SECTION 1: PRICE BEHAVIOR

In this section there are three papers (Bear, Miller, and Meyer) that deal with price behavior; each conducts a specific test of a single behavioral aspect. Bear's paper is concerned with prices and the flow of information overnight; Miller's deals with the relationship between price volatility and contract maturity; and Meyer's tests trading rules on frozen pork-belly spreads.

The flow of information has always been a subject of concern to students of futures markets. Working (1958) was the first to develop a model hypothesizing that new information flows randomly. In futures market literature, this has led to a multitude of tests concerned with the stochastic nature of futures prices, many reviewed by Peck (1977, pp. 253-255). The most recent comprehensive tests have been conducted by Cargill and Rausser (1975), and Mann and Heifner (1976). Both find deviations from randomness.

The subject of information — how it flows from futures markets and the impact it has on current markets — has concerned many. Those who have recently contributed to this literature include: Hirshleifer (1975), Cox (1976), and Grossman (1977). The basic idea in these papers is that the existence of futures markets provides additional information to other markets, thereby improving price formation. The importance of information in markets, its effect on prices, and the costly nature of acquisition, continues to gain critical evaluation. The three studies in this volume contribute to our overall understanding and empirical knowledge of the use of information in markets and its effect on price behavior.

Bear uses the live-cattle and frozen pork-belly futures contracts as an empirical base from which to test hypotheses about information and traders' anticipation of and reaction to information. In a unique methodological application of examining overnight holdings and price changes of futures contracts, he finds that information flows at a steady rate through time, and that traders appear to properly anticipate these flows. These markets seem highly competitive and efficient in the short run, yet traders react slowly and appear averse to risk when anticipating information which may have considerable price impact.

Miller tests the hypothesis that volatility of futures prices increases as the futures contract nears maturity. Miller further develops the model set forth originally by Samuelson (1965) that variances are likely to change over time. She finds evidence from live-cattle futures contracts that there is some systematic volatility and accepts the above hypothesis. However, the model also characterizes spot prices, and evidence from these data is not clear as to whether or not the increased return variability on futures contracts, as maturity approaches, can be attributed to the process generating spot prices.

More recently, Rutledge (1976) has also tested the hypothesis that volatility of futures prices increases in the period immediately prior to contract expiration. Two of four commodities tested provide support for this notion. Samuelson (1976), responding to this paper, implied that an analysis of price changes over a few months is an inadequate test of the basic hypothesis.

Meyer constructs and tests three sets of mechanical trading rules designed to reduce the risk exposure of an investor in commodity futures contracts. Utilizing frozen pork-bellies data, all of the rules employ spread trades. These trades involve the simultaneous sale of a distant futures contract and the purchase of a nearby contract when the premium of the distant over the nearby is of a specific magnitude. Most applications of the strategies generated positive returns which exceeded any negative returns. In fact, in some instances, only positive returns were reported. Unfortunately, generalization of these results to guarantee positive investor returns in the future is not possible.

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Risk and Return Patterns on Overnight Holdings of Livestock Futures

Robert M. Bear

Although a large number of futures traders are in and out of their positions within a few days, often within minutes, most studies on the behavior of forward markets concern price behavior over longer periods. This can be rationalized to an extent; it is more difficult to obtain and work with data on an intraday or interday basis than it is to consider weekly, monthly, or yearly observations. However, as traders know, where work is most tedious, rewards tend to be greater. This study has analyzed short-run price behavior of livestock futures using an approach that this author believes has no precedent in the study of competitive markets. Information — its flow, anticipation, and utilization by traders — is the critical variable of interest.

The following sections outline the findings that should be of particular interest to traders and students of livestock futures. The basic questions asked and the conclusions drawn from this study may be summarized as follows:

1. Is the amount of pertinent new information concerning a futures contract approximately constant between any two successive daily closing quotations? Information is found to flow at a steady rate. When a market is closed over a holiday or weekend, a greater amount of information occurs (on the average) in the interim than occurs between closings on successive weekdays.

2. Do traders act as if they correctly perceive and anticipate the amount of information forthcoming in the next 24 to 72 hours? Findings indicate that traders do properly anticipate information flows. However, there is some evidence to suggest that their reaction is not immediate.

3. What attitude towards risk is suggested by trader behavior in the short run? Position holders who are long in the market show a short-run aversion to risk, demanding a larger return over brief periods when a greater volume of information with potential price impact is anticipated.

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The overall implication of these findings is that the Chicago Mercantile Exchange's livestock futures markets are highly competitive and efficiently operate in a short-run context.[1] Additional implications relevant to existing theoretical models of price behavior are discussed under *Further Evidence and Implications.*

All data, consisting of opening and closing daily prices of July pork bellies and June live cattle from 1965 to 1970, were obtained from CME yearbooks. The selection of one contract in each commodity is appropriate. Two livestock commodities were studied to insure that findings were representative of all livestock futures.

INFORMATION FLOWS

Many factors determine the value of livestock products and hence, livestock futures contracts. New information on any one or combination of factors will have a price effect on the futures. In an efficiently operating market, price effects will be immediate and unbiased. The timing of some new information such as governmental crop reports is known in advance, but most new information is more spontaneous. In either event, the release of new information is not limited to the period from 9 A.M. to 1 P.M. on trading days. The first question considered here is the rate of flow of new information to the market.

More information seems to become available at certain times of the day. For example, expect more information to become publicly available from 9 A.M. to 1 P.M. than from 9 P.M. to 1 A.M. This is not the issue raised here. Of interest is the relative amount of information that becomes available over periods (which vary in length) when the market remains closed. For example, on the average, does the same amount of information tend to become known from 1 P.M. to 9 A.M. on weekdays as becomes known from 1 P.M. on a Friday to 9 A.M. on the next Monday?[2] The former covers a time of 20 hours, while the latter covers 68 hours. If information flows are directly related to length of time, then more information will become known from close to open (or close to close) spanning weekends than during the week.

If information flows were directly related to time, there would be (on the average) larger price changes over weekends and holidays than between successive days of the week, due to the longer time intervals involved and the larger amount of information impacted in the price change within the interval. To test this, the variation in close-to-close

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[1] Other studies have come to this conclusion for the long run, notably Labys and Granger (1970).

[2] Theoretical studies have made the implicit assumption that this is true. See *Further Evidence and Implications.*

prices was measured by calculating the standard deviation of price change from the observed mean. A second, very similar measure was also calculated — the mean absolute deviation. This was done in recognition of the fact that the distribution of price changes may not exactly further the normal probability curve. Daily price differences were divided into two groups — the first spanning all successive weekday intervals, and the second containing all longer intervals (i.e., holidays, weekends, and holiday-plus-weekend combinations). By either measure of variation, there were larger price changes over weekends in both commodities. These results, summarized in Table 1, may be considered significant because the odds of observing a difference of such magnitude by chance in both commodities is very small.

TABLE 1
DISPERSION OF CLOSE-TO-CLOSE PRICE CHANGES IN JULY BELLIES AND JUNE LIVE CATTLE

Commodity and Time Interval	Number of Observations	Standard Deviation[a]	Mean Absolute Deviation[a]
July Bellies			
Weekday	915	.553	.404
Weekday and holiday	260	.594[b]	.451
June Cattle			
Weekday	1,029	.160	.112
Weekday and holiday	291	.201[b]	.148

[a] In cents per pound.
[b] Bartlett's test for homogeneity of variance indicates a significant difference between weekday and weekend observations at $\alpha = .15$ for bellies and $\alpha = .05$ for cattle.

More information seems to become known over a weekend than during a corresponding close-to-close interval during the week. The following sections concern evidence on the way traders react to this situation.

RISK, RETURN, AND TRADER EXPECTATIONS

To a position holder, be he long or short, the liquidity of his position is somewhat less when the market is closed than when it is open. When open, the trader may respond immediately to new information. When closed, the trader must wait until the market opens again to react to information. In the ensuing interval, additional information may become available and/or a fuller assessment of existing information may be made, both possibly to the detriment of the trader's position. Thus, the lack of liquidity is an element in the risk that is borne in a position when the market is closed. Consider the following set of assumptions:

1. Greater price variation occurs over weekends. This was verified in the preceding section.
2. Speculators are typically long position holders (net). This may quickly be verified by inspection of U.S. Department of Agriculture reports.[3]
3. Speculators correctly perceive relative liquidity risks resulting from the market being closed for intervals which vary in length.
4. In the short run, speculators exhibit risk aversion; that is, they demand a larger expected return in periods where risk is greater.
5. Traders' expectations are, on the average, realized.

Under this set of assumptions, we would find short-run (close-to-close) returns larger over a weekend than during the week.[4] The actual close-to-close returns are shown in Table 2. In both commodities, weekend returns were larger than weekday returns. The results are statistically significant, again indicating that the observed differences were not a chance occurrence.[5]

TABLE 2
CLOSE-TO-CLOSE RETURNS ON LONG POSITIONS[a]

Time Interval	July Bellies	June Cattle
Weekday	.0085	—.0050
Weekday and holiday	.0847[b]	.0510[c]

[a] Returns are in cents per pound. Because Bartlett's test for homogeneity of variance was significant (Table 1), the results of this comparison of returns must be interpreted cautiously.
[b] Significant difference between weekday and weekend means at $\alpha = .10$.
[c] Significant difference between weekday and weekend means at $\alpha = .05$.

Observance of larger returns over weekends and holidays is consistent with our assumptions regarding information flows and trader behavior. Two other issues of interest in the analysis of short-run price behavior will be examined. The first is the weekday adjustment mech-

[3] *Trading in Frozen Pork Belly Futures* (October, 1969) and *Trading in Live Beef Cattle Futures* (May, 1970), U.S. Department of Agriculture Commodity Exchange Authority. Also *Commitments of Traders in Commodity Futures* (monthly).

[4] Other combinations of assumptions substituted for assumptions 3-5 would provide the same results. The assumptions given are those most consistent with efficient market operation and also (fortuitously) most consistent with the findings of studies which have taken a longer-run perspective of market operation.

[5] If returns over the long run were positive to one side of the market or the other, adjustment would need to be made for the different time intervals involved. Since long-run return (normal accumulation rate) was about zero for both commodities, no adjustment was made and all return differences were assumed to be related to liquidity risk differentials. The normal accumulation rate adjustment is considered under *Further Evidence and Implications*, p. 19.

anism which accommodates larger weekend returns. The other, discussed in the final section, is the speed of price adjustment to weekend information.

To illustrate the question of how prices adjust during the week to provide larger weekend returns, we will consider an example where the current (and equilibrium) price of a future is 28.00 cents. In the absence of both new information and liquidity-risk differentials, an eight-day sequence of closing prices would be:

Day	Mon.		Tues.		Wed.		Thurs.		Fri.		Sat.		Sun.		Mon.
Price	28.00		28.00		28.00		28.00		28.00						28.00
Change		0		0		0		0				0			

Should liquidity risk adjustment be a constant (linear) factor, we might observe a pattern as follows:

Day	Mon.		Tues.		Wed.		Thurs.		Fri.		Sat.		Sun.		Mon.
Price	28.00		27.97		27.95		27.92		27.90						28.00
Change		−.03		−.02		−.03		−.02				+.10			

Since liquidity risk adjustment is very small in relation to both price changes resulting from new information and the minimum unit of price change (2½/100 cents/pound), most of the adjustment probably occurs on the trading day preceding the weekend. The pattern would then be:

Day	Mon.		Tues.		Wed.		Thurs.		Fri.		Sat.		Sun.		Mon.
Price	28.00		28.00		28.00		28.00		27.95						28.00
Change		0		0		0		−.05				+.05			

This latter hypothesis is consistent with the notion that some traders (net long) prefer to "even up" on a Friday rather than carry a position into the weekend. Breaking the weekday returns down by days of the week did not confirm this hypothesis for the pre-weekend daily return (generally a Thursday-to-Friday close-to-close) for all livestock futures. While pre-weekend return was less than daily return in bellies, the same was not true in cattle. Table 3 provides a summary of these results. However, evidence indicates that in both futures (ignoring transaction costs

TABLE 3
FURTHER BREAKDOWN OF CLOSE-TO-CLOSE RETURNS ON LONG POSITIONS

Time Interval	July Bellies	June Cattle
Weekday excluding pre-weekend	.0146	−.0080
Pre-weekend	−.0080	.0040
Weekend and holiday	.0847	.0510

and risk differentials) a trader who only bought near the close each Friday and sold near the close each Monday would have done markedly better than a trader who only bought each Thursday and sold each Friday.

SPEED OF THE ADJUSTMENT OF PRICES TO NEW INFORMATION

In an efficient market, price responds very quickly to new information. In the strictest definition of market efficiency, this adjustment must be both instantaneous and unbiased. Other studies of futures markets have found that almost all of the proper response to new information occurs sometime within the trading day when information first becomes known.[6] How quickly does a response occur within the trading day? Some evidence on this question can be obtained from our data.

If events occurring over a prolonged weekend closing are immediately reflected on the next trading day, all the results obtained so far using close-to-close price observations should also be evident using close-to-open observations. However, if the impact of new information works itself out sometime later in the first post-weekend trading day, higher risk and return observations will not be evident.

Using June cattle, Table 4 shows that weekend information is not immediately reflected in the opening quotations. Weekend risk and return measures were both very much smaller using close-to-open in place of close-to-close. This was also true of close-to-open measures during the week. Consistency was maintained with results using close-to-close in that both risk and return were significantly larger over weekends than during the week. These results suggest that news received over the weekend, while reflected in price levels by the close on Monday, is not fully acknowledged on the opening.[7] Limit orders and possibly a momentary

[6] Working (1956), Larson (1960), and Smidt (1968).

[7] An alternative explanation of these results is that very little information actually occurs outside of trading hours.

TABLE 4
RISK AND RETURN MEASURED FROM CLOSE-TO-OPEN
(JUNE CATTLE, 1965 to 1970)

Time Interval	Standard Deviation	Mean Absolute Deviation	Return
Weekday	.078	.0201	−.0006
Weekend and holiday	.117[a]	.0533	.0117[a]

[a] Significant difference in variance between weekday and weekend observations at $\alpha = .05$. Again, because population variances appear unequal, significance of difference between means must be interpreted cautiously.

"wait and see" attitude on the part of some traders may account for these results.

FURTHER EVIDENCE AND IMPLICATIONS

Corroborative Evidence under Conditions of Non-normality

Models viewing speculative prices as a stochastic process typically focus on the first differences, or their logarithmic counterparts, of day-to-day closing quotations.[8] Time intervals in such a series are not "fixed" in the sense implicitly assumed by these models: while trading time between successive observations is uniform, the length of time a market is closed and hence, the total time passing between observations, varies with the periodic occurrence of weekends and holidays. The purpose of this research has been to determine empirically if a weekend effect exists, what its pattern may be, and how it affects studies of market mechanisms involving distribution and dependence analysis of daily observations.

Studies of daily prices have been concerned with statistical dependency, distribution properties, and filter analysis. They have in common the treatment of each daily close-to-close observation as being the expected equal of all others in its population parameters, and judgment of market efficiency is rendered in this context. As the first section of this report has shown, there are both theoretical and empirical bases for denying this treatment. Measurement of risk and return were made with standard (parametric) statistical techniques which presume distributions of daily differences to be normally distributed. Caution is required in interpreting these results due to possible non-normal characteristics of livestock futures price series, a condition well-documented in security prices and grain futures.[9] Sufficiently strong non-normality may negate the conclusions drawn from parametric procedures. Various applications of the Kolmogorov-Smirnov test, a non-parametric measure of overall difference between distributions without regard to the contribution of individual parameters to this difference, were conducted to determine the answers to the following questions:[10]

1. Are the distributions of livestock futures in homogeneous groupings (i.e., weekday, pre-weekend, and weekend) normal?
2. Do the significant results obtained in the first section remain significant under the observed degree of non-normality?
3. Is the non-normality consistent with the stable Paretian hypothesis?

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[8] Examples are numerous. The literature through 1963 is well-reviewed in Cootner (1964). An updated survey has recently been provided by Fama (1970).

[9] Cootner (1964), Fama (1963), Larson (1960), and Stevenson and Bear (1970).

[10] Siegel (1956).

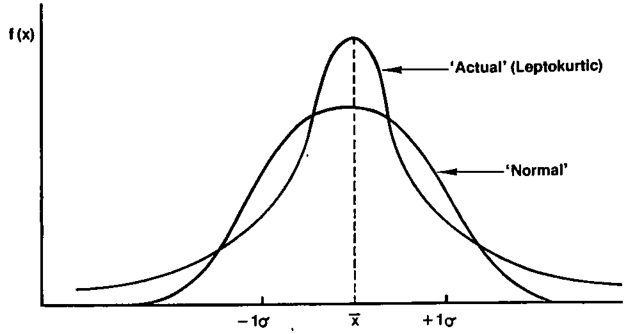

FIGURE 1. THEORETICAL (NORMAL) AND ACTUAL DISTRIBUTIONS OF PRICE CHANGES IN FUTURES MARKETS

In response to the first question, evidence shows that, owing to differing lower moments, aggregate distributions of all daily changes appear more leptokurtic than do their individual summands (see Figure 1). However, does recognizing weekend variation suggest that the distributions are normal (i.e., nonstationary Gaussian)? The one-sample Kolmogorov-Smirnov test against a normal curve indicates that weekday, pre-weekend, and weekend price changes remain too leptokurtic to be considered drawn from a normally distributed population. Thus we must consider the stable Paretian hypothesis as a description of these distributions.

In response to the second question above, a two-sample application of the Kolmogorov-Smirnov test found that the combined disparity in location and dispersion parameters of weekend observations was significantly different from those of weekday and pre-weekend observations. This finding using non-parametric techniques confirms the results of our prior parametric measurements.

A third distribution measurement was made. While leptokurtosis and differences in location and dispersion are consistent with a stable Paretian hypothesis, differences in skewness and characteristic exponents are not.[11] The Kolmogorov-Smirnov test was run on standardized distributions (using the mean absolute deviation as a measure of dispersion) to test consistency in form. Here D values were insignificant, indicating no intraweek shifting of form parameters.

Measurement of Daily Return and Price Dependency

The observation that dispersion, and possibly return, varies in cyclical fashion on an intraweek basis, to the extent that it is motivated by in-

[11]Fama (1963).

formational and liquidity preference factors, is of course completely consistent with the notion of an efficiently operating market.[12] It also suggests that measurements of serial correlation and run analysis (on a daily basis) should evidence some tendency toward reversal rather than the strict statistical independence expected in a time-information homogeneous world. There is another reason to expect negative dependence, namely a measurement bias caused by improper treatment of trend in these algorithms. The bias results from treating trend as a per observation concept, which generally creates an overadjustment across weekday intervals and underadjustment over weekend intervals.

As an example of the above problem, we will consider a simple random-walk model:

$$P_{t+k} = \beta P_t + \epsilon_{t+k} \quad (1)$$

where P_t is a closing price observation, ϵ_{t+k} is a random variable with $E(\epsilon_{t+k}) = 0$ and $r(\epsilon_t, \epsilon_{t+k}) = 0$ for all $K \neq 0$.

In Equation 1, β is a positive constant parameter specifying the level of expected return. If $\beta = 1$, the best estimate of the next closing price is the current closing price: there is no expected upward or downward drift in price through time. Let K represent any specified interval; $K = 1, 2, \ldots L$. Then $f(K)$ would represent the average percentage change in the value of P_t over the interval $(t, t + k)$. We express $f(K)$ in terms of β as:

$$\beta = 1 + f(K). \quad (2)$$

Testing Equation 1 by serial correlation involves the use of an algorithm where $f(K)$ is specified as:

$$f(K) = [(P_n - P_1)K]/P_1 n \quad (3)$$

where n is the number of daily closing price observations in the series $P_1, P_2 \ldots P_n$.

Formulation presumes a uniform interval of time between all observations. An alternative formulation which would correctly specify the accumulation rate recognizing variation in time intervals between closing observations would be:

$$g(K) = [(P_n - P_1)K]/P_1 m \quad (4)$$

where m is the total number of (calendar) days in the sample period —i.e., $m > n$.

[12] That is, current price unbiasedly reflects all information such as that in a martingale context:

$E(Z_{J,t+1} \mid \phi_t) = 0$ implying Z_{Jt} is a "fair game" given the information set ϕ_t where

$Z_{J,t+1} = R_{J,t+1} - E(R_{J,t+1} \mid \phi_t)$. See Fama (1970).

TABLE 5
KOLMOGOROV-SMIRNOV TWO-SAMPLE TEST ON STANDARDIZED FUTURES DISTRIBUTIONS[a]
D Values

Futures	Distribution 1: / Distribution 2:	Daily Except Pre-weekend / Pre-weekend	Daily / Weekend	Pre-weekend / Weekend
July Bellies		.045 (.101)	.079[c] (.096)	.051 (.121)
June Cattle		.067 (.095)	.109[b] (.090)	.071 (.114)

[a] Figures in parentheses indicate critical value for $\alpha = .05$.
[b] D value significant at $\alpha = .05$.
[c] D value significant at $\alpha = .20$.

In the case of daily observations, where $K = 1$, Equation 2 would take the form:

$$\beta = \begin{array}{ll} 1 + g(1) & \text{for all daily } P_t, P_{t+1} \\ 1 + 2g(1) & \text{for all holidays between } P_t, P_{t+1} \\ 1 + 3g(1) & \text{for all weekends between } P_t, P_{t+1} \\ 1 + 4g(1) & \text{for all holidays plus weekends between } P_t, P_{t+1}. \end{array}$$

Algorithms using Equations 2 and 3, thereby treating returns or a linear accumulation rate on an observation basis, systematically overstate weekday returns and understate weekend and holiday returns in markets where there is a positive return to risk-bearing. However, in markets where returns to one side of the market are very close to zero, the correction factor will be trivial. Returns to one side of the market in livestock futures are very close to zero over periods of several years, and we would expect a negligible effect.

Using Equations 4 and 5 instead of Equations 2 and 3 in calculating serial dependency for July bellies and June cattle had only a very minor effect on the correlation coefficient as Tables 5 and 6 indicate. In both

TABLE 6
UNCORRECTED AND CORRECTED SERIAL CORRELATION COEFFICIENTS, ONE-DAY LAG, (JULY BELLIES AND JUNE CATTLE, 1965-1970)

Category	July Bellies	June Cattle
Per Observation		
Accumulation rate (3)[a]	.025	.008
Daily accumulation rate (5)	.018	.005
Uncorrected r (1) (3)	−.029	.120
Corrected r (1) (5)	−.027	.122

[a] Numbers in parentheses refer to equations in this section.

cases the correction, although trivial, was in the expected direction of making the coefficient more positive (less negative). A greater difference between corrected and uncorrected correlations would result in markets and periods where trend is greater.

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