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Simultaneously Derived Optimal Hedge Ratios for East Central Illinois Corn and Soybean Producers

by

Jonathan M. Norvell and Raymond M. Leuthold

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Farm incomes are subject to a variety of risks. One risk is the price variability of commodities produced on farms. The management of price risks faced by East Central Illinois (ECI) corn and soybean producers is the subject of this study. Prices of corn and soybean are volatile. The average difference between high and low price offered during each crop year from 1975 to 1989 was $0.98 for corn and $2.56 for soybeans (Good). One method of managing price risks is hedging in futures contracts.

Much research has dealt with the determination of optimal or minimum risk hedge ratios for hedgers seeking to reduce risk on a commodity. Modern optimal hedging theory is based on seminal studies by Johnson (1960) and Stein (1961). Resulting works such as Peck (1975), Ederington (1979) and more recently, Bond, Thompson and Lee (1987) and Meyers and Thompson (1989) have further developed and defined a standard approach to optimal hedging. The standard approach is to apply optimal hedging theory to a single commodity and use the slope coefficient of an OLS regression to estimate the optimal hedge ratio for that particular commodity.

Modifications and adaptations of the standard approach have been developed. One area that has evolved is the issue of simultaneous, multiple risks which were investigated in Anderson and Danthine (1980), Bond, Thompson and Geldard (1985), Benninga, Eldor and Zilcha (1985), Alexander, Musser and Mason (1986) and Peterson and Leuthold (1987).

A recent article in the Journal of Futures Markets by Tzang and Leuthold (1990) derived a model to generate simultaneous minimum risk hedge ratios among commodities linked by a fixed production relationship. This model extended the standard optimal hedge model to include the inherent risk reduction due to price correlation among differing commodities. Tzang and Leuthold applied their simultaneous model to the soybean complex.

The objectives of this study are to determine *ex-post* minimum-risk hedge ratios first with the standard, single-commodity model and then with a multiple risk, simultaneous model. Both sets of hedge ratios will then be evaluated in *out-of-sample* performance. These tests and evaluations will be applied to producers in ECI who face multiple price risks from corn and soybeans at the same time. The hedge ratios from the simultaneous model are expected to differ from those generated by the single-commodity model because of positive correlation between corn and soybean prices. The hedge ratios will be estimated each month for each crop year from 1976 to 1989 to see how they vary within each year, seasonally, and over the entire data period.[1]

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[1] Recent research has suggested that hedge ratios may vary over time (Meyers (1991)).

MODEL

In the context of modern portfolio theory, investors are assumed to consider the mean and variance of expected returns when appraising portfolios. The expected utility (E(U)) function assumed for the portfolio investor is the following quadratic function:

$$E(U_i) = E(R_i) - \lambda(\sigma^2_i)$$

where i is any portfolio of assets, R_i is returns, and σ^2_i is the variance of the portfolio returns. Rational investors, seeking to maximize utility, would seek to maximize the above function.

In application to hedging, the objective of the hedger is assumed to be to maximize returns subject to a level of variance on those returns, or to minimize the variance. The hedged, gross returns for corn, R_C, and soybeans, R_S, can be defined as:

$$R_C = P_{C2}Q_C + H_C (F_{C1} - F_{C2}) \quad \text{and} \quad R_S = P_{S2}Q_S + H_S (F_{S1} - F_{S2})$$

where:
- P = cash prices
- F = futures prices
- C = corn
- S = soybeans.
- Q = cash quantity
- H = quantity hedged in futures contracts
- 1,2 = represent time periods, variables in period 2 are unknown.

The standard approach for determining hedge ratios for these returns would be to separately minimize the variance of corn returns, $\sigma^2 R_C$, with respect to H_C, and the variance of soybean returns, $\sigma^2 R_S$, with respect to H_S. The standard minimum risk hedge ratios (SHR) equal:

$$H'_C = cov(P_C,F_C)/\sigma^2 F_C \quad \text{and} \quad H'_S = cov(P_S,F_S)/\sigma^2 F_S,$$

where H'_C and H'_S are the slope coefficients from two separate OLS regressions of P_C on F_C and P_S on F_S. The standard estimation form is:

$$\Delta P = \alpha + \beta \Delta F$$

where α and β = parameters and Δ = change in, or first difference, of prices.

The multiple-risk model, using a simultaneous approach, minimizes the variance for returns of multiple commodities together (Anderson and Danthine (1980)). Under the simultaneous approach the gross returns from two commodities considered together is:

$$R = P_{C2}Q_C + H_C (F_{C1} - F_{C2}) + P_{S2}Q_S + H_S (F_{S1} - F_{S2}).$$

The variance of returns is:

$$\begin{aligned}\sigma^2(R) = {} & \sigma^2 P_C Q^2_C + \sigma^2 P_S Q^2_S + \sigma^2 F_C H^2_C + \sigma^2 F_S H^2_S + 2cov(P_C P_S)Q_C Q_S \\ & - 2cov(P_C F_C)Q_C H_C - 2cov(P_C F_S)Q_C H_S - 2cov(P_S F_C)Q_S H_C \\ & - 2cov(P_S F_S)Q_S H_S + 2cov(F_C F_S)H_C H_S.\end{aligned}$$

The minimization of $\sigma^2(R)$ occurs at a point where the first derivatives of $\sigma^2(R)$ with respect to H_C and H_S are equal to zero. The first derivatives are:

The above coefficients will be estimated and the values substituted into the simultaneous hedge ratio model to estimate the hedge ratios. The CHR are equal to the SHR when the correlation between: corn futures price and soybean futures prices = 0, corn cash prices and soybean futures prices = 0, and soybean cash prices and corn futures prices = 0.

The resulting CHR will be compared to the SHR. It is expected that the multiple risk optimal hedge ratios will differ from the traditional single-commodity hedge ratios because corn and soybean prices are usually positively correlated.

DATA

Price data from January, 1975 through August, 1990 will be studied. The data represent a twenty-four month marketing year for fourteen different crop years from the 1974 crop to the 1989 crop. The prices to be used are monthly averages. Futures prices are the Chicago Board of Trade settlement prices. Cash price data are the ECI cash bid, which is not a farmer bid, but represents a rail bid from 1975 to 1980 and a truck bid from 1981 to the present. The margin between the ECI bid price and the price offered to ECI farmers is relatively constant (Harwood and Tomek, 1987). The ECI price is preferred over individual elevator prices because it is free from localized basis changes. Therefore, correlation between the ECI price and the futures price is expected to be similar to the correlation between the average country elevator's price and the futures price.

RESULTS

Ex post hedge ratios and their hedge effectiveness are estimated for corn and soybeans from historical prices. The standard optimal hedge model and the complex, simultaneous model were used to estimate minimum risk hedge ratios over the entire data set. All hedge ratios were based on first differenced, monthly average nearby futures prices and cash prices (Meyers and Thompson (1989)).

The results for the separate, single-commodity hedge ratios over the entire data set (180 observations, January, 1975 through December, 1989) was 0.942 for corn and 0.951 for soybeans. The results of the complex, simultaneous model estimated over the entire data set were 0.839 for corn, and 0.974 for soybeans. These ratios are near the ratios estimated for Michigan prices in Meyers and Thompson (1989). The minimum risk hedge ratios for soybeans in this study were higher than those estimated in Miller and Kahl (1989). However, the ratios were within the range of those estimated with a conventional model in Harwood and Tomek (1987). The ratios are much greater than those estimated by Alexander, et al. (1986).

Hedge ratios were also estimated each month for corn and soybeans from January, 1976 through December, 1989. A total of 672 ratios were estimated. All hedge ratios were estimated from OLS regressions based on a rolling data set of observations of the preceding twelve months. For example, the ratio for corn listed under February, 1976 was estimated from twelve monthly observations from February, 1975 through January, 1976. The monthly minimum risk hedge ratios are summarized yearly and seasonally. Monthly hedge ratios are reported in Tables 1-4. The mean, standard deviation (STD), maximum and minimum are also presented.

For corn prices, the mean of separate hedge ratios estimated was 0.981 the mean for the simultaneous, complex model was 0.811. For soybean prices, the average separately estimated hedge ratio was 0.94 and the average CHR was 1.02.

$$\frac{dR}{dH_C} = F_{C1} - F_{C2} - \lambda[H_C\sigma^2_{CF} - \sigma_{C,CF}Q_C - \sigma_{S,CF}Q_S + \sigma_{CF,SF}H_S]$$

$$\frac{dR}{dH_S} = F_{S1} - F_{S2} - \lambda[H_S\sigma^2_{SF} - \sigma_{C,SF}Q_C - \sigma_{S,SF}Q_S + \sigma_{CF,SF}H_C]$$

where:
C = spot, or cash, corn
S = spot, or cash, soybeans
CF = corn futures
SF = soybean futures.

Equating the above equations to zero and solving for H_C and H_S results in:

$$H_C = \frac{F_{C1} - F_{C2}}{\lambda\sigma^2_{CF}} + \frac{\sigma_{C,CF}Q_C}{\sigma^2_{CF}} + \frac{\sigma_{S,CF}Q_S}{\sigma^2_{CF}} - \frac{\sigma_{CF,SF}H_S}{\sigma^2_{CF}}$$

$$H_S = \frac{F_{S1} - F_{S2}}{\lambda\sigma^2_{SF}} + \frac{\sigma_{C,SF}Q_C}{\sigma^2_{SF}} + \frac{\sigma_{S,SF}Q_S}{\sigma^2_{SF}} - \frac{\sigma_{CF,SF}H_C}{\sigma^2_{SF}}.$$

Futures markets for corn and soybeans are assumed to be unbiased. In an unbiased futures market $F_1 - F_2 = 0$. The speculative component equals zero and the minimum risk hedge ratio is equivalent to the optimal hedge ratio (Bond, Thompson and Lee (1987)). Therefore, the simultaneous optimal hedge model used in this study will minimize variance (risk). Q_C and Q_S are assumed equal to one. Recall that $\sigma_{i,j}/\sigma^2_j$ is equal to the slope coefficients, $\beta_{i,j}$, from an OLS regressions of i on j. Rearranging, substituting the βs and applying Cramer's Rule to solve two equations for two unknowns yields the following:

$$H_C = \frac{\beta_{C,CF} + \beta_{S,CF} - \beta_{SF,CF}\beta_{C,SF} - \beta_{SF,CF}\beta_{S,SF}}{1 - \beta_{SF,CF}\beta_{CF,SF}}$$

$$H_S = \frac{\beta_{C,SF} + \beta_{S,SF} - \beta_{CF,SF}\beta_{C,CF} - \beta_{CF,SF}\beta_{S,CF}}{1 - \beta_{SF,CF}\beta_{CF,SF}}.$$

Thus, the simultaneous, complex hedge ratios (CHR) may be estimated from a series of six OLS regressions. The six regressions are:

$\beta_{C,CF}$ = change in corn cash prices on change in corn futures prices,
$\beta_{S,CF}$ = change in soybean cash prices on change in corn futures prices,
$\beta_{SF,CF}$= change in soybean futures prices on change in corn futures prices,
$\beta_{C,SF}$ = change in corn cash prices on change in soybean futures prices,
$\beta_{S,SF}$ = change in soybean cash prices on change in soybean futures prices,
$\beta_{CF,SF}$= change in corn futures prices on change in soybean futures prices.

Results of Regression of Corn Cash Price Changes on
Futures Price Changes; Each Regression Contains 12 Observations.

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	STD
1976	0.629	0.593	0.555	0.572	0.572	0.623	0.630	0.651	1.145	0.900	0.934	0.928	0.728	0.195
1977	1.027	1.020	1.006	0.995	1.007	0.917	0.978	0.958	0.922	1.148	1.050	1.261	1.024	0.096
1978	1.216	1.254	1.224	1.151	1.158	1.175	1.120	1.153	1.198	1.213	1.254	1.077	1.183	0.054
1979	1.109	1.108	1.108	1.175	1.129	1.109	1.050	1.014	0.909	0.922	0.924	0.917	1.039	0.098
1980	0.906	1.013	0.989	0.954	0.957	0.979	1.041	0.996	1.066	1.028	0.997	0.929	0.988	0.046
1981	0.893	0.785	0.809	0.799	0.790	0.754	0.775	0.685	0.699	0.769	0.772	0.922	0.788	0.067
1982	0.836	0.869	0.870	0.876	0.915	0.965	0.951	0.970	0.982	0.858	0.794	1.017	0.909	0.068
1983	1.196	0.993	1.049	1.104	1.119	1.153	1.160	1.084	0.892	0.945	0.841	0.831	1.031	0.128
1984	0.846	0.877	0.846	0.830	0.784	0.810	0.818	0.845	0.961	0.932	1.024	1.003	0.881	0.079
1985	1.002	1.039	1.044	0.992	0.912	0.887	0.867	0.742	0.500	0.691	0.315	0.747	0.812	0.226
1986	0.816	0.802	0.772	0.747	0.736	0.800	0.794	1.291	1.738	1.728	1.813	1.927	1.164	0.496
1987	1.731	1.696	1.713	1.762	1.662	1.647	1.652	1.112	0.898	0.877	0.915	0.891	1.380	0.395
1988	0.933	0.910	0.878	0.874	0.878	0.845	0.889	0.908	0.893	0.895	0.892	0.907	0.892	0.022
1989	0.907	0.908	0.908	0.907	0.913	0.912	0.964	0.973	1.069	1.025	0.813	0.777	0.923	0.080
MEAN	1.004	0.991	0.984	0.981	0.967	0.970	0.978	0.956	0.991	0.995	0.953	1.010	0.981 *	0.255 *
STD	0.261	0.257	0.266	0.277	0.257	0.249	0.242	0.181	0.278	0.251	0.322	0.294	0.942 **	
MAX	1.731	1.696	1.713	1.762	1.662	1.647	1.652	1.291	1.738	1.728	1.813	1.927		
MIN	0.629	0.593	0.555	0.572	0.572	0.623	0.630	0.651	0.500	0.691	0.315	0.747		

* The mean and standard deviation of all hedge ratios, January 1976 – December 1989.

** The Minimum Risk Hedge Ratio for the entire data set, January 1975 through December 1989, 180 Observations.

Table 1. Traditional, Separately Derived Mimimum Risk Hedge Ratios for Corn.

Results of Simultaneously Derived Hedge Ratios for Corn; Each Regression Contains 12 Observations.

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	STD
1976	−0.529	−0.674	−0.753	−0.690	−0.567	−0.670	−0.300	−0.290	0.058	−0.064	0.606	0.419	−0.288	0.455
1977	0.420	0.331	0.241	0.329	0.469	0.266	0.205	0.133	0.535	0.396	0.310	1.119	0.396	0.254
1978	1.044	1.154	1.148	1.067	0.902	1.241	1.361	0.375	1.112	1.633	1.826	1.694	1.213	0.390
1979	1.681	1.731	1.805	1.927	1.674	1.604	1.827	2.003	1.570	1.421	1.257	1.169	1.639	0.254
1980	1.253	1.329	1.147	1.149	1.156	0.993	1.101	0.485	0.884	0.629	0.953	0.905	0.999	0.248
1981	0.977	0.626	0.714	0.528	0.623	0.491	0.507	0.458	0.487	0.913	0.971	1.055	0.696	0.223
1982	0.782	0.119	−0.044	−0.051	−0.231	−0.528	−0.090	−0.025	0.465	0.227	−0.066	0.196	0.063	0.335
1983	1.097	0.458	0.796	1.014	0.859	1.380	1.453	1.866	1.388	1.418	1.090	0.975	1.150	0.373
1984	0.898	1.068	1.019	0.712	0.477	0.591	0.376	0.512	0.864	0.487	0.845	0.812	0.722	0.229
1985	0.826	0.869	0.869	0.608	0.433	0.588	0.681	0.675	0.341	2.206	0.972	2.357	0.952	0.648
1986	2.182	1.963	1.852	1.644	1.677	1.529	1.463	1.904	2.052	2.125	2.335	1.798	1.877	0.269
1987	1.616	1.508	1.272	1.408	1.336	1.616	1.469	−0.825	−0.187	−0.462	0.071	−0.208	0.718	0.946
1988	−0.125	−0.265	0.521	0.484	0.438	0.374	0.467	0.724	0.681	0.709	0.698	0.751	0.455	0.330
1989	0.744	0.745	0.726	0.725	0.745	0.755	0.925	0.911	1.685	1.497	−0.071	−0.181	0.767	0.525
MEAN	0.919	0.783	0.808	0.775	0.714	0.731	0.818	0.636	0.853	0.938	0.843	0.919	0.811 *	0.694 *
STD	0.697	0.751	0.689	0.678	0.639	0.730	0.652	0.827	0.644	0.804	0.684	0.726	0.839 **	
MAX	2.182	1.963	1.852	1.927	1.677	1.616	1.827	2.003	2.052	2.206	2.335	2.357		
MIN	−0.529	−0.674	−0.753	−0.690	−0.567	−0.670	−0.300	−0.825	−0.187	−0.462	−0.071	−0.208		

* The mean and standard deviation of all hedge ratios, January 1976 – December 1989.

** The Minimum Risk Hedge Ratio for the entire data set, January 1975 through December 1989, 180 Observations.

Table 2. Simultaneously Derived, Complex Hedge Ratios for Corn.

Results of Regression of Soybean Cash Price Changes on
Futures Price Changes; Each Regression Contains 12 Observations.

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	STD
1976	0.838	0.858	0.877	0.883	0.877	0.870	0.898	0.919	0.936	0.894	0.879	0.914	0.887	0.027
1977	0.923	0.917	0.919	0.933	0.945	0.934	0.984	0.976	0.999	0.999	1.000	1.010	0.962	0.036
1978	1.008	1.009	1.009	1.005	1.002	1.006	1.006	1.111	1.031	0.958	0.950	0.848	0.995	0.061
1979	0.855	0.847	0.847	0.631	0.634	0.600	0.671	0.660	0.755	0.863	0.943	0.939	0.770	0.126
1980	0.920	0.915	1.011	0.960	0.965	1.011	0.963	1.007	1.010	1.036	0.997	1.001	0.983	0.038
1981	0.994	0.972	0.973	0.967	0.955	0.941	0.961	0.970	0.969	0.968	0.981	0.988	0.970	0.014
1982	0.959	0.980	0.975	0.976	0.931	1.002	0.953	0.914	1.099	0.993	1.001	1.084	0.989	0.055
1983	1.135	1.088	1.091	1.108	1.135	1.094	1.106	1.001	0.998	0.991	0.974	0.979	1.058	0.064
1984	0.971	0.965	0.966	0.965	0.967	0.972	0.988	0.992	0.980	0.964	0.967	0.965	0.972	0.010
1985	0.969	0.982	0.987	0.983	0.980	0.935	0.890	0.893	0.931	0.785	0.776	0.830	0.912	0.078
1986	0.949	0.951	0.932	0.913	0.914	0.977	1.007	0.958	0.959	0.812	0.729	0.959	0.922	0.077
1987	0.910	0.872	1.036	1.012	1.024	1.039	1.064	0.910	0.871	0.793	0.779	0.819	0.927	0.104
1988	0.829	0.847	0.788	0.781	0.812	0.844	0.857	0.871	0.859	0.857	0.872	0.875	0.841	0.032
1989	0.875	0.874	0.872	0.872	0.877	0.873	0.940	0.917	1.123	1.066	1.121	1.191	0.967	0.122
MEAN	0.938	0.934	0.949	0.928	0.930	0.936	0.949	0.936	0.966	0.927	0.926	0.957	0.940 *	0.097 *
STD	0.080	0.071	0.082	0.114	0.114	0.119	0.104	0.100	0.095	0.092	0.107	0.101	0.951	**
MAX	1.135	1.088	1.091	1.108	1.135	1.094	1.106	1.111	1.123	1.066	1.121	1.191		
MIN	0.829	0.847	0.788	0.631	0.634	0.600	0.671	0.660	0.755	0.785	0.729	0.819		

* The mean and standard deviation of all hedge ratios, January 1976 – December 1989.

** The Minimum Risk Hedge Ratio for the entire data set, January 1975 through December 1989, 180 Observations.

Table 3. Traditional, Separate Derived Mimimum Risk Hedge Ratios for Soybeans.

Results of Simultaneously Derived Hedge Ratios for Soybeans; Each Regression Contains 12 Observations.

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	STD
1976	1.303	1.396	1.428	1.408	1.356	1.414	1.204	1.225	1.159	1.108	0.952	1.012	1.247	0.164
1977	1.060	1.081	1.109	1.077	1.022	1.023	1.067	1.056	1.051	1.066	1.069	1.039	1.060	0.025
1978	1.039	1.034	1.034	1.030	1.061	1.015	0.981	1.321	1.102	0.930	0.879	0.739	1.014	0.138
1979	0.756	0.728	0.694	0.474	0.598	0.600	0.506	0.579	0.588	0.721	0.895	0.909	0.671	0.139
1980	0.872	0.861	1.017	0.920	0.925	1.061	1.073	1.187	1.091	1.161	1.004	1.004	1.014	0.106
1981	0.964	1.007	0.990	1.022	0.983	0.995	1.019	1.002	1.005	0.907	0.905	0.935	0.978	0.041
1982	0.985	1.286	1.369	1.375	1.466	1.702	1.482	1.437	1.402	1.335	1.485	1.554	1.407	0.172
1983	1.244	1.417	1.279	1.209	1.333	0.981	0.946	0.615	0.851	0.837	0.880	0.912	1.042	0.246
1984	0.923	0.887	0.903	0.974	1.020	1.005	1.063	1.046	0.972	1.038	0.979	0.985	0.983	0.056
1985	0.988	1.002	1.010	1.016	1.023	0.945	0.905	0.898	0.984	0.023	0.486	−0.150	0.761	0.413
1986	0.207	0.388	0.392	0.478	0.482	0.534	0.593	0.413	1.052	0.831	0.514	1.211	0.591	0.294
1987	1.159	1.266	1.788	1.680	1.444	1.064	1.198	2.107	1.526	1.598	1.290	1.447	1.464	0.299
1988	1.372	1.445	0.959	0.980	1.026	1.000	1.029	0.935	0.933	0.923	0.933	0.924	1.038	0.178
1989	0.927	0.926	0.929	0.929	0.927	0.921	0.937	0.890	0.988	0.946	1.388	1.449	1.013	0.191
MEAN	0.986	1.052	1.064	1.041	1.048	1.019	1.000	1.051	1.050	0.959	0.976	0.998	1.020 *	0.307 *
STD	0.282	0.296	0.334	0.323	0.287	0.285	0.241	0.418	0.224	0.351	0.281	0.409	0.974 **	
MAX	1.372	1.445	1.788	1.680	1.466	1.702	1.482	2.107	1.526	1.598	1.485	1.554		
MIN	0.207	0.388	0.392	0.474	0.482	0.534	0.506	0.413	0.588	0.023	0.486	−0.150		

* The mean and standard deviation of all hedge ratios, January 1976 – December 1989.

** The Minimum Risk Hedge Ratio for the entire data set, January 1975 through December 1989, 180 Observations.

Table 4. Simultaneously Derived, Complex Hedge Ratios for Soybeans.

Estimating the hedge ratios simultaneously decreased the average minimum risk hedge ratio in corn as expected, however, it increased the mean size of the soybean hedge ratios. The corn simultaneous hedge ratio is significantly less than the separately determined hedge ratio. However, the soybean simultaneously derived hedge ratio was significantly greater than the separate hedge ratio at the five-percent level. Overall, the volatility of the CHR was greater than the SHR. The STD for corn hedge ratios was 0.255 for the SHR and 0.694 for the CHR. In soybeans, the STD was 0.097 for the SHR and 0.307 for the CHR.

SEASONAL ANALYSIS

Traditional hedge ratios (SHR) are shown in Figure 1 along with the simultaneous hedge ratios (CHR) for both corn and soybeans. The corn CHR are less than the SHR ratios as expected, however, soybeans are not.

Both the SHR and CHR hedge ratios for corn displayed a minor seasonal trend. A trend, decreasing from January to May, then increasing to December, is apparent in the SHR and less so in the CHR. The range of the SHR trend, from 1.01 to 0.953, is minimal. The CHR had a larger range of hedge ratios from 0.938 to 0.636.

No soybean hedge ratios showed any obvious sign of a seasonal tendency. However, Figure 1 shows that the mean SHR reached both extremes during September through December. The two largest ratios occur in September and December and the two lowest during October and November. In addition, the two lowest CHR also occur in October and November. The size of the differences in the monthly mean hedge ratios was negligible for the SHR as its range was 0.966 to 0.926. The CHR had a larger range in average values from 1.064 to 0.959.

The variability of the individual month hedge ratios between years was notable. The SHR were less variable than the CHR for corn and soybeans. In corn, the STD of the SHR ranged from the most stable month of August which had a standard deviation of 0.181 to November which was most unstable with a STD of 0.322. The STD of the CHR had a low of 0.639 in May and a high of 0.827 in August. In soybeans, the STD of the SHR ranged from the most stable month of February which had a standard deviation of 0.071 to June which was most unstable with a STD of 0.119. For CHR the range was 0.224 in September to 0.409 in December.

ANNUAL ANALYSIS

The annual mean hedge ratios for corn and soybeans are plotted in Figure 2. No increasing or decreasing trend in either commodity is obvious from the graph.

For corn the annual means for the SHR varied within a range of 0.728 in 1976, to 1.380 in 1987. CHR had a range of 1.877 in 1986 to -0.288 in 1976. Within each year, the inter-month variation between hedge ratios was greater for the CHR than for the SHR. The range of STD was from 0.496 over 1986 to a relatively stable 0.022 for 1988 for the SHR. The CHR had a high STD of 0.946 during 1987 and a low of 0.223 in 1981.

For soybeans the annual mean SHR varied from 0.77 in 1979 to 1.058 in 1983. The annual mean CHR ranged from 1.464 in 1987 to 0.591 in 1986. Within each year, the inter-month variation between hedge ratios was minimal however the standard deviation was generally greater for the CHR. The range for the SHR was a high STD of 0.126 during 1979 and a low of 0.010 over 1984. The CHR ranged from 0.413 in 1985 to 0.025 in 1977.

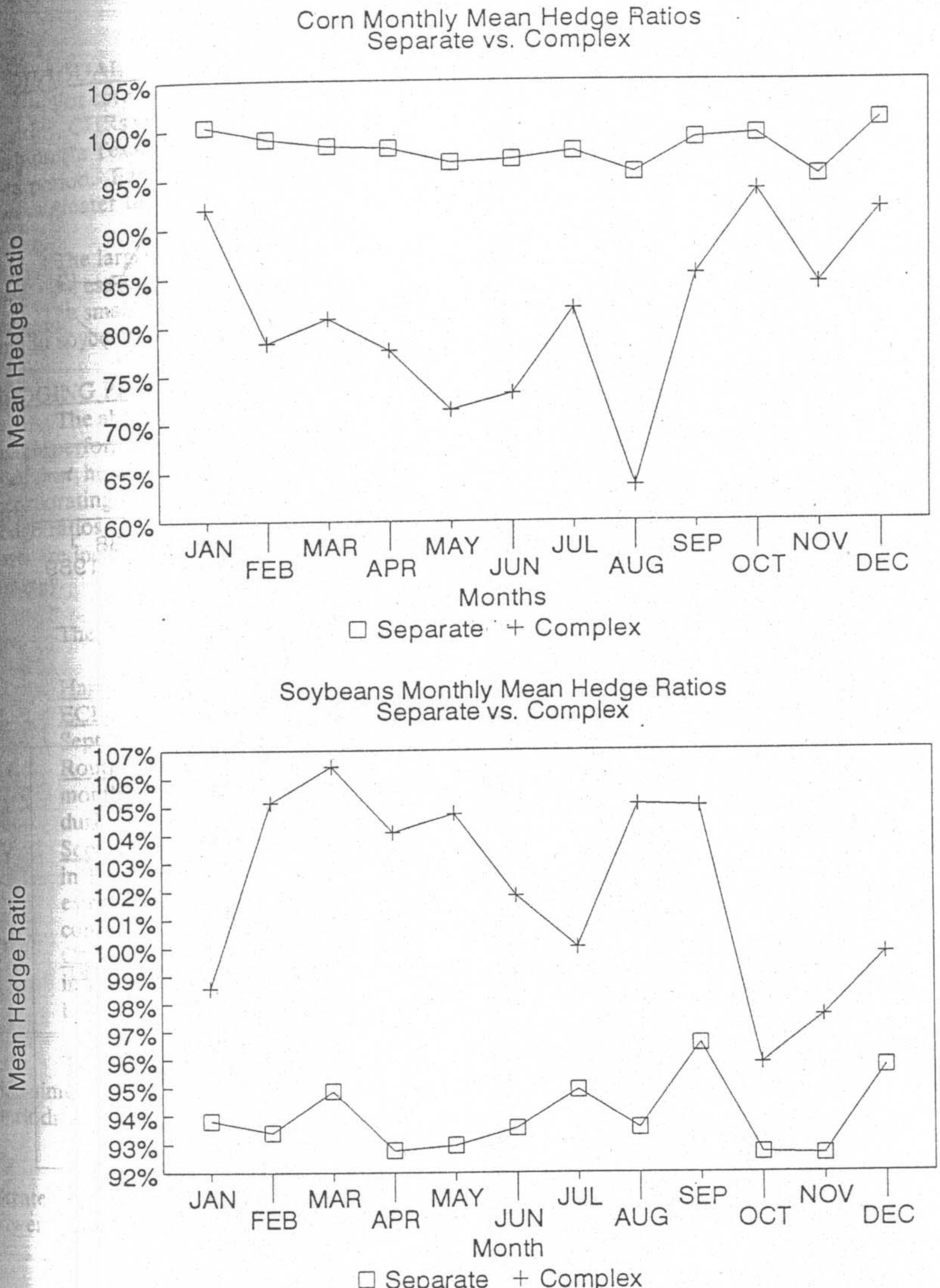
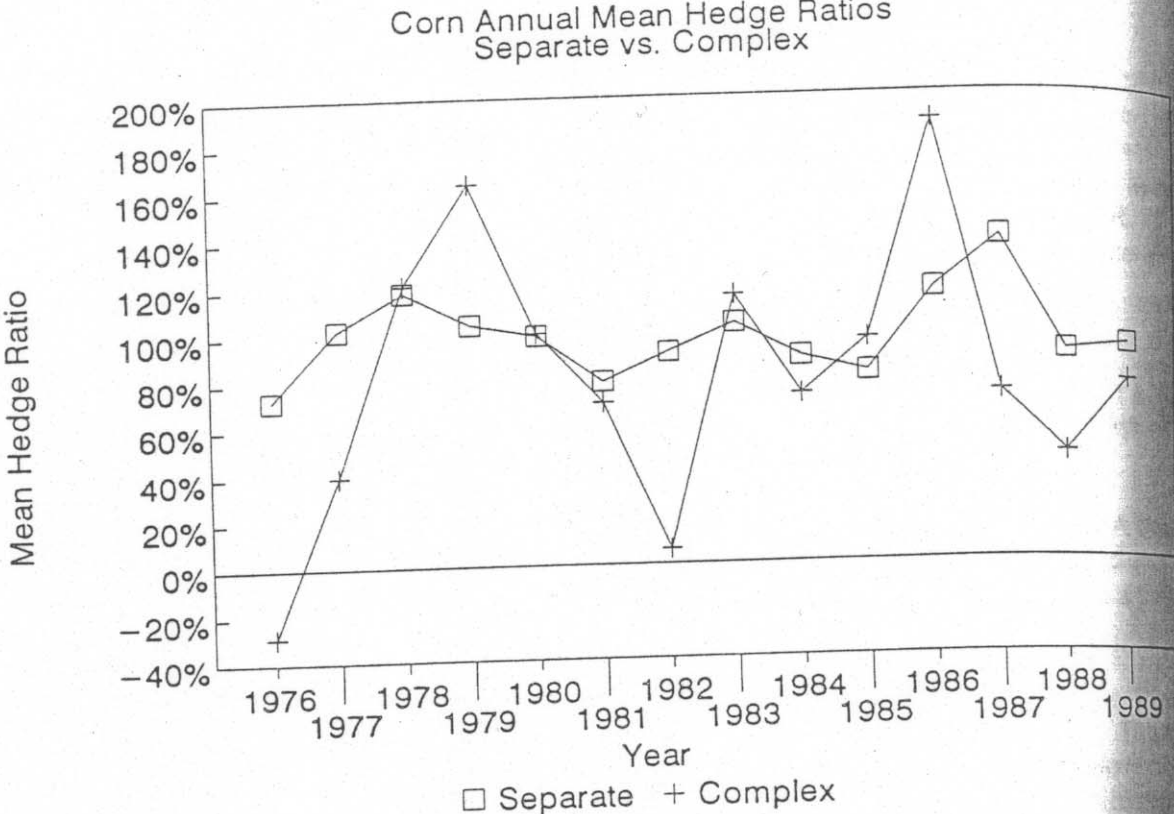


Figure 1. Monthly Mean Values of the Separate and Complex Hedge Ratios.



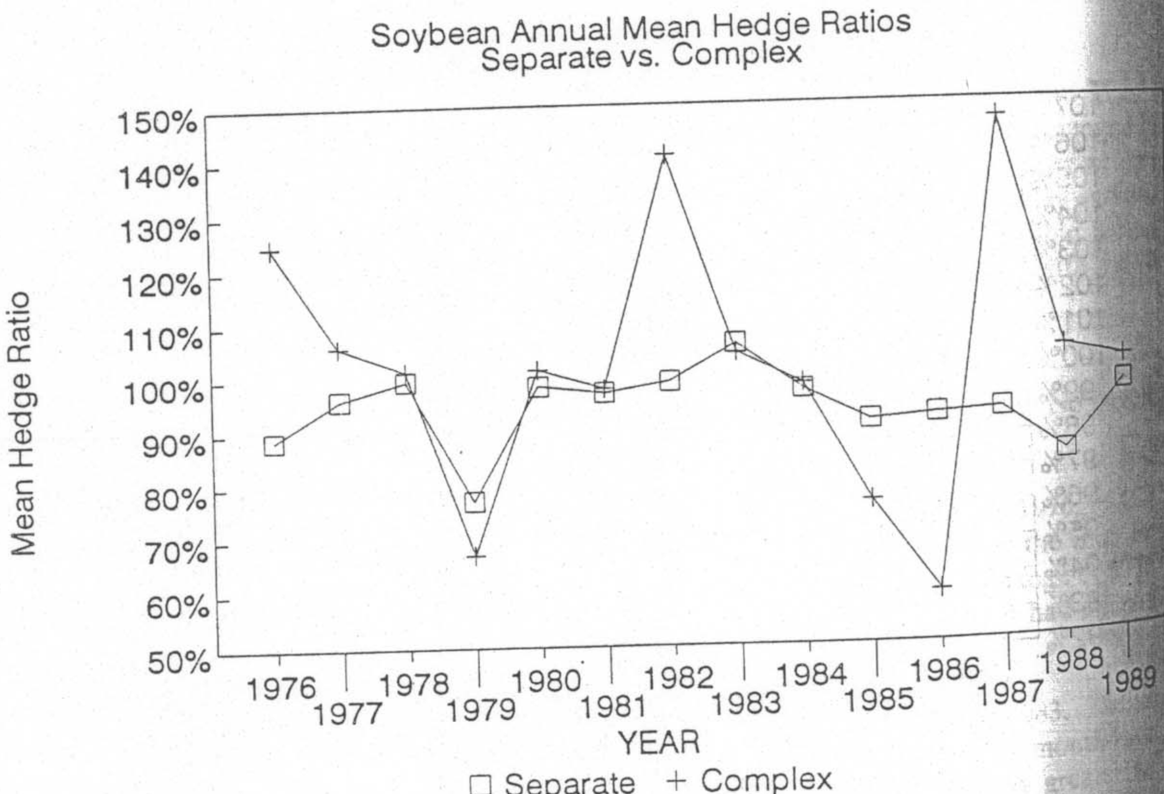


Figure 2. Annual Mean Values of the Separate and Complex Hedge Ratios.

INDIVIDUAL

For corn, the range in individual SHRs for corn was 1.927 to 0.315. The range in individual monthly, CHRs was 2.357 to -0.825. The negative hedge ratio in the CHR represents a long futures position ("a Texas Hedge"). Monthly hedge ratios for corn were negative twenty-four times over the data period. Each time the hedge ratio for corn was negative, the soybean hedge ratio was large, always greater than one.

The largest SHR for soybeans was 1.191, estimated in December, 1989. The smallest SHR was 0.600, estimated in June, 1979. The largest CHR for soybeans was 2.107, estimated in August, 1987. The smallest CHR was -0.15, estimated in December, 1985. The CHR only went negative one time in soybeans and that corresponds to the month of the largest individual corn hedge ratio.

HEDGING PERFORMANCE

The above *ex post* hedge ratios are then incorporated into hedging strategies and their *out-of-sample* performance is simulated. The *out-of-sample* marketing simulation is conducted to determine if *ex post* hedge ratios can be employed by hedgers to manage risk. If the hedging strategies incorporating hedge ratios perform well *out-of-sample* relative to other strategies, then the use of hedge ratios is supported. To allow for fair comparisons between strategies, interest and storage costs are included in the calculation of average returns to obtain a harvest equivalent price for each strategy.

The following five marketing strategies are examined:

I. Harvest Sales -- all grain is priced at the average cash price during October.
II. ECI Average -- an equal proportion of production is priced monthly from October to September of the following year.
III. Routine Sales -- the crop is sold in four equal intervals at the average cash price for the month. Preharvest sales are made in May, harvest sales in October, and postharvest sales during the following May and August.
IV. Separate Risk Min. -- the minimum risk proportion of expected production is hedged in May in December futures. The hedge is lifted at harvest and a minimum risk hedge ratio is estimated for the post-harvest inventory. The post-harvest hedge is placed in the July contract and held until May of the following year.
V. Complex Risk Min. -- the simultaneous risk minimum ratio of expected production is hedged in the same contract, at the same time and price in Strategy IV. Cash sales and the post-harvest hedge are made in the same manner as in Strategy IV.

The results from the *out-of-sample* hedge simulation are reported in Table 5. The results of this simulation are not general results, the strategies may provide different results over other data periods and under other assumptions.

For corn, Strategy V, Complex Risk Minimum, had lower mean and standard deviation than Strategy IV, Separate Risk Minimum. For soybeans, Complex Risk Minimum, Strategy V, had a lower mean return and a higher standard deviation than the Separate Risk Minimum, Strategy IV.

Total returns are the hedged returns for corn plus the hedged returns for soybeans. The total return results are plotted in mean-variance space in Figure 3. Risk averse individuals generally prefer strategies with the highest price and lowest risk (standard deviation). Strategies that appear upward and to the left are preferred by risk averse hedgers.

Strategy: / Crop Year		Average Returns Received. I. Harvest Sales	II. ECI AVERAGE	III. Routine Sales	IV. Separate Risk Min	V. Complex Risk Min
Corn	MEAN	$2.44	$2.35	$2.37	$2.44	$2.41
	STD	$0.58	$0.42	$0.38	$0.42	$0.36
Soybeans	MEAN	$6.29	$6.17	$6.23	$6.37	$6.23
	STD	$1.22	$0.73	$0.59	$0.72	$1.04
Total Returns	MEAN	$8.74	$8.53	$8.60	$8.80	$8.64
	STD	$1.76	$1.01	$0.88	$1.00	$1.26

Table 5. Mean Returns and Standard Deviations of Returns for Different Different Hedging Strategies for the 1976 – 1989 crop years.

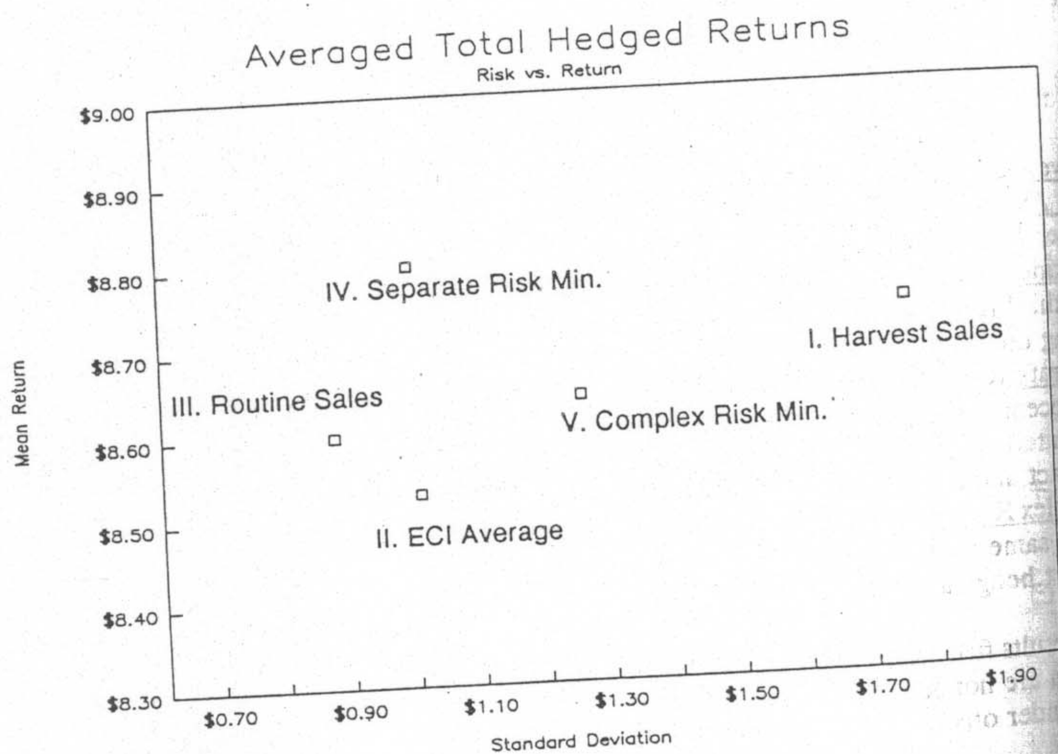


Figure 3. Relationship Between Mean Total Returns and Standard Deviations for the Various Hedging Strategies.

For risk averse hedgers, Strategy IV, Separate Risk Minimum, dominates Strategy I Harvest Sales, Strategy II ECI Average and Strategy V Complex Risk Minimum. Strategy III Routine Sales, dominates Strategy II ECI Average. Selection of the most preferred strategy between Strategy IV and Strategy II depends upon the individuals risk preference.

The most risk averse hedgers would prefer Strategy III, Routine Sales, because it had the lowest standard deviation of returns. The highest risk strategy was Strategy I, Harvest Sales. The highest return strategy was Strategy IV Separate Risk Minimum. It was expected that the Complex Risk Minimum Strategy would provide lower risk than the Separate Risk Minimum Strategy. However in the hedge simulation, Complex Risk Minimum Strategy V had lower returns and higher risk than the Separate Risk Minimum Strategy IV.

4.6 SUMMARY and EVALUATION

This study demonstrated a model to simultaneously derive minimum risk hedge ratios for multiple risks. *Ex-post* minimum risk hedge ratios were determined first with the standard minimum risk hedge ratios (SHR) model and then with the simultaneous, complex hedge ratios (CHR).

As was previously postulated, the simultaneous model estimated significantly different minimum risk hedge ratios. Results suggest that an ECI producer who follows minimum risk hedge ratios for corn and soybeans separately and without considering the positive correlation between the two will have different futures positions. Theoretically, hedge ratios derived independently for corn and soybeans should be greater than hedge ratios that consider multiple risks simultaneously. The results for corn were significantly lower when the ratios were determined simultaneously. Unexpectedly, however, soybeans were just the opposite. Simultaneously derived soybean hedge ratios were significantly greater than hedge ratios derived separately from the influences of corn prices. Results here suggest that if multiple risks are considered, they only should be because different hedge ratios may be realized.

Hedge ratios estimated each month showed that they vary with time. Some evidence of seasonality was noticed, however, it was minimal. The inter-month variation between hedge ratios suggested that hedgers not rely on the minimum risk hedge ratios to predict future hedge ratios. CHR ratios had a higher variance than SHR.

The results of this study indicate that there is little benefit to be gained from generating simultaneous hedge ratios as opposed to the standard hedge ratios for ECI corn and soybeans. The simultaneous model generated more extreme hedge ratios. Some simultaneously derived hedge ratios, especially in corn, were negative indicating a long futures position ("Texas Hedge"). In addition, the *out-of-sample* hedging simulation showed that the CHR generated returns and risks that were inferior to the SHR.

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