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INTERACTIONS AMONG PRICE, PRODUCTION, AND FINANCIAL RISK IN ANALYSIS OF OPTIMAL MARKETING STRATEGIES FOR FARMERS

Vickie J. Alexander and Wesley N. Musser

The magnitude of price risk for farmers has increased considerably in the last decade and has generated considerable interest in the use of marketing strategies to alleviate this risk problem. Prominent among these strategies are those involving use of futures market transactions. The use of futures markets for price risk management has been incorporated in the theory of the firm under uncertainty (McKinnon; Feder et al.). Early empirical studies of farmer use of the futures market were concerned only with price risk (Ward and Fletcher; Peck). Subsequently, research has considered production and price risk (Rolfo), price and financial risk (Harris and Baker) and price, production, and some dimensions of financial risk (Lutgen and Helmers; Berck). However, the financial risk arising from margins have not been explicitly considered. In his review of past studies, Kenyon notes a need for more evaluation of marketing strategies involving simultaneous consideration of production, price, and financial risk.

Some of these above studies suggested that hedging can significantly reduce exposure to risk. Although surveys of farmers have found limited use of futures markets to manage price risk (Paul et al.), the new pricing environment may provide new opportunities (Kenyon). Traditionally, hedging has been viewed as a fundamental use of the futures market for reduction of price risk for farmers (Heifner; Ward and Fletcher; Peck; Hieronymus). However, Paul et al. found farmers also speculating in the futures market. Recent theoretical analysis supports the view that this behavior may be consistent with risk averse behavior (Kenyon). Berck empirically demonstrated that speculative positions in the futures markets can be consistent with risk aversion. Thus, research on marketing strategies to reduce risk should consider both speculation and hedging in the futures market.

This paper presents a theoretical model of optimal firm decisions in cash and futures markets that includes price, production and financial risk. This model of marketing decisions is applicable to both hedging and speculation in the futures market. The model is also adapted for more limited sources of risk. Marketing strategies for corn and soybean producers in Georgia and Illinois are analyzed to determine the optimal amount of futures contracting, whether it is a hedge or speculative position. A comprehensive empirical E-V analysis is included which considers the following marketing strategies: 1) cash sales at harvest, 2)

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a hedging and a speculative position equal to one futures contract (i.e., 5000 bu), and 3) the theoretically optimal size futures contract which could entail a hedge or speculative position. The strategies are analyzed for both situations since a negative covariance between cash price and yield is more likely in Illinois than Georgia because of differences in contributions to aggregate production. The futures market strategies were routine with transactions occurring at planting and harvest. The innovative feature of the analysis is the inclusion of simulated risk associated with margin requirements. Results from analysis of only price and production risk are also presented to allow evaluation of the importance of financial risk. In addition, results from production being nonstochastic are included to evaluate the importance of interaction of this source of risk with marketing strategies.

The Model

This paper considers the mean-variance preference function that assumes the producer's expected utility, EU, is a function of expected returns, E(R), and variance of returns, Var(R), that is,

$$EU = E(R) - mVar(R) \tag{1}$$

where m is a measure of risk aversion. This function has had extensive theoretical and empirical application in former research on futures markets strategies (Peck; Rolfo; Chavas and Pope; Kahl).

Assuming production costs do not vary among marketing alternatives and are non-stochastic, risk analysis can be based on gross revenues less costs of futures market transactions. Returns for the cash, (R), and cash and futures market, (R') are then specified as follows:

$$R = P.Y \tag{2}$$
$$R' = P \cdot Y + (FP-FH)Q - OC \cdot Q - COM \cdot Q \tag{3}$$

where
- P = random cash price at harvest
- Y = random output
- FP = futures price at planting
- FH = random futures price at harvest
- Q = size of contracts in the futures market ($Q > 0$ represents a hedge and $Q < 0$ a speculative position)
- OC = random interest opportunity cost per bushel = the difference between the interest foregone on margin deposits due to losses and interest earned on profits for futures contract.
- COM = brokerage commission per bushel.

Risk analysis of the alternatives can be based on specifying a time series of the variables in (2) and (3). If only price risk is of concern, Y would be fixed and only the price variables would be stochastic. When Y and the price variables are stochastic, both price and yield risk are considered. Finally, including stochastic values for the term OC results in all three forms of risk being considered - price, production and financial risk. The analysis in this paper examines all of the above approaches. The analysis also considers Q equal to average yield for the firm and Q equal to the optimal size futures contract determined by maximization of (1).

The firm is assumed to make production and futures market decisions at the beginning of the production process. Output and price at harvest can be viewed at planting as random variables. At the time of decision making, the quantity as well as the price of the futures contract bought or sold are known. However, the futures price at harvest is assumed to be stochastic at planting. Commission cost is known at the time of the decision making and is non-stochastic; however the opportunity costs associated with margin deposits required by the brokerage firm are not known because deposits fluctuate with margin calls. This opportunity cost reflects interest costs on the difference between margin deposits and accrued profits on the futures contract which can be positive or negative. As margin deposits are required, the farmer may incur increased loan costs or rationing of capital. This cost has been usually assumed nonstochastic in analyses of hedging.

Determination of the optimal size futures contract results from maximization of expected utility in (1) with respect to Q, the size of the futures contract. Using (3), standard statistical formulas and the above assumptions, expected utility of R' can be written:

$$(4)\quad EU(R') = E(P\cdot Y) + (FP - E(FH))Q - E(OC)Q - COM\,Q - m\,[Var(P\cdot Y) + Q^2Var(FH) + Q^2Var(OC) - 2QCov(P\cdot Y,FH) - 2QCov(P\cdot Y,OC) + 2Q^2Cov(FH,OC)]$$

where E, Var, and Cov are the expected value, variance and covariance operators, respectively.

The first order condition[1] identifying the optimal size futures contract, Q*, is:

$$(5)\quad \frac{\partial EU(R')}{\partial Q} = FP - E(FH) - E(OC) - COM - 2QmVar(FH) - 2QmVar(OC) + 2mCov(P\cdot Y,FH) + 2mCov(P\cdot Y,OC) - 4QmCov(FH,OC) = 0$$

Solving for Q* with an assumption that m > 0 yields:

$$(6)\quad Q^* = \frac{1}{2m}\,\frac{FP - E(FH) - E(OC) - COM}{Var(FH)+Var(OC)+2Cov(FH,OC)} + \frac{Cov(P\cdot Y,FH)}{Var(FH)+Var(OC)+2Cov(FH,OC)} + \frac{Cov(P\cdot Y,OC)}{Var(FH)+Var(OC)+2Cov(FH,OC)}$$

For exposition purposes, it is helpful to rewrite (6) as follows:

$$(7)\quad Q^*_{P,Y,OC} = \frac{E(RF)}{2mVar(RF)} + \frac{Cov(P\cdot Y,FH)}{Var(RF)} + \frac{Cov(P\cdot Y,OC)}{Var(RF)}$$

where the subscripts represent stochastic terms, and

E(RF) = expected returns from a futures market transaction which is the numerator of the first term in (6), and

Var(RF) = variance of returns from a futures market transaction which is the denominator of the second and third terms in (6).

The first term is therefore simply the ratio of expected returns from a futures contract to the variance of a futures contract weighted by m. If E(RF) is positive, the first term would support a hedge ($Q^* > 0$) while if E(RF) is negative it would support a speculative position ($Q^* < 0$). The second term is the ratio of the covariance of cash gross revenue and futures price at harvest to Var(RF): a positive covariance supports a hedge ($Q^* > 0$) while a negative value supports a speculative position ($Q^* < 0$). Finally, the third term is the ratio of the covariance of cash market returns and the opportunity costs of a futures market transaction to Var(RF); its relationship to the sign of Q^* is the same as the second term. In empirical situations, the signs of the three terms could differ so their sum would determine Q^*.

Price, production and financial risk have differing effects on Q^* in equation (7). If only price risk is included, Var(RF) is simply Var(FH) and the second and third terms are zero. Production risk does not effect Var(RF) or the first term. Its only impact is in the covariance in the numerators of the second and third terms. These terms would not be zero without production risk but would be rewritten as YCov(P,FH) and YCov(P,OC), respectively, as long as P and OC are stochastic. In constrast financial risk affects all the terms through Var(RF) and the numerator of the third term. If OC is non-stochastic, Var(RF) = Var(FH) and the third term is zero. Q^* in equation (7) can be rewritten to consider (a) price risk, (b) price and production risk, and (c) price and financial risk:

$$(7a)\quad Q^*_P = \frac{E(RF)}{2m\mathrm{Var}(FH)} + \frac{Y\mathrm{Cov}(P,FH)}{\mathrm{Var}(FH)}$$

$$(7b)\quad Q^*_{P,Y} = \frac{E(RF)}{2m\mathrm{Var}(FH)} + \frac{\mathrm{Cov}(P\cdot Y,FH)}{\mathrm{Var}(FH)}$$

$$(7c)\quad Q^*_{P,OC} = \frac{E(RF)}{2m\mathrm{Var}(RF)} + \frac{Y\mathrm{Cov}(P)}{\mathrm{Var}(RF)} + \frac{Y\mathrm{Cov}(P,OC)}{\mathrm{Var}(RF)}$$

Data

Empirical analysis of the optimal futures contract is based on a time series of variables in (2) and (3) for 1973-1981, which corresponds with the recent risky pricing environment. The risk parameter, m, in (1) is selectively varied over the risk-averse range $0 \leq m < \infty$. State average monthly cash corn and soybean prices and annual yields were utilized for Georgia and Illinois (U.S. Department of Agriculture, Agricultural Prices; U.S. Department of Agriculture, Crop Production). State average yields of course are subject to aggregation error. However, most output data in historical risk analysis has similar error. Furthermore, aggregate data have been used in previous risk analyses; for example, Rolfo used national data. Acreages were the average levels producing 5000 bushels (one futures contract) over the time period: 50 acres of corn and 150 acres of soybeans in Illinois and 100 acres of corn and 250 acres of soybeans in Georgia.

Under this formulation, Y in equations (2) and (3) equals output from these acreages.

Corn was assumed to be planted in April in Georgia and May in Illinois with harvest being in September in both states. Planting and harvesting dates for soybeans were June and November in both states. Cash harvest prices were average for these harvest months. With this production timing, September contracts for corn and November contracts for soybeans were used for the futures market transactions. Daily average prices for respective trading months were defined as the average of daily high and low on the Chicago Board of Trade, and the monthly averages of these daily prices were used for FP and FH in equation (3). Use of monthly averages probably reduces the variation in returns from futures market transactions. Rolfo used particular daily prices in his analysis to avoid this problem; however, this specificity in pricing could result in a large random fluctuation in prices for this one day in one year, severely biasing the outcome.

Opportunity costs on margin accounts reflect interest costs on margin deposits required by brokers. Since data on margin requirements were unavailable, a procedure to simulate the requirements was developed after consultation with individuals knowledgeable about futures transactions. Margin accounts include an initial margin and maintenance margin. Initial margin is assumed to be 7.5 percent of the average value of the contract during the year for hedging and ten percent for speculation. Maintenance margin is a threshold level that triggers additional funds to be deposited with the broker; the maintenance margin was assumed to be 75 percent of the initial margin in this analysis. When the value of the contract decreases, the hedger incurs a profit and these funds above the initial margin are available to the producer. If the value of the contract increases, the hedger incurs a loss. When the loss falls below the maintenance margin, a margin call results to bring the balance back up to the initial margin. For a speculative contract, the opposite pattern holds in that a drop in the futures price requires a margin call and a rise results in an excess of capital. For this analysis, daily margin requirements were simulated for each day the contract was open from average daily prices for each year in the time series. The annual margin requirements were then calculated using the average of the daily requirements for each year. An interest rate equal to yields of six month U.S. government bonds was multiplied times this annual margin to yield the opportunity cost of these margin requirements. The opportunity cost associated with hedging is:

$$(8)\quad OCH = [IMH + \sum_{t=1}^{T} (MRH_t)/T]r \div 5000$$

where

OCH = opportunity cost of margin deposits associated with hedging

IMH = initial margin required for hedging

MRH_t = additional margin requirement for hedging

$MRH_t = (P_{t+1} - P_t)Q$ if

(a) $(P_{t+1} - P_t)Q < 0$ or

(b) $(P_{t+1} - P_t)Q > 0$ and $(P_{t+1} - P_t)Q \geq MMH$

$MRH_t = 0$ if
(a) $(P_{t+1} - P_t)Q = 0$ or
(b) $(P_{t+1} - P_t)Q > 0$ and $MMH \leq (P_{t+1} - P_t)Q \leq IMH$

MMH = maintenance margin for hedging
Q = size of futures contract in bushels
T = number of days contract is open
r = semi-annual interest rate.

The opportunity cost of margin deposits associated with speculating is:

$$(9) \quad OCS = [IMS + \sum_{t=1}^{T} (MRS_t)/T]r \div 5000$$

where
OCS = opportunity cost of margin deposits associated with speculation
IMS = initial margin required for speculation
MRS_t = additional margin requirement for speculation

$MRS_t = -(P_{t+1} - P_t)Q$ if
(a) $(P_{t+1} - P_t)Q > 0$ or
(b) $(P_{t+1} - P_t)Q < 0$ and $-(P_{t+1} - P_t)Q \geq MMS$

$MRS_t = 0$ if
(a) $(P_{t+1} - P_t)Q = 0$ or
(b) $(P_{t+1} - P_t)Q < 0$ and $MMS \leq -(P_{t+1} - P_t)Q \leq IMS$

MMS = maintenance margin from speculation
Q = size of futures contract in bushels
T = number of days contract is open
r = semi-annual interest rate.

Differences in average daily prices in the equations above reflect either losses or profits depending on signs of price changes.[2]

Calculated annual average margin requirements per bushel, the interest rates used to calculate opportunity costs, the opportunity costs of margin requirements per bushel, and historical commissions are included in Table 1. Historical means of all the variables used in the analysis are listed in Table 2 along with the variances and covariances of the stochastic variables relevant to the analysis. Mean sample values in Table 2 were utilized in this historical analysis; current values of FP and COM would be used for actual decisions. Means and variances of returns from futures market transactions in equations (6) and (7) are calculated from parameters in Table 2 and listed in Table 3.

Sample moments of OC and therefore for returns for futures market transactions varied between hedges and speculations in Tables 2 and 3. Therefore, the simplifying theoretical assumption in equations (2)-(7) that moments of OC are invariant with the sign of Q* was relaxed in the empirical analysis. The following procedure was then utilized to accommodate this discontinuity: (1) Q* was calculated with both sets of parameters for OC, (2) if Q* > 0 (<0) from both estimates, then the value from using moments of OC from hedging (speculting) was adopted as the appropriate value, and (3) if Q* had opposite signs in the two estimates, equation (1) was used to select the value which maximized expected utility.

Table 1. Average Margin Requirements per Bushel, Opportunity Costs of Margin Requirements per Bushel, Interest Rates, and Commission for Corn and Soybeans Futures Trading for the Hedger and Speculator, 1973-1981.

	Corn (April-September)				Corn (May-September)				Soybeans (June-November)					
	Annual margin requirements		Opportunity cost of margin requirements		Annual margin requirements		Opportunity cost of margin requirements		Annual margin requirements		Opportunity cost of margin requirements		Com-mission	Annual interest rates[a]
Year	Hedger	Speculator	Hedger	Speculator	Hedger	Speculator	Hedger	Speculator	Hedger	Speculator	Hedger	Speculator		
	(Dollars/bushel)													(Percent)
1973	0.2104	0.2994	0.0151	0.0216	0.2512	0.3670	0.0181	0.0264	0.8870	1.2264	0.0639	0.0883	35	7.20
1974	0.3614	0.5001	0.0287	0.0398	0.3511	0.4902	0.0279	0.0389	0.7509	1.0647	0.0597	0.0846	35	7.95
1975	0.3911	0.5276	0.0239	0.0322	0.3654	0.4998	0.0223	0.0305	0.7202	0.9579	0.0440	0.0585	35	6.11
1976	0.3675	0.4937	0.0193	0.0260	0.3792	0.5091	0.0120	0.0268	0.9621	1.2964	0.0506	0.0682	45	5.26
1977	0.3718	0.4832	0.0206	0.0267	0.3541	0.4588	0.0196	0.0254	1.0572	1.3788	0.0585	0.0762	45	5.53
1978	0.3589	0.4705	0.0272	0.0357	0.3593	0.4722	0.0272	0.0358	0.9118	1.2119	0.0691	0.0919	45	7.58
1979	0.3692	0.4960	0.0371	0.0499	0.3841	0.5140	0.0386	0.0517	1.1437	1.5146	0.1151	0.1524	55	10.06
1980	0.3808	0.5210	0.0433	0.0592	0.3790	0.5199	0.0431	0.0591	0.9512	1.3212	0.1081	0.1502	55	11.37
1981	0.5336	0.6912	0.0736	0.0954	0.5118	0.6582	0.0706	0.0908	1.0944	1.4320	0.1510	0.1976	66	13.80

[a]Source: Board of Governors of the Federal Reserve.

Table 2. Sample Means of All Variables and Sample Variance-Covariance of Stochastic Variables Used in the Analysis.[a]

	P_{CG}	$P \cdot Y_{CG}$	FP_{CG}	FH_{CG}	OCH_{CG}	OCS_{CG}	P_{SG}	$P \cdot Y_{SG}$	FP_{SG}	FH_{SG}	OCH_{SG}	OCS_{SG}
Mean	2.72	13803.44	2.68	2.78	0.0321	0.0429	6.29	32910.56	6.52	6.62	0.0800	0.1075
P_{CG}	0.1792			0.1872	0.0028	0.0040						
$P \cdot Y_{CG}$		15234416		1525.35	15.1924	22.1928						
FH_{CG}				0.29087	0.00288	0.00416						
OCH_{CG}					0.00032	0.00041						
OCS_{CG}						0.00053						
P_{SG}							0.6108			0.9086	0.0121	0.0173
$P \cdot Y_{SG}$								57836700		-566.52	-29.093	-41.082
FH_{SG}										1.55975	0.01524	0.02281
OCH_{SG}											0.00131	0.00171
OCS_{SG}												0.00225

	P_{CI}	$P \cdot Y_{CI}$	FP_{CI}	FH_{CI}	OCH_{CI}	OCS_{CI}	P_{SI}	$P \cdot Y_{SI}$	FP_{SI}	FH_{SI}	OCH_{SI}	OCS_{SI}	COM
Mean	2.60	14011.67	2.67	2.78	0.0297	0.0428	6.53	33571.11	6.52	6.62	0.0800	0.1075	0.0092
P_{CI}	0.1476			0.1869	0.0029	0.0040							
$P \cdot Y_{CI}$		5156237		574.395	30.3933	39.0801							
FH_{CI}				0.29087	0.00272	0.00395							
OCH_{CI}					0.00029	0.00036							
OCS_{CI}						0.00046							
P_{SI}							0.6824			0.7939	0.0127	0.0175	
$P \cdot Y_{SI}$								35249095		1699.16	152.008	194.013	
FH_{SI}										1.55975	0.01524	0.02281	
OCH_{SI}											0.00131	0.00171	
OCS_{SI}												0.00225	

[a] Subscripts C and S represent the enterprises corn and soybeans while G and I represent the states Georgia and Illinois, respectively. Other variables are defined in equations (3), (7), and (8).

Table 3. Sample Moments of Probability Distributions Used to Specify Optimal Futures Transactions[a].

State and Commodity	Hedge		Speculation		Var(FH)
	E(RF)	Var(RF)	E(RF)	Var(RF)	
Georgia					
Corn	-0.14354	0.29694	-0.15440	0.29970	0.29087
Soybeans	-0.18591	1.59155	-0.21346	1.60762	1.55975
Illinois					
Corn	-0.15263	0.29659	-0.16352	0.29923	0.29087
Soybeans	-0.18591	1.59155	-0.21346	1.60762	1.55975

[a]E(RF), Var(RF), and Var(FH) refer to components of equation (7).

Empirical Results

Before discussing optimal strategies, it is helpful to relate the moments in Tables 2 and 3 to the equation defining the optimal position in (6) or (7). The negative signs on expected returns of a futures market transaction, E(RF), in Table 3 supports speculative positions in four situations. This negative sign occurs because FP < E(FH) in all situations (Table 2). Without reviewing the controversy on relationships among futures prices, these data support the view of a risk premium to hold futures contracts (Hieronymus). Between 1973 and 1981, speculation would yield a positive return for these positions; this risk premium is consistent with the price volatility in this era assuming speculators are risk averse. Negative values for Cov(P·Y,FH) and Cov(P·Y,OC) also support speculative positions in equations (6) and (7). However, these covariances are negative only for soybeans in Georgia when yield is assumed to be stochastic. Thus, a speculative position would definitely be optimal in this case; the optimal position in the other cases depends on the relative magnitudes of the terms in equations (6) and (7).

Optimal futures contracts as a percent of physical production for various sources of risk are presented in Table 4 for various levels of m, the risk parameter. In the computations, the same sign for Q* is obtained with moments for opportunity costs of hedging and speculation so the third step in the computations identified in the previous section is unnecessary. As discussed above, speculation is always optimal for soybeans in Georgia when yield is assumed stochastic. For the other situations, hedging is optimal for risk aversion coefficients greater than .00001 for corn in Georgia and soybeans in Illinois while hedging is optimal for m less than .0001 for corn in Illinois when production risk is considered. Since m is inversely related to size of the first term in

Table 4. Optimal Futures Position as a Percentage of Production Under a Mean-Variance Preference Function for Various Sources of Risk for Georgia and Illinois Corn and Soybean Producers, 1973-1981.

	Georgia[a,b]				Illinois[a,b]			
	Q^*_P	$Q^*_{P,OC}$	$Q^*_{P,Y}$	$Q^*_{P,Y,OC}$	Q^*_P	$Q^*_{P,OC}$	$Q^*_{P,Y}$	$Q^*_{P,Y,OC}$
	---percent---							
Corn								
m								
≥ 1	64.36	63.98	104.42	105.29	64.24	63.98	36.45	37.64
.1	64.32	63.94	104.37	105.25	64.21	63.95	36.41	37.60
.01	63.86	63.50	103.93	104.82	63.78	63.52	35.97	37.17
.001	59.46	59.18	99.51	100.50	59.42	59.26	31.61	32.89
.0001	15.31	15.93	55.29	57.29	15.89	16.56	-15.44	-12.61
.00001	-463.46	-448.47	-454.08	-410.10	-453.94	-439.93	-482.46	-466.75
Soybeans								
m								
≥ 1	58.25	57.84	-6.85	-7.12	50.90	50.67	21.18	22.61
.1	58.24	57.84	-6.86	-7.14	50.88	50.67	21.17	22.60
.01	58.14	57.75	-6.97	-7.25	50.79	50.57	21.07	22.50
.001	57.12	56.75	-8.13	-8.37	49.74	49.54	20.02	21.48
.0001	47.02	46.83	-19.74	-19.64	39.30	39.32	9.59	11.26
.00001	-70.73	-67.55	-135.87	-132.24	-82.17	-78.63	-111.87	-109.46

[a] Average production values are 5022, 5306, 5417, and 5143 bushels of Georgia corn, Georgia soybeans, Illinois corn, and Illinois soybeans, resp.

[b] A (+) sign represents a hedge while a (-) sign indicates a speculative position.

equations (6) and (7), these results are consistent with the sign of expected returns from a hedge discussed above. More risk averse producers are willing to tradeoff the loss in expected returns for the reduction in variance arising from positive covariances between gross revenue and futures price at harvest and opportunity costs of margins assuming yield is stochastic. The same result occurs when output is assumed nonstochastic. Here covariances between cash price and futures price at harvest and opportunity costs of margins are positive for all cases. Furthermore, the size of the optimal hedging ratio is an increasing function of the risk parameter, m, for situations with $Q^* > 0$, which is also consistent with this logic.

Financial risk has little effect on the results in Table 4. The sign of Q^* is the same with financial risk excluded as when included in all cases; the magnitudes of the optimal ratios are also quite similar. The smaller magnitude of variances and covariances associated with opportunity costs than for futures price at harvest explains these results. For example, the variance of FH_{CG} is 0.29087 and its covariance with $P \cdot Y_{CG}$ is 1525.35 (assuming yield is stochastic) while the variance of OCH_{GG} is 0.00032 and its covariance with $P.Y_{CG}$ is 15.1924 (Table 2). A further implication of these results is that the magnitude and sign of the covariance between P.Y and FH or P and FH is the crucial parameter determining the sign of Q^*. In this analysis, positive covariances in these variables result in hedges being optimal for risk averse individuals in seven of the situations analyzed (Table 4). This result seemingly is a paradox because usually negative covariances are associated with risk reduction. However, future prices at harvest (FH) is actually an input for a hedger, and positive covariances between revenue and input costs reduce variance of returns (Musser, et al). The negative sign on $Cov(P \cdot Y,FH)$ in equation (4) indicates this relationship for choice of futures market transactions.

Unlike financial risk, production risk does greatly affect the results. Without production risk, Q^* does not vary much between the states, being about 64% for corn in both states and about 58% for soybeans in Georgia and 51% in Illinois. Obviously, the cash markets in these states reflect efficient national markets. However, the optimal positions are quite different than when production is stochastic. The results are most dramatic for Georgia soybeans where hedges rather than speculative positions are optimal for $m > .00001$. Rather than $Cov(P.Y,FH)$ 0, $YCov(P,FH)$ 0. For Georgia corn, the opposite effect occurs: Q^* decreases when Y is fixed: $YCov(P,FH)$ $Cov(P \cdot Y,FH)$. In Illinois, the pattern is similar for both commodities with Q^* larger with Y fixed. In these cases, $YCov(P,FH)$ $Cov(P.Y,FH)$. These dramatic differences strongly support the use of stochastic production in formulating pre-harvest marketing strategies.

Since most producers can not freely vary Q^*, a cash market position and a hedge and a speculative position with the contract fixed at an amount equal to average yield, (i.e., 5000 bushels) are analyzed with equations (2), (3), and (4) and (7). Expected values and standard deviations of returns for these strategies for various sources of risk are presented in Table 5 for Georgia and Illinois. Financial risk has limited effect on

Table 5. Expected Returns and Standard Deviations for Corn and Soybean Marketing Strategies With a Fixed Hedge, Fixed Speculative Contract and Optimal Size Contracts for Georgia and Illinois for Various Sources of Risk, 1973-1981.[a]

Sources of risk by commodity and state	Strategy								
	Cash position	Fixed futures contract		Variable futures contract risk parameter					
		Hedge	Speculation	≥1	.1	.01	.001	.0001	.00001
Georgia									
Corn									
Price risk	13803.44[c] (2125.91)	13200.44[c] (1545.99)	14211.05[b,c] (4603.53)	13323.08 (1216.95)	13323.35 (1216.95)	13326.44 (1217.02)	13356.12 (1224.16)	13653.93 (1801.56)	15137.12[b] (14347.60)
Price and financial risk	13803.44[c] (2125.91)	13200.44[c] (1549.66)	14211.05[b,c] (4649.15)	13325.63 (1205.60)	13325.90 (1205.60)	13328.36 (1205.67)	13358.00 (1212.75)	13649.76 (1784.06)	15092.47[b] (14135.10)
Price and production risk	13803.44[c] (3903.13)	13200.44[c] (2693.08)	14211.05[b,c] (6144.89)	13267.08 (2689.86)	13267.29 (2689.86)	13268.82 (2689.89)	13284.67 (2693.16)	13442.80 (3000.96)	15024.39[b] (14564.78)
Price, production and financial risk	13803.44[c] (3903.13)	13200.44[c] (2693.09)	14211.05[b,c] (6180.84)	13176.17 (2691.70)	13176.28 (2691.70)	13177.84 (2691.76)	13192.98 (2692.24)	13344.20 (2671.20)	14653.08[b] (14356.93)
Soybeans									
Price risk	32910.56[c] (4146.83)	32267.24[c] (2829.83)	33211.30[b,c] (10217.73)	32318.26 (1514.90)	32318.44 (1514.90)	32319.32 (1514.92)	32328.86 (1516.74)	32423.56 (1687.83)	32823.50[b] (8680.55)
Price and financial risk	32910.56[c] (4146.83)	32267.24[c] (2851.74)	33211.30[b,c] (10319.47)	32322.15 (1483.58)	32322.15 (1483.58)	32323.03 (1483.60)	32332.40 (1485.41)	32425.32 (1656.73)	32825.33[a] (8546.89)
Price and production risk	32910.56[c] (7605.04)	32267.24 (10124.01)	33211.30[b,c] (9548.05)	32945.74[b] (7591.50)	32945.74[b] (7591.50)	32946.03[b] (7591.50)	32948.84[b] (7591.98)	32977.06[b] (7639.39)	33258.94[b] (11433.65)
Price, production and financial risk	32910.56[c] (7605.04)	32267.24 (10177.49)	33211.30[b,c] (9589.12)	32889.04[b] (7589.53)	32889.04[b] (7589.55)	32889.32[b] (7589.55)	32891.81[b] (7589.87)	32916.73[b] (7633.64)	33165.85[b] (11247.07)
Illinois									
Corn									
Price risk	14011.67[c] (2081.14)	13370.18[c] (1215.95)	14474.21[b,c] (4661.25)	13466.47 (898.41)	13466.76 (898.41)	13470.05 (898.52)	13503.89 (909.43)	13841.99 (1674.33)	15652.51[b] (15165.84)
Price and financial risk	14011.67[c] (2081.14)	13370.18[c] (1210.24)	14474.21[b,c] (4706.69)	13468.46 (875.87)	13468.76 (875.87)	13472.06 (875.87)	13505.18 (886.93)	13836.83 (1650.85)	15600.43[b] (14895.48)
Price and production risk	14011.67[c] (2270.73)	13370.18 (2585.35)	14474.21[b,c] (4262.86)	13754.23 (2005.48)	13754.34 (2005.48)	13755.01 (2005.53)	13761.92 (2010.48)	13831.13[b] (2513.94)	14523.64[b] (15292.33)
Price, production and financial risk	14011.67[c] (2270.73)	13370.18 (2554.09)	14474.21[b,c] (4332.64)	13728.05 (1980.66)	13728.29 (1980.66)	13730.43 (1980.72)	13752.46 (1985.61)	13971.45[b] (2476.64)	15851.96[b] (15078.52)
Soybeans									
Price risk	33571.11[c] (4248.50)	32927.80[c] (4026.53)	33871.80[b,c] (9893.12)	33062.38 (2713.20)	33062.56 (2713.20)	33063.44 (2713.20)	33072.98 (2714.23)	33167.85 (2813.70)	33478.91[b] (8967.45)
Price and financial risk	33571.11[c] (4248.50)	32927.80[c] (4044.11)	33871.80[b,c] (9998.53)	33064.50 (2690.15)	33064.50 (2690.15)	33065.39 (2690.15)	33074.75 (2690.83)	33167.68 (2789.75)	33480.89[b] (9050.45)
Price and production risk	33571.11[c] (5937.00)	32927.80 (7566.46)	33871.80[b,c] (9551.67)	33465.84 (5779.11)	33465.84 (5779.11)	33466.13 (5779.11)	33468.94 (5779.58)	33497.16 (5826.90)	33779.04[b] (10316.14)
Price, production and financial risk	33571.11[c] (5937.00)	32927.80 (7518.37)	33871.80[b,c] (9714.49)	33391.38 (5752.91)	33391.38 (5752.91)	33391.86 (5752.91)	33396.28 (5753.38)	33440.46 (5799.91)	33732.45[b] (10439.89)

[a]Standard deviations are shown in parentheses.

[b]Expected returns and standard deviations for speculative position.

[c]E-V efficient marketing strategy.

statistical parameters and no effect on E-V efficiency. The cash and fixed speculative positions are E-V efficient in all cases for both Georgia and Illinois. The fixed size of futures contracts definitely constrains risk responses. Hedging is the optimal position for most risk aversion coefficients for the variable contracts (Table 4), but the fixed hedge is only E-V efficient for Georgia corn (Table 5). Although financial risk does not affect E-V efficiency, production risk has dramatic effects except for Georgia corn. In the other three cases, hedging is efficient when production is nonstochastic but is E-V dominated by the cash position when production risk is considered.

Larger producers (output > 5,000 bushels) could approximate the optimal variable contracts. For example, the optimal hedge is about 33 percent of production for Illinois corn and about 20 percent for Illinois soybeans when production risk is considered (Table 4). A risk averse producer with 15,000 bushels of corn and 25,000 bushels of soybeans could hedge one contract for each commodity to approximate the optimal hedges. However, the differences in parameters of returns of the optimal hedge compared to the fixed cash position are quite small in most cases. Thus, even large risk averse producers will not gain much from a hedge.

Conclusions

This paper presents an empirical analysis of optimal pre-harvest decisions in the cash and futures market that incorporates price, production and financial risk. The theoretical model for the analysis uses a mean-variance preference function with varying levels of the risk aversion parameter. Two statistical parameters are demonstrated to be important in determining the optimal futures market position: (1) expected returns from a futures market transaction, and (2) the covariance of cash returns from production and the futures price at harvest. A positive value for both parameters supports a hedged position while the opposite signs support a speculative position. In the empirical analysis, expected returns are negative in all cases. The covariance is negative for Georgia soybeans, so speculation is optimal for all risk aversion coefficients. In the other cases, the covariance is positive, and hedging is optimal for most levels of risk aversion. However, the ratio of the futures contract to physical production is well below unity for most cases.

The general theoretical framework assumes futures markets transactions are continuous which is inapproximate for many farmers. Therefore, the E-V efficiency of a cash, fixed quantity hedged and fixed quantity speculative strategies are also evaluated. Hedging is E-V efficient only for corn in Georgia when production risk is considered. This corresponds to previous research on this strategy (Kenyon). This study finds little support for pre-harvest hedges. In contrast, the fixed speculative position is E-V efficient for all cases. However, speculative positions have higher risk than the cash position in these cases which corresponds to conventional wisdom. Given that Berck also found speculative positions E-V efficient, more research on this strategy appears promising.

One of the innovative aspects of this research is the consideration of the impact of financial cost of futures market transactions on the expected value and variance of returns. Exclusion of financial costs has no effect in the E-V set of fixed strategies and very limited effect in the variable futures positions. The results serve to support the tendency in the literature to assume these costs are zero (Peck; Chavas and Pope). In contrast, production risk is very crucial in both the optimal variable contract and the fixed contract results. These results support the recent theoretical and empirical emphasis on considering production risk in marketing analysis.

Footnotes

[1]The second order condition assures a maximum

$$\frac{\partial^2 EU(R')}{\partial Q^2} = -2mVar(FH)-2mVar(OC)+4mCov(FH,OC) = -2mVar(FH-OC) < 0$$

where $0 \leq m < \infty$, assuming risk aversion and Var(FH+OC) > 0 by definition.

[2]The financial cost of margins is conservative in several respects. The alternative investment is assumed to be government bonds. If alternative risky investments are assumed, r would be higher. If investors can earn interest on their margin deposits, r would equal the difference between that interest rate and the rate of return in alternative investments.

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