FUTURES MARKETS AND FIRM DECISIONS UNDER PRICE, PRODUCTION, AND FINANCIAL UNCERTAINTY

Vickie J. Alexander, Wesley N. Musser, and George Mason

Abstract

Incorporation of futures markets into the theory of the firm under uncertainty has received considerable attention in risk management. A theoretical model of optimal firm decisions in cash and futures markets considering price, production, and financial risks is presented. Production and marketing strategies for corn and soybeans in Georgia and Illinois are analyzed to determine the optimal amount of futures contracting which may be a hedge or a speculative position. A partial hedge is optimal for most situations for risk averse producers when the amount hedged is variable. With fixed quantity transactions, speculative and cash positions, but not hedging, tend to be E-V efficient.

Key words: financial risk, optimal futures contract, E-V analysis, speculation.

The theory of optimal firm decisions under uncertainty has been the subject of a considerable amount of literature. Sandmo, Leland, and Batra and Ullah advanced the understanding of the decisionmaking process of firms under uncertainty. 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 the use of futures market transactions. 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 markets were concerned only with price risk (Ward and Fletcher; Peck). Subsequently, research has considered production and price risks (Rolfo), price and financial risks (Harris and Baker) and price, production, and some dimensions of financial risks (Lutgen and Helmers; Berck). However, the financial risk arising from margins have not been explicitly considered. In his review of past studies, Kenyon noted a need for more evaluation of marketing strategies involving simultaneous consideration of production, price, and financial risks.

Some of the studies mentioned suggest 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.), a new pricing environment may provide new opportunities (Kenyon). Traditionally, hedging has been viewed as a fundamental use of futures markets for reducing of price risk by farmers (Heifner; Ward and Fletcher; Peck; Hieronymus). However, Paul et al. found farmers also speculating in the futures market. Recent theoretical analyses support the view that this behavior may be consistent with risk averse behavior. Some of these theoretical analyses are based on differences between futures prices and expected cash prices which Kenyon reviewed. However, speculative positions can also be consistent with risk aversion without differences in expectations if a negative covariance exists between cash price and output (McKinnon; Rolfo). 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 con-

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sider 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 risks. This model of marketing decisions is applicable to both hedging and speculation in the futures markets. 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 a speculative position. A comprehensive empirical E-V analysis is included which considers the following marketing strategies: (1) cash sales at harvest, (2) a hedge and a speculative position equal to one futures contract (i.e. 5,000 bu.), and (3) the theoretically optimal size of futures contract which could support a hedge or a speculative position. The strategies are analyzed for both situations since a negative covariance between cash price and yield is more likely in Illinois than in Georgia because of differences in contributions to aggregate production. The futures market strategies are routine with transactions occurring at planting and harvest. The innovative feature of the analysis is the inclusion of simulated risk associated with margin requirements in the analysis. Results from analyses of only price and production risks are also presented to allow evaluation of the importance of financial risk.

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), such that:

$$(1)\ EU = E(R) - mVar(R),$$

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

Assuming production costs do not vary among marketing alternatives and are nonstochastic, risk analysis can be based on gross revenues less costs of futures market transactions (Anderson et al.). Returns for the cash, R, and cash and futures markets, R′, are then specified as follows:

$$(2)\ R = P \bullet Y$$

and

$$(3)\ R' = P \bullet Y + (FP - FH)Q - OC \bullet Q - COM \bullet Q,$$

where: P = random cash price at harvest;
Y = random output;
FP = futures price at planting;
FH = random futures price at harvest;
Q = size of futures contract (Q > 0 represents a hedge and Q < 0 represents 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); and
COM = brokerage commission per bushel.

Risk analysis of the alternatives can be based on specifying a time series of the variables in equations (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 risks 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 the latter two approaches. The analysis also considers Q equal to average yield for the firm and Q equal to the optimal size of futures contract determined by maximization of equation (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 decisionmaking, 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 decisionmaking 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 and can be positive or negative. As margin deposits are required, a farmer may incur increased loan costs or rationing of capital. This cost is usually assumed nonstochastic in analyses of hedging.

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

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

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:

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

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

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

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

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

where E(RF) is expected returns from a futures market transaction which is the numerator of the first term in equation (6) and Var(RF) is the variance of returns from a futures market transaction which is the denominator of the second and third terms in equation (6). The first term is therefore simply the ratio of expected returns from a 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, Cov(P • Y, FH), 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, Cov(P • Y, OC), to Var(RF). The relationship of this term 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^*.

Production and financial risks have different effects on Q^*. Production risk does not affect Var(RF) or the first term. The only impact of production risk 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 is stochastic. In contrast, 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.

DATA

Empirical analysis of the optimal futures contract is based on a time series of variables in equation (2) and equation (3) for 1973-1981, which corresponds with the recent risky pricing environment. The risk parameter, m, in equation (1) is allowed to vary over the risk-averse range $0<m<\infty$. Monthly state average corn and soybean cash prices and annual yields for this period 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 ag-

[1]The second order condition assures a maximum; that is,

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

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

gregation error. However, most output data in historical risk analysis have similar error. Furthermore, aggregate data have been used in previous risk analyses; for example, Rolfo used national data. The acreages required to produce one futures contract of 5,000 bushels were assumed to be 50 acres of corn or 150 acres of soybeans in Illinois. The acreages in Georgia were assumed to be 100 acres of corn or 250 acres of soybeans. Under this formulation, Y in equations (2) and (3) equals output from these numbers of acres.

Corn was assumed to be planted in April in Georgia and in 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 the average prices for these harvest months. With this production timing, November contracts for soybeans and September contracts for corn 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 time series data on margin requirements were unavailable for this study, a procedure to simulate the requirements was developed after consultation with individuals knowledgeable about futures transactions. Margin accounts included an initial margin and maintenance margin. Initial margin was assumed to be 7.5 percent of the average value of the contract during the year for hedging and 10 percent for speculation.

Maintenance margin represents 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 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.

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 the yield of a 6-month U.S. Government Bond was multiplied times the annual margin to obtain the opportunity cost of the margin requirements. The opportunity cost associated with hedging is:

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

where: OCH = opportunity cost of margin deposits associated with hedging;

IMH = initial margin required for hedging;

MRH_t = additional margin requirement for hedging:

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

or

$= 0$, 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; and

r = semi-annual interest rate.

The opportunity cost associated with speculation is:

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

where: OCS = opportunity cost of margin deposits associated with speculation;

IMS = initial margin required for speculation;

TABLE 1. AVERAGE MARGIN REQUIREMENTS PER BUSHEL, OPPORTUNITY COST OF MARGIN REQUIREMENTS PER BUSHEL, INTEREST RATES, AND COMMISSION FOR CORN AND SOYBEANS FUTURES TRADING FOR THE HEDGER AND SPECULATOR, 1973-1981

Year	Corn (April-September)				Corn (May-September)				Soybeans (June-November)				Commission	Annual interest rates[a]
	Annual margin requirements		Opportunity cost of margin requirements		Annual margin requirements		Opportunity cost of margin requirements		Annual margin requirements		Opportunity cost of margin requirements			
	Hedger	Speculator	Hedger	Speculator	Hedger	Speculator	Hedger	Speculator	Hedger	Speculator	Hedger	Speculator		
	(dollars/bushel)													
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.

MRS_t = additional margin requirement for speculation:

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

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

or

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

or

$= 0$, 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; and

r = semi-annual interest rate.

Differences in average daily prices in the equations reflect either losses or profits, depending on the 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 the 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

TABLE 2. SAMPLE MEANS OF ALL VARIABLES AND SAMPLE VARIANCE-COVARIANCE OF STOCHASTIC VARIABLES USED, 1973-1981[a]

	$P{\bullet}Y_{CG}$	FP_{CG}	FH_{CG}	OCH_{CG}	OCS_{CG}	$P{\bullet}Y_{SG}$	FP_{SG}	FH_{SG}	OCH_{SG}	OCS_{SG}
Mean	13803.44	2.68	2.78	0.0321	0.0429	32910.56	6.52	6.62	0.0800	0.1075
$P{\bullet}Y_{CG}$	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					
$P{\bullet}Y_{SG}$						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

	$P{\bullet}Y_{CI}$	FP_{CI}	FH_{CI}	OCH_{CI}	OCS_{CI}	$P{\bullet}Y_{SI}$	FP_{SI}	FH_{SI}	OCH_{SI}	OCS_{SI}	COM
Mean	14011.67	2.67	2.78	0.0297	0.0428	33571.11	6.52	6.62	0.0800	0.1075	0.0092
$P{\bullet}Y_{CI}$	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						
$P{\bullet}Y_{SI}$						35249095		1699.16	152.088	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, 1973-1981[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).

[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 then equal the difference between that interest rate and the rate of return in alternative investments.

analysis. The following procedure was then utilized to accommodate this discontinuity: (1) Q^* was calculated with both sets of parameters for OC, (2) if $Q^* > 0$ (<O) from both estimates, the value from using moments of OC from hedging (speculating) 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.

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 equations (6) or (7). The negative signs on expected returns of a futures market transaction, E(RF), in Table 3 support speculative positions in four situations. These negative signs occur 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 have yielded 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. Thus, a speculative position would definitely be optimal in this case; the optimal position in 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 risk aversion (m). In the computations, the same sign for Q^* was obtained with the moments for opportunity costs of hedging and speculation, so the third step in the computations identified in the previous section was unnecessary. As discussed, speculation was always optimal for soybeans in Georgia. For the other situations, hedging was optimal for risk aversion coefficients greater than .00001 for corn in Georgia and soybeans in Illinois, while hedging was optimal for m greater than .0001 for corn in Illinois.

Since m is inversely related to the size of the first term in equations (6) and (7), these results are consistent with the sign of expected returns from a hedge discussed previously. More risk averse producers are willing to trade the loss in expected returns for the reduction in variance arising from positive covariances between gross revenue and futures price at harvest as well as opportunity costs of margins. 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^* was the same with financial risk excluded as when included in all cases. Magnitudes of the optimal ratios were 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} was 0.29087 and its covariance with $P \cdot Y_{CG}$ was 1,525.35 while the variance of OCH_{CG} was 0.00032 and its covariance with $P \cdot Y_{CG}$ was 15.1924, Table 2.

A further implication of these results is that the magnitude and sign of the covariance between P • Y and FH is the crucial parameter determining the sign of Q^*. Positive covariances in these three variables resulted in hedges being optimal for risk averse individuals in three of the situations analyzed, Table 4. This result is seemingly a paradox because negative covariances are usually associated with risk reduction. However, futures price at harvest (FH) is actually an input for a hedger and positive covariances between revenue and input costs reduce the variance of returns (Musser et al.). The negative sign on Cov(P • Y,FH) in equation (4) supports this relationship in choosing futures market transactions.

Since most producers cannot freely vary Q^*, a cash, hedge, and speculative positions with a fixed contract at an amount equal to average yield (i.e., 5,000 bushels) were analyzed with equations (2), (3), (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 no effect on E-V efficiency and has a limited effect on statistical parameters. 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 constrain 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.

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

Sources of risk by commodity and state[b]	Risk parameter (m)[a]					
	≥1	.1	.01	.001	.0001	.00001
	percent					
Georgia						
Corn						
Price and production risks	104.42	104.37	103.93	99.51	55.29	−424.08
Price, production and financial risks	105.29	105.25	104.82	100.50	57.29	−410.10
Soybeans						
Price and production risks	−6.85	−6.86	−6.97	−8.13	−19.74	−135.87
Price, production and financial risks	−7.12	−7.14	−7.25	−8.37	−19.64	−132.24
Illinois						
Corn						
Price and production risks	36.45	36.41	35.97	31.61	−15.44	−482.46
Price, production and financial risks	37.64	37.60	37.17	32.89	−12.61	−466.75
Soybeans						
Price and production risks	21.18	21.17	21.07	20.02	9.59	−111.87
Price, production and financial risks	22.61	22.60	22.50	21.48	11.26	−109.49

[a]A (+) sign represents a hedge while a (−) sign indicates a speculative position.
[b]Average production values are 5,022, 5,306, 5,417, and 5,143 bushels of Georgia corn, Georgia soybeans, Illinois corn, and Illinois soybeans, respectively.

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		Varible futures contract risk parameter (m)					
		Hedge	Speculation	≥1	.1	.01	.001	.0001	.00001
Georgia									
Corn									
Price and production risks	13803.44[b]	13200.44[b]	14211.05[b,c]	13267.08	13267.29	13268.82	13284.67	13442.80	15024.39[c]
	(3903.13)	(2693.08)	(6144.89)	(2689.86)	(2689.86)	(2689.89)	(2693.16)	(3000.96)	(14564.78)
Price, production, and financial risks	13803.44[b]	13200.44[b]	14211.05[b,c]	13176.17	13176.28	13177.84	13192.98	13344.20	14653.08[c]
	(3903.13)	(2693.09)	(6180.84)	(2691.70)	(2691.70)	(2691.76)	(2692.24)	(2671.20)	(14356.93)
Soybeans									
Price and production risks	32910.56[b]	32267.24	33211.30[b,c]	32945.74[c]	32945.74[c]	32946.03[c]	32948.84[c]	32977.06[c]	33258.94[c]
	(7605.04)	(10124.01)	(9548.05)	(7591.50)	(7591.50)	(7591.50)	(7591.98)	(7639.39)	(11433.65)
Price, production, and financial risks	32910.56[b]	32267.24	33211.30[b,c]	32889.04[c]	32889.04[c]	32889.32[c]	32891.81[c]	32916.73[c]	33165.85[c]
	(7605.04)	(10177.49)	(9589.12)	(7589.53)	(7589.55)	(7589.55)	(7589.87)	(7633.64)	(11247.07)
Illinois									
Corn									
Price and production risks	14011.67[b]	13370.18	14474.21[b,c]	13754.23	13754.34	13755.01	13761.92	13831.13[c]	14523.64[c]
	(2270.73)	(2585.35)	(4262.86)	(2005.48)	(2005.48)	(2005.53)	(2010.48)	(2513.94)	(15292.33)
Price, production, and financial risks	14011.67[b]	13370.18	14474.21[b,c]	13728.05	13728.29	13730.43	13752.46	13971.45[c]	15851.96[c]
	(2270.73)	(2554.09)	(4332.64)	(1980.66)	(1980.66)	(1980.72)	(1985.61)	(2476.64)	(15078.52)
Soybeans									
Price and production risks	33571.11[b]	32927.80	33871.80[b,c]	33465.84	33465.84	33466.13	33468.94	33497.16	33779.04[c]
	(5937.00)	(7566.46)	(9551.67)	(5779.11)	(5779.11)	(5779.11)	(5779.58)	(5826.90)	(10316.14)
Price, production, and financial risks	33571.11[b]	32927.80	33871.80[b,c]	33391.38	33391.38	33391.86	33396.28	33440.46	33732.45[c]
	(5937.00)	(7518.37)	(9714.49)	(5752.91)	(5752.91)	(5752.91)	(5753.38)	(5799.91)	(10439.89)

[a]Standard deviations are shown in parentheses.
[b]E-V efficient marketing strategy.
[c]Expected returns and standard deviations for speculative position.

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, 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 returns of the optimal hedge compared to the fixed cash position are quite small in most cases. Thus, even large risk averse producers would not gain much from a hedge.

CONCLUSIONS

An empirical analysis of optimal pre-harvest decisions in the cash and futures markets incorporating price, production, and financial risks is presented. 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. Positive values for both parameters support a hedge 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 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 in most cases.

The general theoretical framework assumes that futures market transactions are continuous, which is inappropriate for many farmers. Therefore, the E-V efficiency of cash, fixed hedge, and fixed speculative strategies are also evaluated. Hedging is E-V efficient only for corn in Georgia, which corresponds to previous research on this strategy (Kenyon). This study finds little support for preharvest hedges. In contrast, the fixed speculative position is E-V efficient in 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 to be E-V efficient, more research on this strategy appears promising.

One of the innovative aspects of this research is consideration of the impact of financial costs of futures market transactions on the expected value and variance of returns. Exclusion of financial costs has no effect on the E-V efficient set of fixed strategies and has limited, if any, effect on the variable futures positions. The results serve to support the tendency in the literature to assume these costs are zero (Peck; Chavas and Pope). Given the risk associated with futures market transactions, the government interest rate may be too low. Especially in cases where capital constraints are effective, the opportunity cost for the margin requirements could be much higher which would result in an even lower expected value and higher variance of returns. Berck supports this reasoning in the substitution of more capital intensive production activities for futures market transactions in some solutions. Furthermore, the more important aspect of financial risk on futures market transactions probably is the risk in financial requirements rather than on returns, which was not considered in this paper. More research on the impact of financial risk under capital rationing appears warranted.

As with *all* risk management research, the empirical analysis in this paper has limitations for prescriptive applications. Besides the financial issues discussed previously, the use of state average cash prices and yields and monthly average futures prices can be challenged. Admittedly, state average yields have considerable aggregation error and also bias production risk and, perhaps, cash returns risk downward. Their use in this paper is primarily for convenience and general awareness for readers compared to alternatives such as county average data. The alternative of using firm level data also is not without problems: how representative are the data for one firm? Monthly average futures price data also have pros and cons. These data represent the average situation facing producers within the month but do not represent the outcomes for a single transaction on one day which any producer would face. However, the alternative of basing analyses on transactions for one day also is hazardous. The distribution of prices for one day can be severely biased because of random fluctuations in the historical data. Furthermore, one cannot argue that this situation is representative since widespread futures market transactions that implement desirable marketing strategies would likely have the aggregate consequence of eliminating the desirable feature of this particular day. More methodological research on these issues is necessary before the prescription can be made on the basis of this research. The research does raise issues which extension, classroom, and farm users of futures market strategies need to consider within their particular decision contexts. Most risk management research has a similar conceptive use rather than a prescriptive use.

REFERENCES

Anderson, J. R., J. L. Dillon, and J. B. Hardaker. *Agricultural Decision Analysis.* Ames, Iowa: The Iowa State University Press, 1977.

Batra, R. N. and A. Ullah. "Competitive Firm and the Theory of Input Demand Under Price Uncertainty." *J. Pol. Econ.*, 82(1974): 537-48.

Berck, P. "Portfolio Theory and the Demand for Futures: The Case of California Cotton." *Amer. J. Agr. Econ.*, 63,3(1981): 467-74.

Board of Governors of the Federal Reserve. *Federal Reserve Bulletin.* Washington, D.C., 1973-1981.

Chavas, J. P. and R. D. Pope. "Hedging and Production Decisions Under a Linear Mean-Variance Preference Function." *West. J. Agr. Econ.*, 7(1982): 99-110.

Chicago Board of Trade. Unpublished data. Chicago, Illinois. 1973-1981.

Feder, G., R. E. Just, and A. Schmitz. "Futures Markets and the Theory of the Firm Under Price Uncertainty." *Quarterly J. Econ.*, 44(1980): 317-28.

Harris, K. S. and C. R. Baker. "Does Hedging Increase Credit for Illinois Crop Farmers?" *No. Cent. J. Agr. Econ.*, 3(1981): 47-52.

Heifner, R.G. "Implications of Hedging for the Agricultural Lender." *Agr. Fin. Review*, 33(1972): 8-12.

Hieronymus, T. A. *Economics of Futures Trading.* New York: Commodity Research Bureau, Inc., 1977.

Kahl, Kandice H. "Determination of the Recommended Hedging Ratio." *Amer. J. Agr. Econ.*, 65,3(1983): 603-5.

Kenyon, D. E. "Hedging Strategies for Farmers: Current Knowledge and Research Needs." Selected Paper Presented at the Southern Agricultural Economics Association Meetings, Nashville, Tennessee, February 5-8, 1984.

Leland, H. "Theory of the Firm Facing Random Demand." *Amer. J. Agr. Econ.*, 62,3(1972): 278-91.

Lutgen, L. H. and G. A. Helmers. "Simulation of Production-Marketing Alternatives for Grain Farms Under Uncertainty." *No. Cent. J. Agr. Econ.*, 1(1979): 23-30.

McKinnon, R. I. "Futures Markets, Buffer Stocks, and Income Instability for Primary Producers." *J. Polit. Econ.*, 75(1967): 811-61.

Musser, Wesley N., H. P. Mapp, Jr., and P. J. Barry. "Application I: Risk Programming". *Risk Management in Agriculture*, P. J. Barry, editor. Ames, Iowa: The Iowa State University Press, 1984; pp. 129-47.

Paul, A. B., R. G. Heifner, and J. W. Helmuth. *Farmer's Use of Forward Contracts and Futures Markets,* Agricultural Economic Report No. 320, Economic Research Service, U.S. Department of Agriculture; March, 1976.

Peck, A. E. "Hedging and Income Stability: Concepts, Implications, and an Example." *Amer. J. Agr. Econ.*, 57,3(1975): 410-9.

Rolfo, J. "Optimal Hedging Under Price and Quantity Uncertainty: The Case of a Cocoa Producer." *J. Polit. Econ.*, 88(1980): 100-16.

Sandmo, A. "Competitive Firm Under Price Uncertainty." *Amer. Econ. Rev.*, 61(1971): 65-73.

U. S. Department of Agriculture, Statistical Reporting Service. *Agricultural Prices, Annual Summary.* Washington, D.C., 1973-1981.

____________. *Crop Production, Annual Summary.* Washington, D.C., 1973-81.

Ward, R. W. and L. B. Fletcher. "From Hedging to Speculation: A Micro Model of Optimal Futures and Cash Market Positions." *Amer. J. Agr. Econ.*, 53,1(1971): 71-8.