The Soybean Complex Spread: An Examination of Market Efficiency from the Viewpoint of a Production Process

by

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Market efficiency has been a central topic of research in the academic community. Traditionally, futures market efficiency has meant that futures prices accurately incorporate all currently known information. Therefore, current futures prices are unbiased forecasts of subsequent cash and/or futures prices, and traders cannot earn abnormal returns (Fama, 1970). Previous studies have examined the efficiency of futures markets from the viewpoint of (a) whether futures prices follow a random walk, (b) whether futures prices are efficient forecasts of subsequent prices, and (c) whether profits can be generated from trading rules.

This research tests for trading profits from applying a profit margin trading rule to the intercommodity spread of soybeans, soyoil, and soymeal (i.e., the soy complex). Profit margin trading rules initiate trades when a pre-specified level of implied profit exists. Implied profit is defined as currently-quoted futures prices minus estimated production costs.

Profit margin trading rules have been tested extensively in livestock hedging studies (Shafer, et al., 1978: fed cattle; Holland, et al., 1978: fed cattle; Leuthold and Mokler, 1979: fed cattle; Leuthold and Peterson, 1980: hogs; Helmuth, 1981: fed cattle; Spahr and Sawaya, 1981: fed cattle; Holt and Brandt, 1985: hogs; Kenyon and Clay, 1987: hogs; Schroeder and Hayenga, 1988: fed cattle). In general, these studies have found that selective implementation of a profit margin trading rule increased mean return and/or reduced standard deviation of returns compared to a cash only or routine hedging strategy. This suggests the potential existence of market inefficiency (Helmuth, 1981).

A variation of the profit margin trading rule is used in this study. With exception of Leuthold and Mokler, the livestock studies have examined returns to futures positions only when positive implied profits exist. This study, similar to Leuthold and Mokler, examines returns when both and positive and negative implied profits exist. Specifically, if positive soybean processing profits are implied by futures prices, the normal crush position is taken (long soybeans, short meal, short oil). On the other hand, if processing losses are implied by futures prices, the reverse crush position is taken (short soybeans, long meal, long oil). Despite wide-spread use of futures markets by soybean processors, a review of the literature found only two studies of the soybean crush spread, Hieronymus, 1949 and Dueringer, 1972.

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REVIEW OF RELEVANT LITERATURE

Efficient Market Hypothesis

The efficient market hypothesis (EMH) describes an efficient market as one that accurately incorporates all known information in determining prices (Fama, 1970). EMH assumes that there are no transaction costs, information is costlessly available to all market participants, and implications of current information for both the current price and distributions of future prices are generally accepted by all market participants.

At least two of the three assumptions of the EMH are unrealistic in an actual market place. First, transaction costs (brokerage fees, opportunity cost of margin, etc.) exist. Therefore, Jensen (1968) argued that a market is efficient as long as a trading system cannot produce risk-adjusted profits greater than transaction costs.

Second, information is not costless. Its acquisition involves costs, which demand returns. Returns are earned as traders bid up undervalued securities and sell off overvalued ones. Grossman and Stiglitz (1980) argued the cost of acquiring and interpreting information slows price adjustment.

Furthermore, while Fama (1970) argued that most of the time information arrives in small random doses, empirical evidence suggests that it arrives in large non-random doses and can best be described as a sporadic jump process (Oldfield, et al., 1977). Cohen, et al.'s (1980) study also supports the existence of a noncontinuous information process. Black (1976) showed that an uneven flow of information impedes market reaction, thus creating the potential for profitable trading. Nawrocki (1984) argued that the existence of noncontinuous information flows in combination with institutional impediments, such as transaction costs and information acquisition costs, cause disequilibrium in prices and, thus, opportunities for profitable trading.

The preceding discussion suggests that, unless the cost of acquiring and interpreting information is known, a trading model which minimizes these costs would be more useful for evaluating the efficiency of futures markets. Trading returns to a simple model, in which information costs are low, can be viewed more accurately as returns above the cost of acquiring and interpreting information than a model in which information costs are high.

Tests of Market Efficiency

There have been numerous studies of market efficiency. They can be categorized broadly into random walk studies, forecasting studies, and profit generating studies. Each of these categories is reviewed, and example studies are cited.

Working (1934) first proposed that futures prices changed randomly in reaction to random arrival of information to the market. Irwin (1986) reviewed 18 studies that tested whether changes in futures prices followed a random walk. Most concluded that futures prices did not behave randomly.

Forecasting studies of market efficiency test the unbiased nature of futures prices as predictors of subsequent cash and/or futures prices (for example, Tomek and Gray, 1970: corn, soybeans, and potatoes; Martin and Garcia, 1981: cattle and hogs; Rausser and Carter, 1983: soybeans, soyoil, and soymeal; Kodres, 1988: foreign exchange)[1]. Results have varied, not surprisingly, because different markets have been studied over different time periods at varying trade lengths while testing against alternative forecasting techniques.

Elam and Dixon (1988) have shown that biased results are produced by tests of futures market efficiency based on ordinary least squares regression of the spot price at time t + i on a futures price for time t + i as of some previous time t. The reason is that the independent variable, futures price, is a lagged value of the dependent variable, which produces correlations between the independent variable and error terms. The bias becomes more pronounced the smaller the data set, and small data sets have been a characteristic of many studies that used this methodology (e.g. Martin and Garcia and Tomek and Gray). Therefore, forecasting studies which used this statistical framework may have inappropriately rejected market efficiency.

Profit generating studies test for market efficiency by directly testing for the existence or lack of trading profits. Taylor and Tari (1989) found significant profits from trading in financial and commodity futures. Lukac, Brorsen, and Irwin (1988) and Lukac and Brorsen (1988) found that several technical trading systems earned significant risk-adjusted profits above transaction costs in agricultural and other futures markets. Sweeney (1988) produced significant profits for floor traders that exceeded transaction costs by using a filter rule to trade stocks. These results suggest that futures markets are not priced efficiently at all times.

METHODOLOGY

The Empirical Model

The normal soybean crush position was taken (long soybeans, short meal, short oil) when soy complex futures prices implied that gross returns from processing soybeans exceeded processing costs. When soy complex futures prices implied negative processing profits, the reverse crush position was taken (short soybeans, long meal, long oil).

This trading rule is consistent with market reaction to supply and demand. A positive (negative) profit margin signals that soy complex futures are offering an incentive for producers to enter (exit) the underlying economic activity. Everything else constant, the higher (lower) the profit, the higher (lower) the price paid by consumers. Thus, the signal is also an estimate of the incentive (disincentive) for consumption. Over time, gross crushing margins should adjust to a level that approximates crushing costs as producers and consumers react to profit incentives or disincentives. If gross crushing margins do not move towards crushing costs, arbitrage opportunities would persist in the long run, clearly an unsustainable phenomenon.

Normal crush positions should result in profitable trades when gross crushing margins exceed processing costs. On the other hand, reverse crush positions should result in profitable trades when processing costs exceed gross crushing margins. The larger the difference between gross crushing margins and processing costs, the higher trading profits should be because the market must move further to adjust processing returns to crushing costs.

The gross processing margin impled by soy complex futures prices at time t for time t+n were computed as:

$$GCM_{t,t+n} = [((FM_{t,t+n}*48)/2000 \text{ lbs.}) + ((FO_{t,t+n}*11)/100 \text{ lbs.})] - FS_{t,t+n}$$

where $GCM_{t,t+n}$ = Gross crushing margin in dollars per bushel of soybeans as of time t for time t+n,

$FM_{t,t+n}$ = Futures price of meal in dollars per ton as of time t for time t+n,

$FO_{t,t+n}$ = Futures price of oil in dollars per 100 pounds as of time t for time t+n, and

$FS_{t,t+n}$ = Futures price of soybeans in dollars per bushel as of time t for time t+n,

This calculation utilizes the long-term average of 48 pounds of meal and 11 pounds of oil from 60 pounds or one bushel of soybeans (U.S. Department of Agriculture, 1988).

Subtracting crushing costs from the gross processing margin yields the profit from crushing implied by the futures market as of time t for time t+n. This net crushing margin as of time t for time t + n, which will be called hereafter the implied margin, is calculated as:

$$NCM_{t,t+n} = GCM_{t,t+n} - ECC_t \qquad (2)$$

where,

$NCM_{t,t+n}$ = Net crushing margin (implied margin) in dollars per bushel of soybeans as of time t for t+n, and

ECC_t = Estimated cost of crushing in dollars per bushel of soybeans at time t

An implied margin of zero is consistent with no abnormal processing losses or gains. An implied margin greater than zero signals that a normal crush position (long beans, short meal, short oil) will be taken because profits are expected from processing soybeans. In contrast, an implied margin less than zero signals that a reverse crush position (short soybeans, long meal, long oil) will be taken because, as of time t, processing losses are expected.

The response of producers and consumers to soybean crushing margins depends on cash prices as well as expected futures prices. Therefore, it is important for the price response argument that the cash and futures market send the same price signals. Consequently, a cash soy complex basis was calculated for Decatur, Illinois, a major soybean processing center, for the first trading day of each month over the period 1960 to 1988. On average, the basis was nearly zero. Thus, the resource adjustment signals sent by the soy complex futures markets were, on average, equivalent to those in a major soybean crushing center.

Implementing the Trading Rule

The specific trading strategy used in this study placed five trades at the closing prices on the 15th of every month. One trade was lifted at each of the following times from placement: 9.5, 7.5, 5.5, 3.5, and 1.5 months. Positions were taken in the soybean, meal, and oil futures contracts maturing nearest to but later than the calendar month when the trade was to be lifted. After a trade was initiated based on the implied margin, it was held for the pre-determined trade length. To avoid erratic trading which can occur during the delivery month of a futures contract, all trades were lifted at the closing prices on the first trading day of each month. All prices were obtained from the Dunn and Hargitt, Inc. data base.

Based on historical crushing yield of soybeans, the exact trading relationship is 1.2 and 0.915 contracts of meal and oil, respectively, for each contract of soybeans. However, only one contract of each was traded to keep number of contracts small and in round numbers while maintaining the essential underlying processing relationship.

Because the cost of crushing soybeans is proprietary information, this cost must be estimated. From economic theory, it is assumed that an economic activity must cover its long-run average total cost of production if the activity is to continue. Thus, the cost of crushing was estimated using a moving average of gross crushing margins (eq. 1) calculated on the first trading day of every month using the nearby futures contracts. Again, the first trading day of the month was used to avoid potential erratic trading that can occur as a contract nears expiration. Moving averages of 36, 60, and 120 months were used to test the sensitivity of the trading profits.

Trading in the soy complex futures contracts did not consistently occur 9.5 months from expiration prior to 1973, while trading at 7.5 months from maturity for meal and oil averaged less than 100 contracts per day prior to 1966. Therefore, all trades held 7.5 months or less began in 1966[2]. Trades at the 9.5 month length began in 1973.

All trading results were out-of-sample. Positions were only based on futures prices at the time the positions were taken and on a moving average of past implied gross margins to estimate processing costs.

An advantage of the profit margin trading rule employed in this study is its simplicity in construction and use. It requires access only to the closing futures prices for the soy complex futures, which are reported in many outlets including the Wall Street Journal and New York Times. Because of the minimal costs associated with using this profit margin trading rule, total returns more nearly approximate returns to the trading strategy than for models which incur high construction and use costs.

Transaction Costs

Transaction costs (sum of execution costs and brokerage fees) are estimated for the soy complex trades. Execution costs are associated with having a market order filled. They reflect size of the bid-ask spread, and increase as time from maturity increases and trading becomes less liquid (Brorsen and Nielsen, 1986; Thompson and Waller, 1987). Following Brorsen and Nielsen, cost of executing a trade is estimated at one price tick to get into each contract at trade lengths of 5.5 months or less. At trade lengths of 7.5 and 9.5 months, two ticks were used to get into each contract. The cost to close the trade is estimated at one tick per contract for all trade lengths.

Price ticks for soybeans, meal, and oil are 1/4 cent per bushel, 10 cents per ton, and one cent per pound, respectively. Therefore, execution costs are estimated to be $57 per spread trade for trades held 5.5 months or less and $85.50 for trades held 7.5 and 9.5 months.

Brokerage costs vary between brokerage firms and differ by type of trader. A large brokerage firm recently quoted fees for the crush spread at $150 per round trip for public traders and $75 for commercial hedgers (Markey, 1989). Realizing that brokerage fees vary by both brokerage firm and credit worthiness of the trader, the preceding quote for public traders is used to conduct a conservative test of trading profits.

In summary, for trade lengths of 5.5 months or less, transaction costs were estimated to be $207. For trade lengths of 7.5 months and 9.5 months, transaction costs were estimated to be $235.50.

Profits were measured in dollars per trade and are a return to the spread between the three soybean commodities. Because soy complex prices are highly correlated, the implied risk position is less than that associated with the total value of the contracts. Therefore, a return calculated to the total value of the position would be inappropriate because the implied risk exposure would be overstated. Because it is not possible to determine the risk exposed value of the soy complex trade, profits could not be adjusted for risk, and an exact Jensen test of market efficiency could not be conducted.

RESULTS OF THE TRADING STRATEGY

Aggregate Results

The last trades were lifted on the first trading day of December 1988. Results using historical 36, 60, and 120-month moving averages of spreads near the first trading day of each month were similar; therefore, only the results for the 60 month average are presented.

Average implied margins were positive at the time trades were placed for the 1.5 and 3.5 month trades but became more negative as trade length increased (Table I). The increasingly negative implied margins were associated with higher trading losses for the routine normal crush position. In contrast, the combination of reverse crush positions (short soybeans, long meal, long oil) at implied margins below zero and normal crush positions (long soybeans, short meal, short oil) at implied margins above zero produced profits that exceeded transactions costs at trade lengths of 5.5 months or longer.

Consistent with previous studies of profit margin trading, the normal crush position generated larger profits and a higher percentage of profitable trades as implied margins became more positive (Table II). The same pattern occurred for the reverse crush as implied margins became more negative. Positive trading returns were more consistently generated for the reverse crush (negative implied margins) as opposed to the normal crush (positive implied margins). At trade lengths of 3.5 months or longer, nearly all trades initiated by this trading strategy produced positive returns when implied margins at the time the trade was placed exceeded 20 cents or were less than negative 20 cents.

Statistical tests could not be performed on the aggregate results because positive autocorrelation existed due to the overlapping of trading periods. For example, the holding period for trades placed on January 15, 1966 and February 15, 1966 overlapped 6.5 months for trades held 7.5 months. Positive autocorrelation for returns from trading strategies of individual securities was also found by Taylor and Tari (1989) and Lukac, et al. (1988).

Disaggregated Results

To statistically test the trading results, profits were disaggregated by the month the trade was placed. For example, trades placed in January from 1966 to 1988 and held for 7.5 months were examined as a separate series. The autocorrelation function for these monthly series was not significantly different than zero.

Positive profits were generated in 33 of 36 months at trade lengths of 5.5 months and beyond, while 29 months had profits greater than transaction costs (Table III). At 1.5 and 3.5 month trade lengths, 19 of 24 months had profits greater than zero, but only eight months had profits greater than transaction costs.

Profits significantly greater than transaction costs were generated in 15 of 36 months at trade lengths of 5.5 months and beyond (Table IV). In contrast, at 1.5 and 3.5 month trade lengths, only one of 24 months had profits greater than transaction costs.

Assuming a t distribution, the number of monthly return series expected to have significant profits at the five and ten percent level are 0.6 and 1.2 months, respectively. These critical values were exceeded only at trade lengths of 5.5 months and beyond when tested against transactions costs.

CONCLUSIONS AND IMPLICATIONS

Numerous studies of market efficiency have been conducted, but none have examined market efficiency from the viewpoint of economic response to a production process. This research used a variation of profit margin trading rules previously used in livestock hedging studies to test efficiency of the soy complex (soybeans, soyoil, soymeal). Normal crush positions (long soybeans, short soyoil, short soymeal) were taken when positive processing margins were implied by soy complex futures prices, and reverse crush positions (short soybeans, long oil, long meal) were taken when negative processing margins were implied. Significant profits above transaction costs were found but only at trade lengths of 5.5 months or longer. These findings suggest that distant soy complex futures are not efficient according to Fama's criterion.

Stein (1981) provided theoretical evidence that the optimality of resource allocation depends on the accuracy of futures price forecast of subsequent realized prices. Because this study utilizes a buy (sell) and hold strategy, the trading results provide a test of the unbiased nature of futures prices from the perspective of economic profits associated with trading the soybean crush. Results of this study suggest that soy complex futures prices do not lead to optimal allocation of soybean processing resources over longer time periods. However, the results are consistent with the rational response of producers and consumers to economic incentives or disincentives for soybean processing, thereby causing soybean processing profits to move toward the cost of production. In other words, the trading profits are consistent with a mean reversion process (Fama and French, 1988; DeBondt and Thaler, 1989), with reversion occurring to the cost of production. The trading results are also consistent with Cootner's (1964) and Samuelson's (1976) observation that prices are not truly a random walk but are constrained by economically determined barriers.

This research also has implications for the conventional view of hedging. Traditionally, a futures position is considered a hedge if it "is intended as a temporary substitute for the sale or purchase of the actual commodity" (Chicago Board of Trade, p. 351). However, this research and the commonly-held belief that soybean processors trade the reverse crush suggest that hedging in the soybean complex might be described more accurately as arbitraging the relationship between the cost of an economic activity and the profit futures prices offer for entrance into or exit from the economic activity.

Table I
AVERAGE PROFITS AND IMPLIED MARGINS PER SOY COMPLEX SPREAD TRADE, CHICAGO BOARD OF TRADE, 1966 TO 1988.

			Trading Strategies	
Length of Trade	Trades	Implied Profit Margin[a]	Normal Crush Position[b]	Reverse Crush below 0; Normal Crush Above 0[c]
months	number	cents/bu.[d]	- - - - $ per trade[d] - - - -	
1.5	274	3.3	-166	51
		(17.0)[d]	(905)[d]	(918)[d]
3.5	272	0.1	-270	210
		(15.6)	(1236)	(1248)
5.5	270	-1.2	-356	448
		(15.0)	(1312)	(1283)
7.5	268	-4.1	-486	471
		(11.1)	(1309)	(1315)
9.5[e]	182	-5.5	-601	654
		(13.5)	(1468)	(1445)

[a] Implied profit margin is calculated by subtracting estimated cost of crushing from the gross spread at the time of trade placement. Reported in cents per bushel of soybeans.
[b] The normal crush position is long soybeans, short meal, short oil.
[c] This strategy takes the reverse position (short soybeans, long meal, long oil) at implied margins below zero and the normal crush position at implied margins above zero.
[d] Standard deviations are in parentheses.
[e] Trades at 9.5 months were made over the 1973-1988 period because of thin trading that occurred prior to 1973 in soy complex futures.

Table II
PROFITS PER TRADE AT DIFFERENT LEVELS OF IMPLIED MARGINS; NORMAL CRUSH POSITION AT IMPLIED MARGINS ABOVE ZERO AND REVERSE CRUSH POSITIONS AT IMPLIED MARGINS BELOW ZERO; CHICAGO BOARD OF TRADE, 1966 TO 1988.[a]

Implied Margins cents[c]		Trade Length in Months				
		1.5	3.5	5.5	7.5	9.5[b]
<-20	Mean Profit ($)	137	2169	2910	2694	2532
	SD[d] ($)	377	2128	2236	2131	1932
	Trades (nos.)	2	5	11	15	22
	% Profitable[e]	50%	100%	100%	100%	95%
-20- -10	Mean Profit ($)	212	755	530	458	736
	SD ($)	655	1437	1165	1194	1477
	Trades (nos.)	35	33	37	39	37
	% Profitable	71%	70%	70%	69%	70%
-10-0	Mean Profit ($)	260	281	507	533	453
	SD ($)	740	969	1047	1194	1047
	Trades (nos.)	85	105	112	131	69
	% Profitable	55%	59%	68%	73%	64%
0-10	Mean Profit ($)	-159	-330	-157	-141	-40
	SD ($)	677	911	777	759	914
	Trades (nos.)	94	89	80	69	34
	% Profitable	47%	36%	40%	41%	53%
10-20	Mean Profit ($)	-195	-51	407	234	118
	SD ($)	1393	1281	1515	1581	1135
	Trades (nos.)	34	27	19	10	15
	% Profitable	41%	48%	53%	60%	60%
>20	Mean Profit ($)	245	1733	1561	1328	884
	SD ($)	1550	2001	1848	697	1359
	Trades (nos.)	8	13	11	4	5
	% Profitable	67%	85%	91%	100%	80%

[a] Normal crush is long soybeans, short meal, and short oil. Reverse crush is short soybeans, long meal, and long oil.
[b] Trades at 9.5 months were made over the 1973-1988 period because of thin trading that occurred prior to 1973 in soy complex futures.
[c] Cents per bushel of soybean futures.
[d] Standard deviation of profits per trade.
[e] Percent of trades that produced positive profits.

Table III
DISAGGREGATED PROFITS PER TRADE BY MONTH TRADE IS PLACED; REVERSE CRUSH AT IMPLIED MARGINS BELOW ZERO, NORMAL CRUSH AT IMPLIED MARGINS ABOVE ZERO; CHICAGO BOARD OF TRADE, 1966 TO 1988.[a]

Trade Placed month	Trade Length in Months				
	1.5	3.5	5.5	7.5	9.5
	$ per trade[b,c]				
Jan	-44 (1315)	28 (1016)	703¶¶ (1247)	30 (712)	-108 (1247)
Feb	36 (594)	344 (1550)	685¶ (1378)	214 (974)	632 (1728)
Mar	122 (692)	353 (1084)	178 (827)	-56 (1062)	929¶¶ (1341)
Apr	349 (880)	556¶ (1095)	288 (931)	604 (1412)	891¶¶ (1088)
May	207 (600)	358 (926)	-494 (907)	908¶¶ (1147)	731 (1830)
Jun	141 (1003)	331 (1208)	543 (1250)	802¶¶ (1013)	794¶¶ (1026)
Jul	167 (1159)	-185 (1049)	644¶ (1475)	752 (1871)	671 (1598)
Aug	-5 (788)	8 (1538)	743¶¶ (1362)	573¶ (1155)	858¶ (1701)
Sep	-308 (719)	264 (1438)	547 (1793)	373 (1382)	600 (1663)
Oct	163 (1201)	213 (1328)	275 (1101)	152 (1717)	1021¶ (1779)
Nov	-238 (984)	123 (1684)	513 (1202)	641¶ (1425)	468 (821)
Dec	12 (713)	118 (868)	784¶¶ (1358)	702¶ (1348)	411 (1192)

[a] Normal crush is long soybeans, short meal, and short oil. Reverse crush is short soybeans, long meal, and long oil. Trades were placed from 1966 to 1988 for trades lengths of 7.5 months or less and from 1973 to 1988 for the 9.5 month trade length.
[b] Standard deviations are in parentheses.
[c] ¶ and ¶¶ - profits significantly above transactions costs at 10% and 5%, respectively, using a one-tailed t test.

Table IV

NUMBER OF MONTHLY SERIES WITH SIGNIFICANT TRADING PROFITS ABOVE TRANSACTIONS COSTS: REVERSE CRUSH AT IMPLIED MARGINS BELOW ZERO, NORMAL CRUSH AT IMPLIED MARGINS ABOVE ZERO; CHICAGO BOARD OF TRADE, 1966 TO 1988[a]

Significance Test	Trade Lengths in Months				
	1.5	3.5	5.5	7.5	9.5
	-----------number-----------				
5 percent significance level:					
	0	0	3	2	3
10 percent significance level:					
	0	1	5	5	5

[a] Normal crush is long soybeans, short meal, and short oil. Reverse crush is short soybeans, long meal, and long oil.

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FOOTNOTES

1. See Garcia, et al. (1988) for a review of efficiency studies of agricultural futures markets.

2. Trades could have been placed for shorter trade lengths prior to 1966. However, 1966 was chosen as the starting date to keep results for the 7.5 month and shorter trade lengths comparable.