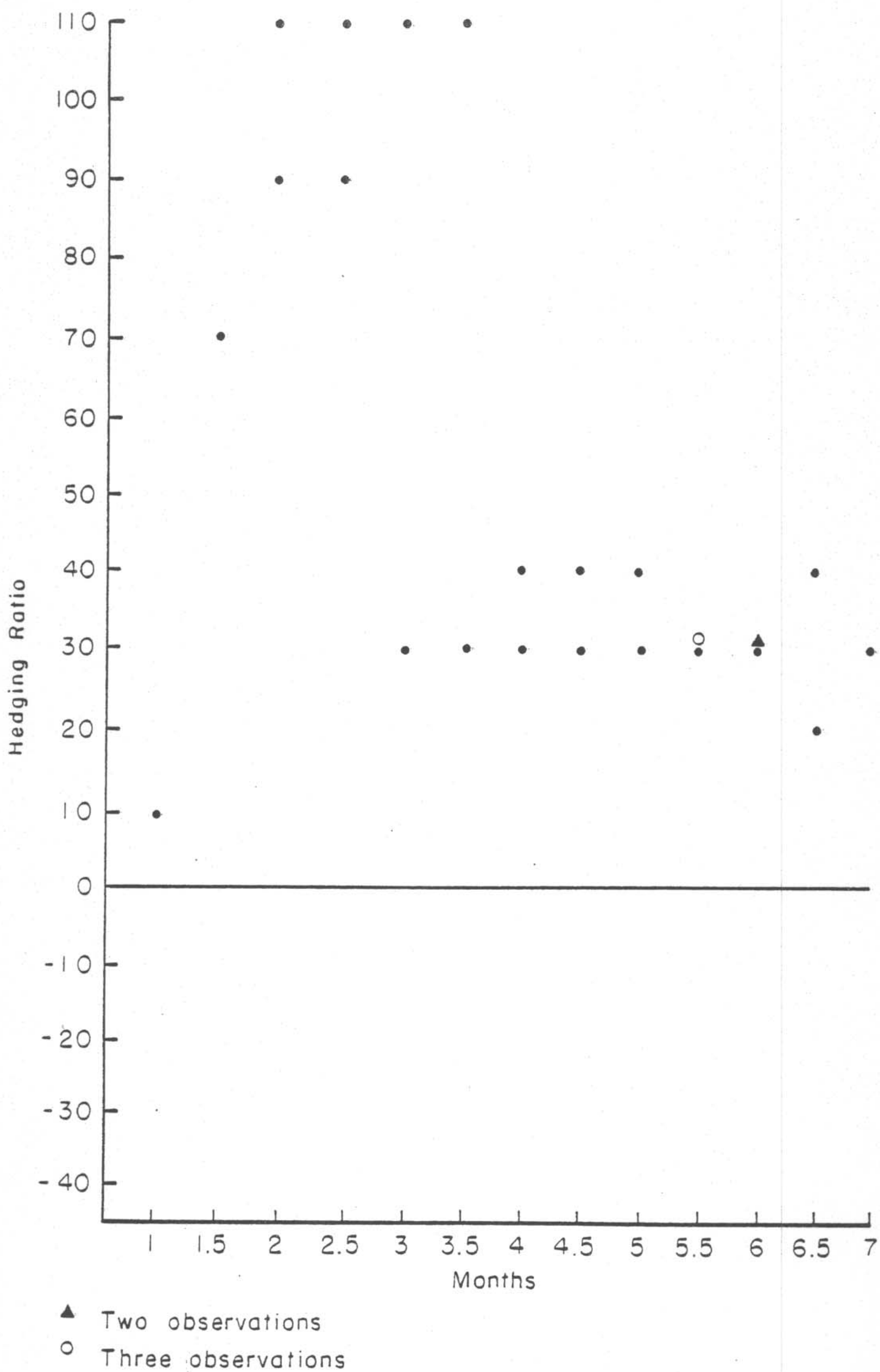

FIGURE I. OPTIMAL HEDGING RATIOS VS TIME HELD FARM I, NEW YORK, λ = .01

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