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Performance of Thin Futures Markets: Rice and Sunflower Seed Futures

By Douglas Gordon*

Abstract

This article examines the performance of three thinly traded futures markets It tests each market with several measures of efficiency and performance and compares the test results with those from a large and mature futures market These thin markets possess some, but not all, of the attributes of an efficient futures market

Keywords

Thin markets, futures markets, market efficiency

Introduction

Agricultural economists have long been interested in studying thin markets (*8*)[1] Their study, however, is often hampered by the very thinness they set out to analyze An agricultural commodity futures market with low trading volume is a particularly good candidate for study Much market information is reported on a futures market, even when trading volume is low The information revealed by a thin futures market may tell us if such a market possesses any of the hedging or price forecast benefits of the more heavily traded ones If thin markets have some, but not all, of these benefits, the data from a thin futures market may suggest which properties are lost and which remain

Thinly traded markets are more susceptible to price manipulation than are heavily traded ones A trade of relatively few contracts may move market price substantially Prices on the futures market may not accurately reflect either price behavior in the cash market or expectations about the future The information content of the futures price is a major benefit of futures markets Inaccurate or biased prices may eliminate this advantage and may prevent farmers from choosing their optimum production plans

Commodity futures markets trading recently with low volume include the rough rice and milled rice futures markets at the New Orleans Commodity Exchange (NOCE) and the sunflower futures market at the Minneapolis Grain Exchange (MGE)[2] Volume was often fewer than 1,000 contracts per month in each of these markets The Commodity Futures Trading Commission (CFTC) designates markets with volume below this level as low-volume markets which may be subject to stricter reporting requirements than other futures markets

Several characteristics are common to most successful futures markets·

> The terms of futures contracts are highly standardized with respect to quantity, grade, and location, time and method of delivery. The only matter to be decided at the time of transaction is price (*18*, p. 6)

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[1]Italicized numbers in parentheses refer to items in the References at the end of this article I follow Hayenga and others who define a thinly traded market as one characterized by two criteria "(1) fewness of negotiated trades in a specified market and time period, and (2) the level of market performance, especially its liquidity and corresponding price sensitivity to incremental buy and sell orders " Tomek has recently analyzed a thinly traded cash commodity market (*24*)

[2]Rough rice futures now trade on the floor of the MidAmerica Exchange Milled rice and sunflower seed futures contracts are no longer traded

The futures market in sunflower seed had most of these characteristics, but those in rice had fewer of them [3]

Hedging Efficiency

In this section, I examine the efficiency of the futures price in relation to the cash market prices for rice and sunflower seed This relationship shows the hedging efficiency (the efficiency of the markets for possible hedges by producers) of the markets If the cash and futures markets behave efficiently, short hedging a crop will reduce a farmer's price risk rather than add to it (*9*, *10*)

Level of Activity in the Markets

Trading in milled rice, rough rice, and sunflower seed futures was generally low Open interest in rice futures contracts never exceeded 10 percent of available stocks or 1 percent of annual production Sunflower seed interest never exceeded 3 percent of production or 20 percent of domestic stocks In contrast, the ratio of peak open interest in the September 1982 soybean contract was 29 percent of total stocks held on September 1, 1982, and the ratio in January 1982 (with much of the new crop in storage) was 12 percent

Although there is no generally accepted lower limit to volume or open interest beyond which a market is deemed thin, the CFTC has defined low-volume contract markets as those where fewer than 1,000 contracts are traded in 4 of any 6 months If contract volume falls below that level, the exchange must report more trading information to the CFTC to insure that there are no trade practice violations Special reports are not required of new futures markets, such as those in sunflower seed and rough and milled rice, for 3 years after the CFTC approves the market Exchanges whose contract markets fall below 1,000 contracts per month may ask the CFTC to waive the reporting requirement (*2*)

Some people believe more activity should be required to avoid the thin or low-volume designation. Silber suggested that a volume of 10,000 contracts traded per year in a commodity by the third year of its existence be the minimum below which a market is not successful (*22*) Successful markets such as soybeans on the Chicago Board of Trade and gold on the New York Commodity Exchange often trade more than 50,000 contracts per day

One of the major reasons for buying or selling futures contracts is to hedge against price changes in the physical commodity Farmers will sometimes short hedge their crop by selling the crop forward on the futures market Processors will often long hedge by buying contracts for future delivery In either case the futures market is used to insure against unanticipated price shifts for the physical commodity [4]

The ability to hedge in a futures market depends on how closely the futures and the cash market prices are related The delivery point basis, the difference between the futures price and the cash market price at a delivery point, should be predictable In an ideal market, the basis would vary little day to day, with the cash price slowly rising toward the futures price over the crop year The idealized trend in the basis reflects storage costs over the crop marketing year The figure depicts the ideal cash-futures relationship.

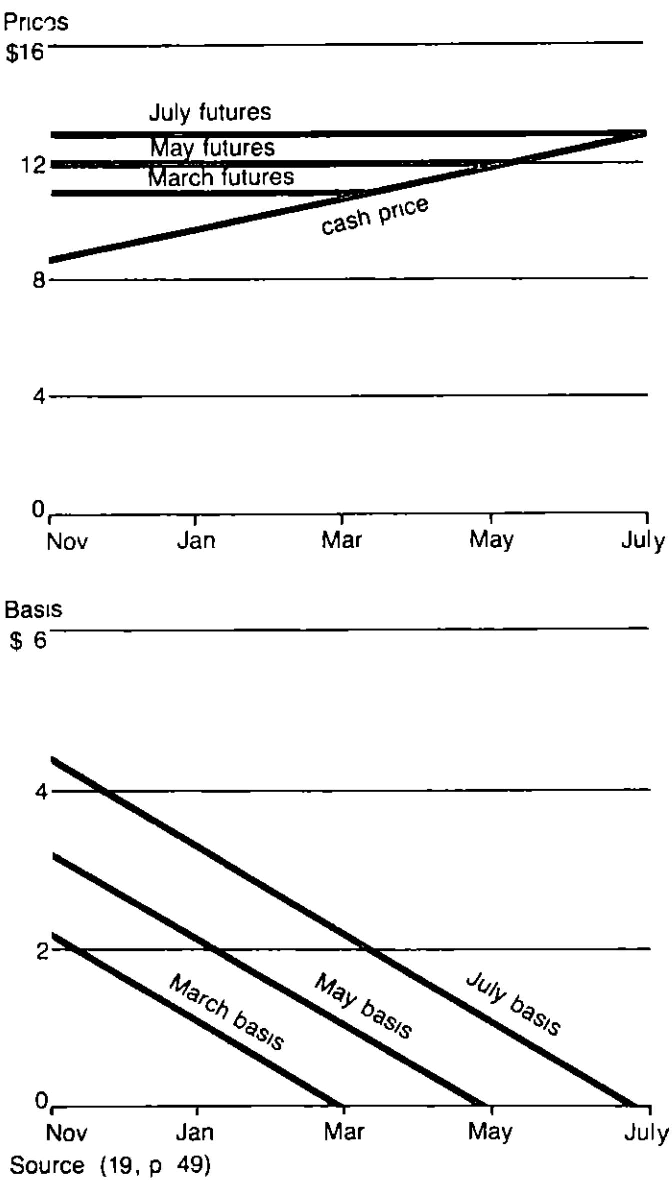
In the top diagram of the figure, the futures price appears as a horizontal line to make the relationship between cash and futures prices clear In reality, both the cash and futures prices will change from day to day Despite daily fluctuations, the basis (the relationship between the two) normally follows the trend shown in the diagrams

Analyzing the futures-cash price relationship is difficult because daily cash prices in the rice markets

[3]The rice futures markets faced several obstacles to successful trading First, rice is not so uniform a commodity as most others traded on futures exchanges There are several varieties of rice and several grades of each variety Second, milling yields vary substantially from one farm to another and from one year to the next Third, reported cash market prices are less specific than those for other commodities There is no daily or weekly rough rice cash market price for a specific variety and grade Weekly cash market prices are reported for milled rice, but they are often expressed as a range, for example, $16-18 per hundredweight (cwt) This range may not vary for several weeks, or it may be occasionally reported as a single price—for example, $18 per cwt Fourth, rice futures markets are new and were the first futures to be traded on the NOCE Few new futures markets become successful For example, milled rice futures were traded on the New York Mercantile Exchange for a short time in 1964 Fewer than 50 contracts were sold, and the market closed after a few months Each of these factors may have hindered growth in volume and open interest in rice futures

[4]A short hedge is the sale of contracts on the futures market by those who plan to sell the physical commodity in the future (for example, a soybean farmer) to insure against a fall in the price of the commodity A long hedge is the purchase of futures contracts by those who plan to purchase the physical commodity in the future to insure against a price increase

Idealized Behavior of Futures Prices, Cash Prices, and the Basis



Source (19, p 49)

are lacking The U.S Department of Agriculture (USDA) quotes cash prices for milled rice in Arkansas and Louisiana 1 day a week The weekly price is usually a range of prices rather than a single price for a specific quality and type of milled rice. Because there are no published cash market prices for a specific deliverable variety and grade of rough rice, basis analysis of that market is impossible To analyze the milled rice basis, one must compare the Monday closing futures price with the midpoint of the range of Monday prices reported for the Louisiana and Arkansas cash markets Thus, the basis analysis can be only a rough estimate of the behavior of the milled rice basis, rather than a precise calculation.

USDA quotes sunflower seed cash market prices daily at Minneapolis and Duluth. Duluth was the par delivery point for sunflower seed futures Sunflower seed could be delivered at Minneapolis at a discount

Correlation between Cash Market and Futures Prices

Table 1 shows the correlation between changes (first differences) in cash market price and futures price for milled rice, sunflower seed, and soybeans Daily price changes are shown for sunflower seed and soybeans, and weekly price changes are shown for milled rice. The correlation between actual cash and futures price will be much higher than the correlation between the first differences of the price series. The correlation between the first differences does show how closely the series move together, which is important to hedgers Correlation between cash and futures price changes will be highest at the par delivery points Other cash markets will have transportation costs and local cost factors which reduce the correlation with the futures price changes

The soybean cash-futures correlation is higher than that for milled rice or sunflower seed The milled rice correlation coefficients are quite low, partly because of the lack of a cash market price at a single delivery point The correlation between changes in the milled rice futures price and those in the Arkansas price were much higher in the second year of the futures market than in the first This disparity suggests that hedgers were better able to avoid basis risk, the random variation in the basis. The correlation between changes in the Duluth cash market price for sunflower seed and those in the futures price fell from 0 529 in the first year to 0.302 in the second year of the futures market. This decrease suggests an increase in basis risk and a deterioration in the ability of farmers to hedge sunflowers

In a normal or carrying-cost market, the cash price at the delivery point will typically be below the futures price for delivery during the crop marketing year This premium of futures over cash gives a return to storing the grain over that period Away from the par delivery points, the cash price may exceed the futures price by the transportation cost

Table 1—Correlation between first differences of cash and futures prices[1]

	Milled rice (weekly price changes)			
	January 1982 contract		January 1983 contract	
	Louisiana	Arkansas	Louisiana	Arkansas
Futures	0 038 (817)	0 104 (523)	0 052 (757)	0 293 (074)
Louisiana		366 (019)		150 (299)
	Sunflower seed (daily price changes)			
	May 1981 contract		March 1982 contract	
	Minneapolis	Duluth	Minneapolis	Duluth
Futures	0 261 (0)	0 529 (0)	0 206 (002)	0 302 (0)
Minneapolis		445 (0)		383 (0)
	Soybeans (daily price changes)			
	November 1981 contract		November 1982 contract	
	Chicago		Chicago	
Futures	0 670 (0)		0 705 (0)	

[1]The probability that the null hypothesis (H_0 correlation = 0) contains the estimate is in parentheses

Subtracting the transportation cost from the cash price would yield a graph similar to that in the figure The cash price at harvest is typically the lowest price of the crop year, with price rising rela tive to the futures price by the approximate cost of storage each month after that. The cash price also typically drops sharply as the new crop is harvested There are no returns to storage in this period Yet, the cash price and the November futures price should converge (the basis approaches 0 or a fixed transportation cost) as the date of contract maturity approaches See Kahl's studies of the corn basis from 1960-75 for a detailed analysis of longrun basis behavior (*11, 12*).

Basis Regressions

Table 2 displays regressions of basis against time If prices behave as expected, the basis (futures minus cash) will fall during the crop marketing year as the contract nears maturity, reflecting carrying costs for the cash commodity The daily basis was regressed on time for sunflower seed and soybeans The weekly basis each Monday was regressed against time for milled rice I used only one contract late in the crop year to represent each crop year Because the data for each contract overlap with data for other contracts within the same marketing year, regressions on several contracts within a year would not be independent

The rice basis over the May 1981 contract behaved as expected The trend in the basis was downward and significant. The trend in the May 1982 contract was significant, but in the wrong direction Cash began above the futures price in that crop marketing year and fell towards the futures price The January 1983 contract once again showed a falling and significant trend in the basis.

In the July 1980 and March 1982 sunflower seed futures contracts, the trend in basis was insignificant or significant in the wrong direction, after corrections for autocorrelation in the errors Only the July

Table 2—Basis regressions[1]

Milled rice					
May 1981	Arkansas	= 1 43 − 0 62 Time (3 38) (−5 65)	R^2 = 0 889	Rho = −0 20 (−0 53)	DFE = 4
	Louisiana	= 0 28 − 0 38 Time (0 45) (−2 35)	R^2 = 0 581	Rho = −0 23 (−0 62)	DFE = 4
May 1982	Arkansas	= −3 88 + 0 09 Time (−10 74) (5 88)	R^2 = 0 455	Rho = 0 64 (4 82)	DFE = 31
	Louisiana	= −3 84 + 0 09 Time (−11 22) (5 19)	R^2 = 0 464	Rho = 0 63 (4 68)	DFE = 31
January 1983	Arkansas	= −0 08 − 0 17 Time (−0 41) (−6 65)	R^2 = 0 815	Rho = 0 09 (0 34)	DFE = 10
	Louisiana	= −0 71 − 0 12 Time (−2 19) (−2 94)	R^2 = 0 464	Rho = 0 47 (1 90)	DFE = 10
Sunflower seed					
July 1980	Minneapolis	= 0 41 + 0 012 Time (1 57) (1 43)	R^2 = 0 043	Rho = 0 793 (9 11)	DFE = 46
	Duluth	= 0 37 − 0 001 Time (5 55) (−0 65)	R^2 = 0 008	Rho = 0 376 (2 93)	DFE = 49
July 1981	Minneapolis	= 4 48 − 0 020 Time (20 2) (−15 2)	R^2 = 0 649	Rho = 0 755 (13 0)	DFE = 125
	Duluth	= 4 61 − 0 022 Time (22 2) (−15 8)	R^2 = 0 682	Rho = 0 661 (9 61)	DFE = 116
March 1982	Minneapolis	= 0 34 + 0 Time (3 91) (0)	R^2 = 0	Rho = 0 688 (7 40)	DFE = 58
	Duluth	= 0 30 − 0 001 Time (5 43) (−0 85)	R^2 = 0 014	Rho = 0 564 (5 06)	DFE = 52
Soybeans					
July 1980	Chicago	= 1 609 − 0 00519 Time (20 1) (−14 0)	R^2 = 0 882	Rho = 0 743 (13 9)	DFE = 155
July 1981	Chicago	= 2 125 − 0 00759 Time (30 2) (−23 5)	R^2 = 0 782	Rho = 0 684 (11 8)	DFE = 154
March 1982	Chicago	= 0 243 − 0 00258 Time (7 70) (−3 61)	R^2 = 0 159	Rho = 0 751 (9 65)	DFE = 69

[1] Arkansas = Monday milled rice futures closing price minus Arkansas Monday cash price Louisiana = Monday milled rice futures closing price minus Louisiana Monday cash price Minneapolis = daily closing sunflower futures price minus daily Minneapolis cash price Duluth = daily closing sunflower futures price minus daily Duluth cash price Chicago = daily closing soybean futures price minus daily Chicago cash price

Time takes the value 1 for the first observation, 2 for the next, and so forth

Rho is the estimated first order serial correlation, calculated as $u_t = ru_{t-1} + e_t$, where u_t are the OLS residuals and e_t is a random error

DFE are the degrees of freedom of the estimate

The first milled rice contract uses data from the start of futures trading until the expiration of the May 1981 contract The last two milled rice regressions use data from October 1 until the expiration of the specified contract

The sunflower seed and soybean regressions use data from December 1 until the expiration of the specified contract, except in the July 1980 sunflower seed contract, where data begin with the start of futures trading in the market, t-statistics are in parentheses

1981 contract basis showed the trend typical of more heavily traded futures markets The soybean basis, by comparison, had a significant and declining trend in each contract tested

These results suggest that farmers' ability to hedge in the milled rice and sunflower futures markets was quite limited The basis tended to move the wrong direction on hedgers in one of the three milled rice contracts and had no significant trend in two of the three sunflower seed contracts

Because cash price was significantly higher than futures price in the early milled rice contracts, hedgers might have been persuaded that transportation and other costs justified a large premium for the cash market They would expect the cash price to continue to rise farther above the futures price (the basis becoming more negative), reflecting the costs of carrying stocks of rice over the period When the cash price fell toward the futures price, hedgers may have been caught by surprise. In later contracts, the basis was closer to normal behavior. The basis itself was closer to zero, and the trend of cash price rose relative to futures price over the crop year

Basis variability seems to be a substantial problem in the rough rice futures market as well Because there is no appropriate cash market price for rough rice, analyzing hedging potential was impossible The rough-rice contract allowed par delivery at several points in Arkansas, Louisiana, Mississippi, and Texas The price differentials between delivery points were unable to accommodate this variability. In late 1982, the New Orleans Commodity Exchange proposed that par delivery be restricted within a 10-mile radius of Greenville, MS Those planning or accepting delivery would then be certain of the delivery location A single delivery point might have reduced the variability between the futures and cash prices as well as have eliminated the variability in price between delivery points (*3*, p. 3400)

Deliveries on Contracts

Most futures markets have a relatively low percentage of deliveries, with an average of less than 2 percent of total volume (*23*, p 24) The milled rice market exceeded this percentage in seven of the nine contracts Although the percentage of deliveries on the rough rice market was generally lower than that on the milled rice market, it was also above 2 percent of all volume in a majority of contract months In May 1982, both the rough and milled rice futures markets had unusually large deliveries Milled rice showed a higher percentage of deliveries on contracts Sunflower seeds had relatively large deliveries on each contract. Deliveries in May 1981 were a much higher percentage of peak open interest than earlier Open interest was very low in the last two contracts, therefore, the ratios provide less information for these contracts

Table 3 presents the peak open interest for each contract maturity traded and the number of contracts delivered on the futures markets as a percentage of peak open interest This fraction is higher than the ratio of deliveries to total volume Unusually large deliveries on a contract show up more clearly when the ratio of deliveries to peak open interest is used than when the deliveries to volume ratio is given This ratio shows when specific contracts have far more deliveries than do other contracts for a given commodity The percentage of deliveries is quite high in some contract maturity months.

If an unusually large number of deliveries are made on a contract, speculators may tend to avoid that market A high ratio of deliveries to open contracts suggests an inefficient pricing mechanism It is generally far less efficient to deliver on a futures contract than to simply offset one's position in the futures market and deliver at a local cash market

> Making delivery on the futures contracts is seldom the most efficient way out of a hedge, particularly for the farmer, Paul says He notes that futures markets are designed to transfer risks, not products
>
> The contracts provide for delivery so that cash and futures prices will be linked together Normally, just the threat of delivery is enough to accomplish that goal Deliveries against agricultural futures contracts usually amount to less than 5 percent of the average number of open positions reported (contracts that have been entered into and not quickly offset) (*17*, p 12)

The high percentage of deliveries in the early contracts of the rough rice futures market is probably due to the problems in starting a new futures

Table 3—Ratio of deliveries on contracts to peak open interest[1]

Contract maturity month	Sunflower seed		Rough rice		Milled rice	
	Ratio	Peak open interest	Ratio	Peak open interest	Ratio	Peak open interest
	Percent	*Contracts*	*Percent*	*Contracts*	*Percent*	*Contracts*
July 80	18	304	—	—	—	—
Nov 80	19	1,259	—	—	—	—
Jan 81	27	570	—	—	—	—
Mar 81	34	570	—	—	—	—
May 81	67	1,308	67	24	6	88
July 81	50	698	49	66	—	—
Sept 81	—	—	15	694	28	253
Nov 81	4	211	32	716	17	449
Jan 82	13	15	28	374	38	294
Mar 82	59	32	10	410	34	193
May 82	—	—	86	336	84	169
July 82	—	—	19	364	—	—
Sept. 82	—	—	18	764	45	461
Nov 82	—	—	13	874	43	221
Jan 83	—	—	44	476	18	233

— = No contracts traded

[1]Ratio is the ratio of deliveries to peak open interest Delivery and open interest data were obtained from the Commodity Futures Trading Commission and from exchange publications

market. The high percentage of deliveries in some later months, particularly in the milled rice market, suggests that the market was too thinly traded to provide an efficient market for hedgers and speculators Short hedgers holding rice or long hedgers wanting rice may deliver or take delivery on the futures market rather than subject themselves to the price necessary to cancel their futures position Volume and open interest figures show that trading in the milled rice market fell off after the September 1982 contract, perhaps as a result of the unusual price and delivery behavior in that contract month. A similar problem probably occurred in the May 1981 sunflower seed contract, when open interest in sunflower seed fell sharply after the contract matured

Pricing Efficiency

Participants in a futures market are much concerned with how well futures prices reflect expectations of future market conditions There is a large and rapidly growing literature on the nature of the futures price/expectations relationship The efficient market hypothesis, summarized by Fama, states that an efficient futures market should reflect all information about expected supply and demand (*5*). Such a market should provide an unbiased and efficient (relative to other forecasting techniques) estimate of the actual price at contract maturity Fama gave three degrees of market efficiency and the information needed to test a market for each one

> Strong-form tests are concerned with whether individual investors or groups have monopolistic access to any information relevant for price formation In the less restrictive semi-strong form tests, the information subset of interest includes all obviously publicly-available information, while in the weak form tests, the information subset is just historical price or return sequences (*5*, p 370)

The limited history of futures prices in the rice and sunflower seed futures markets considerably narrows the variety of tests that may be applied We can apply several weak form tests, however, which should help answer two efficiency questions. Are the futures prices on thinly traded markets efficient ones? Are they reliable estimates of future conditions in the market?

If so, the value of these markets to agriculture is much greater than their hedging value alone If not, farmers may be misled by the posted prices.

Measures of Randomness

One important criterion for the efficiency of a series of day-to-day price changes is that the series be serially uncorrelated. If price changes are significantly related in some fashion, the market is inefficient.[5] For example, if one discovers that price changes in a market are significantly related by some means and if entry into the market is easy, then there is nothing to prevent that person from using a system based on that knowledge to buy and sell enough contracts to make a personal fortune at the expense of the other market participants. Such a market would clearly be inefficient, as there is a disparity of information about the appropriate market price. In an efficient futures market, arbitragers would prevent the price from moving very far from one which represents the underlying supply-demand equilibrium.

Under the hypothesis of market efficiency, futures prices should follow a martingale, or more generally, a submartingale process. This hypothesis means that the price of the commodity on day t + 1 should depend only on the price on day t plus a random quantity, not on the entire history of prices. Thus, if we denote the price of rice futures contracts on day t, calling for delivery in month i by F_{it} and the price for the same futures contract on the following day as $F_{i,t+1}$, then price changes following a martingale process should be serially uncorrelated and the price series should exhibit the following property (*6*, p. 209):

$$E_t(F_{i,t+1}|F_{it},F_{i,t-1},F_{i,t-2}, \ldots) = E_t(F_{i,t+1}|F_{it}) = F_{it} \quad (1)$$

In a submartingale, the equality would be replaced by ≥. This generalization allows an upward drift in the series. That is, prices may have an underlying tendency to rise, because of inflation. A submartingale process could still describe the series of price changes in this case.

[5] Danthine shows that this need not be the case in cash commodity markets (*4*). A cash commodity market may operate efficiently, yet barriers to entry, economies of size, and risk aversion can cause prices to follow an identifiable process. An efficiently performing futures market avoids these problems. The cost to enter or exit the market is quite low (the commission charge) so that a futures market can more closely approximate a perfectly competitive market. In fact, one would expect price changes in the cash markets for a commodity which also trades on the futures market to be less predictable than in cash markets for commodities without futures trading because some potential profit schemes based on price-determined trading rules would be arbitraged away.

A strong requirement for efficiency is often given, that of a random walk. For prices to follow a strict random walk, equation (1) must hold, the price changes must be independent, and the higher moments of the distribution of price changes must be constant. Thus, a distribution of price changes with variance increasing over the life of the contract would not be consistent with the simple version of the random walk hypothesis.

The distribution of price changes in agricultural commodities may have nonconstant variance because of seasonality in the amount of information affecting the market. That is, price changes may be more variable in the summer when day-to-day changes in the weather can affect expected crop size dramatically than in the winter when changes in expectations are fewer. Samuelson has shown how variance should tend to increase over the life of a futures contract (*20, 21*). Anderson presents evidence that seasonality in the size of the variance is typical of agricultural commodity futures markets (*1*).

There are several ways to test the randomness of a series. Mann and Heifner (*15*, p. 13) describe the turning point test, a nonparametric test for serial dependence developed by Kendall and Stuart (*13*):

> Kendall and Stuart (Vol. III, pp. 351-53) show that the expected number of turning points in a random series of length n is:
>
> $$E(p) = \frac{2}{3}(n - 2)$$
>
> and the variance of the number of turning points is:
>
> $$Var(p) = \frac{16n - 29}{90}$$

The turning point test examines the number of times a move upward (or downward) is reversed and compares that number with a theoretically calculated value. A series where each price was above the previous one would have no turning points and would thus fail this test for randomness. This test is a rather weak one against an underlying trend.

> This is intuitively reasonable, for 'turning' is a local property and would not be much

affected by whereabouts along a line of gentle trend development the series had arrived (*13*, p 355)

The test is much stronger against cyclical behavior and runs up and down in price These aspects make it quite useful in testing the submartingale hypothesis

The difference sign test, a test of the number of day-to-day moves in one direction, provides a simple test for trend (*13*, p 355) If the number of daily upward moves is substantially greater than the number of downward moves, the series has a significant trend A significant trend would reject the strict random walk hypothesis, but would not by itself reject efficiency under the more general efficient market hypothesis that price changes follow a submartingale

Tests of Randomness for the Futures Markets

I tested the randomness of the percentage closing price changes in the rough rice, milled rice, and sunflower seed futures markets with the turning point test to see if these markets were economically efficient Table 4 contains the calculated test statistics The turning point test shows that the null hypothesis of randomness could not be rejected in most contract months for each of the futures markets Table 4 also includes turning point test results for changes in the soybean closing price. These data enable one to compare results with those from a larger and long-established market The efficiency hypothesis of randomness could not be rejected at a 95-percent confidence level for any of the soybean contract months This comparison shows that the turning point test was not so sensitive that it would reject efficiency for a heavily traded and presumably efficient futures market. Randomness was not rejected for closing prices in the milled rice market for any contracts Closing price changes in the rough rice contracts for May 1981 and May 1982 were nonrandom In the sunflower seed market, only the last contract, March 1982, showed significant nonrandomness

On many days there were no trades in a particular contract month on the rice and sunflower futures markets Even if there was no trading, a settlement price was established to mark the contracts to market. The daily closing price might not represent the actual trading results in this case because some

Table 4—Turning point test of randomness[1]

Contract month	Sunflower seed		Rough rice		Milled rice		Soybeans
	Close	Open	Close	Open	Close	Open	Close
July 80	−1 53	− 56	—	—	—	—	1 29
Nov 80	− 34	− 54	—	—	—	—	74
Jan 81	−1 09	1 45	—	—	—	—	98
Mar 81	54	81	—	—	—	—	41
May 81	− 34	− 51	−2 73*	−1 66	0 33	0	11
July 81	0	− 71	−1 83	−1 39	—	—	0
Sept 81	—	—	68	.53	−1.43	47	37
Nov 81	−1 82	−1 29	−1 79	− 97	− 64	− 13	58
Jan 82	1 78	0	−1 44	24	−1 71	77	.94
Mar 82	2 05*	0	−1.82	66	− 68	.85	− 35
May 82	—	—	−3 10*	− 44	− 78	−1 15	36
July 82	—	—	− 28	− 78	—	—	− 97
Sept. 82	—	—	18	61	− 78	−2 71*	38
Nov 82	—	—	−1 41	−3 10*	− 41	1 26	− 73
Jan 83	—	—	−1 39	25	− 71	− 08	ND

ND = No data

— = No contracts traded

[1]The turning point test statistic is compared with the 95 percent confidence interval value of the t-distribution For all but the May 1981 rice contracts, the value of the 95-percent level is approximately 1 98 For the May 1981 contracts, it ranges from 2 0 to 2 2 depending on the number of days when that price was recorded For all closing prices in sunflower seed futures, the value at the 95-percent level is between 1 98 and 2 0

*shows that randomness was rejected at the 95-percent confidence level for that contract days had no buyers or sellers at the given settlement price As an alternative one may look at the open, high, low, or mean of high and low prices on the days when there was trading These prices were not reported if no trades occurred Of these, the opening price is the most satisfactory for the markets At first glance the mean might seem preferable, but distributions of changes in means of daily prices have been found to be autocorrelated This appears to be the case even with the means of daily high and low prices (see *26*)

Because closing prices were often nominal (that is, no trading occurred on those days), the opening prices were also tested. The September 1982 milled rice contract failed the randomness test in opening price There was also a large number of deliveries in this contract although not as many as in the May 1982 contract. Percentage changes in rough rice opening prices were nonrandom in the November 1982 contract. All the sunflower contracts appear to be random in changes in opening price Again, efficiency could not be rejected for any soybean contracts

The turning point test results suggest that, despite the thinness of trading in these markets, randomness in price changes was maintained A system could not be devised to take advantage of the history of the futures price changes to predict the future better than the forecast of the current futures price

Trend

Commodity prices gradually trended downward over much of the period studied The difference sign test shows whether there was a significant trend in the price changes. This test was performed on each rough rice, milled rice, and sunflower seed contract for both closing and opening prices Soybeans were tested for comparison (see table 5).

Several contracts showed a significant trend in closing price changes for rough rice. Opening price changes showed a trend in two cases The milled rice contracts showed fewer cases of trend, one in closing price changes and one in opening price changes The November 1981 contract in sunflower seed had a significant trend in opening price changes, whereas the May 1981 contract showed trend in closing price changes. The test results for soybean closes showed no significant trend, but opening price changes showed a significant trend in several contracts

The existence of a trend in several contracts does not reject the general market efficiency hypothesis, as the existence of a trend in price changes is not in-

Table 5—Difference-sign test[1]

Contract month	Sunflower seed		Rough rice		Milled rice		Soybeans
	Close	Open	Close	Open	Close	Open	Close
July 80	-1 00	-1.25	—	—	—	—	1 43
Nov 80	-1 21	- 60	—	—	—	—	- 10
Jan 81	-1 74	-1 11	—	—	—	—	61
Mar 81	- 12	- 13	—	—	—	—	- 92
May 81	-2.18*	69	- 50	0	1 00	-0 35	- 20
July 81	- 57	-1 59	-2 12*	- 58	—	—	- 10
Sept 81	—	—	- 83	-2 00	35	-3 67*	- 43
Nov 81	-1.82	-2 45*	-1 16	-1 16	- 87	-1 73	92
Jan 82	1 78	-1 25	-1 55	-3 10*	-1 03	- 50	1 43
Mar 82	2 05	87	-2 30*	-2 52*	- 38	- 34	- 82
May 82	—	—	-1 21	-3 67*	-1.75	0	41
July 82	—	—	- 43	- 75	—	—	20
Sept. 82	—	—	-1 66	-1 25	-2.67*	- 69	- 21
Nov 82	—	—	-1 44	- 78	1 02	-1 36	- 50
Jan 83	—	—	28	-1 33	.38	- 14	ND

— = No contracts traded
*marks values significant at 95-percent or greater confidence level
ND = No data
[1]The numbers displayed are the t-values

compatible with a submartingale or supermartingale process The strict random walk hypothesis, which does not allow for a trend in the price changes, would be rejected with these data.

A Test for Autocorrelation among the Futures Prices

If one can identify an autoregressive process in the futures market, one can use that information to profit at the expense of other market participants By definition, an efficient market does not allow guaranteed profit of that nature. Estimates of autocorrelation parameters need not yield results identical to other tests of randomness as autocorrelation estimates involve the size of the day-to-day change in price as well as its sign. Autocorrelation estimates are also parametric, that is, they rely on assumptions about the underlying distribution of price changes Autoregressive components were estimated for the price changes of rough rice, milled rice, and sunflower seed futures (see tables 6 and 7) The rough rice and milled rice markets both showed significant autocorrelation in the percentage changes in closing price for several contract months. Autocorrelated futures

Table 6—Autoregressive parameter estimates: Milled rice and rough rice[1]

Contract maturity	Closing price				Opening price			
	Milled rice		Rough rice		Milled rice		Rough rice	
	First order	Second order	First order	Second order	First order	Second order	First order	Second order
May 1981	0.463* (2 41)	- 0 080 (- 42)	0 343 (1 86)	-0.101 (- 55)	0 186 (90)	0 243 (1 18)	0 041 (.15)	-0 058 (- 21)
July 1981	—	—	230 (1 93)	.122 (1 02)	—	—	279 (1 65)	- 161 (- 95)
Sept 1981	198* (2 11)	003 (03)	070 (75)	.093 (1 0)	- 010 (- 11)	158 (1 64)	047 (50)	- 010 (- 10)
Nov 1981	003 (03)	-.073 (-.91)	.135 (1 68)	- 041 (- 50)	067 (0.83)	- 006 (- 08)	.053 (.65)	- 029 (- 36)
Jan 1982	0 144* (2 03)	- 043 (-.66)	.183* (2.61)	- 034 (-.49)	003 (03)	- 065 (- 87)	.045 (61)	- 006 (- 08)
Mar 1982	.135* (2.03)	.021 (32)	.084 (1 30)	-.095 (-1 47)	.264* (3.70)	.041 (.57)	123 (1 78)	015 (.21)
May 1982	.218* (3.46)	.049 (78)	240* (3 78)	-.004 (-.06)	.157* (2 17)	026 (.36)	117 (1 71)	024 (.35)
July 1982	—	—	192* (2 86)	.060 (89)	—	—	.148 (1 83)	129 (1 60)
Sept 1982	155* (2 23)	- 056 (-.81)	073 (96)	127 (1 67)	100 (1.09)	060 (.65)	071 (85)	073 (87)
Nov 1982	077 (1 00)	157* (2 04)	.015 (21)	.069 (.98)	041 (36)	.155 (1.38)	105 (1 29)	- 029 (- 36)
Jan 1983	024 (34)	179* (2 52)	057 (87)	.047 (71)	112 (1 12)	192 (1.91)	- 011 (-.14)	104 (1 34)

— = No contracts traded
*indicates first or second-order autocorrelation was significant at the 95-percent confidence level The estimated equation was $u_t = r_1u_{t-1} + r_2u_{t-2} + e_t$, where u_t is the daily change in the log of price, and r_1 and r_2 are the autoregressive parameters
[1]The value of the t-statistic for the null hypothesis that the parameter equals 0 is in parentheses

Table 7—Autoregressive parameter estimates: Sunflower seed and soybeans[1]

Contract maturity	Sunflower seed				Soybeans	
	Closing price		Opening price		Closing price	
	First order	Second order	First order	Second order	First order	Second order
July 1980	0 214 (1.56)	0.004 (03)	0 127 (90)	0 108 (77)	– 0 061 (– 1 05)	0 031 (54)
Nov 1980	083 (98)	065 (77)	– 042 (– 49)	023 (27)	– 041 (– 70)	– 067 (– 1 16)
Jan 1981	172 (2 30) *	074 (98)	– 024 (– 31)	102 (1 30)	046 (79)	– 038 (– 65)
Mar 1981	024 (35)	026 (39)	– 150 (– 2 05) *	003 (73)	001 (02)	015 (25)
May 1981	082 (1 33)	– 041 (– 66)	– 148 (– 2 30) *	– 089 (– 1 37)	007 (12)	– 072 (– 1 23)
July 1981	040 (63)	– 006 (– 10)	– .038 (– 48)	– 240 (– 3 05) *	– 016 (– 27)	– 068 (– 1 17)
Nov 1981	061 (92)	– 083 (– 1.26)	– 048 (– 60)	– 083 (– 1 03)	– 012 (– 21)	– 047 (– 81)
Jan 1982	– 050 (– 80)	005 (08)	– 082 (– 59)	– .075 (– 54)	– .008 (– 13)	– 045 (– 78)
Mar 1982	083 (1 30)	129 (2 02) *	078 (53)	– 072 (– 49)	– 096 (– 1 64)	– 051 (– 88)

– = No contracts traded
*indicates first- or second order autocorrelation was significant at the 95-percent confidence level The estimated equation was $u_t = r_1 u_{t-1} + r_2 u_{t-2} + e_t$, where u_t is the daily change in the log of price, and r_1 and r_2 are the autoregressive parameters
[1]The value of the t-statistic for the null hypothesis that the parameter equals 0 is in parentheses

price changes would usually indicate an economically inefficient market

Because closing prices were reported even if no trading occurred, tables 6 and 7 also show the autoregressive estimates for opening prices Two of the milled rice contracts (March and May 1982) showed significant first-order autocorrelation in percentage changes in opening price The May contract had an unusually large number of deliveries, which indicates an efficiency problem None of the percentage changes in rough rice opening prices was significantly autocorrelated at the 95-percent confidence level. The high degree of autocorrelation found among the changes in closing prices in both markets is a feature common to thinly traded and inefficient markets However, the low number of contracts where efficiency was rejected means that the null hypothesis of efficiency was not rejected for the group of contracts by the turning point or autocorrelation test when opening prices (those days in which trading occurred) were examined. For example, the probability, under the null hypothesis, that two of the nine milled rice contracts would reject the null hypothesis (assuming independence) is 7 percent, which is greater than the 5-percent significance level The data from different contracts are not completely independent, because they overlap in time Thus, the number of contracts rejecting the null hypothesis must be even greater before we could reject the null hypothesis of randomness for the group of contracts taken as a whole

Futures may follow a higher order process. For example, there may be third-order autocorrelation or even a day-of-the-week effect (fifth-order autocorrelation) I calculated Ljung-Box Q statistics for significance of coefficients of orders 1 through 5. The results are similar, but the apparent lack of autocorrelation of degrees higher than 1 means that fewer Q values than first-order autocorrelation estimates are significant. As for changes in opening price, only the March 1982 rough rice, July 1982 milled rice, and May and July 1981 sunflower seed contracts had Q values which rejected the null hypothesis (tables 6 and 7)

Forecast Accuracy

An important characteristic of an efficient futures market is that market's ability to predict prices in an accurate and unbiased manner Tests of forecast accuracy for futures market prices have become common in the past 15 years In 1970, Tomek and Gray used a forecast accuracy test to examine the efficiency of the potato futures market (*25*) Since then, many others have examined commodity futures markets with this test See, for example, (*14*) and (*16*)

A futures market should ideally provide an unbiased estimate of the price actually occurring in the delivery month To study this matter, one typically regresses the futures price on one day during the delivery period at harvest on the futures price at an earlier time—for example, at planting Because the difference between the futures price at harvest and the cash market price at harvest (the basis at maturity) varies considerably from year to year (because of changing factors such as transport cost and storage space cost), forecast accuracy tests usually test the futures price in the earlier period against the futures price at harvest rather than the cash price at harvest Observations on these two variables covering several years are collected and yield the following equation:

$$F_{D,t} = a + bF_{D-i,t} + e_t \qquad (2)$$

where:

$F_{D,t}$ is the futures price at delivery time in year t, $F_{D-i,t}$ is the futures price i periods before delivery in year t, and e_t is the residual in year t

If the earlier price is an unbiased estimate of the harvest price, coefficient a will equal 0 and coefficient b will equal 1 If the values of a and b are different from 0 and 1, then the futures market is said to give a biased estimate of the delivery price This cannot happen in an efficient market because the bias implies that someone could use the equation to profit at the expense of other market participants. For example, if some traders knew that today's estimate of next fall's price is too high, they would sell the commodity short and expect to make large profits

Because the futures markets for rice and sunflower seed were open for only a short time, the forecast accuracy test cannot be applied to planting time estimates of the price at harvest There are only enough data to allow testing the forecast of the next-to-last month price for the delivery month price and the forecast given by the price 2 months earlier for the delivery period price.

If all possible forecasts are used, the price forecasts 3 months or more into the future will overlap. That is, the same random events will affect at least two of the forecasts at a time The reliability of the June forecast for the September contract and the April forecast for the July contract are both affected by random events occurring from mid-June to mid-July The overlap means that the errors from the two forecasts will not be independent In fact, the errors from the forecast regression will tend to be autocorrelated To regain independence, one must drop some of the forecasts or explicitly account for the nature of the interdependence The aggregation of overlapping forecasts without an acknowledgment of the resulting interdependence of the observations in the equation is a common error in the forecast accuracy literature for agricultural commodities

Table 8 shows the results of these regressions One needs a simultaneous test of the slope and intercept coefficients to evaluate the forecast accuracy of the futures markets, as well as tests on individual coefficients In each regression, I calculated the F-statistic for the joint null hypothesis that (a,b) = (0,1) and compared it with the tabulated values I used the daily closing price on the 15th of the month (or the nearest day where trading occurred) as the representative futures price

The F-values rejected the null hypothesis of efficiency for the 2-month-ahead forecast for milled rice and 1-month-ahead forecast for rough rice at the 95-percent confidence level The calculated F-statistics did not

Table 8—Forecast accuracy of closing prices[1]

Milled rice					
(1)	Outcome = 2 749 + 0 820 $Pred_1$ (1 642) (0 086)	R^2 = 0.927	DW = 2 29 DFE = 7		F(0,1) = 4 12 Pr > F = 0 066
(2)	Outcome = 4 033 + 0 724 $Pred_2$ (1.427)* (0 078)*	R^2 = 0 934	DW = 2 34 DFE = 6		F(0,1) = 19.06# Pr > F = 0 003
Rough rice					
(1)	Outcome = 1 656 + 0 829 $Pred_1$ (0 564)* (0 057)*	R^2 = 0 960	DW = 1 92 DFE = 9		F(0,1) = 4 55# Pr > F = 0.043
(2)	Outcome = 2 711 + 0.697 $Pred_2$ (1 236) (0 128)*	R^2 = 0 787	DW = 1 95 DFE = 8		F(0,1) = 3.29 Pr > F = 0 093
Sunflower seed					
(1)	Outcome = 8 713 + 0 306 $Pred_1$ (3 214)* (0 267)*	R^2 = 0 141	DW = 1 28 DFE = 8		F(0,1) = 4 14 Pr > F = 0 058
(2)	Outcome = 7 738 + 0 376 $Pred_2$ (3.213)* (0 259)*	R^2 = 0 208	DW = 1 38 DFE = 8		F(0,1) = 2 91 Pr > F = 0 112
Soybeans					
(1)	Outcome = 12 038 + 0 991 $Pred_1$ (79.27) (0.117)	R^2 = 0 819	DW = 0 82+ DFE = 16		F(0,1) = 0 21 Pr > F = 0 813
(1a)	Outcome = 41.069 + 0.946 $Pred_1$ (95 20) (0 141)	R^2 = 0 751	Rho = 0.56 (0 19)		
(2)	Outcome = 132 98 + 0 782 $Pred_2$ (109 6) (0 155)	R^2 = 0.614	DW = 1 76 DFE = 13		F(0,1) = 2 05 Pr > F = 0.162

Notes DW is the Durbin-Watson statistic Values significant at a 95-percent or greater confidence level are marked with + DFE are the degrees of freedom of the estimate Rho is the estimated first order autocorrelation Standard errors are in parentheses F(0,1) is the value of the test statistic for the null hypothesis that (a,b) = (0,1) *indicates that the t-value rejected the null hypothesis of no bias for this coefficient at a 95-percent or greater confidence level #indicates that the F-value rejected the null hypothesis that the parameters are (0,1) at a 95-percent or greater confidence level

[1]Outcome is the closing price on the 15th of the delivery month
$Pred_i$ is the closing price on the 15th of the ith month before delivery i = 1,2

reject the null hypothesis both for forecasts for sunflower seed and for the 2-month-ahead forecast for rough rice But, in these cases the t-values for the null hypothesis on the slope and intercept terms individually rejected efficiency in every case but one The short history of these futures markets means that there are few degrees of freedom in the forecast accuracy tests The fewness of degrees of freedom (and the low value of R^2 in the case of sunflower seed futures) partly account for the lower rejection rate by the F-test than by the individual t-tests Neither the F-test nor the t-tests rejected the null hypothesis of forecast accuracy for the 1-month-ahead forecast for milled rice

For comparison, I calculated 1- and 2-month-ahead forecasts for soybean futures during the 1980-82 period The August contract in each year was omitted to prevent overlap in the 2-month-ahead forecasts The efficiency hypothesis could not be rejected with either the 1- or 2-month-ahead forecast in the soybean futures market The 1-month-ahead forecast showed autocorrelation in the residuals, but when corrected for the first-order autocorrelation still gave an unbiased forecast.[6]

Thus, several market prices for rice futures and sunflower seed futures 1 and 2 months prior to delivery were not unbiased predictors of their delivery month values. The F-test rejected efficiency in fewer equations than did the t-statistics on the slope and intercept terms. There are not enough data to test whether the spring price was a biased estimate of the fall price, but the results of the t-tests on the slope and intercept coefficients suggest that the 1- and 2-month-ahead forecasts show a bias towards the mean in their price predictions. The slope coefficients were significantly less than 1, which means that the price forecasts overestimate the deviation of subsequent prices from the mean. A profitable strategy would be to bet that price would return to its longrun level whenever there were wide swings in expected value.

One reason for the low estimates of b may be that the within-day variation in price in thin markets (due to the effect of buy-and-sell orders in moving market price) is large relative to day-to-day changes caused by changing expectations. That is, the lack of forecast accuracy in thin markets may reflect an errors-in-variables problem. In heavily traded markets, price movements due to buy-and-sell orders within a trading day may be smaller than in thin ones, relative to day-to-day price movements due to the arrival of new information.

Gray has suggested that thin markets will show bias (7). The results here tend to support his hypothesis. If the markets were to become more active, the forecast bias would presumably shrink and eventually disappear. Because of the higher entry and exit costs of a thin market in contrast to a liquid one, the ability of any arbitrager to profit from the bias would be limited.

[6] Autocorrelation in the residuals suggests an inefficient market, despite the lack of bias. The autocorrelation information could be used profitably by arbitragers. I estimated forecast accuracy of the 1-month ahead forecast for soybeans from a longer time series (1959-82) to see if autocorrelation was typical of soybean forecasts. The resulting equation shows that the soybean forecast was not representative over the period when rice and sunflower futures were traded.

$$\text{Outcome} = \underset{(9.09)}{15.42} + \underset{(0.018)}{0.968}\ \text{Pred}_1 \qquad R^2 = 0.946$$

$$\text{DFE} = 159 \qquad F(0,1) = 2.98$$

$$\text{DW} = 2.10 \qquad \Pr > F = 0.087$$

Conclusion

Several statistical tests have shown that three thinly traded futures markets—milled rice, rough rice, and sunflower seed—retain some (but not all) of the pricing and hedging characteristics of more heavily traded markets. The three markets exhibited randomness in day-to-day price changes. Without this property they would have little value to the potential hedger. Their hedging performance, as measured by the basis regressions, was mixed.

The forecast accuracy test is perhaps the most important one. Many farmers base their expectations of future supply, demand, and price on futures market quotations, whether or not they participate in futures trading. The apparent tendency for futures prices in thin markets to overreact to changes in supply and demand significantly lowers their value to producers.

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