The Behavior of "False" Futures Prices

Robert I. Webb

INTRODUCTION

Recent financial economic literature pays considerable attention to the analysis of the effects of trading and information on the volatility of speculative prices (e.g., French and Roll, 1986; Marsh and Rosenfeld, 1986; Ross, 1989). French and Roll, for instance, attribute the significantly greater observed volatility of security prices during exchange trading hours largely to market participants acting on private information and, to a lesser extent, to market participants acting on public information or mispricing by traders.

Separating the relative influence of information and mispricing by traders on volatility is impeded by the fact that most speculative price series may be described as a virtually continuous and indistinguishable mixture of equilibrium and provisional or "false" prices. This is because most speculative prices are generated on continuous markets and, as Garbade and Silber (1979) point out, the frequency of market clearing is a "key structural characteristic" of financial markets. In a continuous market, provisional prices are simply transaction prices where excess demand or supply remains after transactions occur at that price. The price is "false" in the sense that it is not a true equilibrium or market clearing price. In contrast, in a periodic call market with a single transaction price, provisional prices are the interim prices quoted in the process of determining the final transaction (and presumably equilibrium) price.

Interestingly, most Japanese commodity futures markets use the Itayose-hoh or single-fixed price auction system, which generates a single equilibrium price for each of several distinct trading sessions.[1] Indeed, the Itayose-hoh auction system closely resembles a series of single-commodity Walrasian tatonnements with no trading occurring at the interim provisional or false prices, and with recontracting allowed until a market clearing price is determined. This difference in market

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[1]The relatively recently established Japanese financial futures markets employ a different system. The Itayose-hoh auction system also resembles the periodic or call market formerly used to determine the prices of certain stocks traded on the Paris Bourse.

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structure allows one largely to distinguish the behavior of provisional prices from the behavior of equilibrium prices and abstract from market-making noise.[2] An understanding of the behavior of provisional prices on Japanese futures markets may provide insights into how new information is incorporated into futures prices, and the extent of possible mispricing by traders in the competitive open outcry auction system employed on U.S. futures markets. Further, given that volatility is arguably the most important determinant of option prices, the behavior of provisional prices may have some implications for the pricing of futures options in competitive open-outcry auction markets as well. This article examines the volatility, path, and speed of convergence to equilibrium using provisional price data on imported soybean futures contracts traded on the Tokyo Grain Exchange (TGE).[3]

WALRASIAN TATONNEMENTS

The Walrasian tatonnement has long been used by classical economists to characterize the determination of prices in a market economy. The Walrasian tatonnement or its variants are frequently used in the contemporary theoretical economic literature to examine issues of the stability of equilibria in competitive markets (see, e.g., Arrow and Hahn, 1971), although other models of the determination of equilibrium obviously exist (see, e.g., Samuelson, 1966). In a Walrasian tatonnement, an auctioneer initially calls out a set of provisional prices for all commodities. If excess demand exists for a commodity, its price is raised. If, instead, excess supply exists, the price of the commodity is lowered. This process continues until a set of equilibrium prices that simultaneously clears all markets is determined. No transactions are assumed to occur at the interim provisional or false prices, with recontracting allowed until an equilibrium set of prices is determined. Further, no time is assumed to elapse during the auction process.

A number of studies (e.g., Smith, 1965) use experimental data to examine how quickly convergence occurs in a Walrasian type of market. Based on the results of a number of empirical studies using experimental data, Smith (1982) advances the following proposition relating to double-auction markets: "Allocations and prices converge to levels near the competitive equilibrium (C.E.) prediction. This convergence is rapid, occurring in three or four trading periods or less when the subject is experienced with the institution... (p. 945)." However, while the use of experimental data has many advantages, it is not clear that the results are necessarily indicative of actual market behavior.[4] The use of actual market data circumvents this problem.

[2]One is not able completely to distinguish the behavior of provisional prices from the behavior of equilibrium prices, since the Itayose-hoh auction takes some (albeit small) amount of time to achieve convergence during which new information may enter the marketplace.

It should also be noted that since all trades are executed at a single price, the resulting equilibrium prices are free of what Marsh and Rosenfeld have termed "market making noise." This eliminates the upward bias in volatility, which results from transaction prices fluctuating between bid and ask prices and liquidity-based trading, as well as the downward bias in volatility, which results from market makers unknowingly trading with information motivated traders.

[3]Presumably, market clearing prices correspond to full information equilibrium prices. If there are lags or uncertainty in the dissemination of information, however, then one would expect to observe serial correlation in "equilibrium" prices.

[4]For instance, Heiner (1985) argues that studies using experimental data assume: "...fully deterministic preference orderings usually in the form of prespecified demand and supply value schedules. This assumption is basic to standard choice theory but it is, nevertheless, a theoretically created rather than an empirically discovered feature."

MARKET EFFICIENCY AND PRICE DISEQUILIBRIA

In the idealized world of a perfectly informationally efficient capital market, a sequence of security prices may be viewed as a sequence of price equilibria. Ross (1989) shows, for a simple martingale model in an arbitrage-free economy, that "the variance of price changes equals the rate of information flow (p. 8)." Intuitively, this result is simply a reflection of the fact that, in an informationally efficient capital market, prices change only in response to new information and, thus, mirror the flow of new information.[5]

The potential existence of price disequilibria is studied also in the financial economic literature. For instance, Beja and Hakannson (1977) note that intervening price disequilibria may emerge in an otherwise informationally efficient market if the auction process takes time. Moreover, changes in security prices are serially correlated as convergence to equilibrium occurs. Goldman and Sosin (1979) argue that uncertainty over the speed and path of dissemination of new information may result in price disequilibria. However, one need not develop an elegant theory to posit the existence of price disequilibria. As explained below, price disequilibria may simply arise from the structure of futures markets.

TESTS OF MARKET STRUCTURE

In an attempt to test certain hypotheses concerning the effects of differences in market structure (in particular, trading frequency) on price volatility, Marsh and Webb (1983) compare the volatility of *transaction* soybean futures prices of similar maturity contracts traded on the TGE and the Chicago Board of Trade (CBT). Contrary to the information dissemination uncertainty hypothesis advanced by Goldman and Sosin, Marsh and Webb report that the (exchange rate adjusted) volatility of TGE soybean futures prices exceeds the price volatility of corresponding CBT soybean futures contracts. However, the results are suggestive but not conclusive because the two markets differ in other aspects of market structure besides trading frequency, which might affect price variability, and because the TGE contracts implicitly reflect exposure to exchange and freight rate risks.[6] Again, it should be emphasized that while Marsh and Webb examine TGE *equilibrium* price data, provisional price data are *not* examined.

COMPETITIVE OPEN-OUTCRY AUCTION SYSTEM

U.S.-style futures markets employ the competitive open-outcry auction system, which generates a virtually continuous stream of futures prices. At any moment, there are always two prices, the bid and the ask, on the floor.[7] Traders indicate

[5]This result is consistent with an earlier observation by Fama (1963) who notes: "New information, in turn, should ultimately reflect changes in the underlying economic conditions that determine equilibrium prices in speculative markets. Thus, following this line of reasoning, the underlying economic conditions must themselves have an asymptotically paretian character and are, therefore, subject to a larger number of abrupt changes than would be the case if the distribution of price changes in speculative markets conformed to the Gaussian hypothesis." If the behavior of speculative prices mirrors changes in the flow of new information, then, as Webb (1985) notes, the time series process of changes in speculative prices imposes certain restrictions on possible linear models of information production as well.

[6]Of course, not all differences in market structure need affect the variability of prices. Similarly, the freight rate and exchange rate risks would increase the volatility of TGE soybean futures prices only if the three are positively correlated.

both the price and the desired quantity they are bidding for or offering. A transaction price results whenever someone hits a bid or takes an offer. There is no assurance, however, that a transaction price represents a market clearing price. The reasons for this are twofold: first, stated quantity demanded (supplied) at a bid (offer) price may not reflect total quantity demanded (supplied); second, whenever apparent excess demand (supply) exists, the initial quantity offered (bid) may be taken (hit) before the offer (bid) price can rise (fall) to reflect the additional demand (supply).[8] This means transactions occur at nonequilibrium prices; that is, price disequilibria arise. In the jargon of economists, trading at "false" prices occurs.

SINGLE FIXED-PRICE AUCTIONS

As noted above, most Japanese commodity futures markets employ the Itayose-hoh or single-fixed price auction system, which closely resembles a time-consuming temporally incomplete single-commodity Walrasian tatonnement. Essentially, the auction process works as follows: the TGE selects an initial opening price for a contract month at the start of a trading session, then quantities demanded or offered at the opening price are solicited from traders. If total quantity demanded exceeds total quantity supplied, no transactions occur and the price is raised. Conversely, if total quantity supplied exceeds total quantity demanded, no transactions occur and the price is lowered. Again, quantities demanded or supplied are solicited from traders at the new provisional price. Traders may recontract, that is, offset in whole or in part an earlier order to buy (sell) by entering an order to sell (buy). If excess demand or supply exists, then the price is changed again. If not, the provisional price becomes the final or equilibrium price and *all* transactions are executed at that price. Trading resumes for that contract month at the start of the next trading session.

New information is used also in an efficient manner. For instance, the various futures contracts are auctioned, in seriatim, by maturity. Presumably, a change in the equilibrium price from the previous trading session reflects new information. Moreover, this new information may be relevant to the adjacent futures contract as well. Accordingly, the market opening price is adjusted to reflect the equilibrium price change, if any, of the auction for the preceding contract month. Thus, if the December soybean futures price rose 30 yen from the previous trading session, the February soybean futures opening price would be determined by adding 30 yen to the last trading session's equilibrium price for February soybeans.

Since the principal focus of this article is on soybean futures trading at the TGE, a few words on the process of trading on the Exchange are in order. In years past, auctions were conducted with the assistance of an Exchange clerk who tallied total offers and bids and changed prices accordingly. In April of 1988, the TGE replaced this mechanism with computers manned by traders on the floor who enter their quantity bid or offered directly. This information is instantly compiled by the TGE and displayed to all traders. The identity of each trader (or rather, member firm) entering the bid or offer as well as cumulative totals by member firms are displayed also. (In 1990, the TGE eliminated the trading floor altogether by allowing members to man the specialized computer terminals in their offices instead.

[7]Exchange rules invariably dictate that only the best (highest) bid and best (lowest) offer can prevail at any moment.

[8]It should be noted that whenever a bid/ask spread exists, apparent excess demand (supply) at the bid (offer) price may not reflect actual excess demand (supply) at the higher (lower) offer (bid) price.

The TGE conducts four trading sessions per day for imported soybean futures.[9] The auctions are held at 10:00 a.m., 11:00 a.m., 1:00 p.m., and 2:00 p.m. Tokyo time. It currently trades six contract months (February, April, June, August, October, and December), with most activity concentrated in the deferred contracts. The auctions are conducted in seriatim. In contrast, the CBT currently lists soybean futures contracts for January, March, May, July, August, September, and November.

TGE soybean futures prices are quoted on a per 60-kilo bag basis. The minimum price change or tick is 10 yen or approximately 6.8¢ at an exchange rate of 150 yen = $1. The maximum daily price change is 150 yen. The size of the futures contract is 15,000 kg or approximately 500 bushels. In contrast, on the Chicago Board of Trade, soybean futures prices are quoted on a per bushel basis and traded in 5000-bushel contracts with a minimum price change of $\frac{1}{4}$¢.

In contrast to the idealized world of the Walrasian tatonnement, the Itayose-hoh auction takes time to conduct. As explained previously, net orders to buy or sell from each member firm are displayed to all traders as the orders are entered, and an updated overall excess demand or supply figure is reported. At selected intervals, the provisional price is changed to reflect excess demand or supply with a bell signaling traders of a change in the provisional price. If equality between quantity demanded and supplied is achieved, or if a dealer takes the excess, then the provisional price becomes the transaction price. If not, a new provisional price is determined and the process continues.

Occasionally, an equilibrium price is not achieved easily. The Exchange then terminates the auction session and relays an indicative price to the public. However, no transactions occur. While infrequent, the inability to reach an equilibrium is thought to be a function of the volume of trading with disequilibrium solutions more commonly associated with lower volumes of trading.[10]

DATA

Equilibrium price and volume data for imported soybean futures contracts are from the TGE for the period January 4, 1989 through December 29, 1989 and for April 23, 1990 through July 13, 1990. Provisional price and volume data are for the April 21, 1990 through July 13, 1990 period for all contract months and trading sessions. Due to holidays and half-day sessions, there are 5930 auctions in the first data set. Due to holidays and some missing data there are 1304 auctions in the second data set.[11] In addition, data on opening and settlement prices for soybean futures contracts traded on the CBT are from *The Wall Street Journal* for the period December 30, 1988 through December 29, 1989.

An examination of the equilibrium price data indicates an absence of any statistically significant serial correlation in successive price changes. First- and second-

[9]The contract specifies IOM soybeans. That is, soybeans grown in three states: Indiana, Ohio, and Michigan. According to TGE officials, it is believed that these soybeans are the best for *human* consumption. Soybeans from other states are simply not deliverable.

[10]There are no set rules for the termination of trading without achieving an equilibrium. Rather, the decision is based on the judgment of a TGE official on the trading floor. The indicative price relayed to the public is the last or second to last provisional price with the basis of selection being the one with the smallest difference between quantity bid and offered.

[11]In addition, provisional price and volume data were obtained for two actively traded contract months for the first two trading sessions each day for the period March 20, 1989 through April 7, 1989. Due to a holiday on March 21, and some missing data, there are 51 observations (i.e., auctions) in this sample.

order correlation coefficients and the associated standard error are reported in Table I. These results suggest that the TGE transaction prices are consistent with true (information) equilibrium prices.

Table II illustrates that disequilibrium auctions are relatively infrequent. In 1989, they occur approximately 5% of the time. The highest concentration of disequilibrium auctions occur in the December 1989 and February 1990 contract months and the two highest percentages of disequilibria occur in the June 1990 and August 1990 contract months.

An analysis of the behavior of TGE soybean futures contract volume data reveals several relationships. First, an analysis of TGE volume data by contract month and trading session (Table III) indicates that average trading volume is consistently greater during the first trading session than during the other three. Similarly, the fourth trading session is consistently the second most active trading session across contract months. Second, average trading volume increases with maturity, which is contrary to its behavior in most U.S. futures markets. Third, an analysis of TGE volume data by contract month and day of the week (Table IV) indicates that (with the singular exception of the February 1989 contract) Tuesday has the greatest average trading volume of any day in the week.

Table V reports the dispersion of changes in TGE equilibrium futures prices between trading sessions for the 12 contract months traded during 1989.[12] The variance is somewhat larger for the first 8 months than the last four months. The range also is significantly larger for the first eight contract months. This may reflect, in part, the somewhat larger number of abrupt overnight price changes that occur during the first half of the year. Part of it may be structural in the sense that there are

Table I
SERIAL CORRELATION IN SUCCESSIVE EQUILIBRIUM TGE SOYBEAN FUTURES PRICE CHANGES BY CONTRACT MONTH DURING 1989

	Correlation Coefficients			
Contract Month	1st Order	2nd Order	Standard Error	No. of Auctions
February 1989	−0.107	0.065	0.086	138
April 1989	−0.02	−0.005	0.057	306
June 1989	0.015	−0.034	0.046	474
August 1989	0.013	−0.036	0.039	650
October 1989	0.009	0.016	0.035	814
December 1989	−0.045	0.001	0.032	962
February 1990	−0.027	−0.035	0.034	852
April 1990	−0.032	−0.045	0.038	682
June 1990	0.041	0.003	0.044	514
August 1990	0.052	0.008	0.055	338
October 1990	−0.027	−0.006	0.077	174
December 1990	−0.104	0.017	0.213	26

[12]It should be noted that the last trading session of the last trading day was deleted for contracts expiring in 1989 in order to avoid introducing distortions in the variance associated with convergence to the cash market price on delivery day.

Table II
DISTRIBUTION OF DISEQUILIBRIUM AUCTIONS BY CONTRACT MONTH AND TRADING SESSION FOR TGE SOYBEAN FUTURES CONTRACTS DURING 1989

	Trading Session						
Contract Month	**1**	**2**	**3**	**4**	**Total**	**Total Auctions**	**% of Total**
February 1989	0	0	2	1	3	138	2.1
April 1989	1	1	5	1	8	306	2.6
June 1989	0	2	6	1	9	474	1.9
August 1989	4	11	12	4	31	650	4.8
October 1989	6	12	8	5	32	814	3.9
December 1989	6	14	25	2	48	962	5.0
February 1990	10	14	18	8	50	852	5.9
April 1990	5	11	11	4	31	682	4.5
June 1990	3	18	8	4	33	514	6.4
August 1990	7	12	5	1	25	338	7.4
October 1990	3	1	4	0	8	174	4.6
December 1990	0	0	0	0	0	26	0
Overall	47	96	104	31	278	5930	4.7

more holiday and half-day trading sessions during the first six months of the year than during the last six months.[13] This could result in more cases of large price changes when the market reopens.

French and Roll measure volatility or risk using the variance of changes in security prices during the trading day and overnight. That approach is used here as well. The variance, of course, is simply the expectation of the squared deviation from the mean. That is,

$$\sigma^2 = E[x - E(x)]^2$$

Table VI provides a measure of the risk (more correctly, the variance) of changes in TGE equilibrium prices over selected time intervals for each of the 12 contract months traded during 1989. Contrary to the results reported by French and Roll for the U.S. equity market, it appears that (with the singular exception of the December 1990 contract) there is more risk overnight than during the trading day. Overnight risk (trading session 1 price less the previous closing price) over all contract months is 796.71, whereas trading day risk (the current day closing price less the same day trading session 1 price) over all contract months is 522.94.

Table VI also indicates that the first trading session has the greatest dispersion of price changes from the previous session. Table VII reports the variance of TGE equilibrium prices by contract month during 1989. Table VII shows that, with few exceptions, Tuesday has the greatest variance of any day of the week. This result is consistent with the view that the TGE determines its prices based on CBT soybean futures prices. One possible explanation is that because Tokyo is 14–15 hours ahead

[13]Holidays and half-day sessions reduced the potential number of auctions by 40 in the first six months of 1989, and by only 18 during the last six months of 1989. January alone accounted for fully half of the reduction in auctions during the first six months of 1989.

Table III
AVERAGE DAILY TRADING VOLUME BY CONTRACT MONTH AND TRADING SESSION FOR TGE SOYBEAN FUTURES CONTRACTS TRADED DURING 1989[a]

Contract Month	Trading Session 1	2	3	4	Average Overall
February 1989	95.51	69.03	73.73	77.06	78.93
σ	(76.13)	(46.25)	(54.32)	(59.80)	(61.06)
n	35	35	33	33	136
April 1989	215.13	150.83	121.41	185.29	168.36
σ	(146.42)	(96.47)	(81.60)	(126.85)	(121.02)
n	77	77	75	75	304
June 1989	223.92	169.93	153.92	210.89	189.73
σ	(176.27)	(111.55)	(143.58)	(145.49)	(148.83)
n	119	119	117	117	472
August 1989	295.64	229.93	176.86	268.11	242.76
σ	(281.74)	(250.39)	(187.00)	(260.14)	(251.44)
n	163	163	161	161	648
October 1989	525.70	401.52	345.94	478.90	438.14
σ	(534.87)	(418.17)	(332.15)	(463.00)	(448.75)
n	204	204	202	202	812
December 1989	685.94	501.41	442.73	588.97	554.93
σ	(691.98)	(501.08)	(484.09)	(536.51)	(567.18)
n	241	241	239	239	960
February 1990	868.55	628.21	636.31	769.58	725.72
σ	(900.00)	(613.17)	(661.99)	(741.92)	(744.14)
n	213	213	212	212	850
April 1990	1297.08	979.55	953.73	1167.67	1099.62
σ	(1368.24)	(951.94)	(950.76)	(1085.84)	(1111.61)
n	171	171	170	170	682
June 1990	1369.36	967.23	1096.09	1276.37	1177.23
σ	(1223.32)	(847.71)	(930.84)	(985.57)	(1018.83)
n	129	129	128	128	514
August 1990	1440.27	1205.36	1345.18	1393.01	1345.82
σ	(1033.86)	(888.73)	(994.00)	(841.49)	(946.95)
n	85	85	84	84	338
October 1990	1816.61	1580.70	1424.81	1749.95	1643.66
σ	(1479.86)	(1038.48)	(999.64)	(832.87)	(1126.09)
n	44	44	43	43	174
December 1990	1026.43	913.57	721.17	1026.33	925.58
σ	(402.34)	(195.96)	(217.94)	(383.76)	(337.09)
n	7	7	6	6	26

[a]Excludes the two trading sessions on the last trading day for all contracts maturing in 1989.
σ = standard deviation; n = number of auctions.

of Chicago, TGE soybean futures prices do not incorporate the weekend volatility of Chicago until after the Chicago futures market reopens (i.e., Tuesday Tokyo time).

This conjecture is partially supported by the day-of-the-week behavior of the variance of changes in CBT soybean futures prices for contract months traded during 1989 and reported in Table VIII. Overnight risk (the variance of the change in

Table IV

AVERAGE DAILY TRADING VOLUME BY CONTRACT MONTH AND DAY OF THE WEEK FOR TGE SOYBEAN FUTURES CONTRACTS TRADED DURING 1989[a]

Contract Month	Monday	Tuesday	Wednesday	Thursday	Friday
February 1989	82.71	81.71	85.42	74.89	73.54
σ	(51.40)	(48.62)	(77.79)	(60.48)	(63.12)
n	24	28	26	28	28
April 1989	152.75	189.39	156.19	168.14	179.38
σ	(126.82)	(130.58)	(114.68)	(123.56)	(106.07)
n	60	56	62	64	60
June 1989	174.72	216.51	176.05	185.35	197.35
σ	(160.05)	(169.50)	(116.17)	(122.47)	(165.85)
n	96	92	94	96	92
August 1989	224.68	261.00	230.99	250.59	245.69
σ	(283.25)	(241.79)	(225.17)	(262.89)	(240.19)
n	128	128	130	132	128
October 1989	364.98	497.93	452.12	437.82	434.35
σ	(451.48)	(484.47)	(443.47)	(402.96)	(449.04)
n	164	160	166	164	156
December 1989	457.35	626.64	544.98	558.96	584.25
σ	(534.12)	(659.23)	(531.34)	(538.97)	(547.32)
n	196	192	194	192	184
February 1990	636.87	820.80	715.15	680.97	782.36
σ	(642.81)	(880.63)	(657.34)	(709.21)	(797.57)
n	176	168	172	172	162
April 1990	927.62	1284.02	979.76	1131.18	1188.00
σ	(853.81)	(1372.93)	(899.03)	(1168.47)	(1155.44)
n	140	136	140	136	130
June 1990	1081.44	1329.71	1077.75	1180.84	1229.08
σ	(815.51)	(1249.93)	(832.48)	(1121.46)	(999.78)
n	104	100	108	104	98
August 1990	1490.34	1327.31	1175.68	1410.54	1334.21
σ	(927.73)	(902.52)	(809.40)	(950.20)	(1112.88)
n	68	68	72	68	62
October 1990	1675.47	2043.83	1731.94	1576.5	1156.00
σ	(1160.06)	(1459.79)	(1148.63)	(819.93)	(598.05)
n	36	36	36	32	34
December 1990	765.75	885.50	117.75	1007.88	821.00
σ	(251.18)	(410.18)	(148.22)	(345.37)	(319.06)
n	4	4	4	8	6

[a]Excludes the two trading sessions on the last trading day for all contracts maturing in 1989. In addition, the single Saturday for which the TGE was open in 1989 is also excluded.

σ = standard deviation; n = number of auctions.

price from the previous close to the next trading day's open) is not uniformly greater for Mondays across contract months. In fact, overnight risk for Friday is greatest in eight of the 13 contract months. The greater observed volatility in TGE soybean futures prices on Tuesdays may be attributable, rather, to the greater trading-day risk (the variance of the change in price from the open to the close)

Table V
DISPERSION OF CHANGES IN TGE SOYBEAN FUTURES EQUILIBRIUM PRICES BETWEEN TRADING SESSIONS BY CONTRACT MONTH FOR THE PERIOD 1/4/1989–12/29/1989[a]

Contract Month	Variance	Standard Deviation	Range	Number of Auctions
February 1989	341.82	18.49	0–100	137
April 1989	276.56	16.63	0–100	305
June 1989	344.09	18.55	0–150	473
August 1989	355.21	18.85	0–120	649
October 1989	334.24	18.28	0–120	813
December 1989	273.31	16.53	0–120	961
February 1990	283.82	16.85	0–120	852
April 1990	274.86	16.58	0–120	682
June 1990	200.34	14.15	0–80	514
August 1990	153.16	12.38	0–50	338
October 1990	199.35	14.12	0–50	174
December 1990	90.56	9.52	0–30	26

[a]Excludes the last trading session of the last trading day for all contracts maturing in 1989.

Table VI
VARIANCE OF CHANGES IN TGE EQUILIBRIUM SOYBEAN FUTURES PRICES BY CONTRACT MONTH AND TRADING SESSION FOR THE PERIOD 1/4/89–12/29/89

Contract Month	Previous Close to Open	Intersession			Open to Close	Previous Close to Close
	T_1-T_4'	T_2-T_1	T_3-T_2	T_4-T_3	T_4-T_1	T_4-T_4'
February 1989	1008.77	99.91	99.17	51.42	229.07	1099.61
April 1989	787.09	126.86	81.32	101.23	390.77	994.38
June 1989	901.12	181.33	104.55	171.65	598.97	1058.80
August 1989	913.97	184.64	134.78	181.74	719.10	1203.11
October 1989	861.15	163.20	118.72	195.06	752.36	1266.45
December 1989	753.99	177.57	104.18	161.63	600.25	1188.99
February 1990	728.07	134.74	109.94	164.03	592.65	1188.39
April 1990	677.16	136.14	130.16	144.88	573.36	1116.66
June 1990	510.22	97.24	77.17	116.44	409.35	917.22
August 1990	353.98	84.28	76.18	86.69	326.23	687.07
October 1990	540.42	68.54	65.76	128.34	318.55	906.12
December 1990	96.00	56.00	56.00	16.00	147.22	120.00
Overall	796.71	133.10	102.01	143.10	522.94	1069.88

Note. T_1 = trading session 1; T_2 = trading session 2; T_3 = trading session 3; T_4 = trading session 4; T_4' = trading session 4 for the previous day.

observed on Mondays for CBT soybean futures prices. As Table VIII indicates, of the 13 months for which variances can be meaningfully determined, trading-day risk is greatest for Mondays in ten cases. (It should be noted that some observers define weekend volatility as the change in price from Friday's close to Monday's close.)

Table VII

VARIANCE OF CHANGES IN TGE EQUILIBRIUM SOYBEAN FUTURES PRICES BY CONTRACT MONTH AND DAY OF THE WEEK FOR THE PERIOD 1/4/89–12/29/89

	February 1989	April 1989	June 1989	August 1989	October 1989	December 1989	February 1990	April 1990	June 1990	August 1990	October 1990	December 1990
Monday												
Variance	402.08	261.42	201.03	233.90	201.20	210.27	214.40	218.06	179.80	177.23	231.17	18.75
n	24	60	96	130	164	196	176	140	104	68	36	4
Tuesday												
Variance	504.46	508.83	473.34	461.62	390.76	327.54	365.49	355.69	311.49	187.84	247.84	88.89
n	28	57	94	128	164	196	171	139	103	70	35	3
Wednesday												
Variance	200	162.21	220.33	262.17	229.52	289.74	215.79	170.07	129.52	78.06	117.99	0
n	26	61	93	129	165	195	170	137	105	70	34	2
Thursday												
Variance	385.20	191.19	470.83	362.12	400.51	378.08	330.81	369.76	176.89	156.29	178.027	53.06
n	28	64	96	132	166	192	171	136	104	68	32	7
Friday												
Variance	185.71	269.42	338.56	453.12	459.26	296.78	300.14	263.58	188.75	140.78	192.09	0
n	28	60	92	128	152	180	156	124	92	56	31	4

Table VIII
VARIANCE OF CHANGES IN CBT SOYBEAN FUTURES PRICES BY CONTRACT MONTH AND DAY OF THE WEEK FOR THE PERIOD 12/30/88–12/29/89

Contract Month	Monday	Tuesday	Wednesday	Thursday	Friday
January 1989					
Open to close	NM	NM	NM	NM	NM
Close to open	NM	NM	NM	NM	NM
Close to close	NM	NM	NM	NM	NM
n	2	3	3	3	4
March 1989					
Open to close	137.34	44.56	72.50	55.54	50.60
Close to open	10.84	13.12	3.65	2.74	13.07
Close to close	180.17	69.98	79.37	66.07	39.38
n	11	12	11	11	12
May 1989					
Open to close	135.36	53.45	67.49	90.23	36.77
Close to open	16.63	10.59	5.56	8.13	13.88
Close to close	193.68	67.30	71.93	86.06	40.19
n	19	20	20	20	21
July 1989					
Open to close	147.59	86.71	106.74	83.19	62.82
Close to open	43.91	44.99	7.59	15.02	22.83
Close to close	253.03	179.75	107.74	75.50	84.16
n	27	28	29	28	29
August 1989					
Open to close	121.82	47.10	70.95	113.66	59.68
Close to open	36.84	24.81	10.46	46.27	31.66
Close to close	209.80	81.84	87.50	91.62	99.06
n	32	32	33	33	33
September 1989					
Open to close	82.16	47.79	40.79	74.98	55.22
Close to open	44.34	18.92	14.45	27.74	47.16
Close to close	150.56	71.09	48.74	80.70	111.16
n	35	37	37	37	38
November 1989					
Open to close	62.51	34.55	36.89	58.08	53.18
Close to open	37.61	19.25	12.01	21.22	41.68
Close to close	112.93	55.38	41.28	63.78	93.50
n	43	45	46	46	47
January 1990					
Open to close	53.46	34.74	28.79	55.34	40.00
Close to open	56.10	20.51	10.93	27.62	65.21
Close to close	106.70	49.41	38.46	63.70	104.75
n	48	51	52	51	52

NM = not meaningful due to small sample size.

Table VIII (continued)

Contract Month	Monday	Tuesday	Wednesday	Thursday	Friday
March 1990					
Open to close	38.98	31.96	23.61	38.67	36.79
Close to open	37.45	24.38	22.35	19.74	52.97
Close to close	90.92	65.66	44.65	50.71	87.79
n	48	51	52	51	52
May 1990					
Open to close	48.28	36.93	32.00	32.91	43.03
Close to open	36.88	18.40	12.98	28.60	59.03
Close to close	108.50	50.71	43.06	55.09	96.09
n	38	40	41	40	40
July 1990					
Open to close	43.79	43.92	29.04	28.27	41.36
Close to open	46.44	24.88	19.54	28.07	70.96
Close to close	105.33	66.80	47.55	36.47	110.53
n	31	33	34	33	34
August 1990					
Open to close	7.62	16.09	7.91	9.18	13.27
Close to open	8.55	11.15	37.90	2.52	23.52
Close to close	7.82	20.37	39.96	12.06	24.44
n	15	17	17	17	17
September 1990					
Open to close	10.57	9.19	11.39	11.42	12.81
Close to open	5.22	8.62	16.08	9.80	29.72
Close to close	4.25	9.91	27.39	5.21	20.31
n	14	15	15	14	14
November 1990					
Open to close	14.24	20.20	21.07	17.91	37.06
Close to open	7.40	10.66	21.24	18.80	26.97
Close to close	17.09	23.84	49.93	27.68	71.05
n	26	27	29	28	28
January 1991					
Open to close	NM	NM	NM	NM	NM
Close to open	NM	NM	NM	NM	NM
Close to close	NM	NM	NM	NM	NM
n	4	5	5	5	4

Table IX provides a listing of overnight risk, trading-day risk, and "total" risk (the variance of changes in consecutive settlement prices) for CBT soybean futures prices by contract month during 1989. Table IX generally supports the French and Roll findings of trading-day risk exceeding overnight risk. Of the 15 contract months traded on the CBT during 1989, trading-day risk exceeds overnight risk in 12 cases.[14]

[14]It should be noted that the variances of TGE and CBT soybean futures price changes are not directly comparable.

Table IX
VARIANCE OF CHANGES IN CBT SOYBEAN FUTURES PRICES BY CONTRACT MONTH FOR THE PERIOD 12/30/88–12/29/89

Contract Month	Overnight Risk (Previous Close to Open)	Trading-Day Risk (Open to Close)	"Total" Risk (Previous Close to Close)	Number of Trading Days[a]
January 1989	10.26	97.70	129.79	15
March 1989	10.13	73.25	90.82	57
May 1989	12.33	75.95	91.97	100
July 1989	26.71	98.64	140.37	140
August 1989	30.18	83.17	115.30	163
September 1989	30.82	60.36	93.46	184
November 1989	26.32	49.91	73.88	226
January 1990	35.91	42.59	72.82	254
March 1990	31.68	34.41	68.66	254
May 1990	31.96	38.96	71.92	199
July 1990	39.37	38.04	76.67	165
August 1990	19.37	11.12	24.74	83
September 1990	15.04	11.44	15.42	72
November 1990	18.49	23.17	40.10	138
January 1991	2.57	9.41	13.50	23

[a]Indicates the number of trading days for which futures prices were reported in *The Wall Street Journal* during 1989.

THE PATH AND SPEED OF CONVERGENCE TO EQUILIBRIUM

As Table X shows, equilibrium is reached very quickly in the single-fixed price auctions employed on the TGE. The average number of iterations or *changes* in provisional price needed to achieve convergence to equilibrium ranges from 2.57 to 3.2, while the standard deviations range from 1.17 to 1.91. These results correspond well with evidence reported in the economic literature using experimental data. If anything, it might be argued that equilibrium occurs slightly more quickly than in the experimental studies Smith (1982) summarizes. The number of iterations ranges from a minimum of 0 to a maximum of 11 in this sample. Much of the required adjustment to equilibrium is made in the selection of the opening price. While there does not seem to be any appreciable difference in the speed of convergence across contract months, the range (i.e., the number of iterations) is greater for the more actively traded contract months.

When disequilibrium auctions are excluded from the sample, the average number of iterations necessary to achieve convergence falls slightly, with the exception of June 1991 contract month. This result is due to the presence of a disequilibrium auction that uncharacteristically was ended after a single iteration and the small sample size of trading sessions for the June 1991 contract.

However, despite the rapid convergence to equilibrium, the path of convergence is not always direct. Indeed, the equilibrium contract price is often a previously *re-*

Table X
"SPEED" OF CONVERGENCE TO EQUILIBRIUM OR CESSATION OF AUCTION BY CONTRACT MONTH FOR THE PERIOD 4/23/90–7/13/90

	Contract Month							
	Apr 1990	June 1990	Aug 1990	Oct 1990	Dec 1990	Feb 1991	Apr 1991	Jun 1991
All Auctions (n = 1304)								
Total number of iterations	16	503	608	563	589	654	629	142
Number of auctions	5	165	216	219	218	218	211	52
Avg. no. of iterations	3.2	3.05	2.81	2.57	2.70	3.0	2.98	2.73
Standard deviation	1.17	1.78	1.73	1.42	1.64	1.91	1.76	1.56
Range	2–5	1–9	1–9	1–7	1–11	1–11	1–10	1–7
Total no. of times final price is previously rejected provisional price	1	49	61	77	92	139	133	29
Average no. of above	0.2	0.30	0.28	0.35	0.42	0.64	0.63	0.56
Excluding Disequilibrium (n = 1252)								
Total no. of iterations	16	488	600	528	560	534	569	147
Number of auctions	5	163	215	212	213	196	199	49
Average no. of iterations	3.2	2.99	2.79	2.49	2.63	2.72	2.86	3.0
Total no. of times final price is previously rejected provisional price	1	44	59	65	82	97	73	24
Average no. of above	0.2	0.27	0.27	0.31	0.38	0.49	0.37	0.49
Disequilibrium Auctions (n = 52)								
Total no. of iterations	0	15	8	35	29	120	60	15
No. of auctions	0	2	1	7	5	22	12	3
Average no. of iterations	0	7.5	8	5	5.8	5.45	5	5
Total no. of times final price is previously rejected provisional price	0	5	2	12	10	42	20	5
Average no. of above	0	2.5	2	1.71	2	1.91	1.67	1.67

jected provisional price.[15] Consequently, under- and overshooting frequently occur, with less serial correlation in provisional prices than one would expect. Table X shows another measure of this phenomenon in the average number of times the equilibrium price appears as a provisional price. The average ranges from 0.2 to

[15]This contrasts with Walras' belief in how equilibrium occurs. Walras (1954) argues: "[I]n all probability equilibrium will be approximated more and more closely at each successive step in the groping [tatonnement] process. . . ;" (p. 470).

Arrow and Hahn (1971) argue that Walras' ". . . successive tatonnement procedure [for determining general equilibrium]. . . is, in fact, what is known as a Gauss–Seidel method of solving a set of simultaneous equations, a method that is not particularly attractive as a computational means" (p. 306).

Using a tatonnement process with a different auctioneer rule, Arrow and Hahn note: "It is important, however, not to be mislead. . . into believing that all prices are monotonically approaching the equilibrium value. The monotonicity of the Lyapounov function here is quite consistent with, say, fluctuations of individual prices of declining amplitude about their equilibrium value" (p. 286).

0.49. Table X also indicates that auctions for more actively traded contracts months are more likely to exhibit under- or overshooting.

Table X also reports statistics for the 52 disequilibrium auctions. The average number of iterations is significantly greater for the auctions that are terminated because they fail to reach an equilibrium between quantity demanded and supplied. Similarly, the average number of times the final price is a previously rejected provisional price rises sharply, ranging from 1.67 to 2.5.

The puzzling behavior of provisional futures prices is reflected also in the behavior of excess demand. Excess demand is sometimes an increasing function of price. That is, excess demand may actually increase as provisional prices increase. For example, an examination of provision price and volume data for the December 1989, February 1990 contracts during the two morning trading sessions for the period March 20, 1989 through April 7, 1989, indicates four instances where excess demand actually increases with an increase in the provisional price, and one instance where excess supply increases with a decrease in the provisional price. One is tempted to attribute this aberrant behavior to timing differences in the receipt of orders to buy or sell, although this may not be the correct explanation. The reason for this relationship is not immediately apparent. It is possible that the orders placed by certain firms are perceived as containing information, thus resulting in an increase in excess demand (supply) as price increases (decreases). Another possible explanation for excess demand increasing with price is "short covering." In any event, the small sample size does not permit one to draw any inferences.

THE VOLATILITY OF "FALSE" FUTURES PRICES

Table XI shows the volatility of TGE soybean futures equilibrium and provisional prices by contract month during the period April 23, 1990 to July 13, 1990. As is apparent, equilibrium prices are more volatile than the combination of equilibrium and provisional prices. This is true whether one compares intersession prices or close to open or open to close volatilities.

Consistent with Table VI, the volatility of equilibrium prices during the trading day (measured from trading session 1 to trading session 4) is less than the volatility experienced overnight (measured from trading session 4 of the previous day to trading session 1), during part of which time U.S. futures markets are open. As noted earlier, this contrasts with the findings reported by French and Roll, who report greater volatility when the U.S. stock market is open than when it is closed. This difference may reflect the fact that most public or private information generated on U.S.-grown soybeans is produced during the U.S. business day, or it may show the greater relative importance of U.S. futures markets in determining grain prices.[16]

As stated earlier, futures prices generated from a competitive open-outcry auction system may be described as a virtually continuous and indistinguishable mixture of equilibrium and provisional prices. If equilibrium and provisional prices are distinguished, separate variances could be calculated for each price series as well as the total. The variance of the total would depend on both the individual variance series and on the covariance of the two component price series. For instance, the lower variance of the combined June 1990 provisional and equilibrium prices is substantially less (228.40) than the variance of equilibrium prices (or indicative prices)

[16]Since the period that the Exchange is open is shorter than the period that the Exchange is closed, the greater volatility observed during market closure may be slightly biased.

[17]Marsh and Rosenfeld (1986) report that intermittent trading does not bias volatility estimates of stock prices (except for extreme values), although the estimator is less efficient.

Table XI
THE VARIANCE OF CHANGES IN TGE EQUILIBRIUM (OR INDICATIVE) AND PROVISIONAL SOYBEAN FUTURES PRICES BY CONTRACT MONTH FOR THE PERIOD 4/23/90–7/13/90

	Contract Month							
	Apr 1990	Jun 1990	Aug 1990	Oct 1990	Dec 1990	Feb 1991	Apr 1991	Jun 1991
Equilibrium (and Indicative) Prices Only								
Variance	65.75	494.36	614.79	544.24	591.298	531.96	438.48	599.388
N^a	4	164	216	218	217	218	210	51
Provisional and Equilibrium Prices								
Variance	59.56	228.40	286.75	271.94	381.31	243.73	213.63	279.899
N	15	502	608	563	588	655	1272	284

[a] N is equivalent to the number of trading sessions less one when equilibrium and indicative prices are considered.

for that period alone (494.36).[17] This suggests a less-than-perfect positive correlation between provisional and equilibrium prices and may indicate negative correlation, especially when coupled with the observed tendency of the equilibrium price to be a previously rejected provisional price. Consequently, it is possible that negative correlation might exist also between equilibrium and provisional futures prices generated from a competitive open-outcry auction system.

If so, this has some implications for option pricing as well. In particular, if the relevant volatility option market participants use is the volatility of equilibrium prices, then this would result in option prices appearing to be overvalued relative to transaction price volatility during periods when there are large swings in underlying equilibrium futures prices and small changes in provisional prices.[18] Simply stated, perceived volatility increases during periods of large swings in equilibrium prices. Conversely, futures option prices may appear undervalued relative to transaction price volatility during periods when changes in provisional prices are large. Such conditions might arise when market participants begin trading.

Keep in mind that the TGE's choice of a market opening price sharply reduces the volatility of provisional prices. For instance, if the opening price in the trading session for a contract month is always the previous closing price, then the volatility of provisional prices would be substantially higher. As it is, the choice of a market opening price reduces the volatility of provisional prices. Even so, the actual amount of mispricing on competitive open-outcry auction markets may be significantly lower, because markets which trade continuously are able to incorporate information as received (usually in small bits) rather than by letting it accumulate. This should result in smaller differences in both equilibrium and provisional prices on competitive open-outcry auction markets.

In a general sense, this is exactly what one would expect to observe given the French and Roll results. That is, most of the variation in speculative prices is due to market participants acting on new information. However, the apparent lack of serially correlated equilibrium prices, noted previously and by Marsh and Webb, suggests that private information may not be as important in these markets as French and Roll observed for the U.S. stock market.

[18] Webb (1987) argues that such conditions arise during "choppy" markets, where large differences between equilibrium futures prices result in an underestimation of perceived volatility.

CONCLUSION

The behavior of provisional prices in single fixed-price auction markets may offer important clues to the way in which new information is incorporated into speculative prices and the extent of mispricing by traders in other markets. Although provisional prices demonstrate a tendency to over- or undershoot the equilibrium price, convergence to equilibrium is reached quickly. This suggests that large changes in prices are more likely due to new information than to the tatonnement process. This is borne out by the lower volatility of provisional prices compared to equilibrium prices. However, given the apparent absence of serial correlation in equilibrium prices, it is not clear that the greater volatility of equilibrium prices is due to market participants acting on private rather than public information. Further, it may be useful to distinguish volatility arising from the behavior of provisional prices from volatility of equilibrium prices in the pricing of futures options.

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