Does Routine Forward Pricing Effectively Reduce Farmers' Risks?

by

Richard Heifner

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Recent studies suggest that farmers typically price forward no more than 10 to 50 percent of their corn and soybeans and smaller percentages of their wheat and cotton. Most of their forward pricing is with cash contracts. Probably no more than 10 percent of these crops are hedged directly in the futures and options markets.[2] This contrasts with the wide use of hedging by merchants and processors. Why is there not more forward pricing by farmers?

Several hypotheses can be offered to explain farmers limited use of forward markets. Many farmers rely on government price supports instead of private contracting for price assurance. Some may not understand how to use forward markets effectively and some may not be very risk averse. The hypothesis examined here is that forward pricing is relatively ineffective in reducing revenue uncertainty in growing crops. This paper refines and extends analyses reported in Heifner and Wright (1989).

Previous studies give somewhat mixed signals about whether farmers can benefit from forward pricing. Analysts have shown that routine hedging of storable crops does not greatly reduce the year-to-year variability of prices received by growers (Tomek and Gray, 1970). However, forward pricing clearly reduces producers' uncertainties about current-year prices and revenues when output is known and basis risk is small. Moreover, recent studies have shown that hedging reduces current-year revenue risk in many cases where yields are uncertain. Grant (1989) estimated that corn and soybean growers can eliminate 0 to 70 percent of the revenue uncertainty that exists at planting time by hedging from 20 to 90 percent of expected output.[3] Miller and Kahl (1989) found that forward selling 60 percent of the expected crop would have reduced revenue variances for the years 1970-84 by 24

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[1] The author is an agricultural economist with the Economic Research Service of the U.S. Department of Agriculture. Views expressed in the paper are solely those of the author and do not necessarily reflect the policies of the Department.

[2] Use of futures and options is highest among corn and soybean producers in the eastern Corn Belt. For information about farmers' use of forward markets see Harwood, Hoffman, and Leath (1987)(2 articles); Leath (1986); Leath and Hacklander (1984); Hoffman, Harwood, and Leath (1988); Smith et al. (1989); and Wright et al (1988). Information about forward pricing by farmers from nine studies is summarized in a recent General Accounting Office study (1988).

[3] Grant measured risk in terms of variances using 1961-83 yields for Iowa, Nebraska, and North Carolina counties as well as state yields.

to 36 percent for six Illinois farms while increasing revenue variance by 9 percent for one farm. When 1974 was excluded, the estimated reductions in revenue variance ranged from 39 percent to 48 percent for all seven farms.

In this paper, I reexamine the concept of risk-shifting effectiveness and apply it to growing and storing corn, soybeans, and wheat. My objective is to help reconcile results in previous studies and draw implications for farmers' forward pricing decisions. I argue that the time dimension of risk needs more attention than it has received in past studies if one is to draw useful conclusions for decision-makers. My results indicate that forward pricing can reduce current-year revenue risks in crop growing modestly and longer-term risks slightly, but proportionately much less than it reduces risks in storage.

Previous authors have noted that risk avoidance alone does not fully explain firm's hedging behavior.[4] Nonetheless, it appears to be important in many cases. Risk clearly remains a major concern of businessmen, investors, and commodity traders. Insurance continues to sell. Moreover, risk and risk aversion play a central role in explaining the institutions and behavior of financial markets. This study analyzes routine forward pricing because it is simpler to evaluate than selective forward pricing and can serve as a starting point for evaluating more complex pricing strategies.

In the next section, some of the conceptual and practical problems of measuring risk-shifting effectiveness are considered. Then after a brief examination of the question of bias in futures prices I present some estimates of the effects of forward pricing on revenue uncertainties within the year. The effects of forward pricing on longer-term risks or revenue variabilities between years occupy the remainder of the paper. First, forward price variability at planting is compared with spot price variability at harvest. Yield risk is then introduced to illustrate the effects of forward pricing on the variability of gross revenues. Finally, input cost variability is added to examine forward pricing effects on net return variability.

Method of Analysis

The terms "risk" and "uncertainty" are used interchangeably in this paper to refer to situations where: (1) outcomes are subject to chance and (2) some outcomes are preferred to others.[5]

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[4] Working (1953) and Williams (1986) have suggested that risk aversion does not play a central role in futures trading. In this paper, I adhere to the more widely held view that risk aversion motivates much of the behavior of traders in commodity markets as well as in security markets.

[5] Because the situations examined here are subject to probabilistic statements they would fall into the narrower category of risk rather than uncertainty if Knight's (1921) distinction were applied.

Risk is burdensome because some producers are risk averse, because it raises the cost of, or constrains borrowing, and because it results in less efficient allocation of resources, even for the risk-neutral producer.

Forward pricing involves setting the price or a minimum price for a product to be delivered later. Farmers can price forward through futures, options, or cash forward markets. Futures prices are used in this analysis, but the results are believed to hold for cash contracting as well.

To choose among risky alternatives one must first describe the randomness that exists under each alternative. Ideally, one would measure and combine all of the risks faced by the firm, including risks associated with different activities and events occurring at different future dates. This study is limited to the more modest task of measuring randomness by enterprise for two different time horizons.

Measuring randomness involves estimating the parameters of probability distributions. Only means and variances are quantified in this study because revenues from growing and storing crops are believed to be approximately normally distributed, working with higher moments is more difficult, and information about farmers' preferences for higher moments is lacking. Under normality, risk-averse decision-makers will choose from among mean-variance efficient combinations of activities--combinations that minimize variance of revenue for a given expected revenue (or equivalently maximize expected revenue for a given revenue variance).

This paper gives little attention to the effects of forward pricing on average revenues because the forward markets studied are believed to be highly efficient. If forward prices were fully efficient and transactions costs were zero then forward pricing would have no effect on expected return and the optimal forward pricing strategy would be the strategy that minimizes risk.

In this study risk is measured in terms of the standard deviations of differences between realized and expected prices or revenues. The standard deviation (root mean square) is used because it is easy to apply and interpret, being measured in the same units as the variables themselves are measured. Risk-reducing effectiveness of forward pricing (z) is defined as:

$$(1) \quad z = 1 - s_h/s_u,$$

where s_h and s_u are standard deviations of differences (D_h and D_u) between expected revenues and realized revenues with and without forward pricing.

Risk and Length of Run

Two dates are required to describe uncertainty for applied decision-making, the date when expectations are formed and decisions made, and the date when the outcome is realized. For example, a farmer may be uncertain at planting time about harvesttime revenues, uncertain when crops enter storage about what they will be worth when sold, or uncertain when buying land and equipment about revenues in future years. At any given time producers face uncertainties about events due to occur on many future dates. The producer's bundle of uncertainties changes daily as events occur and new information about future events arrives.

Uncertainty about future events diminishes as the events approach in time. As new information arrives, the distributions representing the probabilities of various outcomes are replaced by new distributions with smaller variances and expectations nearer to the outcomes to be realized. Expectations must be made explicit to measure uncertainty. In this study, historical averages of deflated end-of-period futures prices serve as price expectations for future years and beginning-of-period futures prices serve as proxies for price expectations for delivery within the year. Trend yields are used for yield expectations.

Data Transformations

Estimates of the variability of crop prices and revenues are based upon 1960-88 observations on midmonth futures prices and state yields.[6] The original series depart greatly from stationarity in mean and variance. Yields trended upward throughout the period while the general price level approximately quadrupled. The price fluctuations were relatively small prior to 1973, very large in the mid-seventies, and moderately large in more recent years. Several transformations and manipulations of the data were employed to approximate stationarity. Yields were measured as relative deviations from least squares trends and then converted to 1988 levels by multiplying by the 1988 trend yields. Futures prices and input prices were deflated with the implicit GNP deflator (1988=100). The deflated prices and revenues were detrended before calculating the variances to remove the effect of the generally declining level of real commodity prices over the period analyzed.

To reduce the effects of changing price volatility, separate analyses were run using only data for the years 1976-88. The results using 1976-88 data were generally similar to the results for 1960-88, but subject to larger sampling errors due to the smaller number of observations. The 1976-88 results are occasionally cited but not fully reported here.

Bias in Futures Prices

Bias in beginning-of-period futures prices was evaluated using a t test of the hypothesis that the mean return was zero on short positions held over the growing or storage season. During the 1960-88 period, holders of short soybean positions experienced relatively large losses on average during both the growing and storage seasons, but the losses were small relative

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[6] The futures prices are settlement or closing prices for the 15th of the month or the trading day nearest the 15th.

to their standard errors (table 1). Results for corn and wheat were mixed. The average losses and gains were large enough to be important to growers and storers, but none differ from zero at the 0.10 level of statistical significance. Thus, the issue of bias remains unresolved, but considering these results, similar results from previous studies, and the competitiveness of the markets, it seems reasonable to assume that the expected returns from routine holding of short futures positions are approximately zero.

Revenue Risks over the Growing Season

The procedure used to measure revenue risks involves first calculating expected revenues for each year and then calculating the standard deviations of the differences between realized revenues and expected revenues. Expected gross revenue per acre from crop growing in the current year (E) was represented as:

$$(2)\quad E = y(F_{01} + b).$$

where capital letters represent annual observations with the time subscript omitted, y is the trend yield for 1988, F_{01} is the futures price at the beginning of the period, and b is the harvesttime basis (table 2). Basis risk is omitted in this analysis. Equation 2 and subsequent equations also apply to storage except that revenues are measured per bushel and the yield variables are replaced by 1's.

Table 1--Average returns on short futures positions held over selected intervals during the growing and storage seasons for corn, soybeans, and wheat, 1960-88 1/

Futures contract and time interval	Mean	Standard error
	Cents per bushel	
Growing season		
December corn, May 15 to Nov. 15	-6.4	15.9
November soybeans, May 15 to Nov. 15	-38.2	29.3
July Chicago wheat, Nov. 15 to Jun 15	16.9	19.0
Storage season		
July corn, Nov. 15 to June 15	0.4	11.4
July soybeans, Nov. 15 to June 15	-62.9	68.7
Dec. Chicago wheat, June 15 to Dec. 15	-30.9	27.6

1/ Calculated from settlement prices on the 15th of the month or trading day nearest the 15th in 1988 dollars.

Table 2--Coefficients used in analysis

Commodity and state	Base yield 1/	Harvest-time basis 2/
	Bushels per acre	Cents per bushel
Corn:		
Iowa	124.9	-50
North Carolina	85.1	4
Ohio	116.6	-36
Soybeans:		
Arkansas	24.1	-18
Georgia	24.9	-49
Illinois	37.3	-30
Winter wheat:		
Kansas	33.6	-50
Texas	21.1	-44

1/ Levels projected for 1988 using least squares trends fitted for 1949-88 (1960-88 for wheat).
2/ November basis for corn and soybeans and June basis for winter wheat were estimated by averaging deflated differences between monthly prices paid to farmers by state and midmonth closing futures prices over 1979-88.

Gross revenue for each year without forward pricing (G_u) equals actual yield times the harvesttime futures price adjusted for basis.

$$(3)\quad G_u = Y(F_{11} + b),$$

where Y is the state average yield adjusted for trend and F_{11} is end-of-period price of the maturing futures contract. Gross return with forward pricing equals gross return without forward pricing plus the gain or loss on the futures position.

$$(4)\quad G_h = G_u + hy(F_{01} - F_{11}),$$

where h is the proportion sold forward. I used 50 percent forward sales for crop growing and 100 percent forward sales for storage as being typical of conventional recommendations and practice.

The resulting expressions for differences between realized and expected current-year revenues unhedged and hedged (D_u and D_h) are:

(5) $D_u = G_u - E$,

(6) $D_h = G_h - E$.

Note that these deviations are the same for current-year net revenues as for current-year gross revenues since input costs are assumed to be known when current-year revenue expectations are formed.

The estimates in table 3 indicate that routinely forward pricing half of the expected crop at planting would have reduced farmers' errors in anticipating returns by 0 to 41 percent for the crop growing situations analyzed. When only 1976-88 data were included, the estimated reductions were of similar magnitude ranging from -3 to 40 percent. These estimates of the effects of forward pricing on current-year revenue uncertainty in crop production are similar in magnitude to those obtained by Grant (1989) and Miller and Kahl (1989) using county and individual farm yields.

Table 3--Root mean square errors in anticipating revenues from growing corn, soybeans, and wheat, without and with routine forward pricing, selected locations, 1960-88 1/

Crop and State	Root mean square deviation between realized and expected revenue		
	Without forward pricing	With forward pricing	Difference 2/
	Dollars per acre		Percent
Corn:			
Iowa	107	68	-36
North Carolina	97	69	-29
Ohio	79	47	-41
Soybeans:			
Arkansas	32	28	-12
Georgia	92	83	-10
Illinois	45	34	-24
Winter wheat:			
Kansas	55	53	-4
Texas	43	43	0

1/ 1988 dollars.

2/ Reductions in standard deviations of 22 percent are statistically significant at the 0.10 level and reductions of 28 percent are statistically significant at the 0.05 level based upon the F test with 27 degrees of freedom in the numerator and denominator.

In contrast, when basis risk is absent as assumed for these analyses, forward pricing a commodity in storage fixes the return thereby completely eliminating current-period revenue uncertainty.

Price Variability at Planting and at Harvest

Uncertainty about prices and returns in future years is important when the producer acquires durable inputs, such as land, machines, and farming skills. Without multi-year contracts, forward pricing clearly cannot fully eliminate uncertainty about future years' revenues. However, forward pricing might reduce year-to-year variability in farmers' incomes if prices for harvesttime delivery were less variable when the contracts were entered than at harvesttime. Since prices at the beginning of the growing season are unaffected by those weather and yield shocks not yet realized it seems plausible that they might be less variable than harvesttime prices. Tomek and Gray (1970) found such differences for potatoes, but not for storables. The question is pursued further here.

The standard deviations of deflated prices of futures for harvesttime delivery were 29 and 40 percent less at planting than at harvest for soybeans and corn, but only 9 percent less for wheat (table 4). These results, which include the large price fluctuations of the early seventies, suggest that forward pricing holds more potential for reducing interyear revenue variability than Tomek and Gray (1970) found. Similar results were obtained when only the years 1976-1988 are included. The corresponding estimates for the storage season were mixed with corn prices showing a markedly higher variance at the beginning of the storage period than at the end of the period.

Variability in Gross Revenues Across Years

Yield variability as well as output price variability is a major source of uncertainty about gross revenues from crop growing. To estimate the variability of gross revenues, data on state yields were multiplied by prices of maturing futures contracts at harvest. Historical averages of maturing futures prices at harvest adjusted for basis served as proxies for longterm price expectations.

Estimates of the effects of forward pricing 50 percent of each expected crop at planting on the level and variability of gross revenues are reported in table 5. The first three columns in the table show that such routine forward pricing would have changed average gross revenues by no more than plus or minus 2 percent for the cases shown. The standard deviations of gross revenues from crop growing would have been reduced from 0 to 25 percent. When the analysis is limited to the years 1976-88, the estimated effects on gross revenue variability range from -30 percent to +26 percent. Overall, it appears that forward pricing at planting can reduce year-to-year variabilities of farmers' revenues slightly, but the effect was statistically significant only for Iowa corn.

Table 4--Standard deviations of deflated futures prices at the end and beginning of growing and storing seasons for corn, soybeans, and wheat, 1960-88 1/

Futures contract and season	Standard deviation of futures price		
	End of season	Beginning of season	Difference 2/
	Cents per bushel		Percent
Growing season			
Dec. corn, May 15 to Nov. 15	121.5	72.6	-40
Nov. soybeans, May 15 to Nov. 15	252.0	178.6	-29
July Chicago wheat, Nov. 15 to June 15	152.2	138.5	-9
Storage season			
July corn, Nov. 15 to June 15	85.9	107.7	25
July soybeans, Nov. 15 to June 15	374.4	233.4	-38
Dec. Chicago wheat, June 15 to Dec. 15	201.0	141.4	-30

1/ 1988 dollars.
2/ Reductions in the standard deviation of 22 percent are statistically significant at the 0.10 level and reductions of 28 percent are statistically significant at the 0.05 level based upon the F test with 27 degrees of freedom in the numerator and denominator.

Variability of Net Returns Across Years

A third source of long-term uncertainty about revenues from crop growing is variability in the costs of inputs which are priced within the year. The next step in the analysis involved introducing input costs into the analysis to measure variability of net returns accruing to the fixed inputs.

Net returns unhedged and hedged (N_u and N_h) are defined as:

(7) $N_u = G_u - C$,

$$(8)\quad N_h = G_h - C,$$

where C is the cost of purchased inputs per acre. To approximate the costs of purchased inputs, cost estimates for 1988 derived from the Economic Research Service's cost of production surveys (table 6) were multiplied by the corresponding deflated indexes of prices paid by farmers for seed, fertilizer, chemicals, and fuel (USDA, Agricultural Prices).

$$(9)\quad C' = sP_s + fP_f + hP_h + pP_p + v,$$

where C' is the cost of inputs per acre in 1988 dollars; s, f, h, p, and v are estimated costs per acre in 1988 for seed, fertilizer, chemicals, fuel, and other variable inputs, respectively; and P_s, P_f, P_h, and P_p are corresponding deflated indexes of prices paid for inputs (1988 = 1).

The major input costs for storage are the cost of the commodity at the beginning of the storage period and interest. The cost of the commodity placed in storage was estimated as,

Table 5--Means and standard deviations of gross revenues from growing and storing corn, soybeans, and wheat, without and with routine forward pricing, selected locations, 1960-88 1/

Commodity and State	Mean			Standard deviation		
	Without forward pricing	With forward pricing	Difference 2/	Without forward pricing	With forward pricing	Difference
	Dollars per acre		Percent	Dollars per acre		Percent
Corn growing:						
Iowa	455	451	-1	138	103	-25
North Carolina	323	320	-1	125	101	-19
Ohio	434	431	-1	120	95	-21
Soybean growing:						
Arkansas	228	224	-2	59	55	-9
Georgia	247	243	-2	110	102	-7
Illinois	344	337	-2	82	74	-10
Winter wheat growing:						
Kansas	164	166	+1	54	53	-2
Texas	106	107	+1	43	43	0

1/ 1988 dollars.

2/ Reductions in the standard deviation of 22 percent are statistically significant at the 0.10 level based upon the F test with 27 degrees of freedom in the numerator and denominator.

(10) $C' = F_{00} + b$

where F_{00} is the beginning-of-period price for the futures contract then maturing. For example, input costs for storage periods beginning in November were set equal to the price in mid-November of the maturing futures contract plus the estimated basis. Basis relative to the nearby futures contract was assumed to be the same at the end as at the beginning of the storage interval.

For both growing and storage activities input costs were increased by interest on the cost of the purchased inputs,

(11) $C = [(1 + Im/12)/100]C'$,

where I is the prime rate of interest and m is the length of the growing period in months.

The estimated effects of forward pricing on the variability of net revenues shown in table 7 are not much different from the estimated effects for gross revenues. The reductions in variability range from 0 to 6 percent for winter wheat to over 20 percent for corn. This compares with estimated reductions in the variability of net returns from storing crops that range from 76 to 93 percent.

Table 6--Input cost estimates used in analysis

Commodity and State	Estimated 1988 cost per acre 1/				
	Seed	Fertilizer	Chemicals	Fuel	Other
	------Dollars per acre------				
Corn:					
Iowa	19.78	49.56	22.60	10.16	27.48
North Carolina	18.35	63.78	22.69	9.78	34.11
Ohio	21.00	63.97	20.89	10.47	30.62
Soybeans:					
Arkansas	9.61	3.95	12.88	8.62	16.31
Georgia	10.03	15.48	27.25	9.44	23.27
Illinois	11.74	5.83	19.31	7.68	13.32
Winter wheat:					
Kansas	6.16	17.71	1.60	6.40	17.06
Texas	6.32	14.37	4.16	8.49	14.08

1/ Calculated by converting estimates in Davenport (1988), McElroy (1986, 1987), and McElroy, Dismukes, and Ali (1989), to 1988 dollars and averaging for 1984-87.

Table 7--Means and standard deviations of net revenues from growing corn, soybeans, and wheat without and with routine forward pricing, selected locations, 1960-88 1/

Commodity and State	Mean			Standard deviation		
	Without forward pricing	With forward pricing	Difference2/	Without forward pricing	With forward pricing	Difference2/
	Dollars per acre		Percent	Dollars per acre		Percent
Corn:						
Iowa	294	290	-1	135	110	-26
North Carolina	137	135	-2	120	101	-19
Ohio	251	247	-2	112	85	-24
Soybeans:						
Arkansas	166	161	-3	58	55	-5
Georgia	137	133	-3	110	102	-7
Illinois	271	264	-3	81	72	-11
Winter wheat:						
Kansas	107	109	+2	53	50	-6
Texas	50	51	+2	40	40	0
	Dollars/bushel		Percent	Dollars/bushel		Percent
Storage:						
Corn	0.08	0.08	0	0.64	0.15	-76
Soybeans	0.59	-0.04	-106	3.57	0.25	-93
Wheat	0.37	0.06	-83	1.40	0.15	-89

1/ 1988 dollars.
2/ Reductions in standard deviations of 22 percent are statistically significant at the 0.10 level and reductions of 28 percent are statistically significant at the 0.05 level based upon the F test with 27 degrees of freedom in the numerator and denominator.

Summary and Conclusions

Routine forward pricing appears to reduce year-to-year variability in real returns from crop growing, but not by much. The estimated reductions in the standard deviations of net revenues are mostly less than 20 percent. This compares with estimated reductions in the 70 to 90 percent range for crop storage. These results suggest that routine forward pricing opportunities do relatively little to make investments in crop farming safer.

Crop growers uncertainties about current-year revenues at planting time can be reduced by 0 to about 40 percent by forward pricing. Risk-reducing effectiveness appears to be greatest for corn, less for soybeans, and quite low for winter wheat. This compares with the virtual elimination of current-period storage revenue uncertainty by forward pricing. Whether the modest reduction in uncertainty obtained by crop growers exceeds the small costs of forward pricing depends upon the individual farmer's financial situation and risk preferences.

The relative ineffectiveness of forward pricing for reducing crop growers' risks helps to explain why more farmers do not use futures and cash forward contracts. To more effectively reduce revenue risks in crop growing, other mechanisms, such as crop yield insurance or revenue insurance, need to be considered in combination with forward pricing.

Several further steps can be suggested to provide more precise and meaningful estimates of the effects of forward pricing on crop growers' risks. These include using county or farm-level yields to more fully capture the yield variability faced by farmers, using local spot prices to incorporate basis risk, and refining the estimates of input costs. Finally, improved operational methods for analyzing risks associated with events that occur at different future dates need to be developed.

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