Testing Rationality in Futures Markets

Christopher K. Ma
William H. Dare
Darla R. Donaldson

INTRODUCTION

In recent years, the possibility of market irrationality has generated significant discussion among financial economists. One area of interest concerns the path of the reaction of security prices to new information. This issue has been examined from different perspectives. Shiller (1981, 1984) claimed that the observed volatility in stock returns is excessive in the sense that it cannot be solely explained by the uncertainty of future real dividends. French and Roll (1986) formulated testable hypotheses to identify three possible causes of market volatility: the release of public information, the production of private information, and trading noise. The trading noise hypothesis suggests that traders tend to overreact to others' trading and this overreaction creates noise in the market. French and Roll (1986), Makihija and Nachmann (1988), and Ma, Rao, and Sears (1988) have all provided empirical evidence of such overreaction in financial markets.

The second form of testing market rationality is based on the overreaction of securities prices *per se* to the release of unexpected information. A study in experimental psychology by Kahneman and Tversky (1981) showed that people tend to overreact to unexpected and dramatic events. They argued for the so-called "overreaction hypothesis" that individuals tend to overweight recent information and underweight prior information when revising their beliefs. This violates the basic Bayesian rule that the extremeness of predictions must be moderated with considerations of probability of its occurrence. Based on this hypothesis, DeBondt and Thaler (1985, 1987) reported that large abnormal returns can be earned by the contrarian investment strategy in the stock

The authors wish to thank Don Chance, Luc Soneon, Chip Peterson, Scott Hein, and participants of Research Seminar in Texas Tech University.

Christopher K. Ma is an Associate Professor in the College of Business Administration, Texas Tech University.

William H. Dare is a Ph.D. Student in the College of Business Administration, Texas Tech University.

Darla R. Donaldson is a Ph.D. Student in the College of Business Administration, Texas Tech University.

The Journal of Futures Markets, Vol. 10, No. 2, 137–152 (1990)
© 1990 by John Wiley & Sons, Inc.
CCC 0270-7314/90/020137-16$04.00

market. They concluded that market participants consistently overreact to substantive news of any nature. Their findings have raised subsequent debate.[1]

On the other hand, some totally "rational" explanations for the seemingly irrational overreaction in the stock market have been offered by several other studies. Brown, Harlow, and Tinic (1988) proposed the uncertain information hypothesis that, in the presence of imperfect information, rational, risk-averse investors will respond by initially overreacting to bad news and underreacting to good news. This is due to the fact that subsequent to the news of a dramatic financial event, both the risk level and the expected return of the affected companies will increase as a result of the information uncertainty. Consequently, the immediate price changes of significantly favorable events will ostensibly be followed by positive returns during the post-event period. The post-announcement price adjustment, while not rejecting market rationality, suggests that the market reacts to uncertain information in an efficient, if not instantaneous, manner.

Similarly, DeLong, Shleifer, Summers, and Waldmann (1987) found that noise traders with erroneous and stochastic beliefs can earn higher returns than do rational investors since they bear a large amount of risk. Their presence raises overall expected returns because sophisticated investors dislike bearing the "noise trader risk", i.e., the risk that noise traders may be irrationally pessimistic and push asset prices down in the future. Given this additional risk in asset markets, the average price of assets will be below fundamental values in the short run. This divergence, however, will decrease once the noise is reduced, giving rise to the patterns of mean reversion in stock and bond prices as noted by Fama and French (1986), and the price reversals in the empirical literature of overreaction.

The third possible explanation is called "the overshooting hypothesis." Dornbush (1976) argued that while interest rates can adjust to new information instantaneously, the money supply cannot. The different adjustment speeds lead exchange rates to overshoot in the short run. At the new equilibrium, the exchange rate reverses itself when the money supply is eventually able to adjust. Using the same argument in the stock market, Fabozzi, Ma, and Lindsley (1988) claimed that securities prices generally adjust to information faster than trading volume. The latent trading volume induced by investors' portfolio revisions will reverse the price pattern which creates a short run price overreaction.

The issue of price overreaction is particularly relevant in the futures markets. Since the two major functions of futures prices are to provide information discovery and resolution to cash traders, the speed and the nature of futures price adjustments to new information suggest important welfare considerations. This article investigates the adjustment process of futures prices in reaction to significant events. Contrary to previous studies, statistically significant price changes are used as proxies for the arrival of significant events. The evidence indicates that, in general, futures prices of agricultural commodities tend to overreact to significant events, while financial futures prices tend to underreact to significant events. The fact that the price does not adjust to information instantaneously seems to imply that either there is information asymmetry among traders in the market and/or that traders do not have homogenous risk attitudes. The contribution of this study goes beyond the academic interest on the efficiency of futures markets. The findings of this study provide strong (dis)justifications to the design and implementation of most regulatory devices in futures markets, especially if the effectiveness of

[1]For details, See Brown, Harlow, and Tinic (1988), Chan (1988), DeBondt and Makhija (1988), Delong, Shleifer, Summers, and Waldmann (1987), Dyl and Maxfield (1987), Gandar, Zuber, O'Brien, and Russo (1988), Jones (1987), and Summers (1986).

these regulations depends upon the stabilizing implications of the generating process underlying the futures price.

EMPIRICAL DESIGN

Sample

Since there is not an *a priori* reason why the price adjustment process subsequent to significant events should be uniform across different futures contracts, the same procedure of testing rationality is repeated across twelve different types of futures contracts. In Table I, the sample is briefly described. There are six futures contracts for agricultural commodities, two metal futures contracts, and four financial futures contracts.[2] Daily closing prices for the nearby contract were collected.[3] Note that the varying lengths of the sample period are restricted by the data availability and the life of the specific futures market.

Daily prices, rather than prices with a longer time horizon (used in earlier studies) are used for testing rationality because of the nature of futures markets. Since liquid futures trading is uniquely characterized by the short maturity of the asset and by the aggressive basis and spread arbitrage that occurs, the time to respond to significant daily events is expected to be relatively short. Using market price data of longer time intervals will not allow us to observe reactions of the type under study.

Methodology

Significant price changes are used in this study as proxies for the occurrence of significant events which is different from previous studies where information is often characterized by a specific event. A significant price change is defined in a statistical sense. Since the time series of historical prices is invariably affected by the underlying fundamental trend of each commodity, identifying an abnormal price movement is only possible when the "normal" price movement is ascertained. That is, the return-generating process can be described as follows:

$$R_{it} = E(R_{it} \mid I_{t-1}) + \varepsilon_{it}$$

where R_{it} is the actual daily return measured by the logarithm of price changes during period t for the ith futures contract, and $E(R_{it} \mid I_{t-1})$ is the expected ("normal") rate of return, given the information set, I_{t-1} at time $t - 1$. The issue of market irrationality may only be examined after a certain form of rationality is defined. The rationality of market expectations, as shown by $E(R_{it} \mid I_{t-1})$, is determined under the condition that the estimation error, ε_{it}, is a result of the assumption that the market formulates expected returns on a rational expectation basis. Specifically, using all currently available information, rational trading agents will not consistently make biased estimates. Under this

[2]21 futures contracts serve as the preliminary sample. The sample was screened according to the number of the observations and significant events for each contract. The final sample consisted of 12 different contracts.

[3]The potential problems of using closing prices instead of actual transaction prices are acknowledged. However, the extent and the relevance of possible biases can vary depending on the issues investigated. If the purpose of identifying irrationality is to explore trading profit, the testing is better served by actual transaction prices. Since it is the price adjustment process after significant events that is of interest, the bias is considered not to be crucial to the conclusion. Note that the bias attributed to the thin trading of certain contracts is further reduced in this study, since only nearby contracts are used.

Table I
SAMPLE DESCRIPTION

Futures Contract	Sample Period	Number of Obs.	ARIMA Model	Chi-Square Lags: 6	12	18	Min. Days
Commodities Futures							
Com	Jan. 1977–Dec. 1987	2528	$R_t = -7.39E\text{-}05 + .0092\,R_{t-1} + \varepsilon_t$	7.84	15.97	25.75	3
Coffee	Jan. 1977–Dec. 1987	2514	$R_t = -.00022 - .0387\,R_{t-1} + \varepsilon_t$	15.86	21.03	31.87	72
Pork Bellies	Jan. 1977–Dec. 1987	2531	$R_t = -.0454 - .00003\,t = .1102\,R_{t-1} + .0585\,R_{t-10} + \varepsilon_t$	8.57	16.16	18.27	3
Soybean	Jan. 1977–Dec. 1987	2528	$R_t = -3.322E\text{-}06 - .0253\,R_{t-1} + \varepsilon_t$	8.39	18.83	25.01	6
Soymeal	Jan. 1977–Dec. 1987	2527	$R_t = -.00011 - .0123\,R_{t-1} + \varepsilon_t$	5.33	11.77	17.00	4
Wheat	Jan. 1977–Dec. 1987	2528	$R_t = .0001 - .0180\,R_{t-1} + \varepsilon_t$	5.54	12.65	24.42	26
Metal Futures							
Gold	Jan. 1975–July 1987	2899	$R_t + .1138 - .0001\,t = -.0719\,R_{t-1} - .0908\,R_{t-4} + .039\,R_{t-10} + .0592\,R_{t-12} + .0575\,R_{t-13} + \varepsilon_t$	4.05	6.61	24.09	9
Silver	Jan. 1975–July 1988	3149	$R_t + .0804 - .00004\,t = .0583\,R_{t-1} - .0569\,R_{t-4} - .0602\,R_{t-5} + .0698\,R_{t-8} + .0498\,R_{t-12} + .0411\,R_{t-13} + \varepsilon_t$	1.35	4.40	18.13	13
Financial Futures							
Treasury Bond	July 1977–July 1988	2744	$R_t = -6.349E\text{-}05 - .0505\,R_{t-1} + \varepsilon_t$	11.42	17.65	21.79	1
Muni Bond	June 1985–July 1988	775	$R_t = -1.679E\text{-}0.6 + .0226\,R_{t-1} + \varepsilon_t$	6.14	14.82	20.72	33
S&P 500	April 1982–July 1988	1568	$R_t = -.2539 + .0003\,t + \varepsilon_t$	2.36	2.74	3.14	10
Value Line	Aug. 1985–July 1988	1584	$R_t = .0004 - .0109\,R_{t-1} + \varepsilon_t$	16.87	21.98	24.73	8

*: All chi-square statistics are insignificant at one percent level.

Min. Days: The minimum number of days between two consecutive significant events.

assumption, ε_{it} is the white noise which represents the unexpected, abnormal component of the return-generating process[4], with the following properties:

$$E(\varepsilon_{it} \mid I_{t-1}) = 0, \qquad V(\varepsilon_{it} \mid I_{t-1}) = \sigma_i^2, \qquad \text{and } \mathrm{Cov}(\varepsilon_{it}, \varepsilon_{it-1}) = 0.$$

Undoubtedly, there may be numerous possible candidates for the expectation scheme in each market. Since it is the unexpected component of market reaction being investigated, one must first identify the expected component of the return-generating process of each futures contract with the most parsimonious model of the autoregressive integrated moving average process (ARIMA) using the Box and Jenkins' method.[5] The values of the parameters for the ARIMA model are estimated to minimize the deviation of actual returns from returns predicted by the specified model, subject to the condition that the resulting estimation error follows a white-noise process. The exact estimation procedure starts by identifying any trend, linear or not, inherent in the return series. Once the seasonal component is removed, the remaining return is estimated for the ARIMA model. The relevance (fitness) of any specific model is tested by comparing the forecasted returns based on the model with the actual returns in the testing sample. The residual between the forecasted return and the actual return is tested for randomness. The most parsimonious model is defined by the simplest model which results in residuals of white noise.

In Table I, the ARIMA model for each contract and the chi-square statistics for the fitness of the process are presented.[6] It is noted that most contracts can be described by a simple autoregressive (*AR*) model. For simplicity, only the chi-square statistics of lags 6, 12, and 18 are reported. It appears that each return series well fits by the model specified, given the insignificant chi-square statistics at the one percent level. The series of each residual, ε_{ijk}, in the form of white noise, therefore, may be considered the abnormal component of the price movement.

Statistically, a significant price change can be identified by the statistical significance of the residual return generated by the above procedure. A significant positive (negative) event is identified by the residual which is statistically positive (negative), significant at the five percent level. After using this guideline to select significant price changes, a

[4]Since the purpose of the article is to examine the unexpected component of the return-generating process, the specific form of the model for each series is not as important as the resulting residual being white noise. This identification is similar to Flannery and James (1984).

[5]The expected component of the return-generating process of each futures contract can be described by the general form ARIMA (p, d, q)

$$\varphi(B)R_t = \phi(B)\Delta^d R_t = \theta_o + \theta(B)\varepsilon_t$$

where

$$\phi(B) = 1 - \phi_1 B - \phi_2 B^2 \ldots\ldots\ldots -\phi_p B^p$$
$$\theta(B) = 1 - \theta_1 B - \theta_2 B^2 \ldots\ldots\ldots -\theta_q B^q$$

and Δ^d is the dth difference operator. In what follows:

(1) $\phi(B)$ is called the autogressive operator; it is assumed to be stationary, that is the roots of $\phi(B) = 0$ lie outside the unit circle.
(2) $\varphi(B) = \Delta^d \phi(B)$ is called generalized autogressive operator; it is a nonstationary operator with d of the roots of $\varphi(B) = 0$ equal to unity.
(3) $\theta(B)$ is called the moving average operator; it is assumed to be invertible, that is, the roots of $\theta(B) = 0$ lie outside the unit circle.

[6]Again, there may have been other fitted models for each series. However, for the purpose of this article, the simplest form is used.

sample of positive and negative event dates are identified. Standard event methodology is employed to examine the price adjustment process subsequent to these event dates, that is, a cumulative average residual return (*CAR*) is computed for each observation period after an event date as follows:

$$CAR_{it} = \sum_{j=1}^{t} \sum_{k=1}^{n} \varepsilon_{ijk}/n$$

and

i: the ith futures contract
j: the jth day after the significant event date
k: the kth significant event
t: the tth in the observation period
n: the total number of significant events for the ith contract

where ε_{ijk} is the residual return for the ith futures contract the jth day after the kth significant positive (negative) event date. The CAR_{it} measures the cumulative average residual return for the ith contract from one day after the event date up to the tth day after each event. The pattern of the *CAR* subsequent to event dates will reveal the process by which futures prices adjust to significant events. An overreaction of futures prices is observed when the *CAR* reverses itself shortly after the event date. An underreaction is observed when the *CAR* exhibits persistent increasing movement after the event date. In either case, the market price does not adjust to the event instantaneously.

Standard event study test statistics are employed to examine the statistical significance of the price reversal and dependence following the event dates (see Brown and Warner (1985)). For a given day t after the event date, the statistical significance for the residual return, ε_{ijk}, can be tested by the following Z statistics:

$$Z_{ijk} = \varepsilon_{ijk}/[(1 + \sum_{j=1}^{l-1} \varphi_j^2)^{1/2} s_\varepsilon/n]$$

where

$$s_\varepsilon = (1 - \phi^2)R_1^2 + \sum_{t=2}^{n} (R_t - \phi R_{t-1})^2$$

where $\varphi(B)$ and $\phi(B)$ are the autoregressive operators described in Footnote 4, and Z_{ijk} is the test statistic for the residual return on the jth day from the kth event date for the ith futures contract.[7] The test statistic for the significance of the *CAR* for the ith futures contract over a given time interval, i.e., t days from the event date, is given by:

$$CZ_{it} = \sum_{j=1}^{t} \sum_{k=1}^{n} Z_{ijk}/(nt)^{1/2}$$

where n is the number of significant events in the sample for a given day t.[8] The level of CZ_{it} determines if the cumulative average residual t days from event date is significantly

[7]See Box and Jankins (1976) for details.

[8]The number of cases, n, may vary in the post-event period. If there is no trading or the closing price is not available, the number of cases will be reduced.

different from zero. This allows one to test whether there is a significant price reversal or a price dependence t days after an event date.

The determination of the length of an observation period after each significant price change for individual futures contract warrants further explanation. Since the length of the reaction period may not be uniform across different futures contracts, the minimum time period between two consecutive significantly positive (negative) daily residuals is first determined in each sample. In Table I, the length of the minimum time period between any two consecutive significant events for each contract is reported. The length of the minimum time period ranges from one day (Treasury Bond) to seventy-two days (Coffee). However in the empirical testing of this study, five days was used as the minimum observation period. That is, significant events which are at least five days apart are considered independent cases in the sample. Any significant events identified within five days after the first event is not treated as a separate case to avoid overlapping observation periods. For any time period longer than fifteen days, fifteen days was used as the observation period.[9] When the length of the observation period is determined by this procedure, the biases resulting from overlapping observation periods and insufficient degrees of freedom are reduced.

EMPIRICAL RESULTS AND IMPLICATIONS

Based on the methodology described in the last section, the daily average residuals and cumulative average residuals after the event day (Day 0) and the corresponding test statistics are presented in Table II(A) (positive events) and II(B) (negative events). The significance on the *CAR* level over any time interval after the event day allows one to examine the *duration* of the price adjustment. The pattern of individual average daily residual (*AR*) provides a view of the *process* of that adjustment. For most of the contracts, there are statistically significant price reactions after an event date. Specifically, there are significant price reversals for the contracts on Coffee, Corn, Soybeans, Wheat, Gold, and Silver following positive events. For negative events, Coffee, Soymeal, Wheat, Pork Bellies, and Silver contracts also show some overreaction. On the other hand, the Muni-Bond, Treasury Bond, Value Line Index, and S&P 500 futures prices demonstrate some dependence after either positive or negative events. The reaction starts as early as one day after the event (Wheat, Pork Bellies, Muni-Bond, Soybeans, etc.) to as late as seven days after the event (Gold). The duration of the reactions lasts from one day (Corn) to thirteen days (Wheat). It is easy to note that in most of the contracts, the price movement after an event date violates the random walk hypothesis; price levels do not adjust to the new equilibrium instantaneously. Further insights are evident from the often reversing price movements which are evident by the significant test statistics for average daily residual returns in the post-event period. It appears that the price level moves toward a pattern of random walk, but the process takes longer than one day.

Essentially, price reversals following event dates imply overreaction of market participants, while price dependences suggest underreaction. While there is strong evidence of noninstantaneous price adjustments, the direction of reaction is not uniform across different futures contracts. In general, financial futures prices tend to underreact to significant information.

[9]The test is replicated using observation periods other than the minimum 5 days and the maximum 15 days. The conclusion is not sensitive to these parameters.

Table II(A)
THE PRICE ADJUSTMENT PROCESS FOR
POSITIVE EVENTS-AGRICULTURAL FUTURES

	COFFEE		n = 39		PORK BELLIES		n = 15	
Days	**AR**	**Z**	**CAR**	**CZ**	**AR**	**Z**	**CAR**	**CZ**
Days	−0.0000	−00.000[b]	−0.000	−00.000[b]	−0.000	−00.000[b]	−0.0000	−00.000[b]
0	6.055	17.673[a]	0.000	17.673[a]	8.717	13.836[a]	0.000	13.836[a]
1	−1.014	−2.959[a]	−1.014	−2.959[a]	−0.644	−1.023[a]	−0.644	−1.023[a]
2	0.429	1.251	−0.585	−1.208	0.454	0.720	−0.191	−0.214
3	−0.116	−0.338	−0.701	−1.182	−0.287	−0.455	−0.477	−0.437
4	0.341	0.995	−0.360	−0.526	0.671	1.065	0.194	0.154
5	0.204	0.597	−0.156	−0.203	1.021	1.621[b]	1.215	0.862

	CORN		n = 44		SOYBEANS		n = 40	
Days	**AR**	**Z**	**CAR**	**CZ**	**AR**	**Z**	**CAR**	**CZ**
0	3.635	18.046[a]	0.000	18.046[a]	3.655	16.723[a]	0.000	16.723[a]
1	−0.491	−2.438[a]	−0.491	−2.438[a]	−0.319	−1.458	−0.319	−1.458
2	0.175	0.866	−0.317	−1.111	−0.036	−0.164	−0.355	−1.147
3	0.296	1.471	−0.020	−0.058	−0.313	−1.431	−0.667	−1.763[b]
4	0.032	0.160	0.012	0.030	0.184	0.842	−0.483	−1.106
5	0.146	0.727	0.158	0.352	−0.351	−1.607[b]	−0.835	−1.708[b]
6	−0.557	−2.766[a]	−0.399	−0.808	0.446	2.041[b]	−0.388	−0.725
7	0.155	0.768	−0.244	−0.458	−0.110	−0.504	−0.499	−0.862
8	−0.059	−0.293	−0.303	−0.532	0.201	0.920	−0.298	−0.481
9	0.139	0.689	−0.164	−0.272	0.166	0.760	−0.131	−0.200
10	−0.205	−1.019	−0.370	−0.580	0.200	0.914	0.068	0.099
11	0.114	0.565	−0.256	−0.383	0.239	1.092	0.307	0.423
12	−0.086	−0.428	−0.342	−0.490	−0.067	−0.307	0.240	0.317
13	0.115	0.570	−0.227	−0.313	−0.213	−0.973	0.027	0.035
14	−0.131	−0.652	−0.358	−0.476	−0.254	−1.162	−0.227	−0.277
15	−0.249	−1.238	−0.608	−0.779	0.048	0.220	−0.179	−0.211

	SOYMEAL		n = 78		WHEAT		n = 38	
Days	**AR**	**Z**	**CAR**	**CZ**	**AR**	**Z**	**CAR**	**CZ**
0	4.228	24.740[a]	0.000	24.740[a]	4.298	16.578[a]	0.000	16.578[a]
1	−0.199	−1.164	−0.199	−1.164	−0.967	−3.731[a]	−0.967	−3.731[a]
2	−0.050	−0.291	−0.249	−1.029	−0.299	−1.153	−1.266	−3.454[a]
3	−0.190	−1.111	−0.439	−1.482	−0.334	−1.288	−1.600	−3.563[a]
4	0.358	2.097[b]	−0.080	−0.235	0.032	0.124	−1.568	−3.024[a]
5	−0.165	−0.966	−0.245	−0.642	0.095	0.366	−1.473	−2.541[a]
6	−0.125	−0.732	−0.370	−0.885	−0.147	−0.568	−1.620	−2.551[a]
7	0.064	0.372	−0.031	−0.678	−0.192	−0.741	−1.812	−2.642[a]
8	−0.003	−0.017	−0.310	−0.641	0.408	1.575[b]	−1.404	−1.915[b]
9	−0.045	−0.251	−0.354	−0.691	−0.113	−0.437	−1.517	−1.951[b]
10					0.074	0.286	−1.443	−1.760[a]
11					0.372	1.436	−1.071	−1.245
12					−0.015	−0.059	−1.086	−1.209
13					−0.153	−0.589	−1.239	−1.325

Days	S&P 500 AR	Z	n = 14 CAR	CZ	VALUE LINE AR	Z	n = 20 CAR	CZ
0	3.936	9.745[a]	0.000	9.745[a]	3.694	12.580[a]	0.000	12.580[a]
1	1.111	2.750[a]	1.111	2.750[a]	−0.035	−0.120	−0.035	−0.120
2	0.318	0.788	1.429	2.502[a]	0.380	1.292	0.344	0.829
3	0.646	1.599[b]	2.075	2.966[a]	−0.515	−1.755[b]	−0.171	−0.336
4	0.079	0.195	2.154	2.666[a]	0.369	1.257	0.198	0.337
5	−0.104	−0.258	2.050	2.269[a]	−0.067	−0.230	0.131	0.199

Days	T-BONDS AR	Z	n = 41 CAR	CZ	MUNI-BONDS AR	Z	n = 13 CAR	CZ
0	2.496	16.687[a]	0.000	16.687[a]	2.394	10.498[a]	0.000	10.498[a]
1	0.139	0.927	0.139	0.927[a]	0.347	1.521[b]	0.347	1.521
2	0.211	1.409	0.349	1.652	0.595	2.607[a]	0.941	2.919
3	0.113	0.756	0.463	1.785	0.269	1.184	1.211	3.067[a]
4	0.209	1.396	0.671	2.244	−0.240	−1.052	0.971	2.130[b]
5	0.300	2.002[b]	0.971	2.903	−0.702	−3.078[a]	0.270	0.529
6	0.355	2.372[a]	1.326	3.618				
7	0.113	0.754	1.439	3.635				
8	0.078	0.520	1.516	3.584				
9	0.195	1.303	1.711	3.813				
10	0.113	0.755	1.824	3.856				
11	0.081	0.538	1.905	3.882				
12	0.092	0.615	1.997	3.894				
13	−0.332	−2.220[a]	1.665	3.126				
14	0.217	1.451	1.882	3.400				
15	0.083	0.555	1.965	3.428				

Days	GOLD AR	Z	n = 39 CAR	CZ	SILVER AR	Z	n = 35 CAR	CZ
0	4.738	17.884[a]	0.000	17.884[a]	7.322	16.648[a]	0.000	16.648[a]
1	0.350	1.320	0.350	1.320	−1.106	−2.515[a]	−1.106	−2.515[a]
2	−0.203	−0.765	0.147	0.392	0.276	0.628	−0.830	−1.334
3	0.059	0.222	0.206	0.449	1.172	2.666[a]	0.343	0.450
4	−0.207	−0.781	−0.001	−0.002	−0.744	−1.691[b]	−0.401	−0.456
5	0.057	0.216	0.056	0.095	−0.298	−0.678	−0.699	−0.711
6	−0.922	−3.480[a]	−0.866	−1.334	−0.295	−0.670	−0.994	−0.923
7	0.705	2.660[a]	−0.161	−0.230	0.835	1.898[b]	−0.159	−0.137
8	0.680	2.566[a]	0.519	0.693	0.06	0.137	−0.099	−0.080
9	−0.367	−1.383	0.152	0.192				
10	−0.362	−1.366	−0.210	−0.250				
11	0.407	1.536	0.197	0.225				
12	−0.581	−2.192[a]	−0.383	−0.418				
13	−0.137	−0.517	−0.520	−0.545				
14	−0.025	−0.093	−0.545	−0.550				
15	−0.039	−0.148	−0.584	−0.569				

n: # of Significant events.
[a]Significant at the 1% level.
[b]Significant at the 5% level.
AR: Average Residual.
Z: Test Statistic for *AR*.
CAR: Cumulative Average Residual.
CZ: Test Statistic for *CAR*.

Table II(B)
THE PRICE ADJUSTMENT PROCESS FOR NEGATIVE EVENTS-AGRICULTURAL FUTURES

	COFFEE		$n = 35$		PORK BELLIES		$n = 16$	
Days	AR	Z	CAR	CZ	AR	Z	CAR	CZ
0	−6.856	−18.956[a]	0.000	−18.956[a]	−8.768	−14.374[a]	0.000	−14.374[a]
1	−0.099	−0.274	−0.099	−0.274	0.948	1.554	0.948	1.554
2	1.007	2.783[a]	0.908	1.775[b]	0.358	0.586	1.306	1.514
3	0.746	2.062[b]	1.654	2.640[a]	1.185	1.943[b]	2.491	2.357[a]
4	−0.019	−0.053	1.635	2.260[b]	0.808	1.325	3.299	2.704[a]
5	0.222	0.613	1.856	2.295[b]	0.856	1.403	4.155	3.046[a]

	CORN		$n = 36$		SOYBEANS		$n = 47$	
Days	AR	Z	CAR	CZ	AR	Z	CAR	CZ
0	−4.820	−21.645[a]	0.000	−21.645[a]	−3.600	−17.855[a]	0.000	−17.855[a]
1	0.030	0.136	0.030	0.136	−0.097	−0.48	−0.097	−0.480
2	0.042	0.187	0.072	0.228	0.033	0.164	−0.064	−0.223
3	0.020	0.090	0.092	0.239	0.337	1.671[b]	0.273	0.782
4	−0.149	−0.670	−0.057	−0.129	−0.051	−0.252	0.222	0.551
5	−0.092	−0.413	−0.149	−0.299	0.139	0.691	0.362	0.802
6	−0.102	−0.456	−0.251	−0.459	0.233	1.155	0.595	1.204
7	0.090	0.405	−0.160	−0.272	−0.184	−0.913	0.411	0.770
8	−0.130	−0.583	−0.290	−0.460	−0.485	−2.406[a]	−0.074	−0.131
9	0.245	1.101	−0.045	−0.067	0.276	1.370	0.202	0.334
10	0.013	0.059	−0.032	−0.045	−0.346	−1.718[b]	−0.145	−0.227
11	−0.173	−0.774	−0.204	−0.276	−0.215	−1.066	−0.360	−0.538
12	0.109	0.490	−0.095	−0.123	−0.315	−1.562[b]	−0.675	−0.966
13	0.192	0.860	0.097	0.120	0.075	0.372	−0.600	−0.825
14	0.000	−0.002	0.096	0.115	0.010	0.051	−0.589	−0.781
15	0.162	0.728	0.258	0.300	0.101	0.499	−0.489	−0.626

	SOYMEAL		$n = 76$		WHEAT		$n = 30$	
Days	AR	Z	CAR	CZ	AR	Z	CAR	CZ
0	−4.071	−23.511[a]	0.000	−23.511[a]	−5.953	−20.404[a]	0.000	−20.404[a]
1	0.128	0.738	0.128	0.738	0.521	1.784	0.521	1.784[b]
2	0.159	0.918	0.287	1.171	0.020	0.067	0.540	1.309
3	0.214	1.238	0.501	1.671[b]	0.114	0.390	0.654	1.294
4	0.364	2.103[b]	0.865	2.498[a]	−0.345	−1.183	0.309	0.529
5	0.403	2.329[a]	1.268	3.276[a]	−0.046	−0.158	0.263	0.403
6	0.046	0.264	1.314	3.099[a]	−0.116	−0.397	0.147	0.205
7	−0.453	−2.614[a]	0.861	1.881[a]	0.478	1.639[b]	0.625	0.810
8	−0.330	−1.906[b]	0.531	1.085	0.301	1.031	0.926	1.122
9	−0.127	−0.732	0.405	0.779	0.067	0.228	0.992	1.134
10					0.038	0.131	1.031	1.117
11					0.018	0.063	1.049	1.084
12					−0.454	−1.554[b]	0.596	0.589
13					0.359	1.229	0.954	0.907
14					0.329	1.127	1.283	1.175
15					0.195	0.668	1.478	1.308

	S&P 500		n = 21		VALUE LINE		n = 32	
Days	**AR**	**Z**	**CAR**	**CZ**	**AR**	**Z**	**CAR**	**CZ**
0	−5.749	−17.432[a]	0.000	−17.432[a]	−4.386	−18.872[a]	0.000	−18.872[a]
1	−0.859	−2.603[a]	−0.859	−2.603[a]	−0.669	−2.881[a]	−0.669	−2.881[a]
2	−0.217	−0.659	−1.076	−2.307[b]	−0.069	−0.300	−0.739	−2.250[b]
3	−0.407	−1.507	−1.573	−2.754[a]	0.060	0.258	−0.679	−1.688[b]
4	0.305	0.925	−1.268	−1.922[b]	−0.133	−0.574	−0.812	−1.749[b]
5	0.99	3.001[a]	−0.278	−0.377	0.185	0.799	−0.627	−1.207

	T-BONDS		n = 48		MUNI-BONDS		n = 13	
Days	**AR**	**Z**	**CAR**	**CZ**	**AR**	**Z**	**CAR**	**CZ**
0	−2.460	−17.792[a]	0.000	−17.792[a]	−2.387	−10.467[a]	0.000	−10.467[a]
1	−0.174	−1.258	−0.174	−1.258	−0.309	−1.355	−0.309	−1.355
2	−0.337	−2.436[a]	−0.511	−2.612[a]	−0.279	−1.222	−0.588	−1.823[b]
3	0.281	2.003	−0.230	−0.959	0.084	0.366	−0.504	−1.277
4	0.278	2.010	0.048	0.175	0.199	0.874	−0.305	−0.699
5	0.263	1.901	0.311	1.007	0.433	1.899[b]	0.128	0.251

	GOLD		n = 50		SILVER		n = 41	
Days	**AR**	**Z**	**CAR**	**CZ**	**AR**	**Z**	**CAR**	**CZ**
0	−4.445	−18.997[a]	0.000	−18.997[a]	−7.417	−18.253[a]	0.000	−18.253[a]
1	−0.359	−1.536	−0.359	−1.536	0.187	0.460	0.187	0.460
2	0.297	1.267	−0.063	−0.190	0.084	0.208	0.271	0.472
3	−0.087	−0.373	−0.150	−0.370	0.359	0.883	0.630	0.895
4	0.004	0.015	−0.147	−0.313	0.105	0.258	0.735	0.904
5	0.616	2.632[a]	0.469	0.897	0.456	1.123	1.191	1.311
6	0.051	0.219	0.521	0.908	−0.098	−0.240	1.094	1.099
7	0.622	2.658[a]	1.143	1.846[b]	0.286	0.703	1.379	1.283
8	−0.324	−1.383	0.819	1.237	0.492	1.211	1.872	1.628[b]
9	−0.052	−0.224	0.766	1.092				
10	−0.697	−2.980[a]	0.069	0.093				
11	0.217	0.926	0.286	0.368				
12	−0.115	−0.491	0.171	0.211				
13	0.124	0.529	0.295	0.349				
14	0.118	0.503	0.412	0.471				
15	−0.045	−0.190	0.368	0.406				

n: # of Significant events.
[a]Significant at the 1% level.
[b]Significant at the 5% level.
AR-:- Average Residual.
Z: Test Statistic for *AR*.
CAR: Cumulative Average Residual.
CZ: Test Statistic for *CAR*.

Some Conjectures

The differential price adjustment process of agricultural futures versus financial futures to significant events, while puzzling, can possibly be attributed to the idiosyncrasies in each market. Several possible conjectures for the observed market irrationality follow. There is a different mix of informed and uninformed traders in the agricultural and financial futures environments. Informed traders are distinguished by their superior estimation ability resulting in fewer prediction errors, and smaller biases between the predicted equilibrium level and the true equilibrium level. Consider a market which is composed of a queue of agents with different information sets. Since a rational informed trader will not trade instantly to the predicted equilibrium level if the trading counterpart is not yet informed, the deviation between the initial clearing price and the predicted equilibrium level is thus determined by the difference in information sets between two trading agents. Given the nonuniform information sets, the trading will be triggered on a sequential basis; with the more informed agents trading first; and then the less informed agents trading later. The sequential arrival and revelation of information will set a motion in action which results in a noticeable price dependence.

At the other extreme, when the market is predominantly occupied by informed traders, the mere competition among informed traders to trade with a limited number of uninformed traders will lead to a price so close to the upper range of the new predicted equilibrium level which may be beyond the true equilibrium level in the short run. Once the uninformed traders become informed, and this "disequilibrium" price level is well known, subsequent arbitraging behavior will reverse the price to the true equilibrium level. Therefore, a price reversal or an overreaction may have been a result of the dominating market power of informed traders. Note that the differential reaction in price movements found in various futures markets may be consistent with this hypothesis. Obviously, it is presumptuous to argue that there are more informed traders in agricultural futures markets than in financial futures markets without further supporting evidence. Since the degree of informativeness is not readily observable, and therefore not comparable across different markets, the empirical evidence that financial futures prices and agricultural futures prices react to information differently does not provide a direct test of the hypothesis.

Another possible explanation for the overreaction/underreaction of futures prices is the impact of price limit rules on futures markets. Price limits have been deemed necessary by exchange officials because limiting the magnitude of daily price changes is believed to reduce excessive market volatility, thus enabling the market to move in an orderly fashion. However, opponents of price limits contend that such restrictions produce, rather than eliminate, significant price discontinuities by preventing the price from reaching its new, anticipated equilibrium level. Consider a market where the futures price and its volatility are driven by the arrival of information. Assume all traders are equally informed with respect to both the information and the true equilibrium level. If the price limits are present and the true equilibrium price falls outside the current day's price limit range, the futures price will move to the appropriate price limit and all trading will suspend. The trading resumes when the equilibrium price lies within the newly established trading limits. If this scenario is correct, the futures price and its related volatility will reflect no information during the limit move; the price limit merely serves to delay trading to the next tradeable period. Because the futures price was not allowed to trade at its true equilibrium level during the current session, the price adjustment process is lengthened to subsequent periods. Therefore, a price dependence will emerge especially when the market hits limits consecutively.

To test this possibility, the actual limit moves of each contract during the sample period is identified. In Table III(A), the daily price limit for each futures contract is presented. Daily high and low prices along with the closing price of the previous trading session of each contract are used to identify the days when limit moves may have occurred. In Table III(A), the numbers of days when the futures price reached the up limit

Table III(A)
PRICE LIMIT RULES AND NUMBER OF LIMIT MOVES

Futures Contracts	Daily Limit	Number of Up Limits	Number of Down Limits
Coffee	4 cent	10	12
Corn	10 cent	31	24
Pork Bellies	2 points	396	393
Soybeans	30 cent	32	48
Soymeal	1 cent	22	28
Wheat	20 cent	18	13
Gold	50 dollar	9	5
Silver	1 dollar	58	61
Muni-Bond	2 points*	6	9
S&P 500	NA**	NA	NA
Treasury Bond	2 points*	92	74
Value-Line Index	NA**	NA	NA

*Changed to 3 points since August 1987.
**No price limits until early 1988.
(A variable limit rule (150%) applies when three consecutive limit moves occur.)

level or the down limit level are reported. The original sample is screened by removing significant event dates which are also limit dates. The same testing procedure is replicated on this sample which is now free from the possible impact of limit moves. This screening procedure only affects four futures contracts. Table III(B), and III(C) present the results of these four futures contracts. First, only one of the four financial futures (Treasury Bonds) had limit moves at all in the original sample while all four exhibit price dependence. In some cases, the reaction after the event day may have been weakened by the removal of days of limit moves; however, the same statistically significant patterns of reactions still prevail as before. This implies that while the price limit rules may explain partially the underreaction in financial futures, it is not the only cause for price dependence. One more puzzling point on the impact of price limit rules is that it is inconsistent with the overreaction in agricultural futures. Even considering the possibility that limit moves may have occurred more often in financial futures markets than in agricultural futures markets, the lack of limit moves should not result in overreaction.

CONCLUSIONS

This article examines market rationality in futures pricing and, in particular, the adjustment process of futures prices subsequent to the occurrence of significant events. Using statistically significant price changes as proxies of significant events, futures price adjustments demonstrate significant deviations from the prediction of market rationality. Specifically, the evidence suggests that futures prices of agricultural commodities tend to overreact to significant events, whereas financial futures prices tend to underreact to significant events.

The fact that the price does not adjust to information instantaneously is consistent with that either all traders do not share the same information set, or they do not have the same analytical abilities. The findings of this study provide fruitful implications to regulators, exchanges, and traders. The success of a number of regulatory devices in curbing excessive volatility and speculation depends on the understanding of the nature of a mar-

Table III(B)
THE PRICE ADJUSTMENT PROCESS FOR POSITIVE EVENTS WITHOUT LIMIT MOVES

	COFFEE		n = 37		T-BONDS		n = 39	
Days	AR	Z	CAR	CZ	AR	Z	CAR	CZ
0	6.058	17.221[a]	0.000	17.221[a]	2.479	16.160[a]	0.000	16.160[a]
1	−0.889	−2.526[a]	−0.889	−2.526[a]	0.145	0.937	0.143	0.937
2	0.441	1.253	−0.448	−0.901	0.252	1.644[b]	0.396	1.825[b]
3	−0.079	−0.224	−0.527	−0.865	0.112	0.728	0.508	1.910[b]
4	0.268	0.762	−0.259	−0.368	0.157	1.024	0.665	2.166[b]
5	0.094	0.267	−0.161	−0.210	0.232	1.511[b]	0.896	2.613[a]

	WHEAT		n = 18		SOYBEANS		n = 33	
Days	AR	Z	CAR	CZ	AR	Z	CAR	CZ
0	4.202	11.158[a]	0.000	11.158[a]	3.630	15.083[a]	0.000	15.083[a]
1	−2.262	−6.007[a]	−2.262	−6.007[a]	−0.499	−2.074[b]	−0.499	−2.074[b]
2	−0.274	−0.729	−2.537	−4.763[a]	−0.110	−0.456	−0.609	−1.789[b]
3	−0.054	−0.146	−2.591	−3.971[a]	−0.349	−1.448	−0.957	−2.297[b]
4	0.292	0.775	−2.299	−3.052[a]	0.242	1.005	−0.715	−1.486
5	−0.245	−0.650	−2.544	−3.020[a]	−0.386	−1.604[b]	−1.101	−2.047[b]
6	−0.079	−0.210	−2.623	−2.843[a]	0.583	2.423[a]	−0.518	−0.879
7	−0.406	−1.076	−3.029	−3.039[a]	−0.216	−0.896	−0.734	−1.153
8	0.188	0.498	−2.841	−2.667[a]	0.407	1.692[b]	−0.327	−0.480
9	0.053	0.141	−2.788	−2.467[a]	0.247	1.028	−0.079	−0.110
10	0.400	1.061	−2.388	−2.005[b]	0.123	0.509	0.043	0.057
11	0.165	0.440	−2.222	−1.779[b]	0.114	0.472	0.157	0.196
12	−0.153	−0.407	−2.376	−1.821[b]	0.041	0.170	0.198	0.237
13	−0.269	−0.714	−2.644	−1.947[b]	−0.335	−1.474	−0.157	−0.181
14	−0.099	−0.262	−2.744	−1.947[b]	−0.293	−1.219	−0.450	−0.500
15	−0.424	−1.127	−3.168	−2.172[b]	0.119	0.494	−0.331	−0.356

n: # of Significant events.
[a]Significant at the 1% level.
[b]Significant at the 5% level.
AR: Average Residual.
Z: Test Statistic for *AR*.
CAR: Cumulative Average Residual.
CZ: Test Statistic for *CAR*.

ket's price movement. In particular, the design and the justification of margin requirements, price limit rules, and position limits rely heavily on the assumption that the futures market overreacts to information in the short run. For example, price limits will prove futile if the market price always adjusts to equilibrium instantaneously. On the other hand, frequent changes in margin requirements and position limits to control default risks of traders may mean only illiquidity and obstacles to trading if the market price tends to overreact in the short run.

The tendency of the market to overreact/underreact to significant events also suggests trading implications for traders. If the market tends to overreact to information and the price reverses in the near future, a contrarian strategy may prove profitable in the short

Table III(C)
THE PRICE ADJUSTMENT PROCESS FOR
NEGATIVE EVENTS WITHOUT LIMIT MOVES

	COFFEE		$n = 33$		T-BONDS		$n = 46$	
Days	AR	Z	CAR	CZ	AR	Z	CAR	CZ
0	−6.964	−18.699[a]	0.000	−18.699[a]	−2.446	16.687[a]	0.000	−17.321[a]
1	−0.176	−0.472	−0.176	−0.472	−0.169	−1.193	−0.169	−1.193
2	0.799	2.145[a]	0.623	1.183	−0.255	−1.805[b]	−0.423	−2.120[b]
3	−0.541	1.454	1.165	1.805[b]	0.226	1.601	−0.197	−0.806
4	0.111	0.297	1.275	1.712[b]	0.290	2.055[b]	0.093	0.329
5	0.116	0.312	1.391	1.671[b]	0.272	1.926[b]	0.365	1.156

	WHEAT		$n = 19$		SOYBEANS		$n = 37$	
Days	AR	Z	CAR	CZ	AR	Z	CAR	CZ
0	−5.399	−14.727[a]	0.000	−14.727[a]	−3.655	−15.389	0.000	−15.723[a]
1	0.739	2.015[b]	0.739	2.015	0.021	0.092	0.021	0.092
2	0.139	0.380	0.878	1.694	0.128	0.563	0.149	0.463
3	0.033	0.091	0.911	1.435	0.334	1.470	0.483	1.227
4	−0.760	−2.073[b]	0.151	0.206	−0.174	−0.765	0.309	0.680
5	0.296	0.806	0.447	0.545	0.264	1.161	0.573	1.128
6	−0.0636	−0.173	0.383	0.427	0.284	1.250	0.867	1.640
7	0.372	1.014	0.755	0.778	−0.015	−0.067	0.842	1.400
8	0.270	0.737	1.025	0.989	−0.387	−1.704	0.455	0.708
9	0.319	0.869	1.344	1.222	0.195	0.859	0.650	0.953
10	0.169	0.460	1.512	1.305	−0.367	−1.615	0.283	0.394
11	0.009	0.024	1.521	1.251	−0.552	−2.427[a]	−0.269	0.394
12	−0.507	−1.384	1.014	0.798	−0.473	−2.080[b]	−0.742	−0.356
13	0.530	1.445	1.544	1.168	−0.143	−0.627	−0.884	−0.942
14	0.479	1.307	2.023	1.474	0.045	0.199	−0.888	−1.079
15	0.344	0.939	2.367	1.667	−0.109	−0.488	−0.948	−0.986

n: # of Significant events.
[a]Significant at the 1% level.
[b]Significant at the 5% level.
AR: Average Residual.
Z: Test Statistic for *AR*.
CAR: Cumulative Average Residual.
CZ: Test Statistic for *CAR*.

run. On the other hand, if the price underreacts to information, a strategy of "jumping on the bandwagon" may generate significant short-term profit.[10]

Bibliography

Box, G., and Jenkins, G. (1976): *Time Series Analysis Forecasting and Control,* San Francisco: Holden-Day.

[10]The potential of profiting from the market overreaction/underreaction identified in this study is currently under study.

Brown, K., Harlow W., and Tinic, S. (1988): "Risk Aversion, Uncertain Information, and Market Efficiency," *Journal of Financial Economics,* forthcoming.

Brown, S., and Warner, J. (1985): "Using Daily Returns," *Journal of Financial Economics,* 14:3–31.

Chan, K. C. (1988): "On the Return of the Contrarian Investment Strategy," *Journal of Business,* 61, no. 2, 147–163.

DeBondt, W. E., and Thaler, R. (1985): "Does the Stock Market Overreact?," *Journal of Finance,* 40:793–804.

DeBondt, W. E. (1987): "Further Evidence of Investor Overreaction and Stock Market Seasonality," *Journal of Finance,* 42:557–582.

DeBondt, W. E., and Makhija, A. (1988): "Throwing Good Money After Bad?: Nuclear Power Plant Investment Decisions and the Relevance of Sunk Costs," *Journal of Economic Behavior and Organization,* forthcoming.

DeLong, J., Shleifer A., Summers, L., and Waldman, R. (1987): "The Economic Consequences of Noise Traders," Working paper, Boston University and NBER.

Dornbush, R. (1976): "Expectations and Exchange Rate Dynamics," *Journal of Political Economy,* 84:1161–1176.

Dyl, E., and Maxfield, K. (1987): "Does the Market Overreact? Additional Evidence," Working paper, University of Arizona.

Fabozzi, F., Ma, C., and Linksley, D. (1988): "Overreaction, Rational Expectation, and the Relationship Between Trading Volume and Security Price Changes," *Research in Finance,* Andrew Chen, Ed., JAI Press, forthcoming.

Fama, E., and French, K. (1986): "Permanent and Temporary Components of Stock Prices," Chicago: University of Chicago xerox.

Flannery, M., and James, C. (1984): "The Effect of Interest Rate Changes on Common Stock Returns of Financial Institutions," *Journal of Finance,* 39:1141–1154.

French, K., and Roll, R. (1986): "Stock Return Variances: The Arrival of Information and the Reaction of Traders," *Journal of Financial Economics,* 17:5–26.

Gandar, J., Zuber, R., O'Brien, T., and Russo, B. (1988): "Testing Rationality in the Point Spread Betting Market," *Journal of Finance,* 43:995–1008.

Jones, S. (1987): "Reaction to the Overreaction Hypothesis," Working paper, Purdue University.

Kahneman, D., and Tversky, A. (1981): "Intuitive Prediction: Biases and Corrective Procedures," in *Judgement Under Uncertainty: Heuristics and Biases,* Kahneman, Slovic, and Tversky, Eds., Cambridge University Press.

Ma, C., Rao, R., and Sears, S. (1989): "Limit Moves and Price Resolution: The Case in Treasury Bond Futures Market," *Journal of Futures Markets,* 9:321–335.

Makhija, A., and Nachtmann, R. (1988): "Is Trading Self-Generated?: The Case of NYSE-ASE Listed Stocks," Working paper, University of Pittsburgh.

Shiller, R. (1981): "Do Stock Prices Move Too Much to be Justified by Subsequent Changes in Dividends?," *American Economic Review,* 71:421–350.

Shiller, R. (1984): "Theory of Aggregate Stock Price Movements," *Journal of Portfolio Management,* 10:28–37.

Summers, L. H. (1986): "Does the Stock Market Rationally Reflect Fundamental Values?" *Journal of Finance,* 41:591–601.

Copyright of Journal of Futures Markets is the property of John Wiley & Sons, Inc. / Business and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.