TESTING FOR ASYMMETRY IN COMMODITY FUTURES PRICES

Rony S. Gravelines

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TESTING FOR ASYMMETRY IN COMMODITY FUTURES PRICES

BY

RONY S. GRAVELINES

A Thesis/Practicum submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

ABSTRACT

There is considerable research relating to the asymmetry of price transmission within spatial markets and vertical price transmission within a marketing channel. If asymmetry is present within a market, current price changes may react to past price increases and decreases asymmetrically. Asymmetric price research has mostly focused on agricultural markets, however, this study also includes non agricultural markets.

This study tests for asymmetry in futures price changes of various commodities. Daily, weekly, and monthly data is used to test for asymmetry in live cattle, corn, gold, lightcrude oil, Standard & Poors 500, silver, US treasury bills, and wheat. Asymmetry is examined through the use of two tests: the sum of coefficients test and the speed of adjustment test. A Monte Carlo study is used to compare coefficients from observed daily price changes in lightcrude oil versus a random series of price changes from a normal distribution with the same mean and standard deviation, in order to ensure that asymmetry results are reliable.

The results show that some asymmetry is present in futures price changes. The first symmetry hypothesis that the overall impact of prices increases is equal to price decreases is rejected for daily cattle and daily corn. Weekly cattle and weekly treasury bills also exhibited asymmetry in the overall impact of increases and decreases. The second symmetry hypothesis, the speed of adjustment, is rejected for daily data in wheat, Standard & Poors 500, gold, oil, and corn. Weekly data in gold, oil, corn, treasury bills and monthly data in silver and cattle also show evidence of asymmetry in the speed of adjustment.

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CHAPTER 1

INTRODUCTION

Considerable research is devoted to investigating whether price changes in a central market are transmitted to a local market in a symmetrical fashion (Bailey and Brorsen, 1989; Punyawadee, et al., 1991). Others have researched the possibility of asymmetry in vertical marketing channels (Boyd and Brorsen, 1988; Griffith and Piggott, 1994). Another area of research is the behaviour of price changes within the same market, examining whether price increases occur as often as decreases. Is the average price increase equal to the average price decrease in absolute terms? Do current price changes react differently to past price increases compared to past price decreases. To date, little research is documented on the asymmetric behaviour of price changes in futures markets. Kang and Brorsen (1995) tested for asymmetry in Kansas City daily wheat futures and find that the total impact of past rising prices is not significantly different from that of past falling prices. However, the speed of adjustment is significantly different for price increases than for price decreases.

Asymmetry has a number of implications for markets. First, if such behaviour can be confirmed, market regulators and policy-makers may wish to improve the functioning of various markets to more symmetrical behaviour. This may help avoid market crashes and sudden unexpected price adjustments adversely affecting market participants. Secondly, if price changes are asymmetric, this implies they contain valuable past information affecting current prices and forecasters and traders may find this information useful for improved decision making. For example, investors may remain for a longer time on the buying side of a market and a shorter time on the selling side if they feel a particular market is subject to some asymmetry with prices moving down faster than they move up. This in turn implies that because markets contain this useful past price information for trading, then markets are no longer weak form efficient (Fama, 1965) as described by Fama. Thirdly, the traditional Black-Scholes option pricing model is based upon the assumption that futures prices are distributed normally. Research has confirmed that futures price changes are not normal and contain kurtosis, skewness, and conditional heteroskedasticity. Improvements to the Black-Scholes model have been proposed and do provide better estimates for deep in-the-money and deep out-of-the-money options. Asymmetric price changes may be the next characteristic incorporated into an option pricing model in order to obtain better estimates.

Therefore, the objective of the research in this paper is to test for asymmetry in various commodity futures. Commodities are tested over daily, weekly, and monthly prices provides a common foundation to make comparisons between commodities from different groups. Agricultural, financial, metals, and oil commodities are tested for asymmetry. The first hypothesis tested is that past positive price changes have an identical effect on current price changes as do past negative price changes. The second hypothesis tested is that the speed of adjustment for past price changes will be the same for increases and decreases.

CHAPTER 2

DESIGNING A MODEL AND TESTING FOR ASYMMETRY

Introduction

The concept of price asymmetry has been raised by a number of researchers. In the Keynsian model, nominal wages are assumed to be sticky downwards due to labor contracts. Wages are easy to raise but difficult to lower, therefore, wages in the Keynsian model behave asymmetrically. For the case of commodity markets, according to commodity fund manager Jack Alban (1990, 49) " a rising market is the mirror image of a declining market in the financial sectors. But not so in commodities, which decline at a much greater rate than they rise."

While there has been only limited analysis of asymmetry in financial markets, there is considerable research on asymmetry in the agricultural literature, Kinnucan and Forker (1987) study price transmission from farm to retail for dairy products. They find that retail dairy product prices adjust more rapidly and more fully to increases in the farm price of milk than to decreases. Boyd and Brosen (1988) look at the U.S. pork marketing channel and find no evidence of asymmetry contrary to Hahn's study (1990) which finds asymmetry in both the U.S. pork and beef marketing channels. Griffith and Piggott (1994) confirm Freebairn's (1984) conclusion relating to the absence of price asymmetry for pork, but not for beef and lamb in the Australian marketing channel. Hansmire and Willet (1992) conclude that the farm-retail price transmission process for New York State apples is asymmetric. While most of the literature relates to agricultural products and prices, it also concentrates on price transmission in spatial markets or vertical transmission in a marketing channel. Kang and Brorsen (1995) test for asymmetry within the same market, and they report that the Kansas City Wheat futures market had asymmetry in the speed of the adjustment.

The theory of futures markets assumes that changes in futures prices are based on revised expectations about the factors determining prices. Since most futures markets are highly competitive, prices are often assumed to follow a random walk. The first difference of prices are thus simply a random series or white noise with no systematic differences between price increases and decreases. However, human behaviour does not always coincide with rational behaviour. Speculative bubbles are an example of irrational behaviour which causes a price to increase contrary to rational behaviour. Individuals realize that a price today is abnormally high, and despite this knowledge, they still bid the price higher because they do not want to miss out on potential capital gains from the price going even higher tomorrow. Eventually the bubble bursts and the price drops rapidly.

Since futures contracts require only a small initial commitment, investors use this leverage to control futures contracts with minimal investment. Traders sometimes act as a herd mentally because under certain circumstances the action of a few are duplicated by the whole. Humans can also become slowly attached to their assets and increase their investment over time for psychological and emotional reason. However, they are reluctant to sell and only do so when they have to because the asset has begun to decline in value. Sales in turn further decrease the value of the assets which causes more sales, fuelling the downward price spiral. This type of attachment can result in a large liquidation very quickly as declining price causes declining collective value which forces liquidation which further causes declining collective value.

Econometric Model

Tweeten and Quance (1971) developed a simple price asymmetry model, which was later improved by Wolfram (1971) and Houck (1977). Ward (1982) further modified the model and made it dynamic by adding lagged prices. Boyd and Brorsen (1988) and also Bailey and Brorsen (1989) used a dynamic model in order to test for both aggregate impact and speed of adjustment. The tests used in these models are similar to the model used in this study. Kang and Brorsen (1995) added dummy variables to capture the day of the week effect, and also added trigonometric functions in an attempt to model seasonality. This study regresses price changes the dependent variable, against both positive and negative lagged prices changes within the same series, which are the independent variables. The model for asymmetry is obtained by segmenting lagged price changes into two sets, one for positive lagged price increases and another for lagged price decreases. The logarithmic price changes, PC, are segmented as,

$$PPC_t = \begin{cases} PC_t, & PC_t \geq 0 \\ 0, & otherwise, \end{cases}$$

$$NPC_t = \begin{cases} PC_t, & PC_t < 0 \\ 0, & otherwise, \end{cases}$$

where PC_t is the logarithmic difference of returns at time t. The following is the model to be estimated which is similar to Kang and Brorsen (1995).

$$PC_t = a_0 + \sum_{i=1}^{6} \lambda_i PPC_{t-i} + \sum_{i=1}^{6} \gamma_i NPC_{t-i} + a_1 D_{MON} + a_2 D_{TUE} + a_3 D_{WED}$$
$$+ a_4 D_{THU} + a_5 \, SIN(2\pi K/C) + a_6 \, COS(2\pi K/C) + a_7 \, SIN(2\pi K/SC)$$
$$+ a_8 \, COS(2\pi K/SC) + \varepsilon_t \tag{1}$$

where λ_i and γ_i represent the net effect of the ith positive and negative changes of PC_t, respectively, and six is the number of lags. A lag of six periods was chosen because it is assumed long enough to capture any delays in information being incorporated into the price of the commodity. By keeping the lag period constant across commodities comparisons can be made between the models and results. D represents dummy variables for each day of the week; D_{MON} = 1 if Monday and 0 otherwise, D_{TUE} = 1 if Tuesday and 0 otherwise, D_{WED} = 1 if Wednesday and 0 otherwise, D_{THU} = 1 if Thursday and 0 otherwise. The day of the week variables are only included in models that use daily data. SIN and COS represent the sine and cosine functions, respectively, and π is approximated by 3.14. K is the number of trading days after January 1 of the particular year. Denominators in the sine and cosine functions are the specified cycle length in trading days. For daily data, Cycle (C) = 252 and Semi-Cycle (SC) = 126, for weekly data, C = 52 and SC = 26, and for monthly data, C = 12 and SC = 6.

The twenty four equations, eight commodities over three time periods, are estimated using least squares procedures. Autocorrelation is not a significant problem with the data since first differences are used. The two traditional tests for asymmetry are evaluated for the rejection of the null hypothesis that price changes are symmetrical. The sum of the coefficients, the first hypothesis, tests the aggregate impact of past price increases and decreases to determine whether they are different:

$$H_O : \sum_{i=1}^{6} \lambda_i = \sum_{i=1}^{6} \gamma_i$$

$$H_A : H_O \text{ is not true}$$

The second hypothesis tests whether the speed of adjustment is different for both price increases and decreases:

$$H_O : \lambda_i = \gamma_i, \text{ for all } i$$

$$H_A : H_O \text{ is not true}$$

The first hypothesis test implies that the market reacts differently to the total impact of past rising prices than past falling prices. In conventional autoregressive models, current price changes are regressed against lagged price changes. This forces the coefficient for a certain lag to be the same for increases and decreases. Separating past price changes into positive and negative changes allows the coefficient for increases to differ from that of decreases. Asymmetry is reflected by a difference between the coefficients for increases and decreases. Positive and negative regression coefficients are expected to have positive signs if past price changes are positively correlated with current price changes. Coefficients can differ in two respects. The first is when the positive and negative coefficients of the same lag period have different magnitudes but the same sign. The second possible way that asymmetry can be present is if the signs of the coefficients are different for increases and decreases. Opposite signs for the same lag period implies that a past increase affects the current price change in the same direction as a decrease.

The speed of adjustment test involves a joint test for pairs of coefficients. Rejection of this hypothesis forces the inspection of the individual coefficients for a an appropriate explanation of the asymmetry. In some cases, it may be difficult to determine whether there is a faster speed of adjustment for increases rather than decreases.

Data

The data used in this study consists of daily, weekly, and monthly closing futures prices for each commodity. There are eight commodities in the study; cattle, corn, gold, silver, oil, Standard & Poors 500, treasury bills, and wheat. By choosing an assortment of commodities over different time horizons (daily, weekly, monthly data) comparisons can be made to determine if asymmetry is found in futures markets. The models are estimated by using the first difference of the natural logarithmic closing futures prices for the particular commodity. Fama (1965) provides reasons for using the logarithmic changes (which are approximate percentage changes). A rationale is that while variability of simple price changes increases as the price level increases, log differences neutralize price level effects. The natural logarithmic differences used here are then rescaled by multiplying them by 100 in order to avoid computational error from small values. The data are obtained from Technical Tools' Continuous Contractor. A nearby series is used for each commodity. The rollover date is approximately the 25th day of the previous month to expiration and rollover dates are removed from the data set to avoid spurious price jumps due to changing from one contract month to the next. The weekly data is obtained by choosing the friday (or last day) of each week in the daily series. Monthly data is obtained from the daily series by choosing the last trading day in each month. Autocorrelation is not a significant concern due to the fact that first differences are being used. Table 2.1 contains the correlation matrix for daily logarithmic wheat changes and indicates no high correlation or multicollinearity problems in the estimation of equation (1).

Cattle

Live cattle futures prices are from the Chicago Mercantile Exchange (CME). Prices are quoted in US dollars per hundred pounds (cents per pound) and there are seven contract months per year; February, April, June, August, September, October, and December. The prices are from January 1976 through December 1995, and a daily price change limit of 1.5 cents per pound is imposed and can be seen in figure A.1 by the distinct box bounded by 1.5. Figure A.1 is a graph which displays the one lag positive and negative changes versus current price changes.

Corn

Corn futures prices are from the Chicago Board of Trade (CBOT). Prices are quoted in cents per bushel for the 5 contract months per year; December, March, May, July, and September. The prices are from January 1969 through December 1995, and a daily price change limit of 10 cents per bushel is imposed which can be seen in figure A.2 by the box bounded by 10. Any observations outside the 10 cent boundary that are a result of the rollover effect are removed from the analysis. In certain cases, daily price change limits are relaxed if a legitimate event forces the price to change drastically, such as Chernobyl.

Gold

Gold futures are traded on the New York Commodity Exchange (COMEX). Prices are quoted in US dollars per troy ounce for the 6 contracts per year; February, April, June, August, October, December, plus the current month and the next two calender months. Gold data is from January 1975 through December 1995, there is no daily limit on price changes.

Oil

Light sweet crude oil futures are traded on the New York Mercantile Exchange (NYMEX). Prices are quoted in US dollars per barrel for the numerous contracts per year, a contract lasts for 18 consecutive months, beginning with the current month. Crude oil data is from January 1984 through December 1995, and there is a daily price change limit of one dollar per barrel.

Silver

Silver futures are traded on the New York Commodity Exchange (COMEX). Prices are quoted in cents per troy ounce for the 6 contracts per year; January, March, May, July, September, December, plus the current month and the next two calender months. The prices are from January 1972 through December 1995, with no daily limit on price changes.

Standard & Poors 500

S&P 500 futures are traded on the Chicago Mercantile Exchange (CME). Prices are quoted as points, one point represents $500. There are 4 contract months per year; March, June, September, and December. Prices are from January 1983 through December 1995, there may be a limit put in place which is coordinated with trading halts of the underlying stocks listed for trading in the securities markets. During the opening range, no trading is allowed at a price more than five index points above or below the previous day's settlement price.

T-bills

90-day US treasury bill futures are traded on the International Monetary Market (IMM) of the CME. Prices are quoted in US dollars per $100 par value bond. There are 4 contract months per year; March, June, September, and December. The treasury bill data is from January 1983 through December 1995, and there is no daily limit is in place for price changes. Data for the month of December 1994, is missing from the data set.

Wheat

No. 2 soft red winter wheat futures are traded on the Chicago Board of Trade (CBOT). Prices are quoted in cents per bushel for the 5 contract months per year; July, September, December, March, and May. Wheat price data is from January 1970 through December 1995, and a daily price change limit of 20 cents a bushel is in effect.

Table 2.1
Daily Logarithmic Wheat Price Change Variable Correlations, January 1970 through December 1995

Price Variable	Pos1	Pos2	Pos3	Pos4	Pos5	Pos6	Neg1	Neg2	Neg3	Neg4	Neg5	Neg6
Lch	0.003	0.0004	0.001	-0.002	-0.007	0.002	0.027	-0.073	-0.004	0.015	-0.014	-0.003
Pos1		0.0001	-0.0002	-0.0004	-0.0004	-0.0006	0.059	0.002	-0.012	-0.001	0.0009	-0.002
Pos2			0.0002	-0.0002	-0.0003	-0.0004	-0.005	0.059	0.002	-0.012	-0.001	0.0009
Pos3				0.0002	-0.0001	-0.0003	-0.005	-0.004	0.059	0.002	-0.012	-0.0009
Pos4					0.0002	-0.0002	-0.004	-0.006	-0.005	0.059	0.002	-0.012
Pos5						0.0002	-0.009	-0.004	-0.006	-0.004	0.059	0.0022
Pos6							-0.013	-0.009	-0.004	-0.006	-0.005	0.059
Neg1								0.071	-0.009	0.04	0.056	0.043
Neg2									0.075	-0.01	0.039	0.057
Neg3										0.074	-0.009	0.038
Neg4											0.075	-0.009
Neg5												0.075

Lch = logarithmic price change
Pos i = positive logarithmic price change lagged i periods
Neg i = negative logarithmic price change lagged i periods

CHAPTER 3

RESULTS

In all, twenty four equations are estimated, with three time horizons for each of the eight commodities. The equations are of the form specified in Eq. 1, though equations involving weekly or monthly data will not have the dummy variables for the day of the week effect because they are not daily data estimates. Augmented Dickey-Fuller unit-root tests are conducted for futures prices, for the logarithm of the futures prices, and for the logarithmic first difference of futures prices. All commodities have significant statistics for the logarithmic first differenced futures data which indicates stationarity of the variables. Table 3.1 presents the results of the unit-root tests for daily gold and is representative of the other commodities as well.

Aggregate Impact Test

The results of the first asymmetry hypothesis test, the impact test, is shown at the bottom "Sum F-value" in each of Tables 3.2 through 3.9 for the various commodities. The results suggest that there is evidence of asymmetry in futures markets, based on the first hypothesis, that the total impact of past increases is the same as past decreases. The hypothesis is rejected under four situations, including daily and weekly cattle, daily corn, and weekly T-bills. In the results for cattle for example, the sum of the positive changes is larger in absolute terms than negative changes for daily prices. Closer inspection of the coefficients shed some light onto the interpretation. The intercept for daily cattle is significantly greater than zero, this implies that every thing else being equal, today's price change will have a tendency to be positive. The sum of the POS coefficients is positive which contrasts the sum of the NEG coefficients which are negative.

For weekly cattle price changes, no POS coefficients are significantly different from zero, therefore, the sum of positive change coefficients is negative but essentially zero. The sum of the NEG coefficients is negative and two of the coefficients are significant. This implies that past price decreases have a positive effect on the current price change.

Another situation in which the total impact is not the same is daily corn. Table 3.3 shows the results for corn, and the signs are the same for the sums of the positive and negative coefficients. The sum of positive changes is greater than that for negative changes implying that past price increases have a larger impact on the current price change than do decreases. A reason for this is the fact that NEG1 is positive and NEG2 is negative and are of comparable magnitude, they cancel each other out when the sum is calculated. POS4 is the only significant coefficient for POS coefficients therefore it has a larger impact then the NEG coefficients.

The final commodity which rejects the null hypothesis of the impact on current price changes as being the same for past increases and decreases is weekly treasury bills. By calculating the sums of the positive and negative lagged coefficients one can observe that the sum of the positive coefficients is greater than that of the negative coefficients. In fact the sum of the negative coefficients can be considered to be zero. This implies that current price changes are affected by past price increases and past price decreases have no effect on current price changes.

Adjustment Test

The second hypothesis, that the coefficients for each lag will be the same for increases as for decreases, reported as "Identical F-value" at the bottom of each table 3.2 through 3.9 for the various commodities, was rejected for eleven of the twenty-four situations. These rejections include daily data in corn, gold, oil, standard & poors 500, wheat, weekly data in gold, silver, T-bills, oil, and monthly data in cattle and silver are the eleven situations where asymmetry is detected. Six of the eleven situations involve daily data, this was expected because asymmetry has often been found in the short run. An insight as to which direction the asymmetry is affecting the price changes can be gained by looking at the daily Standard & Poors 500 results in Table 3.7. Focusing on the difference between the coefficients POS2, NEG2 and POS3, NEG3 may give an indication as to how to interpret the asymmetry.

The difference between POS2 and NEG2 is greater than zero and looking at the individual coefficients it can be seen that POS2 is greater than zero and that NEG2 is less than zero. The coefficients indicate a positive price change two periods ago will have a positive effect on today's price change, but a negative price change two periods ago has a greater impact on today's price change and surprisingly will tend to cause it to be positive. This result is observed during the week of October 19, 1987 to October 23, 1987. On Monday, October 19, 1987 the stock market crashed, plummeting more than 80 points in a single day and two days later the market rebounded with relatively large positive change on Wednesday, October 21, 1987 of approximately 40 points. The 1987 crash may be considered an anomaly, it may be that the coefficients are being influenced by this one extreme event. Table 3.10 contains the daily coefficients for the S&P 500 with and without the 1987 crash. Obviously the crash has an effect on the coefficients, NEG2 is significant when the crash is included and is insignificant when it is removed. The inclusion of the crash is important in the sense that models should be aware of the possibility of these drastic changes. On the other hand, since a cause can be assigned to the outlier and it has a large influence on the coefficients it should be removed to better represent the majority of the data.

The following analysis on daily S&P 500 uses the data set with the market crash removed, e.g. Table 3.10. With the crash removed the hypothesis is still rejected. The first period lags have statistically different coefficients, POS1 is insignificant meaning that if the price went up last period there is no effect on today's price change. The same can not be said about NEG1, if the index dropped last period today's price will tend to rise, all other things being equal. The third lag rejects the symmetry hypothesis as well, if the stock market went up three periods ago, it can be expected it will fall this period. NEG3 is also significant and indicates that the current price will drop if the price fell three periods earlier. In this case the asymmetry occurs because the current price will decrease regardless of the directional change three periods ago. The price will decrease with a greater magnitude if the price increases rather than decreases three periods ago. This analysis assumes, however, that every thing else remains constant, the price does not change for any other lag and there are no other factors affecting the price change. The other situations can be analyzed in a similar fashion as outlined above. By testing each set of POS and NEG coefficients an insight can be gained as to which way the market adjusts asymmetrically to past price changes.

Descriptive Statistics

The number of increases and decreases, and the average size of the positive and negative changes are presented in Table 3.11. A two sample pooled t-test is used to verify any statistical differences between the means for positive changes and negative changes. Daily corn is the only commodity which rejected the hypothesis of equal means. It should be noted that these statistics are only testing certain characteristics of a distribution and price change behaviour. Having the same number of increases and decreases with the same average change does not necessarily confirm symmetry within a series. A simple example that demonstrates this is as follows; assume there are ten periods in a series. In the first period the price rises 2 units, second period decreases 1 unit, third period increases 2 units, fourth period decreases 1 unit,..., ninth period increases 2 units, tenth period decreases 6 units. The number of increases is 5, number of decreases is 5, average increase is 2, average decrease is 2. The summary statistics seem to suggest that increases behave in the same manner as decreases. This is obviously misleading because there is a large decrease at the end which happens to combine with the smaller decreases to equal the average increase. A frequency distribution is able to display any difference if the distribution for the increases is overlayed on the distribution for the decreases.

Figure A.1 plots positive and negative distributions for a similar hypothetical situation in which negative changes occur far into the tail of the distribution. The positive price changes are concentrated between a one unit change and a 4 unit change, the tail is flatter indicating few positive changes are large. The negative distribution is clearly different due to the fact that it is below the positive distribution for smaller changes and above for larger changes. The two price change distributions are different and this difference implies asymmetry within the series. Figures A.4-A.11 display the positive and negative distributions for daily data. All daily commodities show no obvious differences in the way positive and negative changes are distributed.

Table 3.12 consists of summary statistics for the twenty four data series analyzed. It is well documented that futures price changes are leptokurtic, meaning a high level of positive kurtosis (Hall et al. (1989); Hudson et al. (1987); Kang and Brorsen (1995)). A large kurtosis is a result of more observations in the tails and around the mean than that of a normal distribution. The commodity with the largest kurtosis was daily S&P 500. The stock market, for the most part, has a small variability as can be seen in Figure A.25 However, the market has been known to correct itself periodically in the past with relatively large decreases. At certain times such as Monday, October 19, 1987 the stock market takes a tumble but can rally very quickly pushing up the index, like on Wednesday October 21, 1987. These extreme situations account for more observations in the tails of the distribution. For the most part however, the stock market does not have high variability, the standard deviation is only 1.1778 with large changes included like black monday and only 0.9724 with changes greater than forty points removed. A small variability signifies more observations near the mean than a normal distribution, thus the stock market changes are leptokurtic.

Seasonality and Day of Week Effects

Table 3.13 contains the results of the tests for day of the week effect and seasonality. Of the eight commodities examined, only two, cattle and wheat, have a day of the week effect. The variables for Monday, Tuesday, and Wednesday are significantly different from zero for daily cattle price changes. The coefficients for these variables are negative causing the intercept to be negative for these days. This results in the likelihood of price decreases during the beginning of the week and increases at the end of the week. Daily wheat also indicated a day of the week effect. According to the coefficients only thursday is significantly different from the other days. The coefficient is negative resulting in more price decreases on Thursdays. Seasonality is detectable in seven of the twenty four combinations. Wheat is the only daily commodity that rejects the null hypothesis of no seasonality in favour of the alternative, seasonality. Weekly cattle, corn, and wheat all show evidence of seasonality in the data. Monthly cattle and wheat also reject the null hypothesis to suggest seasonality is present in monthly price changes. Conclusions drawn from the seasonality tests are that agricultural commodities are the only commodities that exhibit seasonality. This pattern may be due to the biological production nature of these commodities.

Monte Carlo Simulation

The efficient markets hypothesis holds that in a highly competitive and organized market, price changes will be essentially random. The model for such market price behaviour is the random walk theory. The underlying economic foundation for random price changes is that efficient markets are comprised of numerous well-informed participants that should create prices which accurately reflect all current information. Thus the commodity in question will be priced at a reliable estimate of its true value. However, if a commodity shows asymmetry, then past prices influence current prices and the efficient market hypothesis no longer holds.

In order to make sure that asymmetry results truly show asymmetry and are not due purely to chance, a Monte Carlo simulation is used. The Monte Carlo simulation is used to compare the regression results of daily oil price changes versus 1000 replications from a random sample drawn from a normal distribution of the same size with the same mean and standard deviation as daily oil. Table 3.14 presents the regression results for daily oil and compares them to the estimates obtained from the Monte Carlo simulation. The estimates from the Monte Carlo simulation are obtained from purely random data and thus the expectation is that there will be no information in the data and the estimates should not be significant. A 95% confidence interval is also constructed to obtain a range in which one would expect coefficients to be if the underlying data is random. Four coefficients are significant in the daily oil regression; POS1, POS5, NEG2, and NEG3. These four estimates also fall outside the 95% confidence interval from the Monte Carlo simulation indicating that these coefficients are different than would be expected. The verification with a monte carlo experiment ensures the integrity of the model and tests, if asymmetry is found in the random data, this would raise doubt in the model and tests used.

Table 3.1
Unit Root Test Results of Daily Gold Futures Prices, Logarithmic Prices, and Logarithmic First Differences, January 1975 to December 1995

Null Hypothesis	Test Statistic	Critical Value 10%
	Futures Prices	
Constant, no trend		
A(1)=0 T-Test	-2.0231	-2.57
A(0)=A(1)=0	2.1766	3.78
Constant, trend		
A(1)=0 T-Test	-1.9626	-3.13
A(0)=A(1)=A(2)=0	1.4830	4.03
A(1)=A(2)=0	2.0944	5.34
	Logarithmic Futures	
Constant, no trend		
A(1)=0 T-Test	-1.5966	-2.57
A(0)=A(1)=0	1.6004	3.78
Constant, trend		
A(1)=0 T-Test	-1.3928	-3.13
A(0)=A(1)=A(2)=0	1.0712	4.03
A(1)=A(2)=0	1.2811	5.34
	Logarithmic First	
Constant, no trend		
A(1)=0 T-Test	-27.792	-2.57
A(0)=A(1)=0	386.21	3.78
Constant, trend		
A(1)=0 T-Test	-27.803	-3.13
A(0)=A(1)=A(2)=0	257.67	4.03
A(1)=A(2)=0	386.51	5.34

All statistics are significant for the logarithmic differenced data which indicates stationarity of the variables.

Table 3.2
CME Cattle Price Regression Results and Asymmetry Tests, January 1976 through December 1995

Independent[a] Variables	Daily[b] Coefficients	Weekly[b] Coefficients	Monthly[b] Coefficients
Intercept	0.0953*	-0.3846	-0.8894
POS1	0.0479*	0.0954	0.1552
POS2	-0.0056	-0.0646	-0.0665
POS3	0.0414	0.0385	-0.0031
POS4	0.0104	0.0034	-0.0826
POS5	0.0149	-0.0792	-0.1301
POS6	0.0022	-0.0127	-0.1865
NEG1	-0.0251	-0.1783*	-0.5279*
NEG2	0.0154	-0.0585	-0.0098
NEG3	0.0555*	-0.0960	-0.3729*
NEG4	0.0313	-0.0615	-0.2526
NEG5	-0.0566*	-0.1267*	0.1708
NEG6	-0.0544*	0.0471	0.0290
D_{MON}	-0.1943*		
D_{TUE}	-0.2172*		
D_{WED}	-0.1601*		
D_{THU}	-0.0729		
COS(cycle)	0.0406	0.3835*	1.7524*
SIN(cycle)	-0.0041	-0.1346	-0.0438
COS(semi-cycle)	0.0102	-0.1056	-0.1412
SIN(semi-cycle)	0.0442*	0.4607*	1.3198*
Sum F-value[c]	3.9642*	5.4352*	2.9016
Identical F-value[d]	1.9251	2.0337	3.1882*

* Significant at the 5% level
[a] Where POSi and NEGi are the nearby futures positive and negative log price changes (multiplied by 100) in the ith lag, DMON,..., DTHU are dummy variables for the day of the week, the trigonometric functions COS and SIN capture seasonality.
[b] The dependant variable is the nearby futures log price change (multiplied by 100).
[c] Null hypothesis is that the total impact of past price increases on current price changes are equal to past decreases.
[d] Null hypothesis is that the speed of adjustment to price increases and price decreases are the same.

Table 3.3
CBOT Corn Price Regression Results and Asymmetry Tests, January 1969 through December 1995

Independent[a] Variables	Daily[b] Coefficients	Weekly[b] Coefficients	Monthly[b] Coefficients
Intercept	-0.0237	-0.0851	0.6757
POS1	0.0267	0.1282*	-0.1615
POS2	0.0123	0.0356	0.2394*
POS3	0.0311	0.0673	-0.1901*
POS4	0.0529*	0.1361*	0.0557
POS5	0.0221	-0.1137*	-0.0607
POS6	-0.0083	-0.1449*	0.1673
NEG1	0.0658*	-0.0079	0.1951
NEG2	-0.0585*	0.0290	-0.0916
NEG3	-0.0151	0.0001	0.1391
NEG4	-0.0271	-0.0864	-0.1052
NEG5	0.0200	-0.0206	0.1183
NEG6	0.0394	0.0399	-0.0439
D_{MON}	0.1414		
D_{TUE}	-0.0146		
D_{WED}	0.0133		
D_{THU}	-0.0569		
COS(cycle)	0.0216	0.2267	0.5139
SIN(cycle)	0.0395	0.1867	0.3047
COS(semi-cycle)	-0.0182	-0.1178	-0.5046
SIN(semi-cycle)	-0.0423	-0.2912*	-0.8721
Sum F-value[c]	4.0515*	1.3325	0.2085
Identical F-value[d]	2.5448*	3.0030	1.7924

* Significant at the 5% level

[a] Where POSi and NEGi are the nearby futures positive and negative log price changes (multiplied by 100) in the ith lag, DMON,..., DTHU are dummy variables for the day of the week, the trigonometric functions COS and SIN capture seasonality.

[b] The dependant variable is the nearby futures log price change (multiplied by 100).

[c] Null hypothesis is that the total impact of past price increases on current price changes are equal to past decreases.

[d] Null hypothesis is that the speed of adjustment to price increases and price decreases are the same.

Table 3.4
COMEX Gold Price Regression Results and Asymmetry Tests, January 1975 through December 1995

Independent[a] Variables	Daily[b] Coefficients	Weekly[b] Coefficients	Monthly[b] Coefficients
Intercept	0.0193	0.0973	-0.4324
POS1	-0.0448	-0.0104*	0.0143
POS2	0.1151*	0.3630*	0.0028
POS3	0.0284	-0.1099*	0.1372
POS4	-0.0961*	0.0121	0.0299
POS5	-0.0250	-0.0326	0.3859*
POS6	0.0292	-0.1007	-0.2799*
NEG1	0.0193	0.0546	0.0827
NEG2	-0.0452	-0.1557*	-0.0983
NEG3	0.0181	0.1432*	-0.1790
NEG4	-0.0365	-0.0191	0.1840
NEG5	0.0185	-0.0333	-0.1229
NEG6	-0.0331	0.0716	0.0898
D_{MON}	-0.0913		
D_{TUE}	0.0131		
D_{WED}	-0.0112		
D_{THU}	-0.0836		
COS(cycle)	-0.0148	-0.0438	-0.2060
SIN(cycle)	-0.0395	-0.1771	-1.1141*
COS(semi-cycle)	0.0206	0.0671	0.2025
SIN(semi-cycle)	-0.0071	-0.0328	-0.0803
Sum F-value[c]	1.3099	0.0663	1.0767
Identical F-value[d]	3.5545*	7.0539*	1.8144

* Significant at the 5% level

[a] Where POSi and NEGi are the nearby futures positive and negative log price changes (multiplied by 100) in the ith lag, DMON,..., DTHU are dummy variables for the day of the week, the trigonometric functions COS and SIN capture seasonality.

[b] The dependant variable is the nearby futures log price change (multiplied by 100).

[c] Null hypothesis is that the total impact of past price increases on current price changes are equal to past decreases.

[d] Null hypothesis is that the speed of adjustment to price increases and price decreases are the same.

Table 3.5
NYMEX Crude Oil Price Regression Results and Asymmetry Tests, January 1984 through december 1995

Independent[a] Variables	Daily[b] Coefficients	Weekly[b] Coefficients	Monthly[b] Coefficients
Intercept	-0.0122	-0.3084	-0.0721
POS1	-0.1213*	0.0115	0.2059
POS2	0.0445	0.1301	-0.3744*
POS3	-0.0448	0.1884*	0.0514
POS4	0.0157	-0.0041	0.0538
POS5	-0.1549*	-0.0595	-0.3315
POS6	0.0014	-0.0384	0.0829
NEG1	0.0834*	-0.1854*	0.2577
NEG2	-0.1399*	-0.0177	0.1326
NEG3	-0.1275*	-0.0509	-0.2836
NEG4	0.0439	0.1714*	0.0855
NEG5	-0.0014	0.1610	-0.2159
NEG6	-0.0235	-0.0039	-0.1770
D_{MON}	0.0568		
D_{TUE}	0.0109		
D_{WED}	0.0671		
D_{THU}	0.1798		
COS(cycle)	-0.0968	-0.3761	-1.1735
SIN(cycle)	-0.0048	-0.0235	-0.9142
COS(semi-cycle)	-0.0967	-0.4616	-2.3152
SIN(semi-cycle)	0.0543	0.1244	-0.0051
Sum F-value[c]	1.7410	0.8077	0.1079
Identical F-value[d]	5.4916*	2.1331*	0.7173

* Significant at the 5% level

[a] Where POSi and NEGi are the nearby futures positive and negative log price changes (multiplied by 100) in the ith lag, DMON,..., DTHU are dummy variables for the day of the week, the trigonometric functions COS and SIN capture seasonality.

[b] The dependant variable is the nearby futures log price change (multiplied by 100).

[c] Null hypothesis is that the total impact of past price increases on current price changes are equal to past decreases.

[d] Null hypothesis is that the speed of adjustment to price increases and price decreases are the same.

Table 3.6
COMEX Silver Price Regression Results and Asymmetry Tests, January 1972 through December 1995

Independent[a] Variables	Daily[b] Coefficients	Weekly[b] Coefficients	Monthly[b] Coefficients
Intercept	0.0168	0.4036	0.6469
POS1	0.0059	0.0544	0.1566
POS2	0.0678*	0.0879	0.0087
POS3	0.0570*	0.0776	0.2021
POS4	-0.0095	0.0436	-0.1599
POS5	0.0252	-0.1476*	0.1630
POS6	0.0249	-0.0729	-0.5047*
NEG1	0.1004*	0.0980	0.2517*
NEG2	0.0310	-0.0556	-0.2442*
NEG3	0.0465*	0.0694	-0.1551
NEG4	-0.0174	-0.0009	0.1698
NEG5	0.0206	0.0548	-0.2539*
NEG6	-0.0305	0.0776	0.1695
D_{MON}	-0.0816		
D_{TUE}	-0.0489		
D_{WED}	0.0487		
D_{THU}	0.0073		
COS(cycle)	0.0076	0.0117	0.5039
SIN(cycle)	-0.0179	-0.0821	-0.4914
COS(semi-cycle)	0.0233	0.0657	-0.3784
SIN(semi-cycle)	0.0305	0.1432	0.8906
Sum F-value[c]	0.1146	2.4763	0.0743
Identical F-value[d]	1.2115	2.0942*	3.8281*

* Significant at the 5% level
[a] Where POSi and NEGi are the nearby futures positive and negative log price changes (multiplied by 100) in the ith lag, DMON,..., DTHU are dummy variables for the day of the week, the trigonometric functions COS and SIN capture seasonality.
[b] The dependant variable is the nearby futures log price change (multiplied by 100).
[c] Null hypothesis is that the total impact of past price increases on current price changes are equal to past decreases.
[d] Null hypothesis is that the speed of adjustment to price increases and price decreases are the same.

Table 3.7
CME Standard & Poors Price Regression Results and Asymmetry Tests, January 1983 through December 1995

Independent[a] Variables	Daily[b] Coefficients	Weekly[b] Coefficients	Monthly[b] Coefficients
Intercept	-0.0548	0.5040*	0.7984
POS1	0.0345	-0.0609	-0.1859
POS2	0.0635	-0.0343	-0.1709
POS3	-0.1760*	-0.0637	-0.1193
POS4	-0.0025	-0.1439	-0.0669
POS5	-0.0308	-0.0049	0.1215
POS6	0.0465	-0.0131	0.2711
NEG1	-0.0361	-0.1056	0.1044
NEG2	-0.2696*	0.0701	-0.0394
NEG3	0.1149*	-0.0347	0.0064
NEG4	-0.0590*	0.0708	-0.1974
NEG5	0.0968*	-0.0703	0.1276
NEG6	-0.0524	0.0897	-0.3546*
D_{MON}	0.0834		
D_{TUE}	0.0616		
D_{WED}	0.1013		
D_{THU}	0.0376		
COS(cycle)	0.0174	0.0873	0.0572
SIN(cycle)	0.0525	0.2464*	0.8088
COS(semi-cycle)	0.0543	0.2305*	0.5722
SIN(semi-cycle)	0.0098	0.0666	0.6035
Sum F-value[c]	3.5969	2.5811	0.1653
Identical F-value[d]	15.2634*	0.9394	1.3122

* Significant at the 5% level

[a] Where POSi and NEGi are the nearby futures positive and negative log price changes (multiplied by 100) in the ith lag, DMON,..., DTHU are dummy variables for the day of the week, the trigonometric functions COS and SIN capture seasonality.

[b] The dependant variable is the nearby futures log price change (multiplied by 100).

[c] Null hypothesis is that the total impact of past price increases on current price changes are equal to past decreases.

[d] Null hypothesis is that the speed of adjustment to price increases and price decreases are the same.

Table 3.8
IMM US Treasury Bill Price Regression Results and Asymmetry Tests, January 1983 through December 1995

Independent[a] Variables	Daily[b] Coefficients	Weekly[b] Coefficients	Monthly[b] Coefficients
Intercept	0.0003	-0.0384*	-0.0410
POS1	0.0635*	0.1696*	0.2321*
POS2	-0.0118	-0.0792	-0.1834
POS3	0.0019	0.0723	-0.1532
POS4	-0.0064	-0.0703	-0.3713*
POS5	-0.0016	0.0981	0.2260
POS6	0.0444	0.0436	0.0333
NEG1	0.1145*	-0.0161	-0.2143
NEG2	-0.0127	0.0618	0.1049
NEG3	-0.0317	-0.0212	-0.0527
NEG4	0.0018	-0.0203	0.0748
NEG5	-0.0030	-0.0731	-0.0485
NEG6	-0.0398	-0.0131	-0.2449
D_{MON}	-0.0178*		
D_{TUE}	0.0014		
D_{WED}	-0.0014		
D_{THU}	0.0003		
COS(cycle)	-0.0021	-0.0124	-0.0205
SIN(cycle)	0.0008	0.0036	-0.0293
COS(semi-cycle)	-0.0027	-0.0085	0.0309
SIN(semi-cycle)	-0.0059	-0.0301	-0.0705
Sum F-value[c]	1.4462	7.7765*	0.4089
Identical F-value[d]	1.1289	2.5003*	1.8887

* Significant at the 5% level

[a] Where POSi and NEGi are the nearby futures positive and negative log price changes (multiplied by 100) in the ith lag, DMON,..., DTHU are dummy variables for the day of the week, the trigonometric functions COS and SIN capture seasonality.

[b] The dependant variable is the nearby futures log price change (multiplied by 100).

[c] Null hypothesis is that the total impact of past price increases on current price changes are equal to past decreases.

[d] Null hypothesis is that the speed of adjustment to price increases and price decreases are the same.

Table 3.9
CBOT Wheat Price Regression Results and Asymmetry Tests, January 1970 through December 1995

Independent[a] Variables	Daily[b] Coefficients	Weekly[b] Coefficients	Monthly[b] Coefficients
Intercept	0.0412	0.0636	-0.3421
POS1	-0.0344	-0.0269	0.1492
POS2	-0.0055	0.1588*	-0.0735
POS3	0.0157	0.0144	0.0139
POS4	0.0351	-0.0365	-0.0784
POS5	0.0026	0.0440	0.0284
POS6	-0.0196	-0.0616	0.0504
NEG1	0.0655*	-0.0189	0.0545
NEG2	-0.1153*	-0.0354	-0.0871
NEG3	-0.0105	0.0499	-0.0663
NEG4	0.0086	0.0157	0.0135
NEG5	-0.0266	0.0197	0.1449
NEG6	0.0119	0.0497	-0.2411*
D_{MON}	-0.0645		
D_{TUE}	-0.0702		
D_{WED}	0.0302		
D_{THU}	-0.1479*		
COS(cycle)	-0.0543*	-0.2299	-0.7243
SIN(cycle)	-0.0923*	-0.5434*	-2.5111*
COS(semi-cycle)	0.0178	0.1297	0.5230
SIN(semi-cycle)	0.0205	0.1188	0.3635
Sum F-value[c]	0.9832	0.0054	0.6879
Identical F-value[d]	3.0294*	1.2345	0.6702

* Significant at the 5% level
[a] Where POSi and NEGi are the nearby futures positive and negative log price changes (multiplied by 100) in the ith lag, DMON,..., DTHU are dummy variables for the day of the week, the trigonometric functions COS and SIN capture seasonality.
[b] The dependant variable is the nearby futures log price change (multiplied by 100).
[c] Null hypothesis is that the total impact of past price increases on current price changes are equal to past decreases.
[d] Null hypothesis is that the speed of adjustment to price increases and price decreases are the same.

Table 3.10
Daily Regression Results and Asymmetry Tests for Nearby CME Standard & Poors 500 Futures Log Price Changes, With and Without Large Price Changes, January 1983 through December 1995

Independent[a] Variables	Coefficients[b] (with large changes)	Coefficients[b] (without large changes)
Intercept	-0.0548	-0.0175
POS1	0.0345	0.0123
POS2	0.0635	-0.0343
POS3	-0.1760*	-0.1530*
POS4	-0.0025	0.0106
POS5	-0.0308	-0.0094
POS6	0.0465	0.0475
NEG1	-0.0361	-0.1288*
NEG2	-0.2696*	-0.0236
NEG3	0.1149*	0.0695*
NEG4	-0.0590*	-0.0634*
NEG5	0.0968*	-0.0938*
NEG6	-0.0524	-0.0499*
D_{MON}	0.0834	0.1475
D_{TUE}	0.0616	0.0802
D_{WED}	0.1013	0.0942
D_{THU}	0.0376	0.0575
COS(cycle)	0.0174	0.0237
SIN(cycle)	0.0525	0.0379
COS(semi-cycle)	0.0543	0.0407
SIN(semi-cycle)	0.0098	0.0010
Sum F-value[c]	3.5969	0.0387
Identical F-value[d]	15.2634*	8.5583*

* Significant at the 5% level

[a] Where POSi and NEGi are the nearby futures positive and negative log price changes (multiplied by 100) in the ith lag, DMON,..., DTHU are dummy variables for the day of the week, the trigonometric functions COS and SIN capture seasonality.

[b] The dependant variable is the nearby futures log price change (multiplied by 100).

[c] Null hypothesis is that the total impact of past price increases on current price changes are equal to past decreases.

[d] Null hypothesis is that the speed of adjustment to price increases and price decreases are the same.

Table 3.11
Numbers and means of logarithmic increases and decreases in price for various commodities and time horizons

Price	Increases		Decreases		Stable	t-test
	No.	Mean	No.	Mean		Statistic[a]
Cattle						
Daily	2373	0.7945	2226	-0.7919	117	0.1345
Weekly	524	1.9643	460	-2.1102	5	-1.2917
Monthly	120	2.5242	106	-2.5889	0	-0.0250
Corn						
Daily	3219	0.9834	3258	-0.9281	300	2.4896*
Weekly	715	2.1144	662	-2.1216	30	-0.0611
Monthly	163	5.0984	157	-4.6367	2	0.8112
Gold						
Daily	2595	0.9095	2572	-0.8867	114	0.8141
Weekly	559	1.9485	526	-1.9190	9	0.2213
Monthly	121	4.7431	128	-3.8737	1	1.6086
Silver						
Daily	3030	1.3855	2869	-1.4197	126	-0.9971
Weekly	628	3.2768	609	-3.1804	13	0.5105
Monthly	144	6.8544	139	-6.2478	3	0.6713
Oil						
Daily	1492	1.4650	1470	-1.5153	48	-0.7186
Weekly	317	3.0293	305	-3.2867	2	-0.9191
Monthly	72	6.1474	69	-7.1396	1	-0.8056
S & P 500						
Daily	1742	0.6819	1498	-0.6934	44	-0.3370
Weekly	398	1.4564	276	-1.5796	2	-1.0688
Monthly	97	3.2792	57	-3.0784	0	0.4026
T-Bills						
Daily	2163	0.1086	2106	-0.1116	0	-0.6598
Weekly	475	0.2486	476	-0.2481	34	0.0235
Monthly	112	0.5252	111	0.4773	3	-0.0388
Wheat						
Daily	3200	1.1608	3178	-1.1189	159	1.6388
Weekly	683	2.5691	655	-2.4903	16	0.6348
Monthly	165	5.4458	144	-5.3813	1	0.1156

* Significant at the 5% level.

Table 3.12
Summary Statistics on Logarithmic Differences of Various Commodity Futures Prices

Commodity	Sample Size	Mean	Standard Deviation	Skewness	Kurtosis
Daily					
Cattle	4716	0.0260	1.0155	-0.0952	0.0791
Corn	6777	0.0209	1.2792	0.0260	2.7641
Gold	5281	0.0151	1.3344	-0.2028	15.8971
Silver	6025	0.0208	1.9032	-0.1322	10.8624
Oil	3010	-0.0139	2.3988	-3.3520	69.8220
S & P 500	3284	0.0454	1.1778	-4.2132	118.4917
T-Bills	4777	-0.0001	0.1774	0.5431	22.3275
Wheat	6537	0.0243	1.5116	0.0064	3.0502
Weekly					
Cattle	989	0.0592	2.6875	-0.4776	1.5180
Corn	1407	0.0763	3.0091	-0.0186	5.9465
Gold	1094	0.0730	2.9120	0.4088	70.4104
Silver	1250	0.0978	4.6070	-0.4108	31.0345
Oil	624	-0.0676	4.6996	-1.2965	12.5216
S & P 500	676	0.2125	2.0585	-0.9057	5.1735
T-Bills	985	-0.00002	0.3943	0.4406	6.6312
Wheat	1354	0.0912	3.3785	0.2001	4.3155
Monthly					
Cattle	226	0.2418	5.1405	-0.1415	0.6302
Corn	322	0.3201	7.0196	1.2163	7.7740
Gold	250	0.3123	6.1745	0.8659	10.3286
Silver	286	0.4146	9.9769	-3.9172	67.0595
Oil	142	-0.3523	9.8387	0.8417	10.1952
S & P 500	154	0.9261	4.2847	-0.9481	4.7984
T-Bills	226	0.0007	0.8078	0.7832	6.8719
Wheat	310	0.3989	7.2764	0.0560	4.6633

Table 3.13
F Statistics for Tests of Seasonality and Day of the Week Effect for Various Commodities

Commodity	Seasonality[a]	Day of the Week[b]
Daily		
Cattle	2.1110	7.5211*
Corn	1.9550	0.7055
Gold	0.8425	1.4139
Silver	0.3872	0.3538
Oil	1.4035	0.5375
S&P 500	1.8769	0.7830
T-Bills	0.9079	1.8772
Wheat	4.2807*	2.7630*
Weekly		
Cattle	6.2206*	
Corn	2.9981*	
Gold	0.6361	
Silver	0.2333	
Oil	1.2608	
S&P 500	2.3608	
T-Bills	0.8907	
Wheat	5.2694*	
Monthly		
Cattle	5.4141*	
Corn	0.9197	
Gold	1.0391	
Silver	0.4772	
Oil	1.3428	
S&P 500	1.2939	
T-Bills	0.2818	
Wheat	4.3704*	

* Significant at the 5% level
[a] Joint test of the cyclical and semi-cyclical trigonometric functions; COS(cycle)=SIN(cycle)=COS(semi-cycle)=SIN(semi-cycle)=0.
[b] Joint test of the dummy variables for day of the week; $D_{MON}=D_{TUE}=D_{WED}=D_{THU}=0$.

Table 3.14
Regression Results and Monte Carlo (N=1000) 95% Confidence Interval for Daily Nearby NYMEX Oil Futures Log Price Changes, January 1984 to December 1995

Independent[a] Variables	Estimated[b] Coefficients	Monte Carlo[c] Coefficients	Monte Carlo 95% Confidence Interval[d]	
			Lower Limit	Upper Limit
Intercept	-0.0122	-0.0106	-0.4596	0.4383
POS1	-0.1213*	-0.0006	-0.0604	0.0592
POS2	0.0445	-0.0023	-0.0647	0.0601
POS3	-0.0448	-0.0011	-0.0617	0.0594
POS4	0.0157	-0.0000	-0.0618	0.0617
POS5	-0.1549*	-0.0016	-0.0630	0.0597
POS6	0.0014	-0.0008	-0.0628	0.0612
NEG1	0.0834	-0.0014	-0.0616	0.0588
NEG2	-0.1399*	-0.0004	-0.0614	0.0605
NEG3	-0.1275*	-0.0022	-0.0624	0.0580
NEG4	0.0439	0.0004	-0.0589	0.0596
NEG5	-0.0014	-0.0020	-0.0639	0.0599
NEG6	-0.0235	0.0002	-0.0584	0.0589
DMON	0.0568	0.0021	-0.2759	0.2801
DTUE	0.0109	-0.0089	-0.2728	0.2550
DWED	0.0671	-0.0028	-0.2826	0.2709
DTHU	0.1798	-0.0043	-0.2768	0.2682
COS(cycle)	-0.0968	-0.0007	-0.1249	0.1236
SIN(cycle)	-0.0048	0.0016	-0.1252	0.1285
COS(semi-cycle)	-0.0967	0.0013	-0.1215	0.1241
SIN(semi-cycle)	0.0543	-0.0002	-0.1267	0.1263

* Significant at the 5% level, falls outside the 95% Monte Carlo confidence interval.
[a] Where POSi and NEGi are the nearby futures positive and negative log price changes (multiplied by 100) in the ith lag, DMON,..., DTHU are dummy variables for the day of the week, the trigonometric functions COS and SIN capture seasonality.
[b] The dependant variable is the nearby futures log price change (multiplied by 100).
[c] 1000 repeated random samples of size n=3010 from a N(-0.0139,2.3988) distribution were used, the coefficients are the average of the 1000 replications.
[d] $\mu \pm 2\sigma$ is used as an approximation to the 95% confidence interval for the coefficients.

CHAPTER 4

SUMMARY

There is considerable research relating to the asymmetry of price transmission within spatial markets and vertical price transmission within a marketing channel. If asymmetry is present within a market, current price changes may react to past price increases and decreases asymmetrically. Asymmetric price research has mostly focused on agricultural markets, however, this study also includes non agricultural markets.

This study tests for asymmetry in futures price changes of various commodities. Daily, weekly, and monthly data is used to test for asymmetry in live cattle, corn, gold, lightcrude oil, Standard & Poors 500, silver, US treasury bills, and wheat. Asymmetry is examined through the use of two tests: the sum of coefficients test and the speed of adjustment test.

In a traditional model, there is only one coefficient for a lagged price change variable, forcing the assumption that past price increases have the same effect on the current price change as past price decreases. An asymmetry model distinguishes between price increases and price decreases by creating two variables for a lagged price change. By separating price changes into positive and negative changes, the coefficients can be examined to determine whether past price increases affect the current price change in a similar manner as past price decreases.

Results of the model and asymmetry tests imply that every commodity analyzed in this study featured some degree of asymmetry. Therefore, traditional models in time series may be slightly biased when forecasting future prices because they assume an increase in price has the same effect as a decrease. For cattle, the overall impact of past price increases is different from past decreases for daily and weekly prices. The overall impact of past increases and decreases was also found to be asymmetric in daily corn futures prices. The speed of adjustment test for asymmetry was rejected for every commodity in at least one time horizon.

These results have a number of implications. First, asymmetry may imply that the weak form efficient hypothesis appears to be contradicted for certain commodities indicating that past prices affect current prices and contain information. Therefore, traders may wish to adjust their trade entry and exit points for commodities that behave asymmetrically. This is in contrast to using entry and exit points that are symmetrical in the sense that the condition for entering the market is the mirror image of the exit condition.

Secondly, asymmetric models could be developed similar to the one presented in this study, to better specify the underlying data than a traditional autoregressive model that does not separate positive and negative changes. Another model that would benefit from recognizing asymmetry within a market would be option pricing. The traditional Black-Scholes option pricing model is based upon the assumption that futures prices are distributed normally. Research has confirmed that futures price changes are not normal and contain kurtosis, skewness, and conditional heteroskedasticity. Improvements to the Black-Scholes model have been proposed and do provide better estimates for deep in-the-money and deep out-of-the-money options. Asymmetric price changes may be the next characteristic incorporated into an option pricing model in order to obtain better estimates.

Thirdly, certain markets are known to crash or suddenly correct themselves from time to time, and the stock market is the most well known. These adjustments are asymmetric because they occur predominantly with a sudden decrease in the value of the underlying commodity or security. Regulators have a role in these markets to avoid such devaluation in such a short period of time. In futures markets, and even the cash stock market, leverage is used to control large positions with a relatively small initial outlay. Many times the collateral used is the same commodity or stock that is being leveraged or one with relatively high correlation. Under these circumstances, if the underlying asset begins to decrease in value, not only does the investor lose money on the investment but also on the collateral decreasing in value. This in turn causes the market to spiral down further when collateral becomes worth less. If regulators are better prepared for downward asymmetric price movements in assets such as stocks and commodities, this information could be used in advance to adjust margins. Increased margin requirements may help avoid excessive upward price movement, which eventually results in a fast downward movement, with adverse impacts for market participants.

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APPENDIX

Figure A.1
CME Daily Cattle Positive and Negative Lagged Price Changes (cents/pound) Plotted against Current Price Changes

Figure A.1
CME Daily Cattle Positive and Negative Lagged Price Changes (cents/pound) Plotted against Current Price Changes

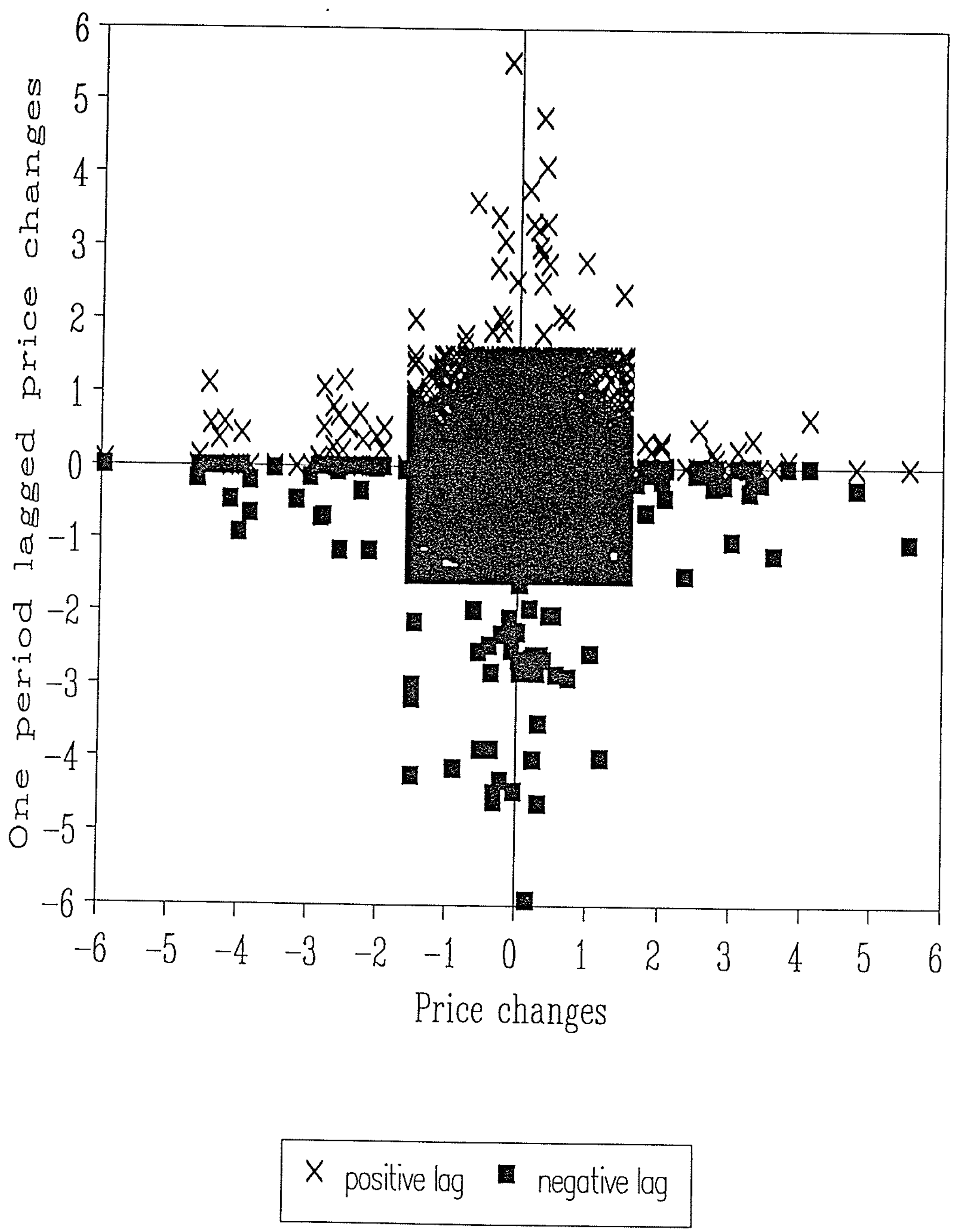


Figure A.2
CBOT Daily Corn Positive and Negative Lagged Price Changes (cents/bushel) Plotted against Current Price Changes

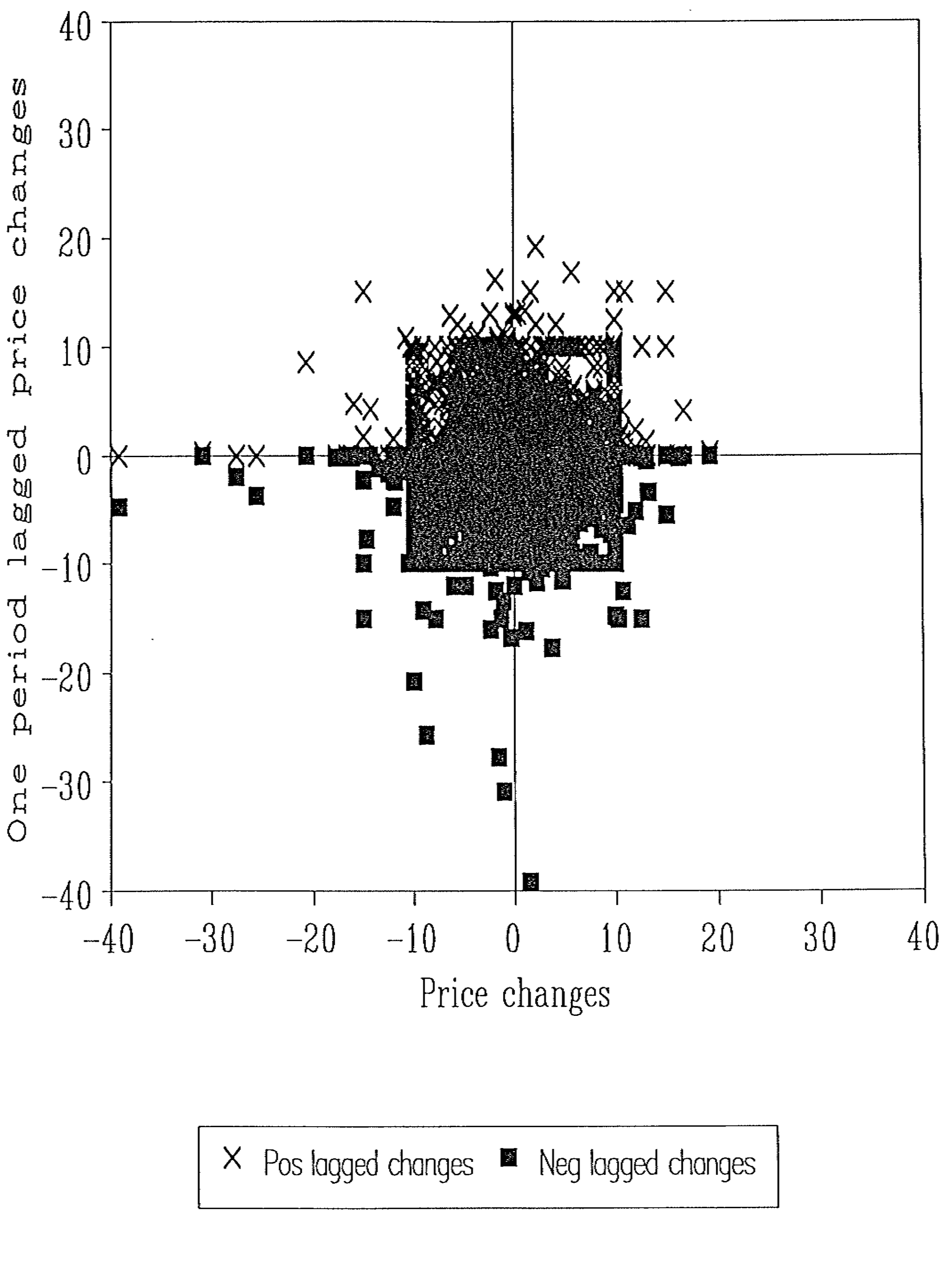


Figure A.3
Hypothetical Example of Positive and Negative Price Changes that are Distributed Differently

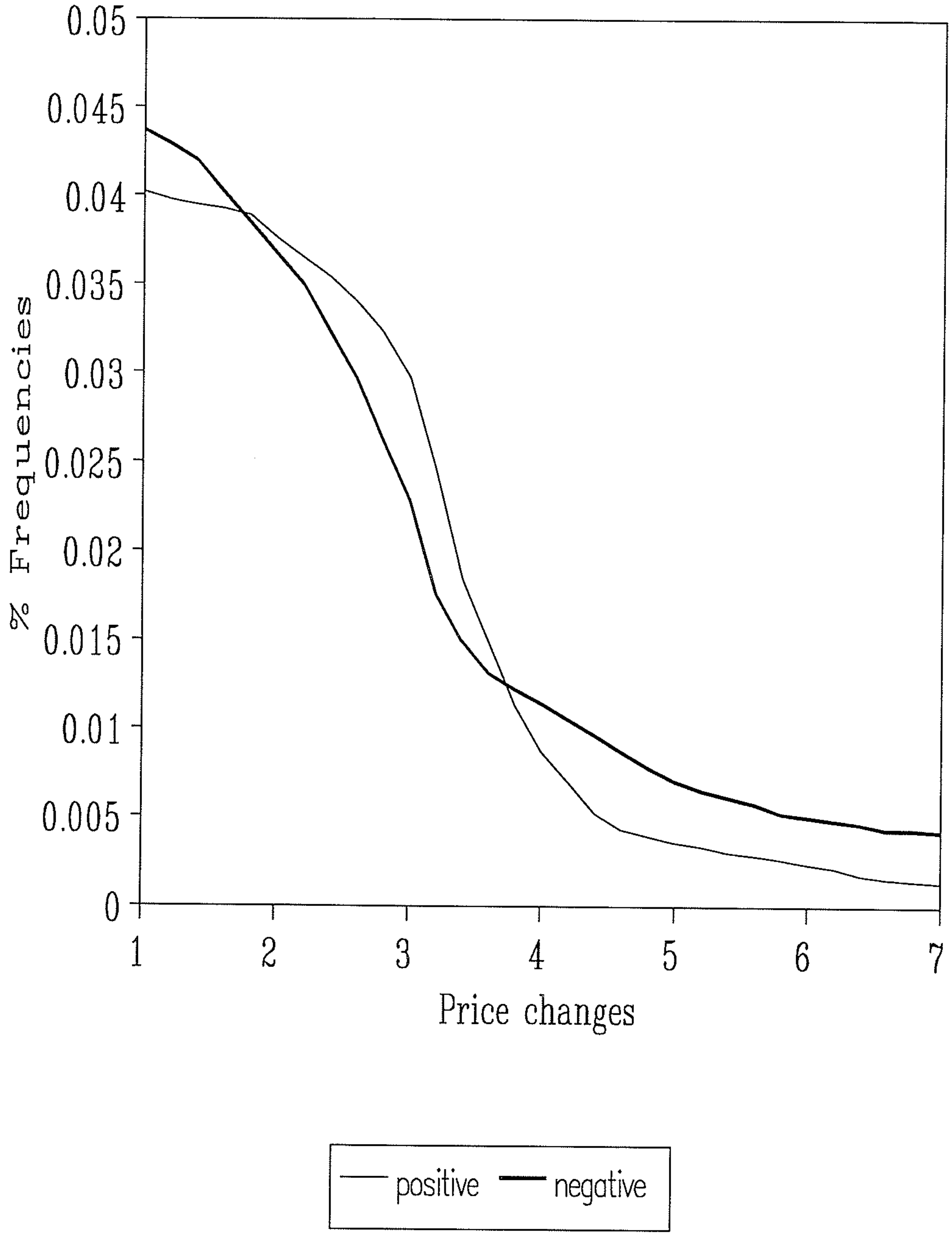
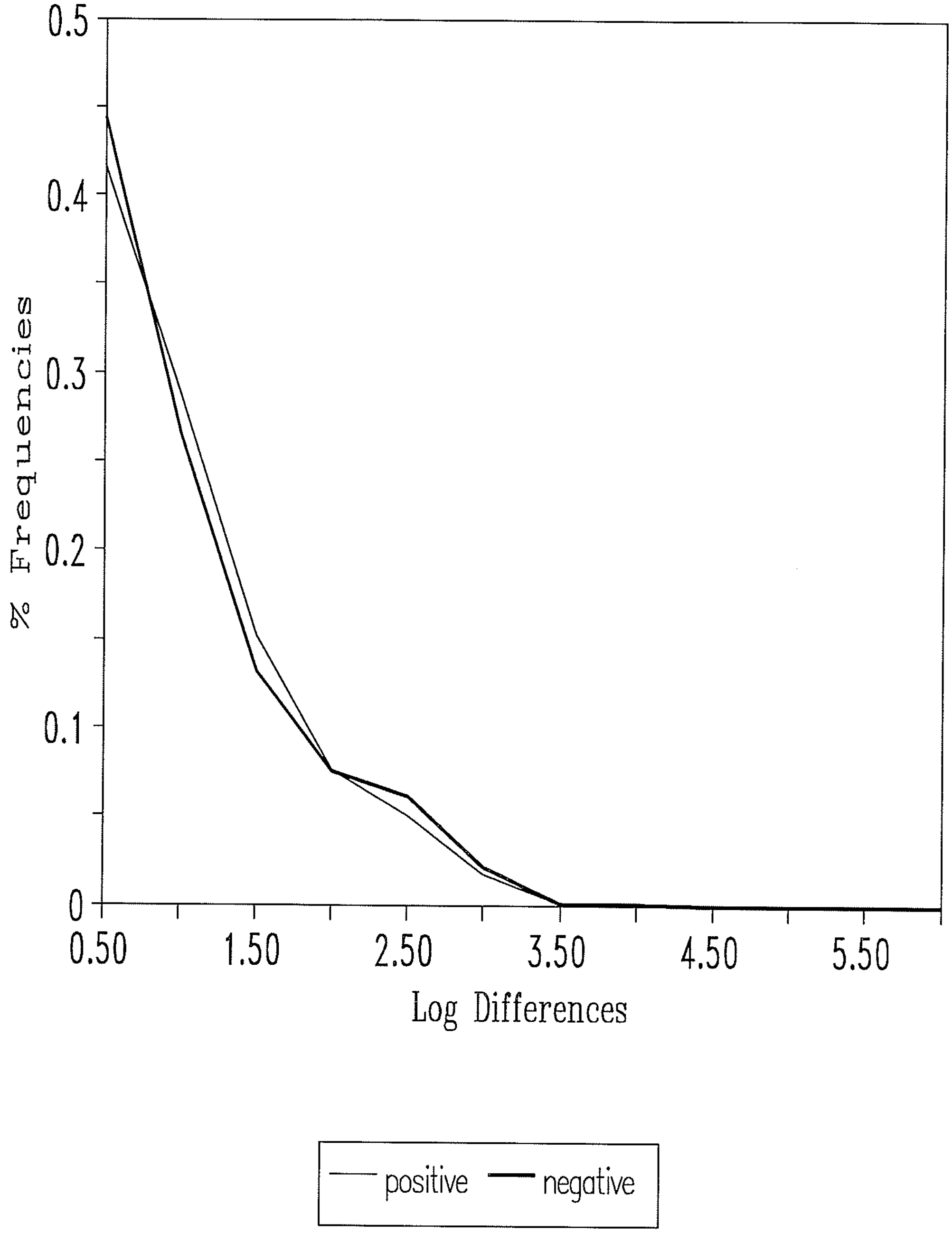
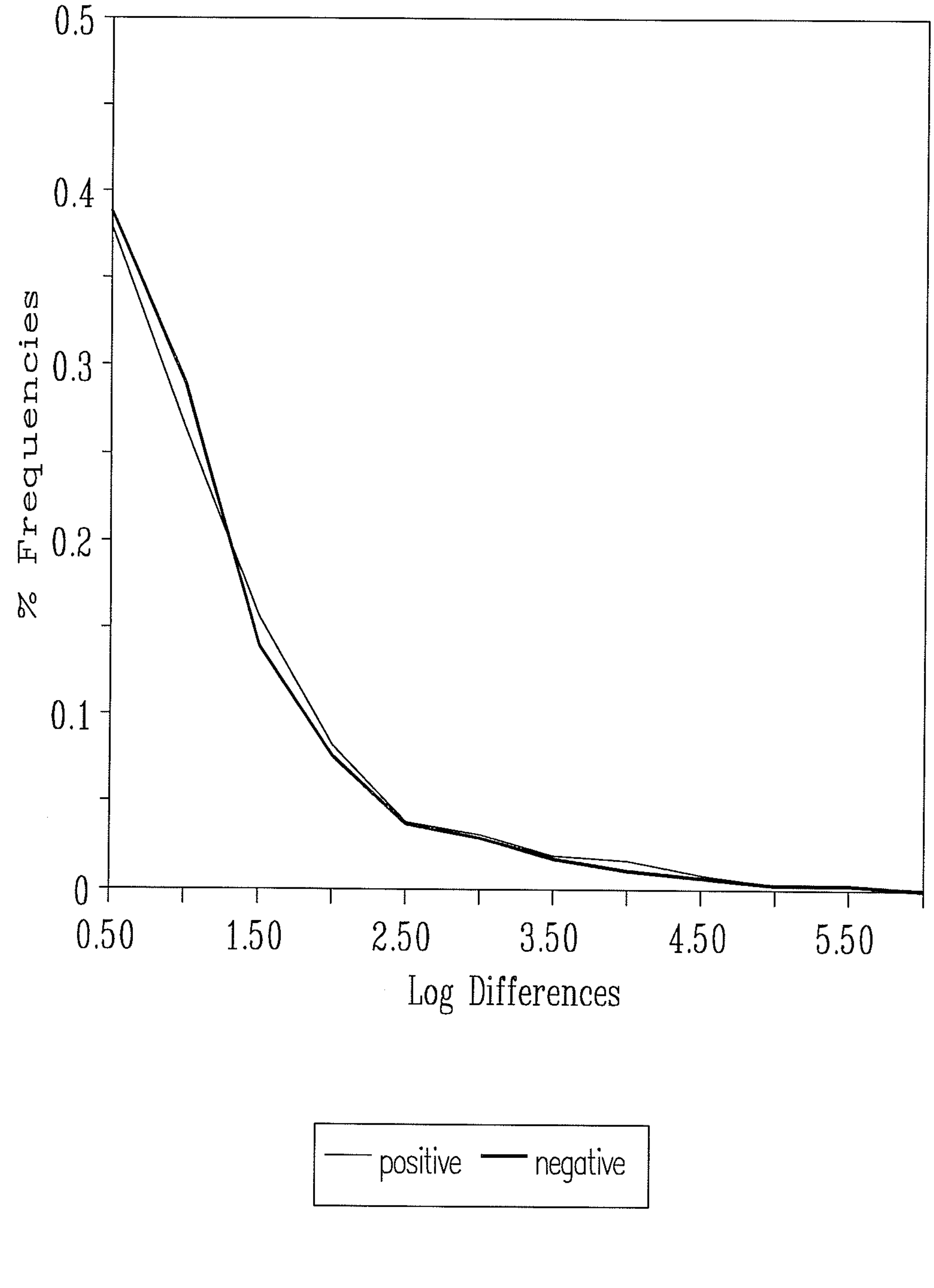


Figure A.4
CME Daily Cattle Empirical Distributions of Positive and Negative Logarithmic Price Changes[a]



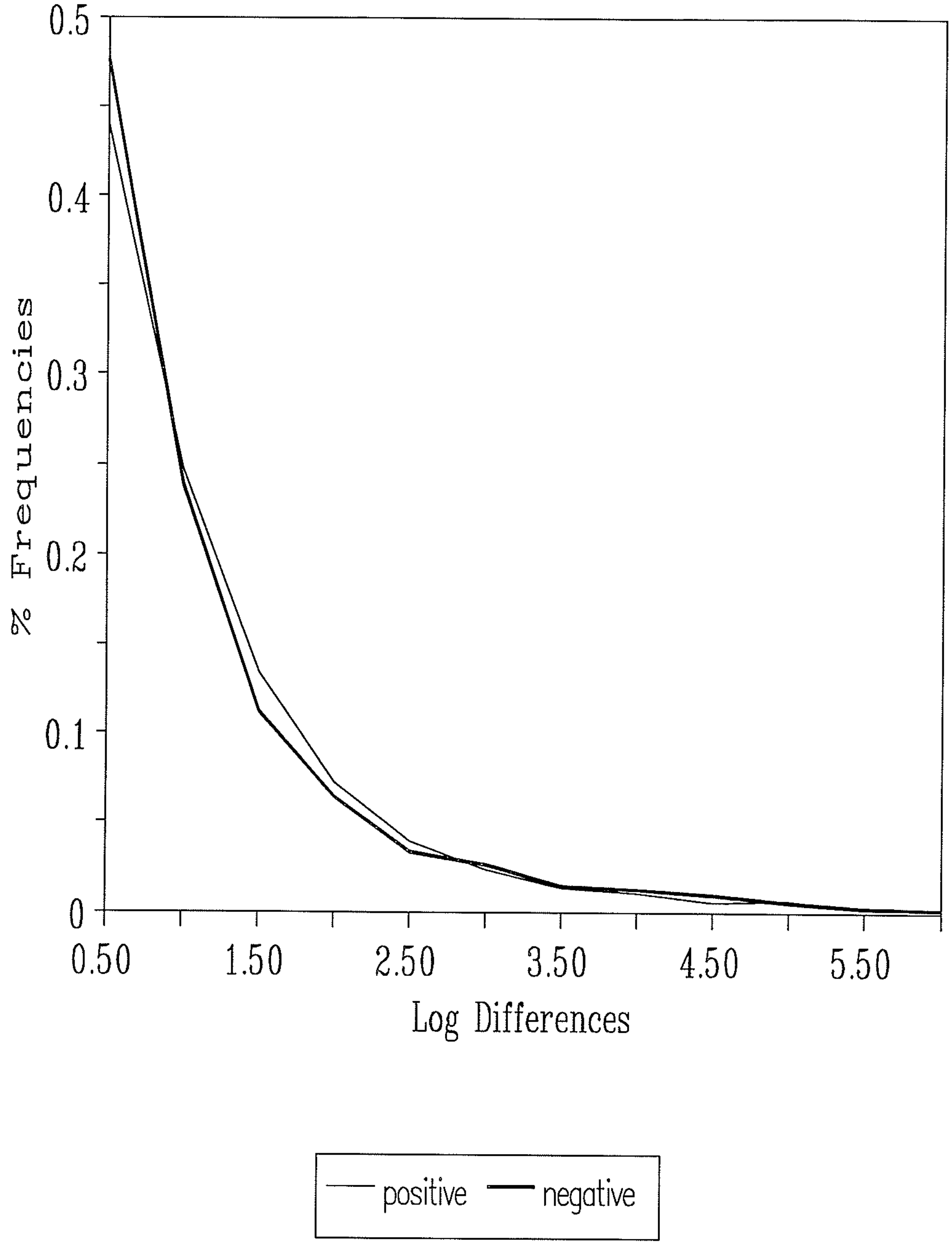
[a] Logarithmic changes are multiplied by 100

Figure A.5
CBOT Daily Corn Empirical Distributions of Positive and Negative Logarithmic Price Changes[a]



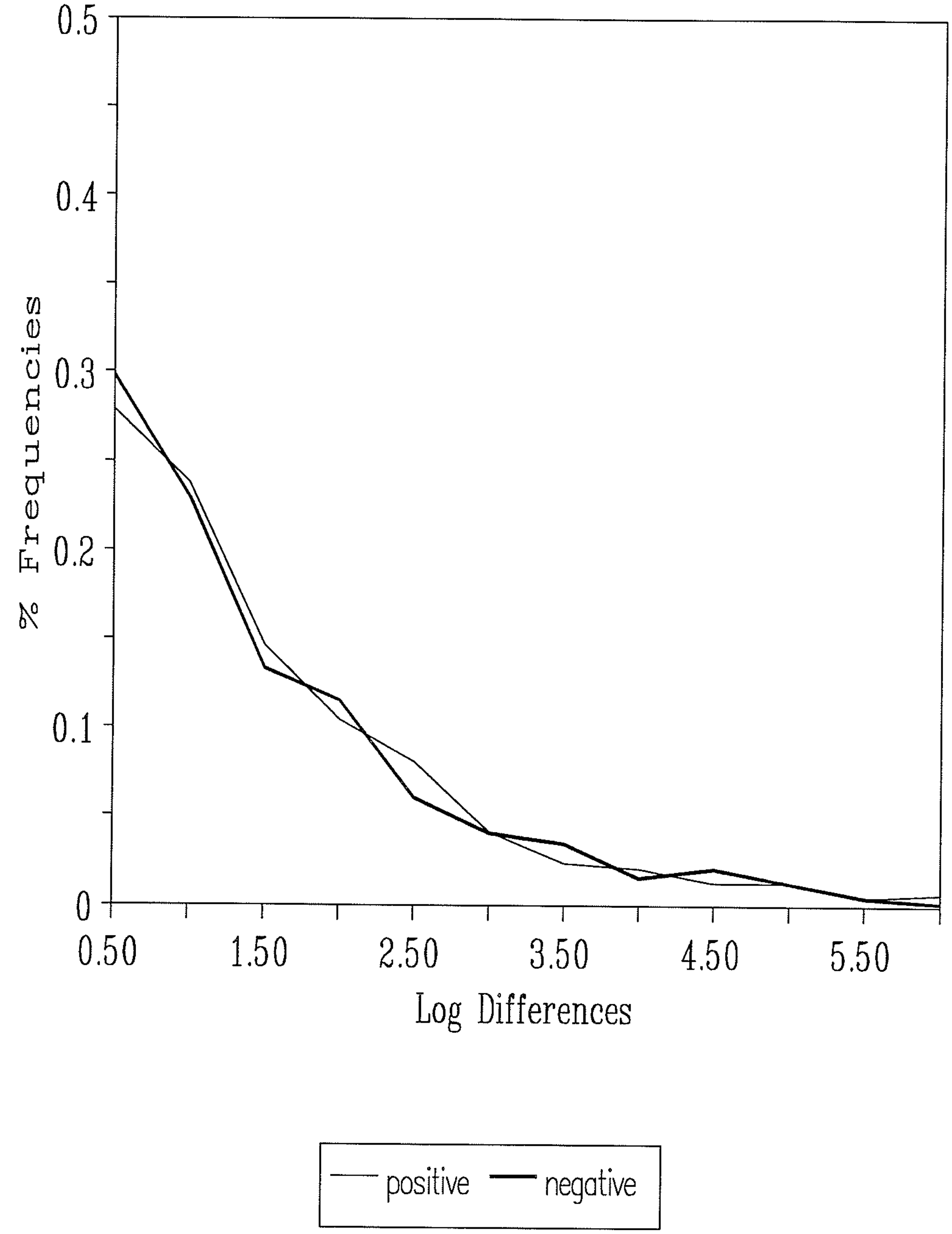
[a] Logarithmic changes are multiplied by 100

Figure A.6
COMEX Daily Gold Empirical Distributions of Positive and Negative Logarithmic Price Changes[a]



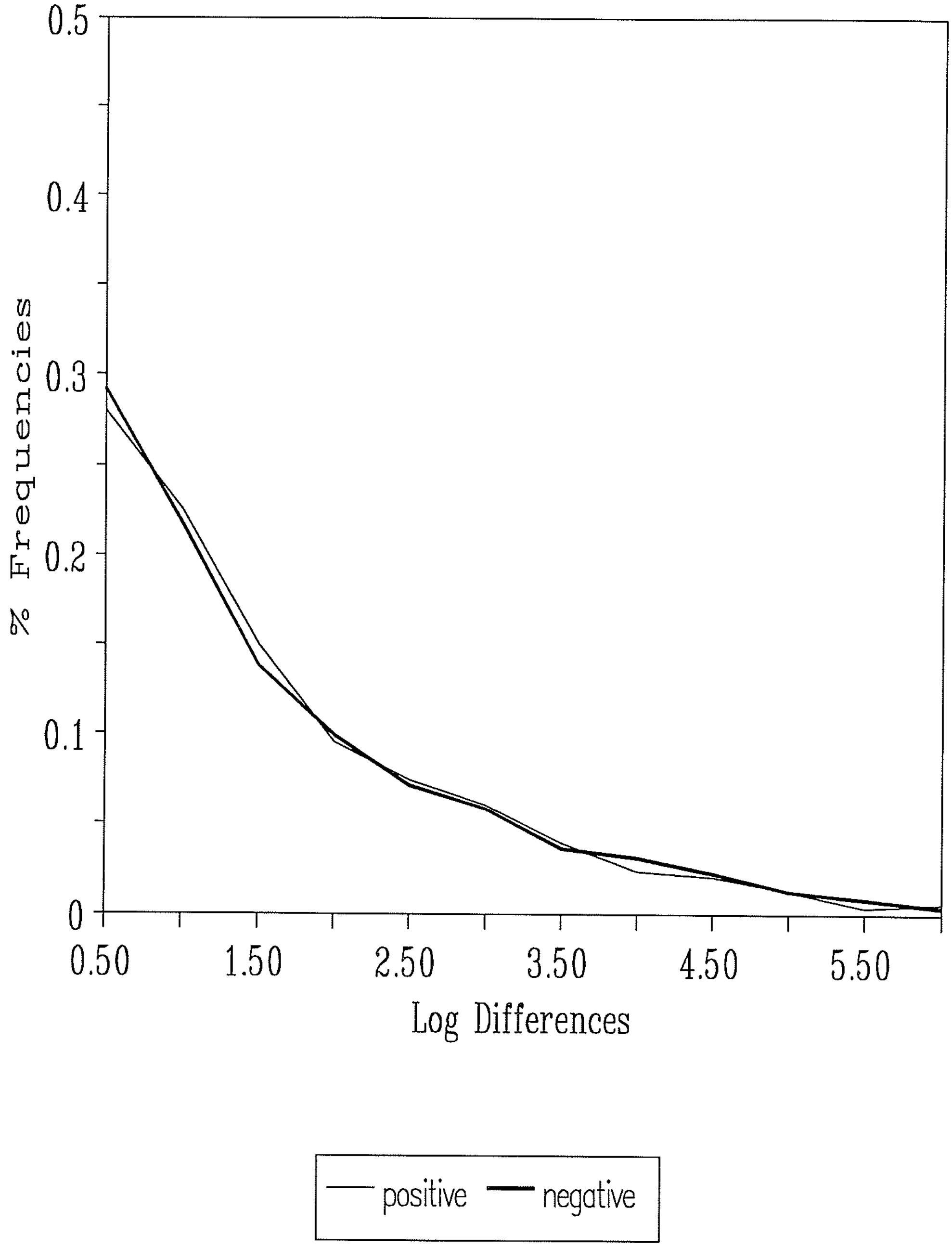
[a] Logarithmic changes are multiplied by 100

Figure A.7
NYMEX Daily Oil Empirical Distributions of Positive and Negative Logarithmic Price Changes[a]



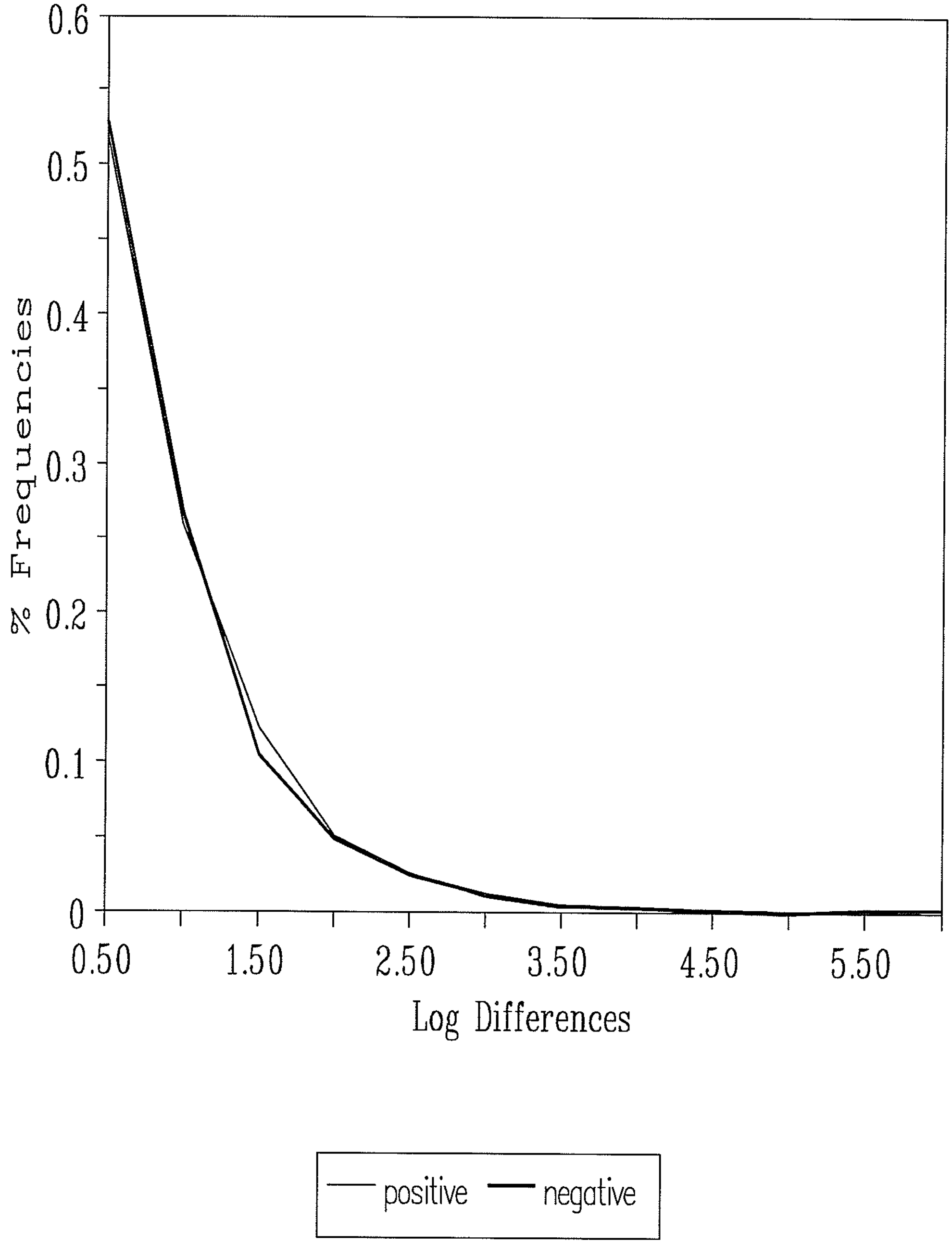
[a] Logarithmic changes are multiplied by 100

Figure A.8
COMEX Daily Silver Empirical Distributions of Positive and Negative Logarithmic Price Changes[a]



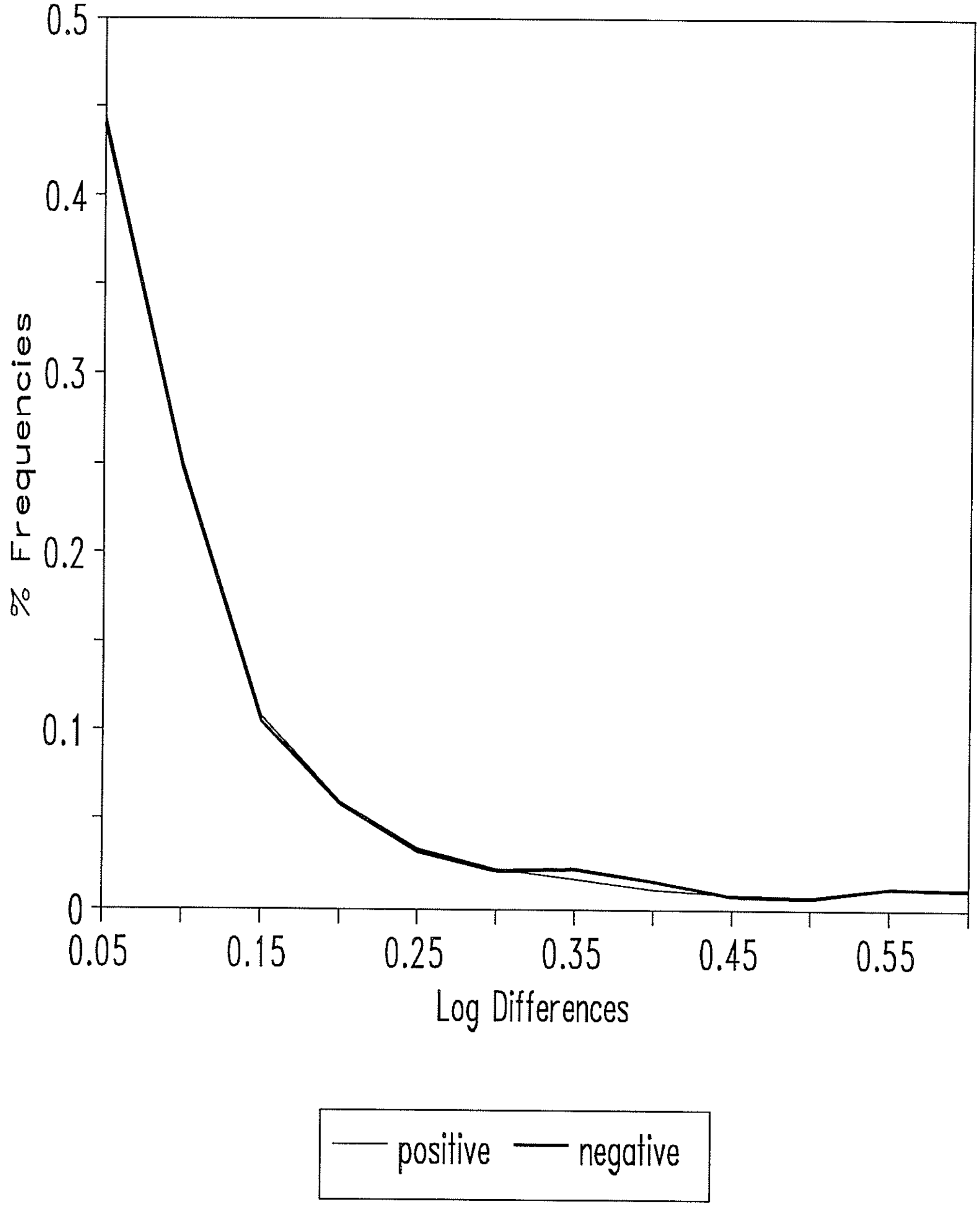
[a] Logarithmic changes are multiplied by 100

Figure A.9
CME Daily Standard & Poors 500 Empirical Distributions of Positive and Negative Logarithmic Price Changes[a]



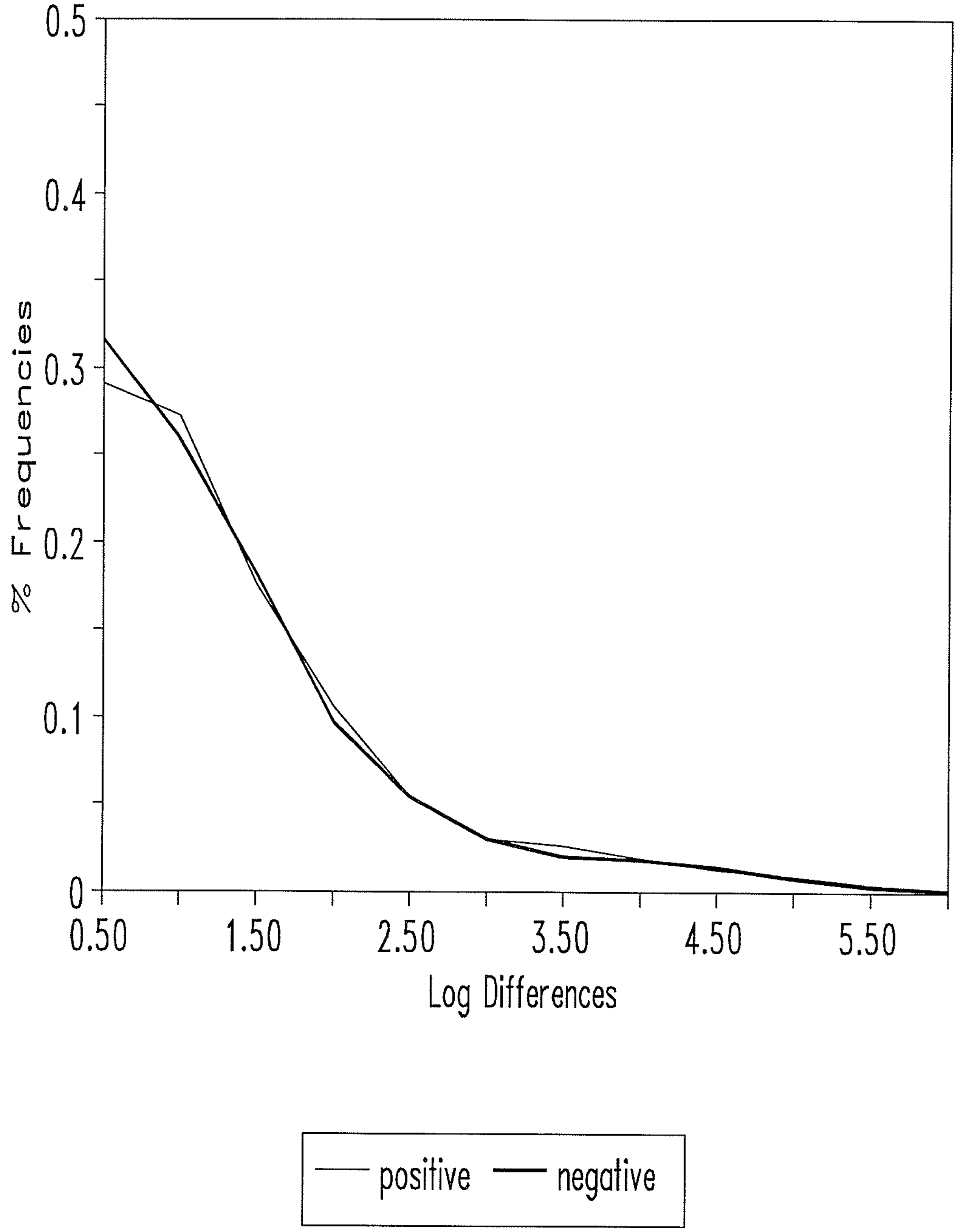
[a] Logarithmic changes are multiplied by 100

Figure A.10
IMM Daily Treasury Bills Empirical Distributions of Positive and Negative Logarithmic Price Changes[a]



[a] Logarithmic changes are multiplied by 100

Figure A.11
CBOT Daily Wheat Empirical Distributions of Positive and Negative Logarithmic Price Changes[a]



[a] Logarithmic changes are multiplied by 100

Figure A.12
CME Daily Cattle Empirical Distribution of Logarithmic Futures Price Changes Compared to a Random Sample from a Normal Distribution with the Same Sample Size and Standard Deviation

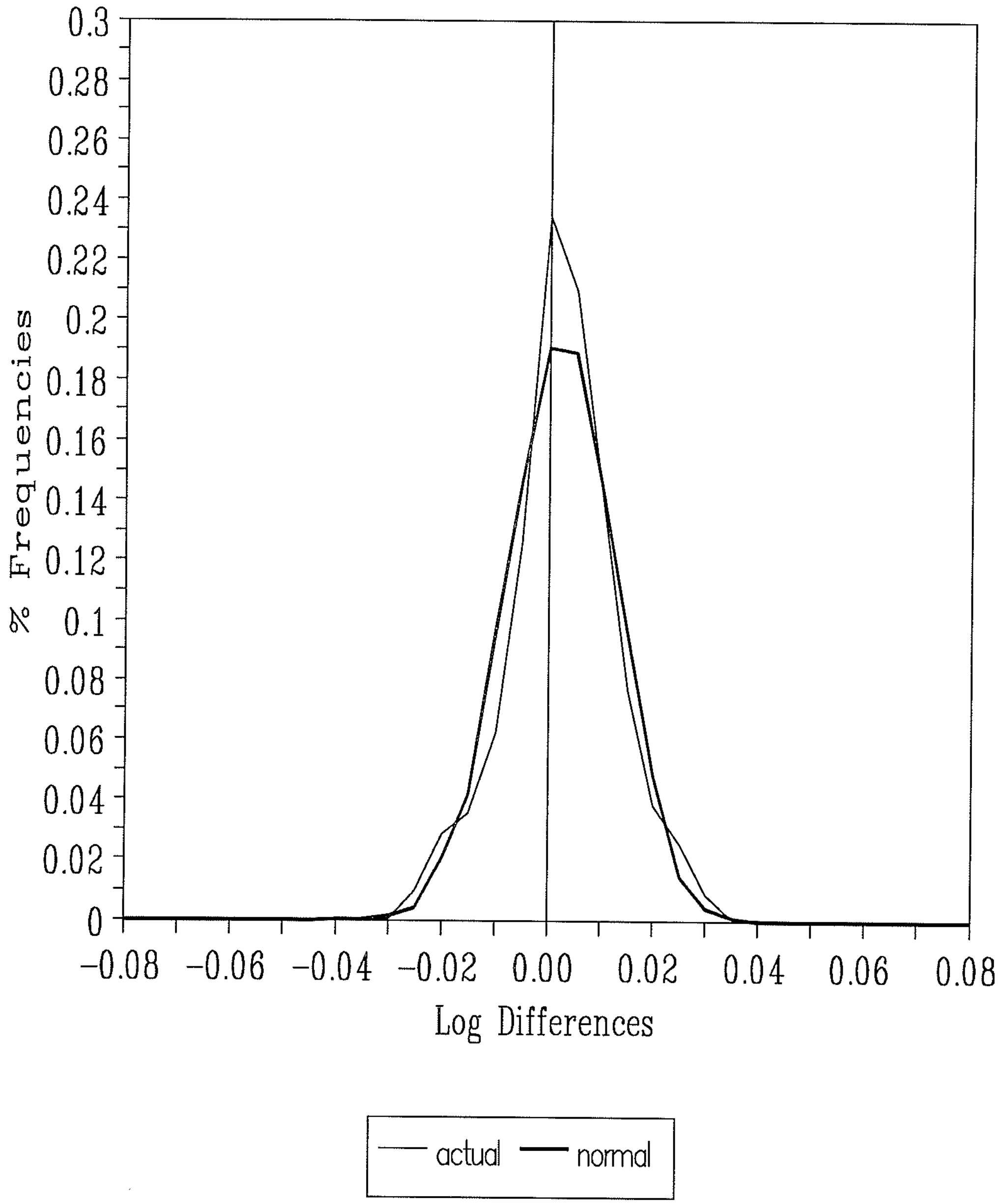


Figure A.13
CBOT Daily Corn Empirical Distribution of Logarithmic Futures Price Changes Compared to a Random Sample from a Normal Distribution with the Same Sample Size and Standard Deviation

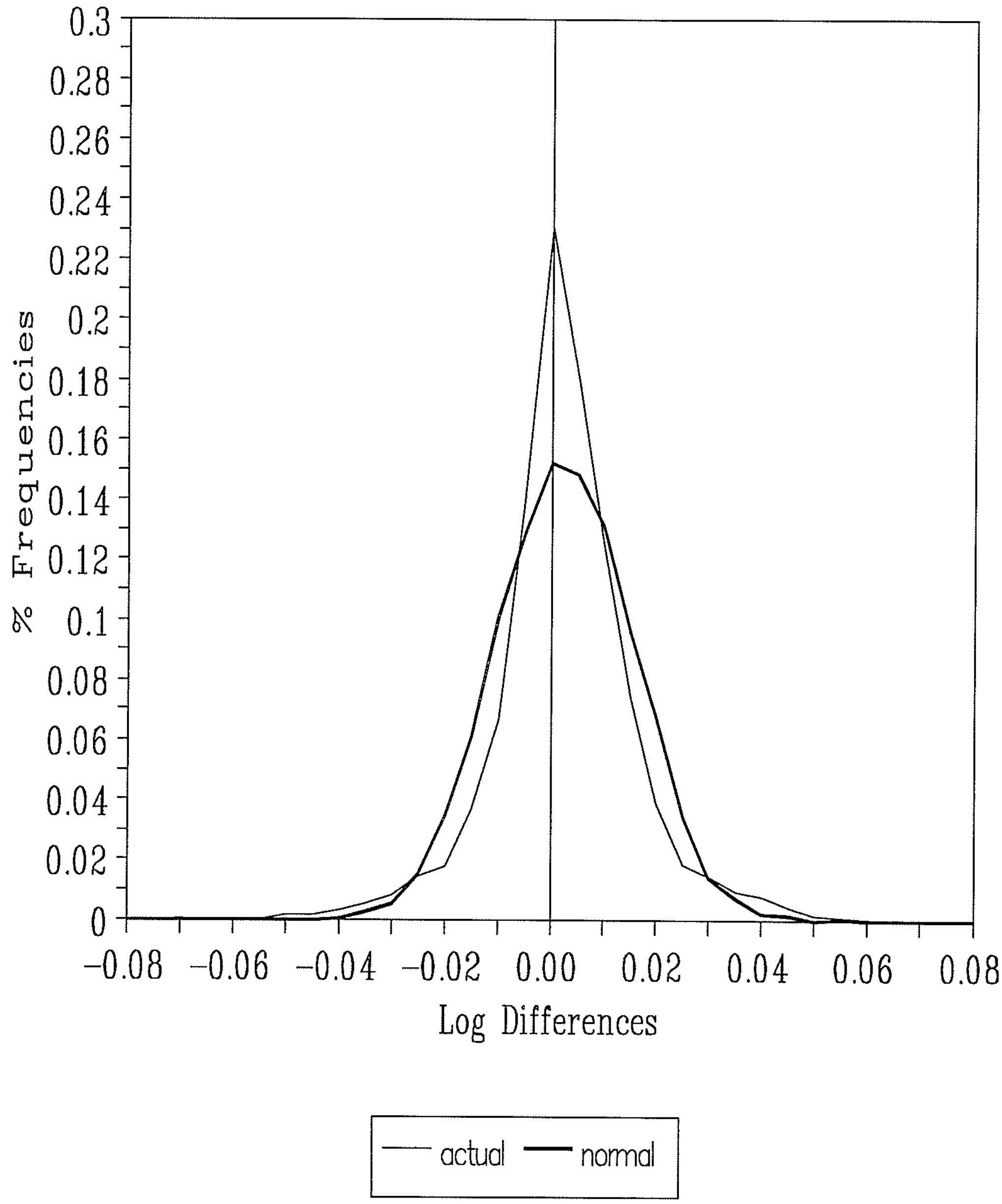


Figure A.14
COMEX Daily Gold Empirical Distribution of Logarithmic Futures Price Changes Compared to a Random Sample from a Normal Distribution with the Same Sample Size and Standard Deviation

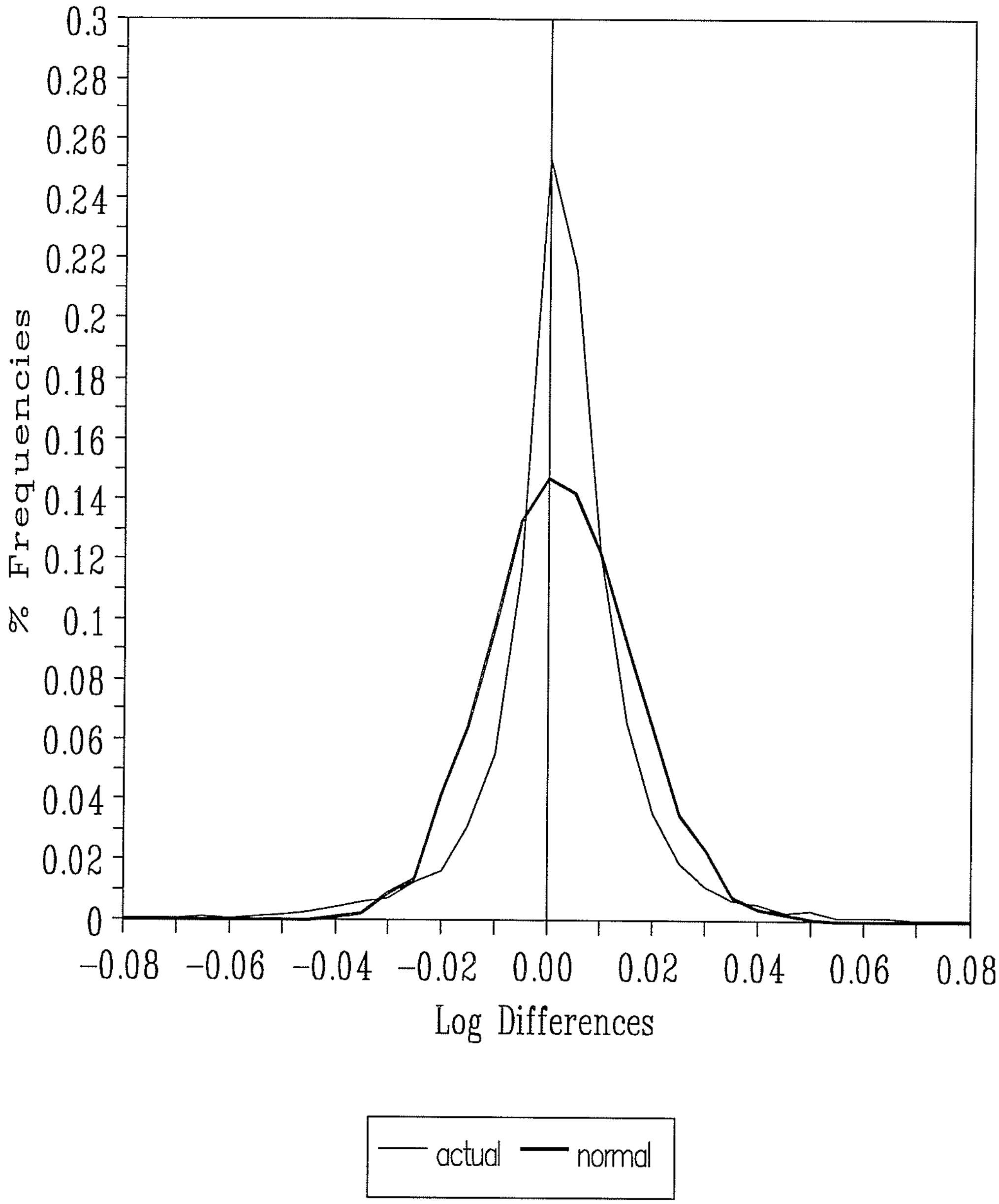


Figure A.15
NYMEX Daily Oil Empirical Distribution of Logarithmic Futures Price Changes Compared to a Random Sample from a Normal Distribution with the Same Sample Size and Standard Deviation

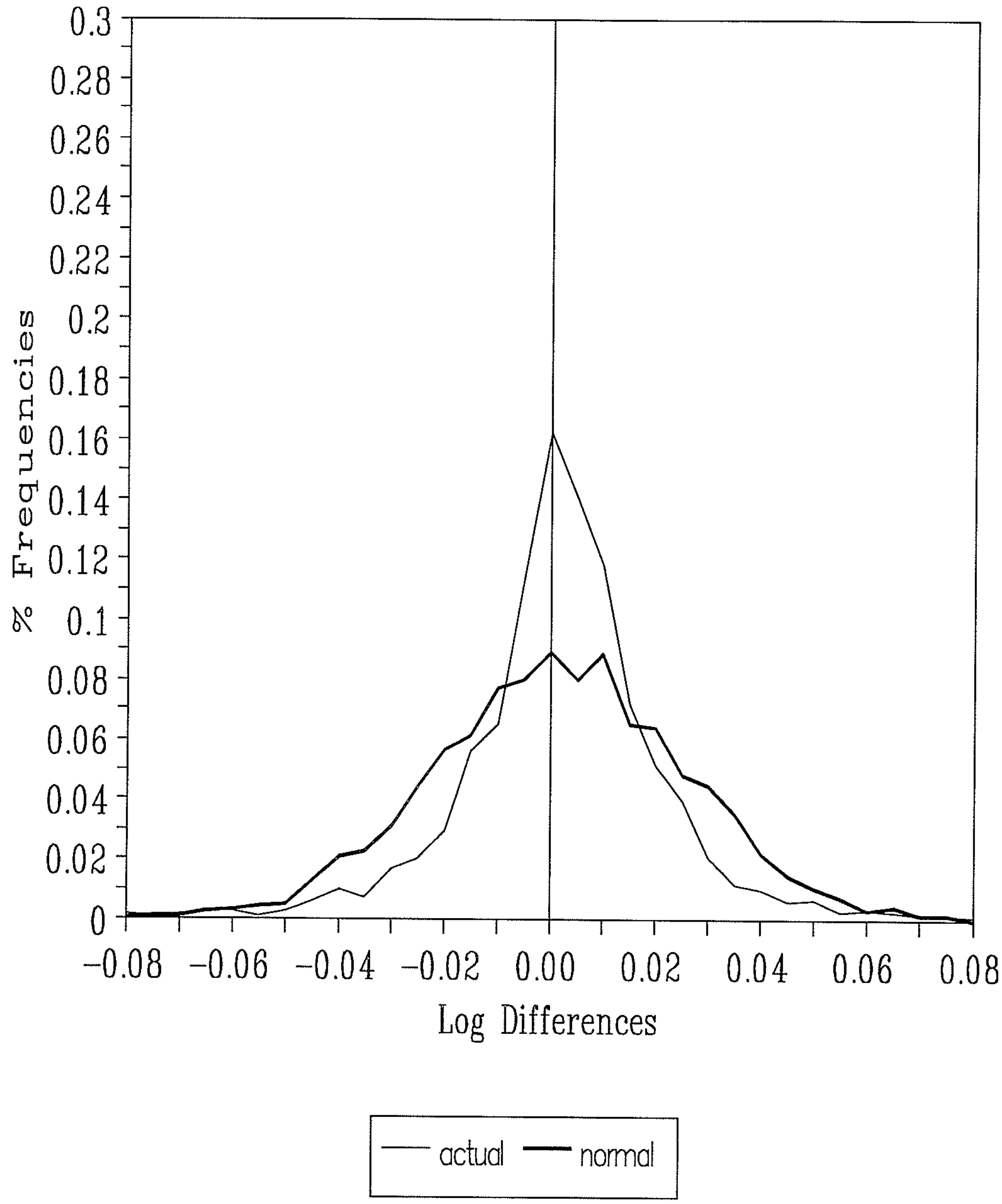


Figure A.16
COMEX Daily Silver Empirical Distribution of Logarithmic Futures Price Changes Compared to a Random Sample from a Normal Distribution with the Same Sample Size and Standard Deviation

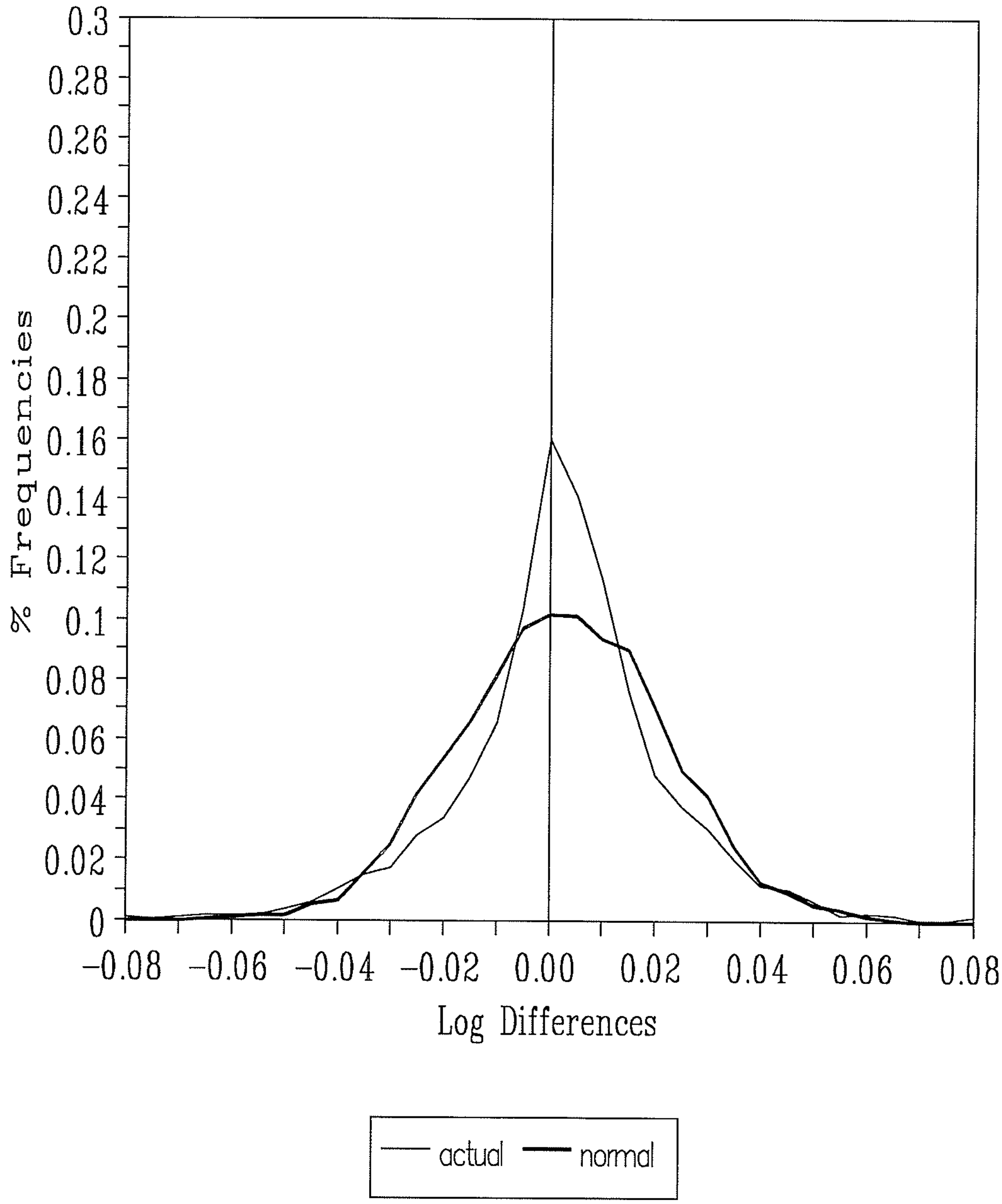


Figure A.17
CME Daily Standard & Poors 500 Empirical Distribution of Logarithmic Futures Price Changes Compared to a Random Sample from a Normal Distribution with the Same Sample Size and Standard Deviation

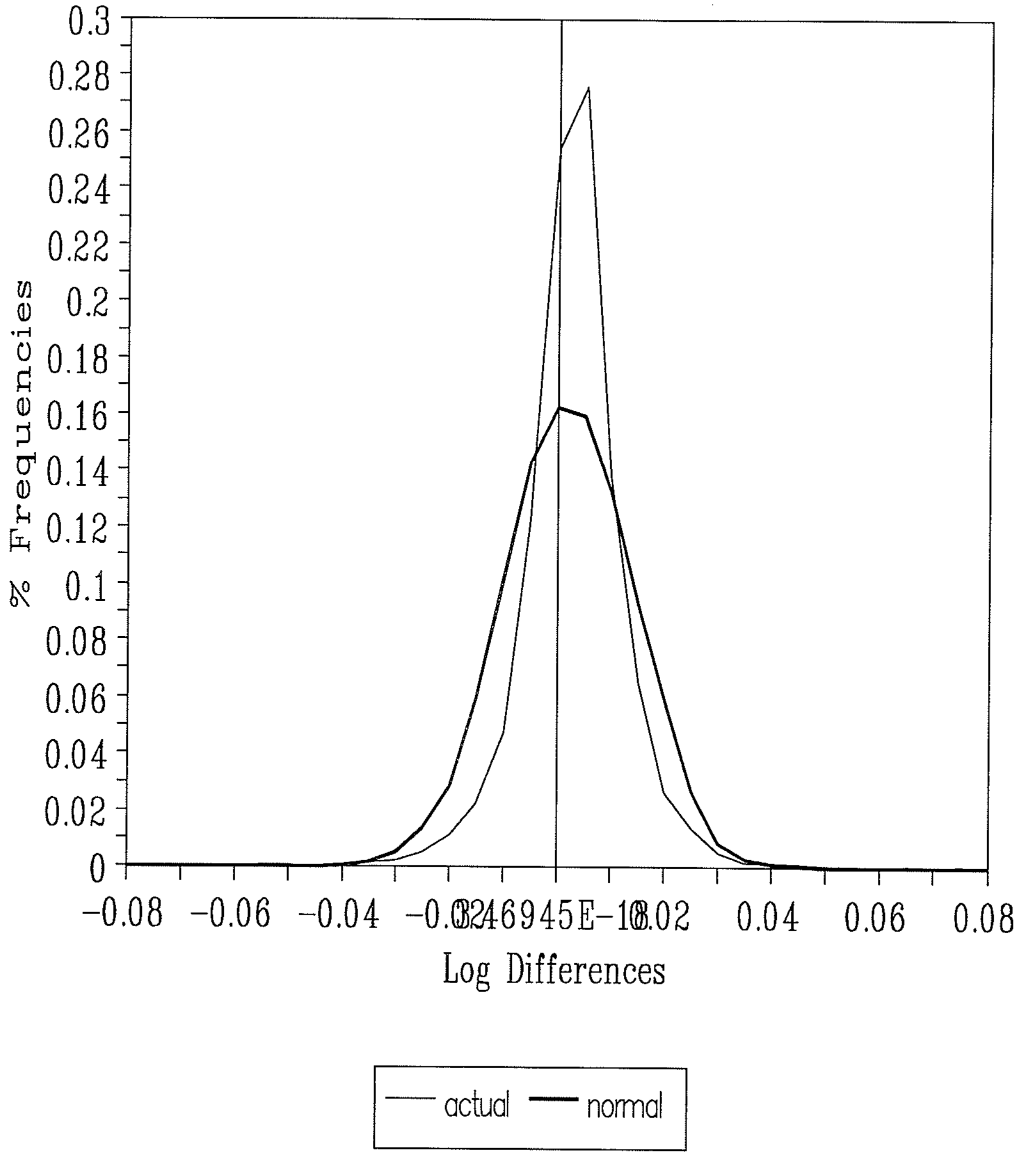


Figure A.18
IMM Daily Treasury Bills Empirical Distribution of Logarithmic Futures Price Changes Compared to a Random Sample from a Normal Distribution with the Same Sample Size and Standard Deviation

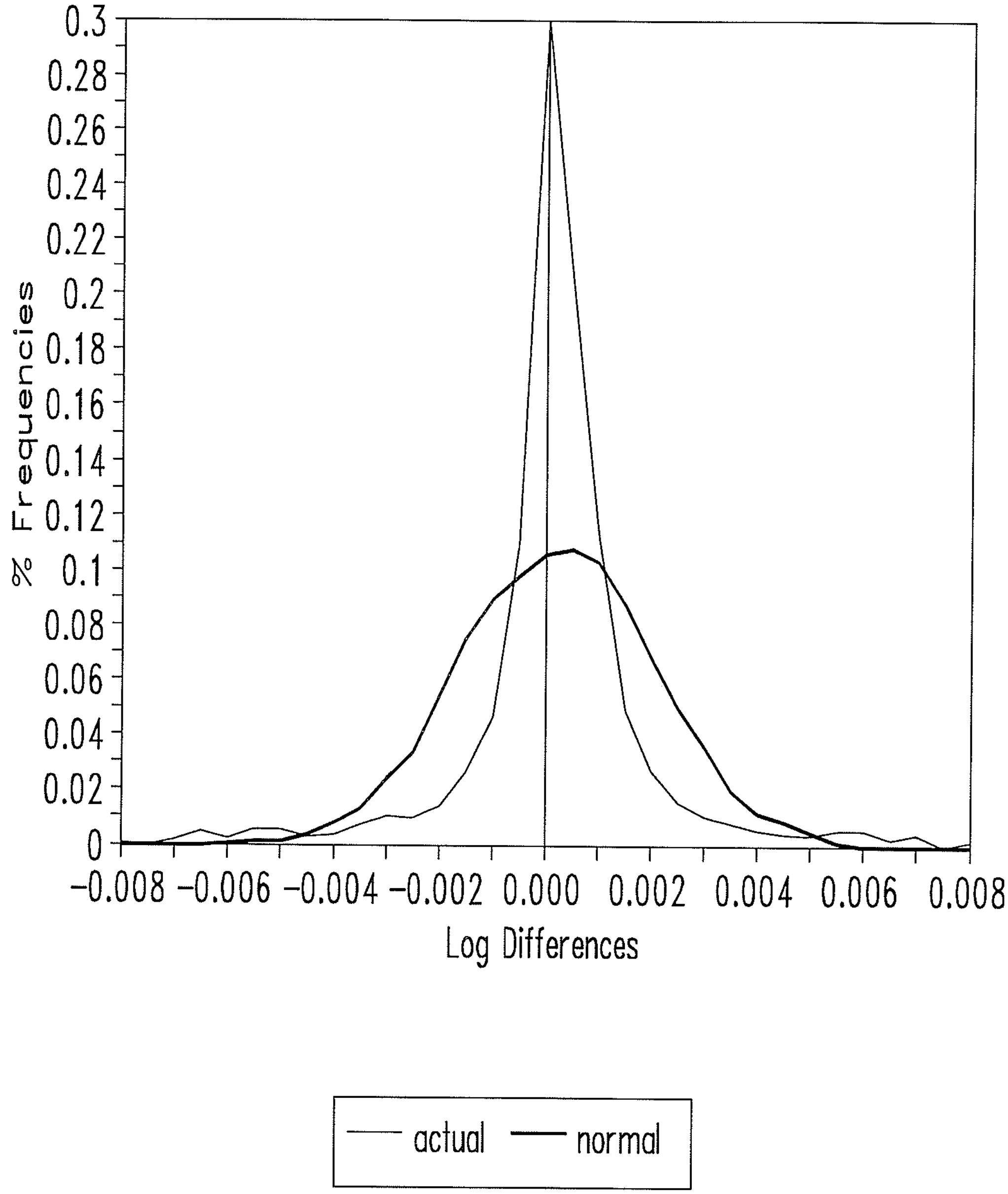


Figure A.19
CBOT Daily Wheat Empirical Distribution of Logarithmic Futures Price Changes Compared to a Random Sample from a Normal Distribution with the Same Sample Size and Standard Deviation

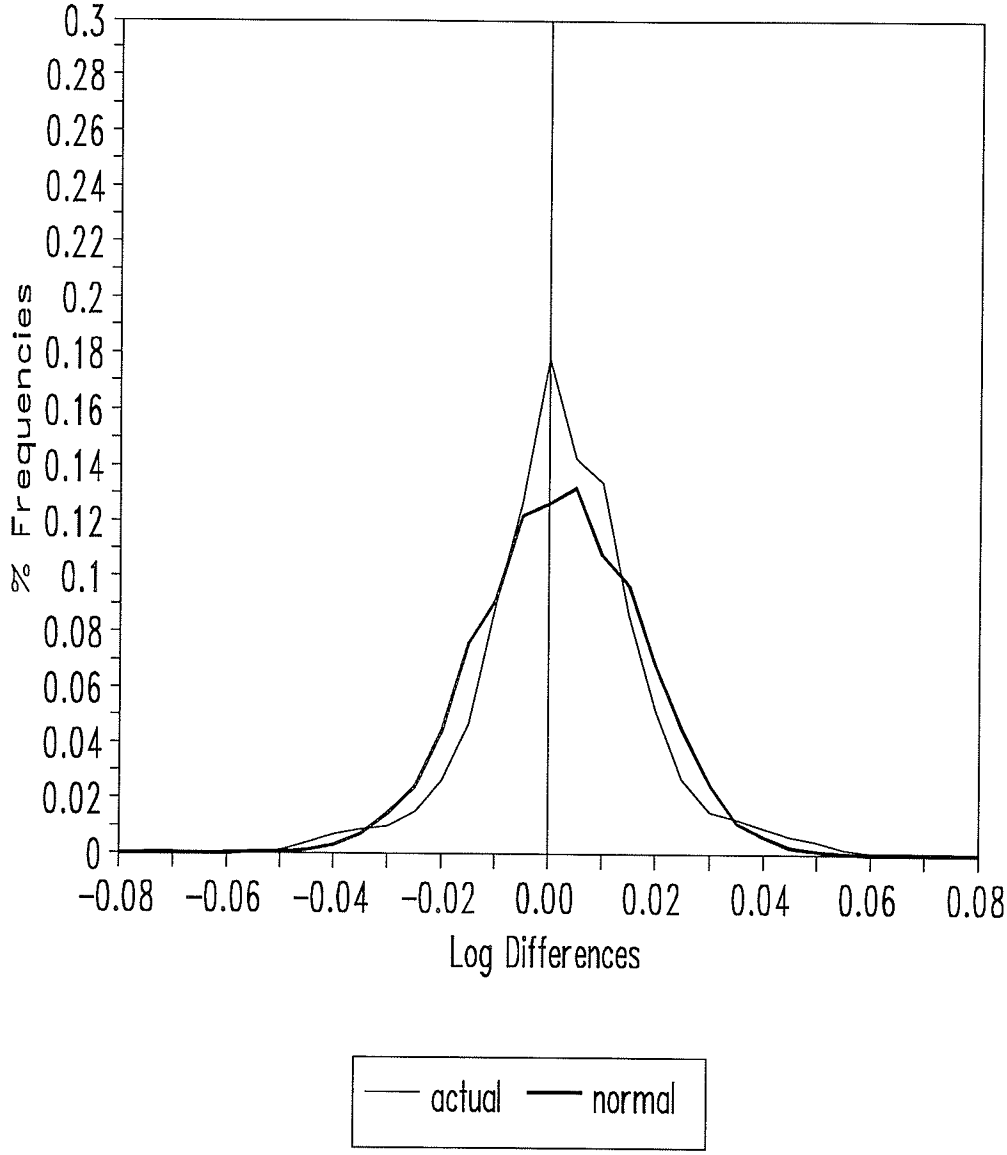


Figure A.20
CME Daily Cattle Futures Prices (cents/pound) and Logarithmic Differences

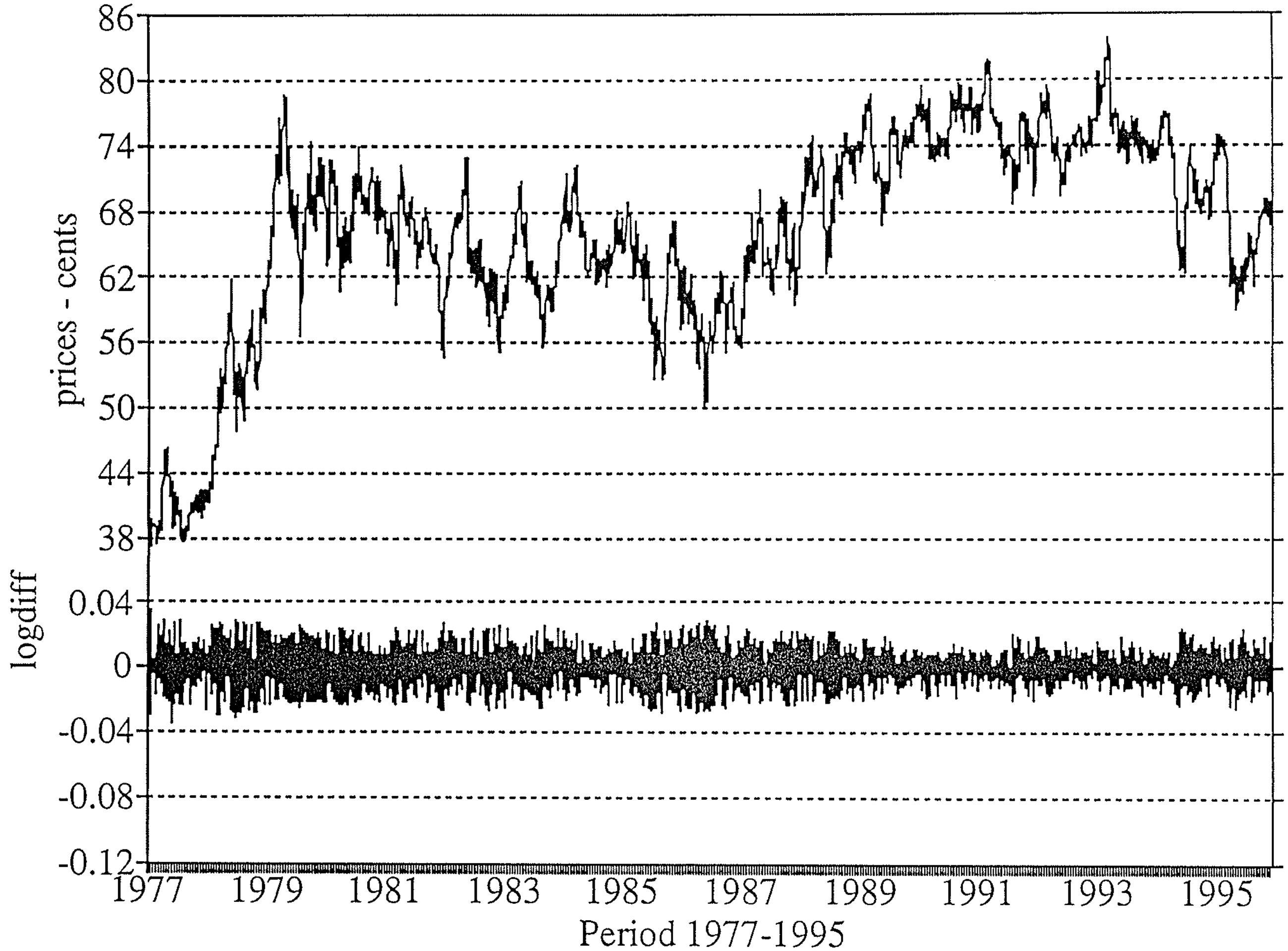


Figure A.21
CBOT Daily Corn Futures Prices (cents/bushel) and Logarithmic Differences

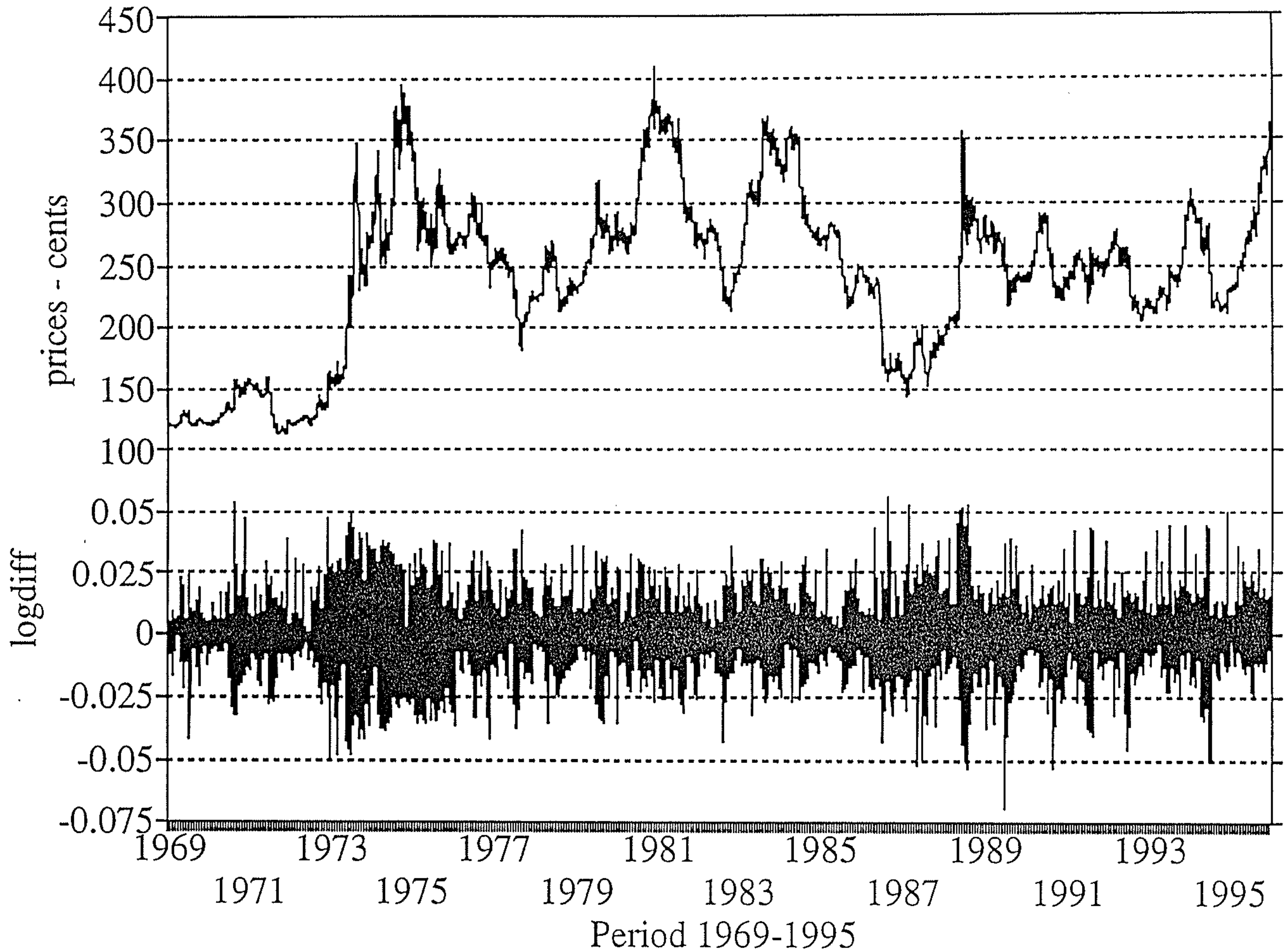


Figure A.22
COMEX Daily Gold Futures Prices (dollars/ounce) and Logarithmic Differences

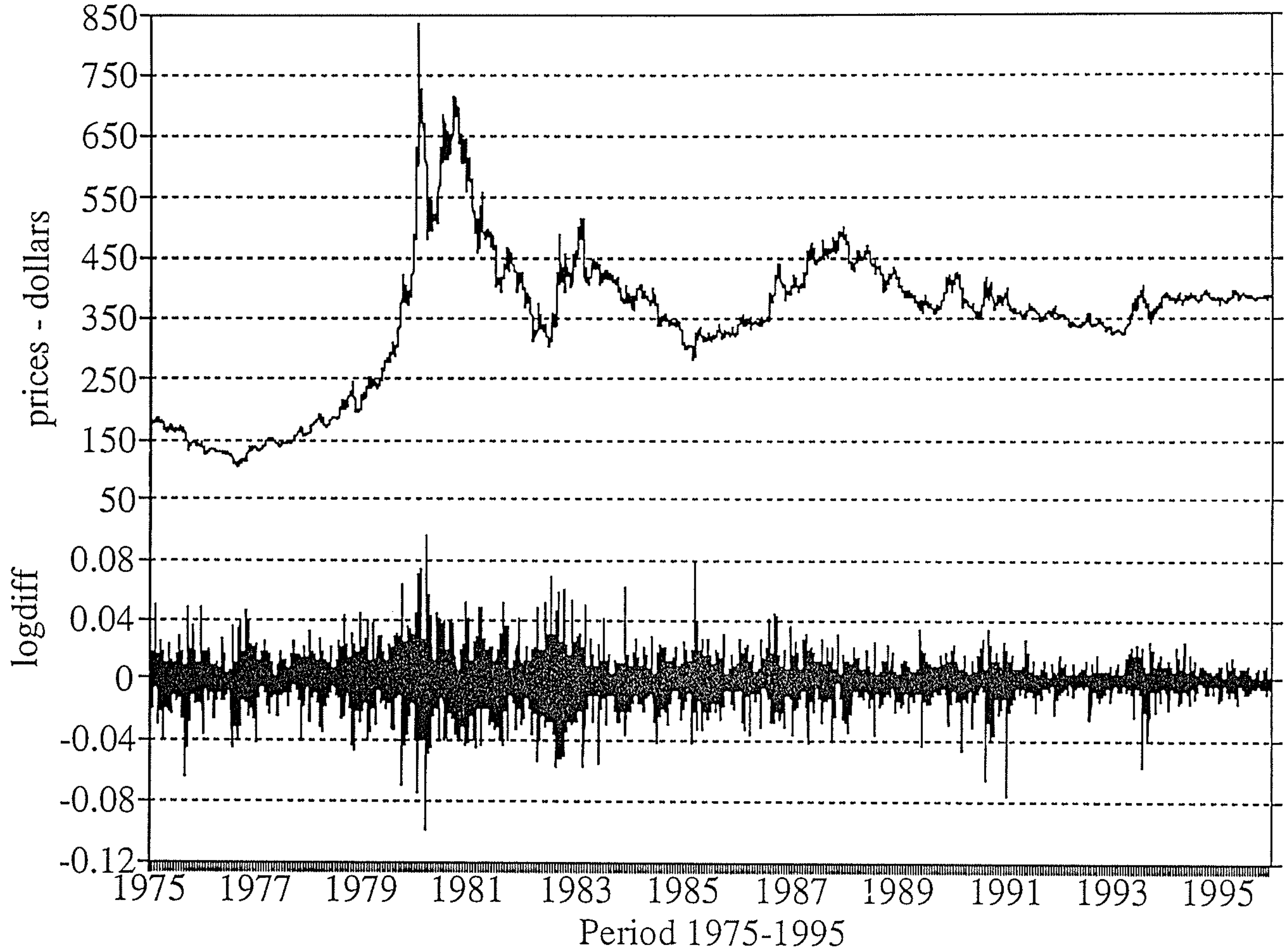


Figure A.23
NYMEX Daily Oil Futures Prices (dollars/barrel) and Logarithmic Differences

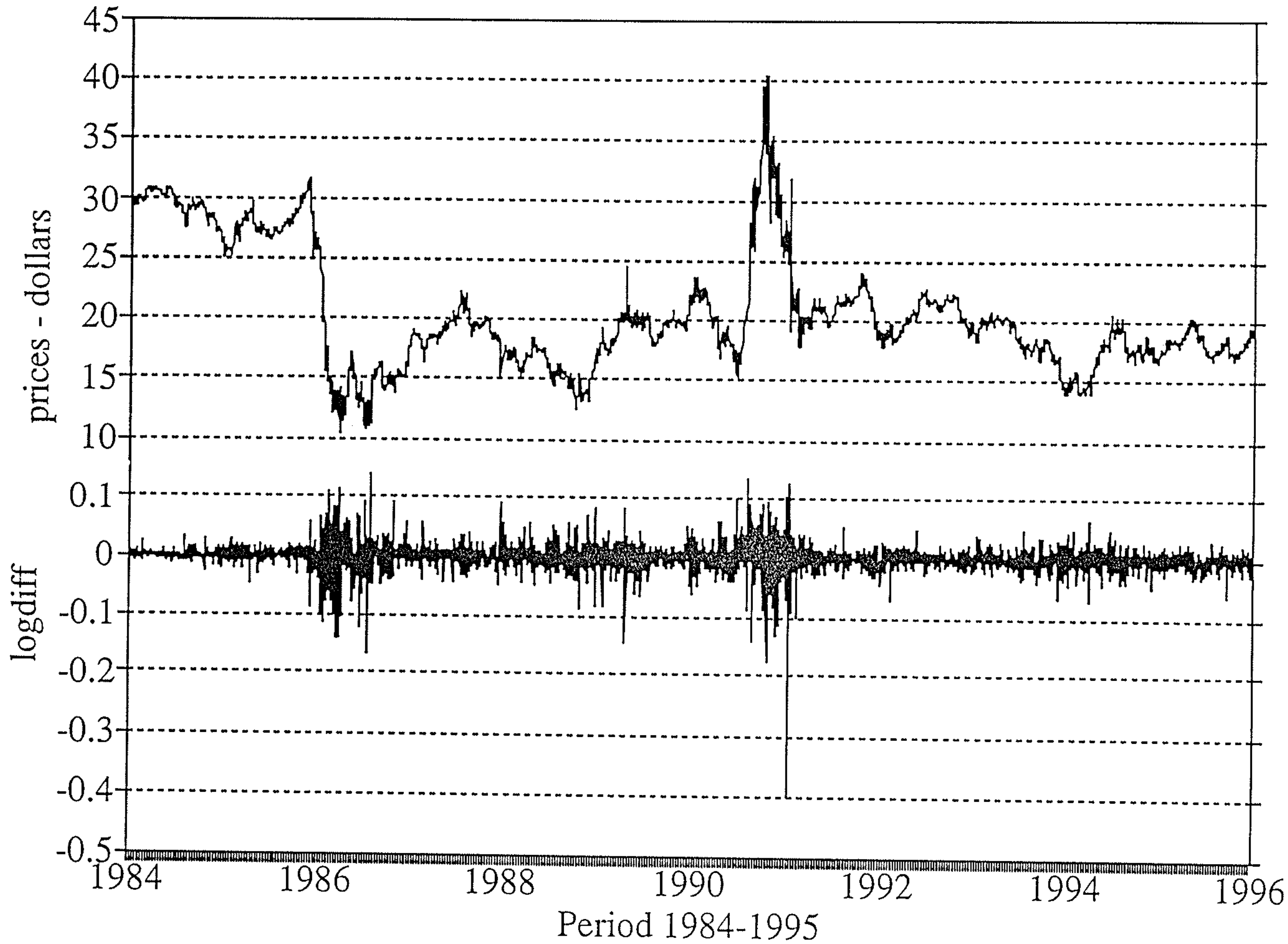


Figure A.24
COMEX Daily Silver Futures Prices (cents/ounce) and Logarithmic Differences

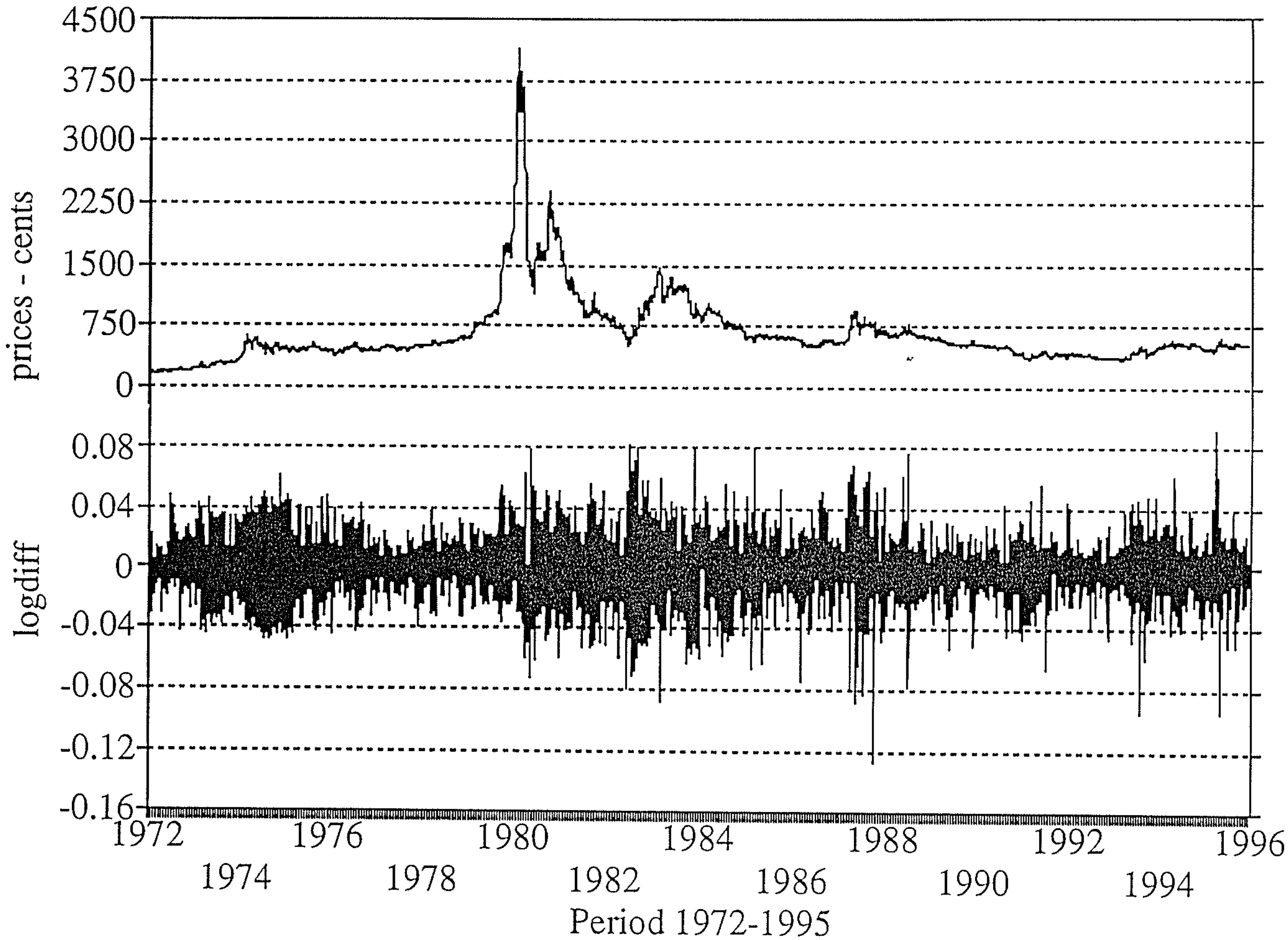


Figure A.25
CME Daily Standard & Poors 500 Prices (index) and Logarithmic Differences

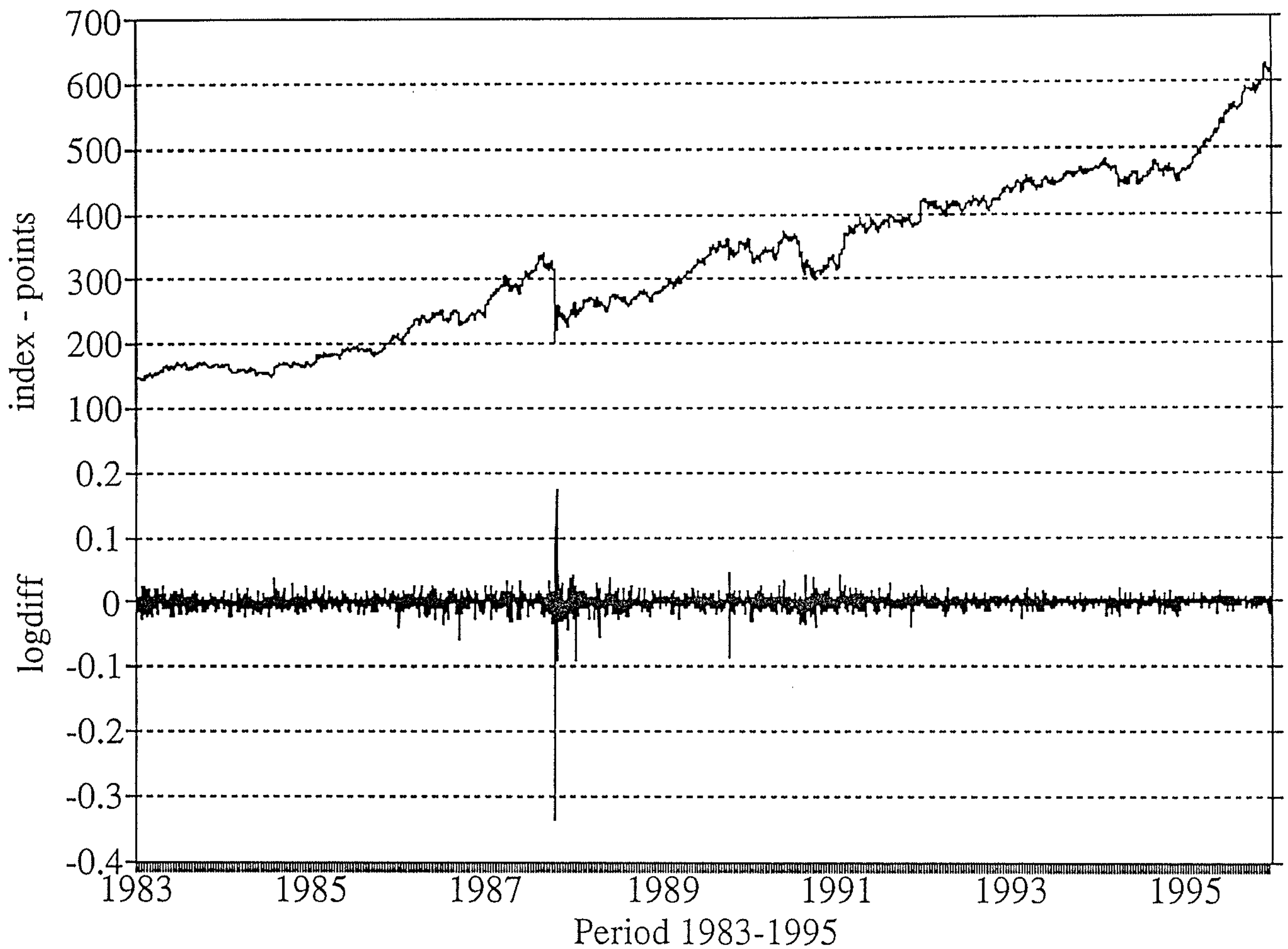


Figure A.26
IMM Daily US Treasury Bill Futures Prices (dollars) and Logarithmic Differences

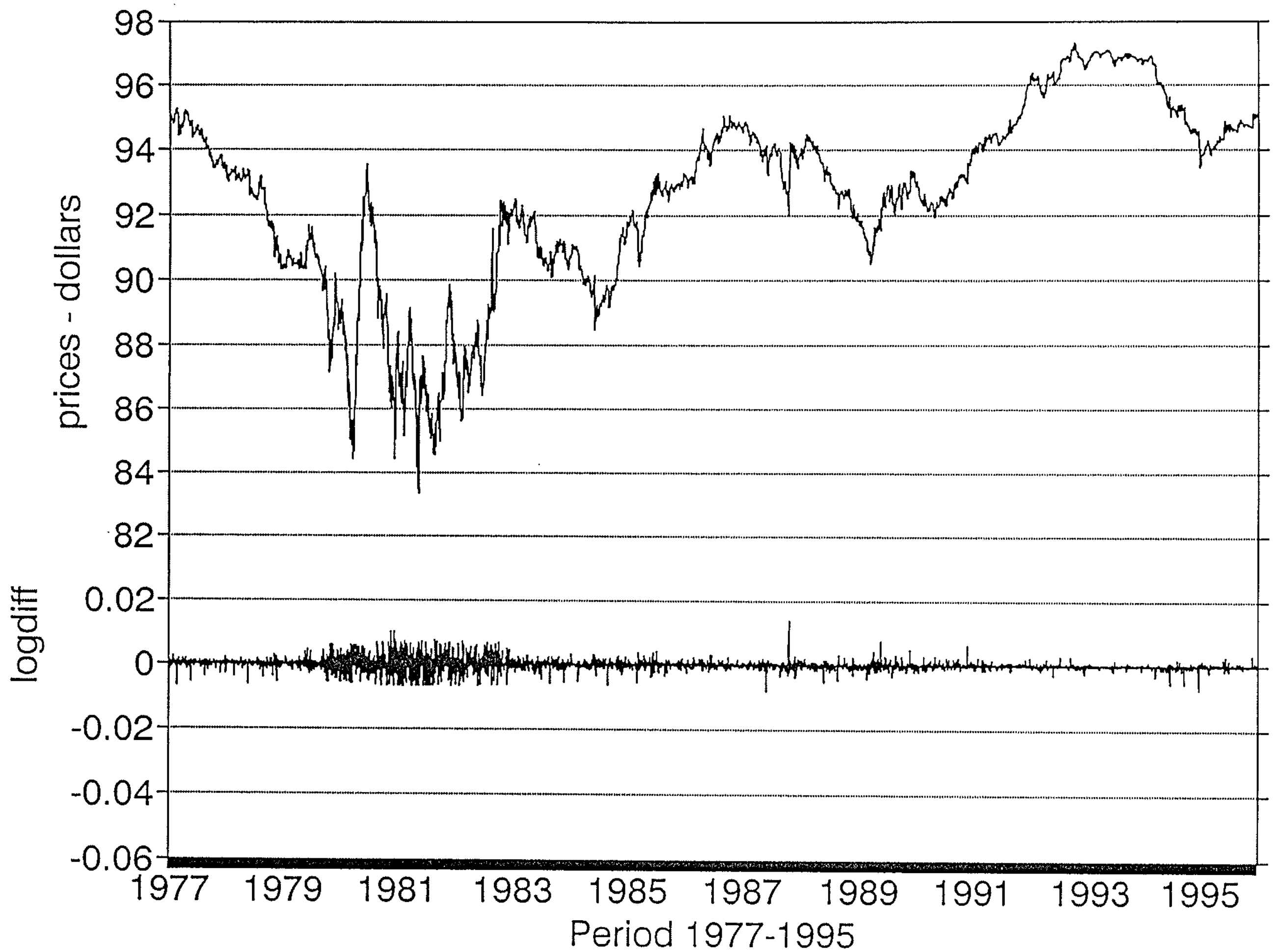


Figure A.27
CBOT Daily Wheat Futures Prices (cents/bushel) and Logarithmic Differences