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The MMI Cash-Futures Spread On October 19, 1987

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University of Illinois Urbana-Champaign

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ABSTRACT

On Monday October 19, 1987, the day of the record stock market decline, the stable spread relationship between stock market indices and their associated futures contracts apparently ceased to exist. For considerable periods of time throughout the day the futures contracts sold at deep discounts to the value of the indices. The size of the spread was unprecedented and it has received considerable publicity since October 19. The discussion has ranged from the mere observation that the size of the large negative basis was a singular event emerging out of the unusual conditions of the 19th to the possibility that the spread actually played a causal role in setting off and determining the severity of the crash.

The extent to which there actually were discrepancies between the price of futures and stocks at approximately the same time is considered in this paper. The MMI futures contract and its constituent stocks are examined to see whether the large spread was due to the last trade method used to compute the cash value of the index and hence whether there was in fact an actual real-time discount between futures and stocks. Further, the minute-by-minute price movements of each of the stocks is used to test the sensitivity of the spread to slight changes in the time path of reported prices.

The analysis shows that the large discount between the cash value and the price of the futures contract during the opening two hours of trading occurred because Friday prices were being used to estimate the values of unopened stocks. During the rest of the day the large spread was mostly due to the rapid change in prices. The spread diminishes when the cash value and futures price are compared at about the same time. The large reported spread is therefore misleading because prices in the stock and futures markets at about the same time were not far apart from one another.

The MMI Cash-Futures Spread On October 19, 1987

On Monday October 19, 1987, the day of the record stock market decline, the stable relationship between the price of stock index futures and the value of the constituent stocks in the indices apparently ceased to exist. For considerable periods of time throughout the day the futures contracts sold at deep discounts to the value of the indices. Figure 1 depicts the difference between the value of the Major Market Index (MMI) contract and the cash value of its constituent stocks; the spread on the previous trading day is shown in Figure 2.[1] The size of the spread for the MMI as well as other index futures was unprecedented and it has received considerable publicity since October 19. The discussion has ranged from the mere observation that the size of the spread was a singular event emerging out of the unusual conditions of the 19th to the possibility that the spread actually played a causal role in setting off and determining the severity of the crash.[2]

The extent to which there actually were discrepancies between the price of the MMI futures contract and its constituent stocks at approximately the same time on the day of the market crash is considered in this report. The evidence in Figure 1 is not by itself conclusive evidence for the existence of different prices in the two markets at about the same time. One reason for this is related to the way the value of the cash index is computed. Another reason is related to the behavior of the spread when prices are changing rapidly. Either of these factors can generate a large spread even when conditions are similar in the futures and stock markets.[3]

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[1] The terms--cash-futures spread, spread, basis, and basis spread--have all been used to refer to the difference between the cash value and futures price of a stock index contract. In this report the term--spread--will usually be used to refer to the cash value-futures difference; it should not be confused with the price differences of contracts in different months.

[2] See Edwards(1988) for an overview of the government reports on the crash.

[3] The issue here is not whether or not arbitrage was feasible on the 19th. In the chaotic conditions of the day there was no reasonable expectation of that trades would be executed, and so arbitrage opportunities were probably nonexistent. Arbitrage however is only a sufficient condition for prices in two markets to be about the same. If prices were being influenced by similar information then we would expect prices in the two markets to be approximately the same even in the absence of any arbitrage.

The spread shown in Figure 1 is based on an estimate of the market index value which is computed using the most recently traded prices of the stocks in the index; see Figure 3 for the cash and futures values on the 19th. This means that the estimated cash value of the index will not necessarily be an accurate measure of the current value of the futures contract when index stocks do not trade. Since prices were changing rapidly and there were gaps in trading, especially at the open, it is possible that the large spread was due to the last-trade method used to estimate the cash value of the index and that there was not an actual real-time discount between futures and stocks values.

The possibility that the spread on the 19th was a result of gaps in stock trading has been investigated previously. It is considered in the government reports which were issued in the aftermath of the crash and also in Harris(1987). The studies have focused on the S&P 500 futures contract and they have examined transactions on intervals as short as five minutes.

In this report the MMI futures contract which is based on twenty stocks will be examined. The minute-by-minute price movements of each of the stocks and the futures contract will be examined in order to assess the extent to which there were discrepancies between the value of the futures contract and the associated stocks.

The previous studies have found that the bias due to infrequent trading and delayed openings cannot account for all the time periods on the 19th when there was a large negative spread. From the time (10:23) at which all stocks had opened until right before the close there were no large time intervals in which the MMI stocks did not trade. The cash value of the index was therefore being computed with recent price information of the stocks and yet, as shown in the Figure 1, the large spread was not confined to the opening.[4] This has led some to conclude that values in the two markets departed from each other for considerable periods of time on the 19th.

The large spread combined with continuous trading does not necessarily mean

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[4] The situation on the next day when there was also a large spread was quite different. Even after the opening there were long periods of time when some of the MMI stocks did not trade. For example, IBM did not trade between 10:30 and 12:26; see the SEC (1988) report for a description of trading conditions on Tuesday, October 20. We are only looking at the 19th in this report because after the open trading was fairly continuous, and continuous trading is needed to compute the window width spreads in section III.

however that values in the two markets were different at about the same period of time. When prices are changing rapidly the spread can increase if there are only slight differences in the time paths of prices in the two markets. This is illustrated in Figure 4 which shows the spread between prices in two markets increasing even though conditions in the two markets at about the same time (that is, within a few periods of one another) are almost the same. Only minor changes in the time path of prices can give the appearance of a large spread if prices are changing rapidly. If prices are stable, a large spread means that there are large price differences in the two markets. Such differences will not be sensitive to slight changes in the time paths of prices in the two markets due to reporting delays or slight differences in the speed with which new information is incorporated into prices. In a rapidly changing market, however, such slight differences will lead to large spreads even though prices in the markets are similar at about the same time.[5]

The sensitivity of the spread to slight changes in reporting conditions or in the speed with which information is transmitted to changing prices will be evaluated by recomputing the spread using a neighborhood of nearby futures and stock prices.[6] If prices in the two markets really did depart from one another for considerable periods of time then this revised spread will still be large. Alternatively, if the spread is found to be sensitive to slight variations in the time path of prices then the existence of the large spread for long periods of time would not be evidence that values in the two markets were markedly different at about the same time.[7]

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[5]The sensitivity of the spread to slight differences in the times when stock and futures prices are compared may be due to what Kleidon(1988) calls "stale" prices. Prices are stale when there is a difference between the price of a security at the time of order submission and order execution. This will occur when prices are changing rapidly and can lead to the appearance of large spreads at the short time scales which are considered in this paper.

[6] Stoll and Whaley (1988) found that since the inception of futures trading the MMI and S&P 500 futures returns have tended to lead stocks by about five and sometimes ten minutes even after returns have been purged of infrequent trading effects. The analysis was based on a time series of five minute intraday returns.

[7] It should be noted that the analysis will not directly concern the question of whether futures prices played a causal role in the crash. It is conceivable that short lead-lag relations between the prices in the two markets occur because traders act in one market based on price information coming from the other market. Alternatively, lead-lag relations could exist in the absence of any direct link between the two markets. If the two markets are totally

The data base for stocks consists of minute-by-minute prices for each of the twenty MMI securities. The data on the MMI stocks were extracted from transaction data on all NYSE stocks which was obtained from the Francis Emory Fitch Company. The price at each minute was taken as the price of the first listed transaction during that minute; if there was no trade the price record was left blank. Transaction data on the MMI futures contract was provided by the CBOT. The price of the futures at minute t was taken as the price of the first reported trade during the minute.

Section II describes the open on Monday morning. This covers the first two hours of trading and ends with the open of the last MMI stock at 10:23 (all times are Chicago time). Reasonable assumptions about the values of not-yet-opened stocks are shown to explain the large spreads which were observed during this time period.

The spread during the rest of the day is described in Section III. The first part presents evidence which shows that the bias caused by gaps in trading cannot explain the large spreads after the open. There were simply not enough gaps or gaps of sufficient length for there to be a large bias in the cash value of the MMI index; trading in the MMI stocks after the open was fairly continuous. The second part of the section shows, however, that the large spread during much of this part of the day is sensitive to slight changes in the time paths of the stocks and futures prices. The existence of a large spread during most of the afternoon did not therefore mean that values in the markets were far from one another for extended periods of time. Concluding comments are in the final section.

II. The Open 8:30-10:30

Table 1 lists the twenty MMI stocks and the times and prices at which they opened on Monday morning. It also shows the price of the last transaction from the previous

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isolated from one another there will exist lead-lag relations if new information is translated into new prices in one market more rapidly than in the other market. Some of the scenarios presented for the crash require the existence of large differences in prices in the stock and futures markets for lengthy periods of time. If the large spread is sensitive to slight changes in the price series then these scenarios for the crash will be less likely.

trading day on Friday. The opening period lasted from 8:30 to 10:23 when the last MMI stock, Exxon, opened. This means that until 10:23 the cash value of the index was utilizing prices of stocks from the previous Friday close. The gap between the last trade prices on Friday and the opening prices on Monday shows that the value of unopened stocks was being biased by the higher Friday prices.

To determine the extent to which the last-trade index was biased by the use of Friday prices, several alternative indices were computed. These alternatives did not use information from Friday to estimate the value of unopened stocks. Instead, the value of unopened stocks was estimated using information on stocks which were trading and which therefore reflected market conditions on Monday. An illustration of the method used to estimate the values at the open will be presented after first introducing the following notation.[8]

Let t_i denote the minute when the i^{th} MMI stock began trading and let Z(t) denote the set of MMI stocks which opened prior to time t. A minute-by-minute price series

$$P_i(t), \quad t=t_i,t_{i+1},t_{i+2},\ldots$$

for each of the opened MMI stocks was constructed by filling in any trading gaps with last-trade prices. (Prior to 10:23 there were two gaps of four minutes, one gap of three minutes, and all other gaps for opened MMI stocks were two minutes or less).

For each opened stock the price relative to 10:23 was computed for each minute,

$$r_i(t)=P_i(t)/P_i(10:23), \qquad t_i<t<10:23,$$

[8] The estimated prices of the unopened stocks are based on only the distribution of the opened stocks--we did not use betas or the correlations within the portfolio of MMI stocks or between MMI and other stocks. We suspect that this additional information would not change our conclusions about the spread at the opening. Such an analysis is needed, however, for analyzing events on Tuesday when the gaps in trading were much more numerous and lengthy than on Monday.

where $P_i(t)$ denotes the price of stock i at minute t.[9] Finally, the distribution of price changes of the opened stocks at time t is denoted by D(t) where

$$D(t)=\{r_i(t) \mid i \epsilon Z(t)\} \qquad 8:30<t<10:23.$$

The price changes of the unopened stocks are estimated using the minimum, the average, and the maximum of the price change distribution. The average provides an estimate of central tendency, while the maximum and minimum provide bounds on the values of unopened stocks. The index value is then computed using the estimated values of unopened stocks and the actual prices of trading stocks. The estimation method is explained in the following example.

Example

To illustrate how the values of unopened stocks were estimated, consider the following simple example of an index which is just the ordinary average of three stocks. Table 2 shows the illustrative data for the periods prior to the time that all stocks open. It also shows the previous close of each stock as well as the index value based on a last trade index. The two features of the 19th which are included in the illustrative data are the delayed openings and the lower prices at the open compared to the previous close.

The 10:23 time at which all MMI stocks had opened corresponds in this example to period five. Stock A begins trading at the open of trading, Stock B does not open until period three, and the stock C does not open until period five. This means that until period five the last trade index value is being computed using at least one price from the previous close.

Table 2b and 2c show the price changes of the index stocks relative to period five. Also shown are the minimum, average, and maximum values of the price change distribution. Each row of the table determines, D(t), the distribution of price changes of those stocks which had already opened.

The estimates of the values of the not-yet-opened stocks are shown in Table 2d. The

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[9] This procedure makes the price change distribution sensitive to the stock prices at exactly 10:23. An alternative would have been to use an average prices around 10:23 and thereby smooth out any large price changes which occurred at the exact 10:23 minute.The price changes of the individual stocks around 10:23 are however not large and it did not seem that the use of a smoothed price series would alter the price change distribution.

estimates are computed using the average of the price change distribution. For example, at period 3 there are two opened stocks. These two stocks were trading during period three at prices which were on average 3.5% higher than at period five. Since the price of stock C at period five is 75, its estimated value at period three using this average of opened stocks is 1.035*75=77.625. The table shows how the values of the unopened stocks at other times were estimated.

Table 2e shows the estimated index values using the average and also the minimum and maximum values of the distribution of opened stocks. It illustrates the differences which can exist between the last-trade index and estimated indices which use information on only opened stocks.

The method used to construct estimated values for unopened stocks and the MMI index is identical to that shown in the example except that there are twenty rather than three stocks and there are 113 (minutes) rather than five periods before all stocks begin trading.

Figure 5 shows the spread at the open which results when the prices of the unopened stocks are estimated using the mean or average of the D(t) distribution; Figure 6 shows the corresponding value of the index. The estimated value of each unopened stock, $P_i(t)$, $t<t_i$, is given by

$$P_i(t)=a(t)P_i(10{:}23)$$

where a(t) is the mean or average of the price change distribution D(t). The value of the MMI index was computed by summing the actual and estimated prices of the index stocks and dividing by, 3.18322, the MMI divisor which was valid on October 19.[10]

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[10] The MMI, like the Dow Jones Industrials average which it was designed to mimic, is just a scaled summation of stock prices. This differs from other indices (e.g. the S&P 500) which are based on the total value of outstanding shares of stock. The MMI method means that the index is influenced most by high priced stocks (IBM and Merck) and least by low priced stocks, even if the total value of outstanding shares is large (e.g. AT&T).

Figures 5 and 6 show that the cash and futures prices track far better than when the last trade cash index is computed with Friday prices. This occurs because the cash value of the index is being estimated using only the information from Monday the 19th.

Figure 7 shows the estimated value of the index which results when the minimum and maximum values of the price change distribution are used to estimate the values of unopened stocks. As in the illustrative example, the upper bound on $P_i(t)$ for $t<t_i$ is given by,

$$P_i(t)=\max\{D(t)\}\ P_i(10{:}23)$$

and similarly for the minimum estimate of $P_i(t)$. Using these maximum and minimum estimates yields the minimum and maximum estimates of the index shown in Figure 7. It shows that throughout most of the opening two hours the futures contract traded within the upper and lower estimates of the futures contract value.

The estimates of the futures index value derived from Monday price information provide persuasive support for the position that the large spread at the opening was not due to different values in the futures and stock markets. The higher Friday prices included in the last trade based estimate of the futures contract caused it to overstate the value of the index. This finding, using minute-by-minute transaction data, is similar to that in the government reports on the crash where transactions were examined at five minute and longer intervals.

III. The Spread From 10:30 to 15:00

The first part of this section presents evidence which shows that trading gaps were not long enough or numerous enough to account for the large spread after the open. The second part examines the sensitivity of the spread to slight changes in the time path of futures and stock prices.

Trading Gaps

Summary data on gaps in trading is presented in Table 3 and Figure 8. Table 3 shows for each MMI stock the number of minutes during each half hour when there were no transactions. For example, IBM traded in all but two minutes in the half hour after 12:30. The table shows that each MMI stock traded in about 80% of the minutes during the

day. (The only long trading gap occurred for Merck which did not trade for a period of 28 minutes in the hour after 2:00). The half hour pattern of trading for most of the stocks remained constant until just prior to the close.

Figure 8 shows the frequency of all gaps. It shows that there were very few gaps longer than three minutes. The figure reveals that there was fairly continuous trading in all of the MMI stocks. This continuous trading means that the kind of reasoning used to explain the large spread at the open cannot be used to account for the large spreads observed during the rest of the trading day.

Further evidence for continuous trading is provided by a comparison of the last-trade index and another index based on a look ahead at a stock's next transaction price. The bias caused by infrequent trading in a next-trade index will be equal in magnitude but opposite in sign to the bias of the standard last-trade estimate. The numerical difference between the two estimates will indicate the times when stocks were trading infrequently and with large price differences between subsequent trades.

Figure 9 depicts the difference between the last and next trade estimates of the index value. The difference is seen to be negligible during most of the day. It reaches a maximum of only about 4 points. This is far smaller than the spread of 15 and more points using the last-trade estimate. The large spread would therefore still exist if the cash value of the index was computed using a next-trade index. The large spread evidently is not explained by the bias caused by non-trading stocks.

The evidence in Figure 10 is similar. The figure depicts the spread between the MMI futures price and an estimate of the cash value which is computed at only those times when all MMI stocks have recently traded. At such times there will be little bias from untraded stocks and the spread should be near zero. The gaps in the picture correspond to the times when there was at least one MMI stock which had not traded for five or more minutes. At all other times every MMI stock has traded within the past four minutes. The figure shows the spread which results at only the times when all of the MMI stocks have recently traded. It shows that the spread is still large; it is again about 15 points in the early afternoon and about 25 points near the close. The figure shows again that the large spread after the open cannot be associated with any bias from untraded stocks. When every MMI stock is trading there is still a large difference between the reported futures and stock prices.

The large spread recorded after all stocks had opened could not have been due to the bias of the last-trade based estimate of the index value. The trading gaps were not long enough for the last-trade index to become a biased estimate of real-time conditions in the stock market. The next-trade index which should have the opposite bias still leaves a large negative spread. Further, the large spread exists when attention is restricted to only those times when trading in all MMI stocks was nearly continuous.

Window Width Spreads

As suggested in the introduction, the large spread combined with continuous trading does not by itself imply that futures and stock values were significantly different at about the same time. Slight differences in the time paths of futures and stock prices coupled with steep price trends can generate pictures which show a large spread existing for long periods of time. The misleading impression from the picture is a large and persistent divergence in prices when, in fact, the prices in the two markets are close together. We examine this possibility by examining the sensitivity of the spread to slight changes in the time paths of the futures and stock prices.

The cash value of the MMI contract at minute t is denoted by $M^*(t)$. This series was made continuous (minute-by-minute) by using last-trade prices of the stocks which did not trade during a minute.(As explained above, the nearly continuous trading after the open means that the series is not strongly dependent on the use of last-trade prices; a next-trade or interpolation based index would lead to essentially the same continuous price series.)[11] The price of the futures contract at time t is denoted by F(t). Except for three different minutes the contract traded in every minute during the trading day; the series was made continuous using previous trades for the minutes when the contract was not traded.

The sensitivity of the spread to slight variations in the time paths of prices is measured by what is called a window width spread. The window width is measured by a parameter, w, which measures the length of the time interval on which the two price series

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[11] A continuous price series is needed to compute the window width spread. While such a series can be constructed for prices on Monday, it cannot be done for the next day because the trading gaps preclude reasonable estimates (using anything other than the futures contract itself) of stock values during the extended gaps in trading.

are compared. The window width spread of length w is denoted by $s_w(t)$ and it is defined as

$$s_w(t)=\min\{\ |F(\tau)-M^*(\tau')|\ :\ \tau\epsilon t(w),\tau'\epsilon t(w)\}$$

where t(w) is the interval [t-w,t+w]. The spread $s_w(t)$ is necessarily decreasing in w and at w=0 it is identical to the usual spread. It measures the minimum difference between the cash and futures prices for any two, possibly different, times between t-w and t+w. We will examine window width spreads with w set at five and ten minutes.

The sensitivity of the usual spread to changes in the price paths in the two markets is indicated by the size of $s_w(t)$ as a function of w. If small values of w eliminate the spread then only slight shifts in the time paths of the futures and stock prices can account for the size of the spread. Contrary to the impression given by Figure 1 this would mean that futures and stocks, while being considerably different at exactly the same minute, were actually close together within a few minutes of each other. Conversely, if the spread stays large as w increases then slight changes in the time paths will not account for the large spread. This would be the best evidence for genuine discrepancies between the futures and stock prices over extended time periods.[12]

Figure 11 and 12 depict the window width spreads using w=5 and w=10 minutes. The five minute window width eliminates most of the spread which existed between noon and 1:30. The large spread which existed during the last hour of trading is reduced but is still substantial with this window. Using a ten minute window eliminates the spread in the last hour except for short time periods at about 2:20 and right before the close.

IV. Conclusions

First, the large reported spread on Monday morning was primarily due to the delayed opening of the MMI stocks. The cash value of the MMI index computed using

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[12] A better, but more complicated, way to measure the sensitivity of the spread to slight shifts in the time paths of prices would be to compute a "nearby" cash price of the futures contract using nearby prices for the individual stock prices. That is, instead of perturbing the cash value of the index by ±w minutes, a range of cash values would be computed using $\{\ \Sigma P_i(t+\tau)|\ -w<\tau<w\ \}$. When this estimate was evaluated for selected minutes it did not give very different values than the window width spreads using $M^*(t)$, and we therefore used the simpler method.

Monday morning price information (rather than the previous Friday closing prices) does not exhibit a large discount from the futures price.

Second, during the rest of the day the gaps in trading were not large enough or numerous enough to account for the spread. The spread stays large when the cash value of the index is recomputed in a number of different ways designed to minimize the impact of gaps in trading.

Third, for much of the trading day the futures and stock prices were close together at about the same time despite the fact that the instantaneous spread stayed large for extended periods. An exception to this occurred in the last hour of trading when futures traded below stocks even after allowing a ten minute period for the prices to come in line with one another.

Finally, it should be noted that we have not considered the reason why asset values fell by over 20% on the 19th. Our findings support the position that the futures and stock prices tended to move together and stay at comparable (and falling) levels on the day of the market crash. Since the large spread was due to gaps at the open and to rapid, but not perfectly correlated, price changes in the futures and stock markets, the hypothesis that the large spread played a causal role in the events of the 19th is not supported or it has to be combined with the dubious assumption that investors perceived different price behavior when none existed. Alternatively, other explanations for the crash which do not rely on price differences at about the same time in the futures and stock markets must be examined as possible causes of the crash.

Figure 1
The MMI Spread
October 19,1987

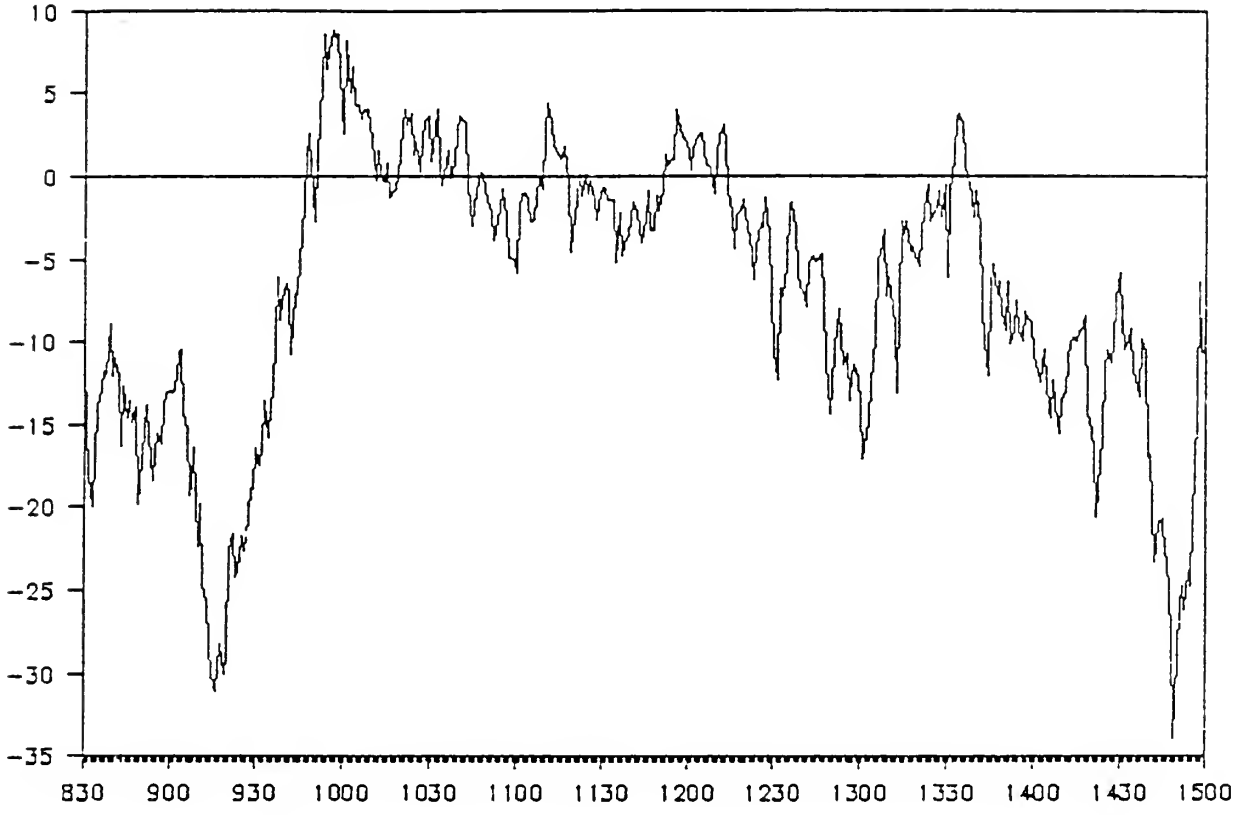


Figure 2
The MMI Spread
October 16 and 19,1987

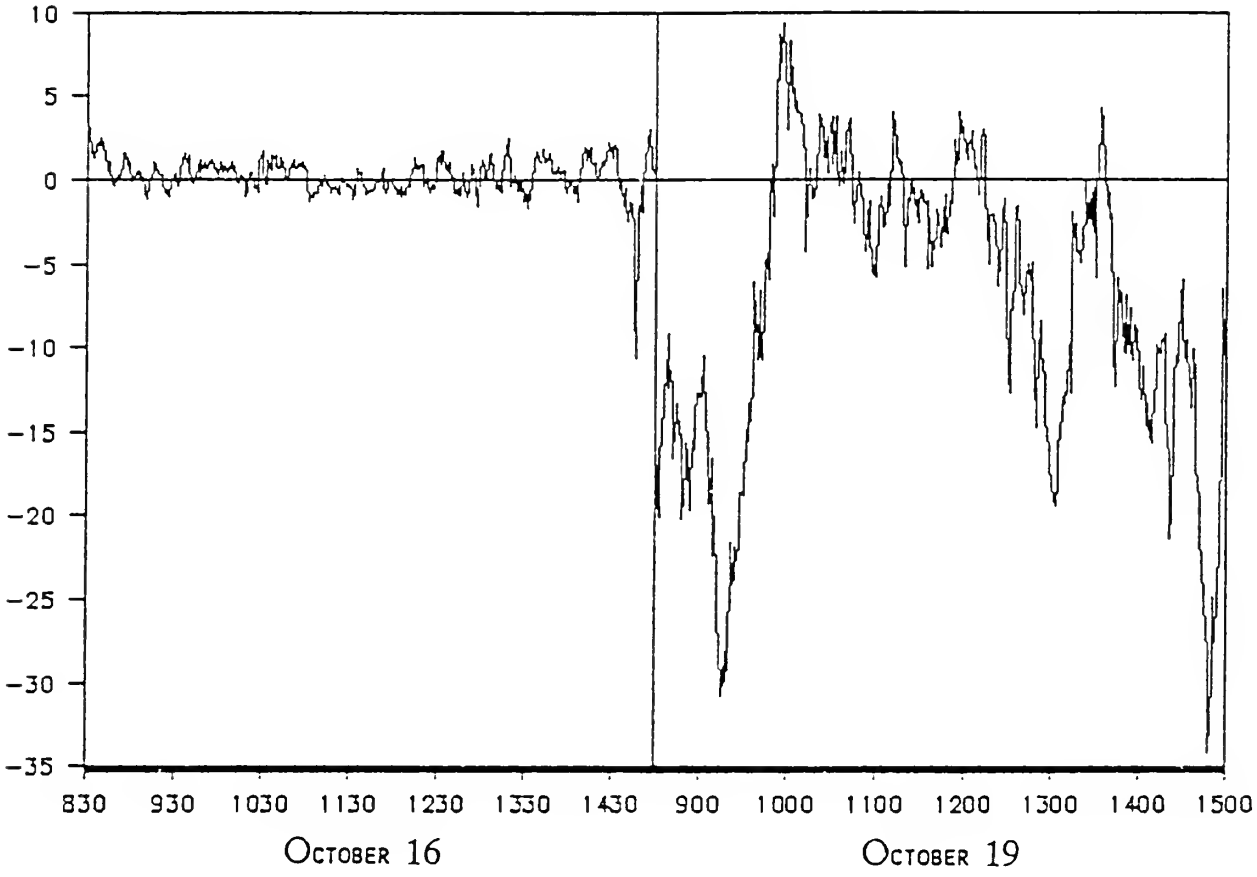


Figure 3
The MMI Futures Prices and Cash Values
October 19,1987

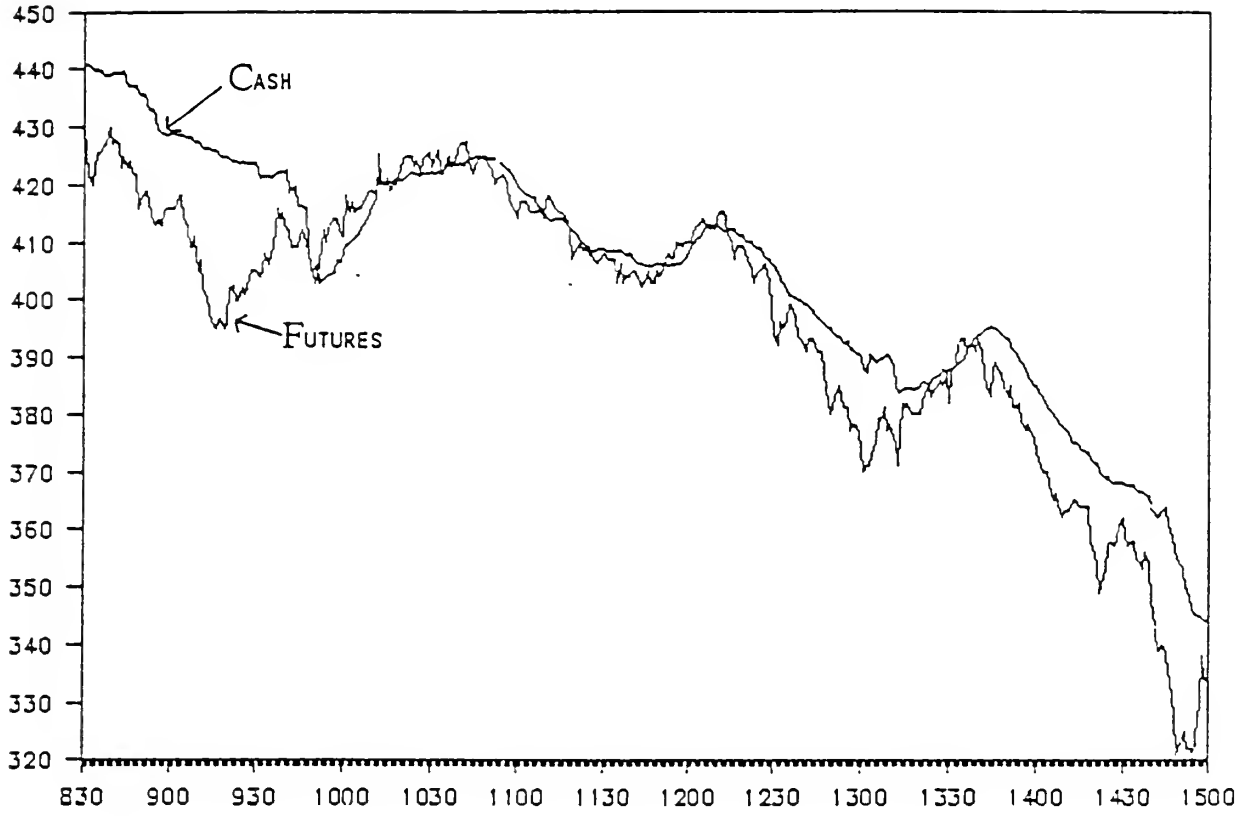


Figure 4
Example of A Large Spread
with Prices Close Together

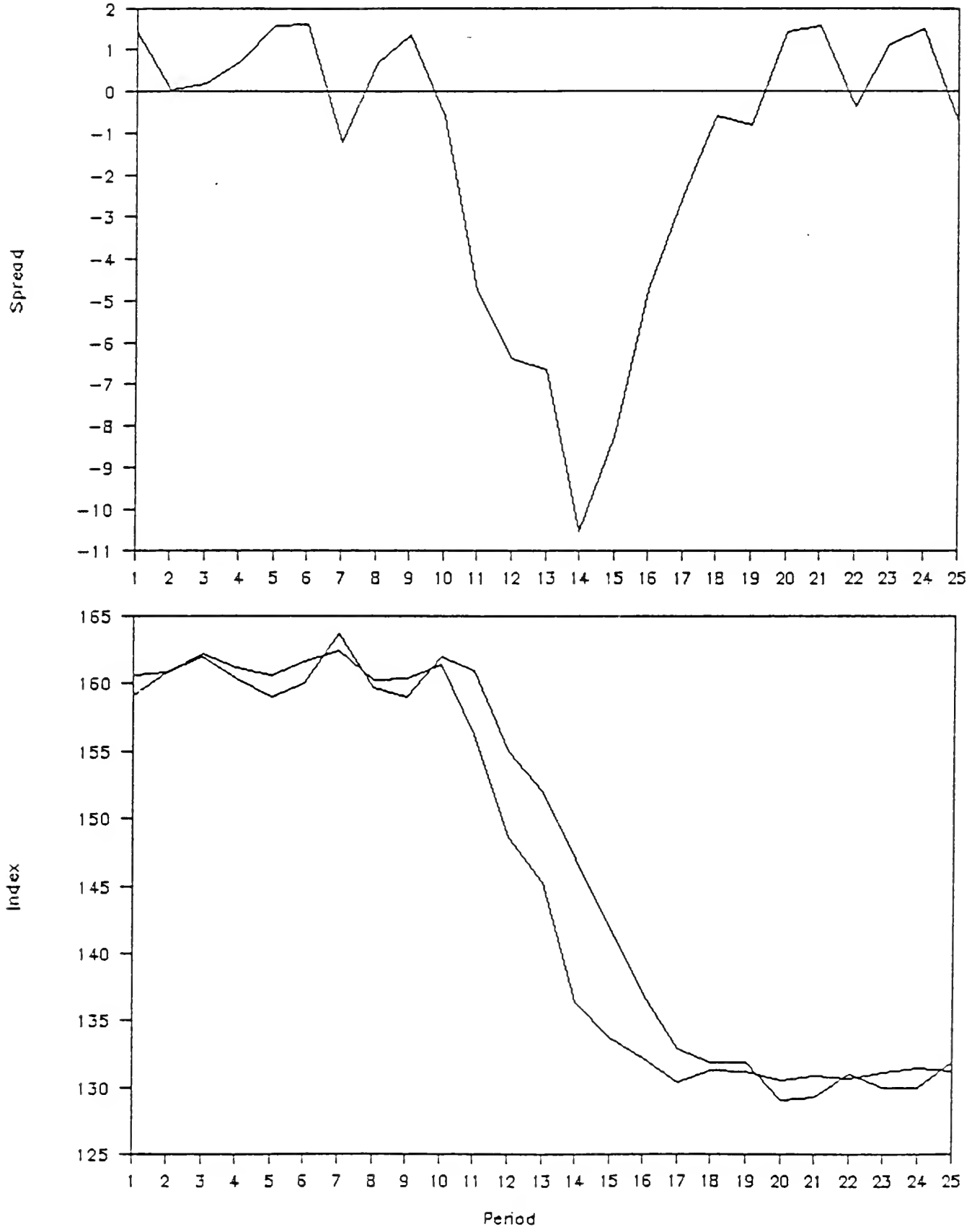
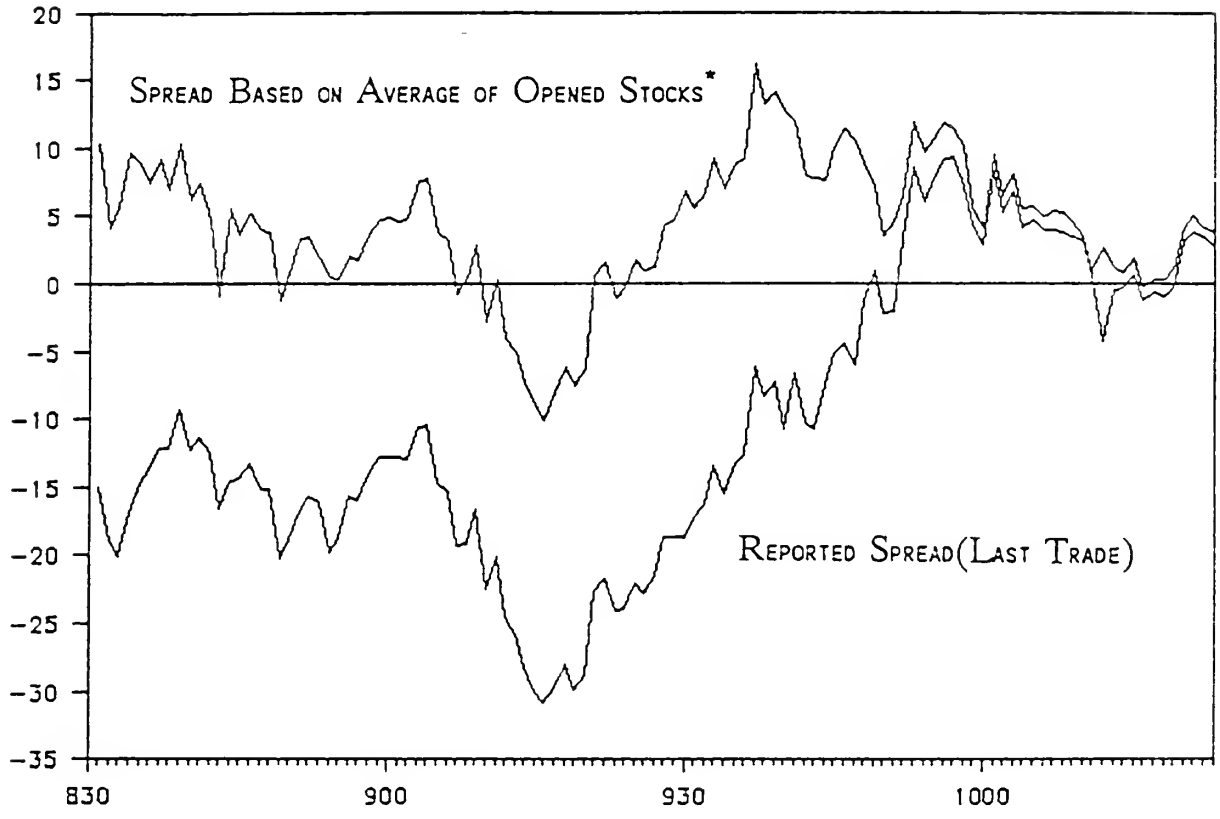
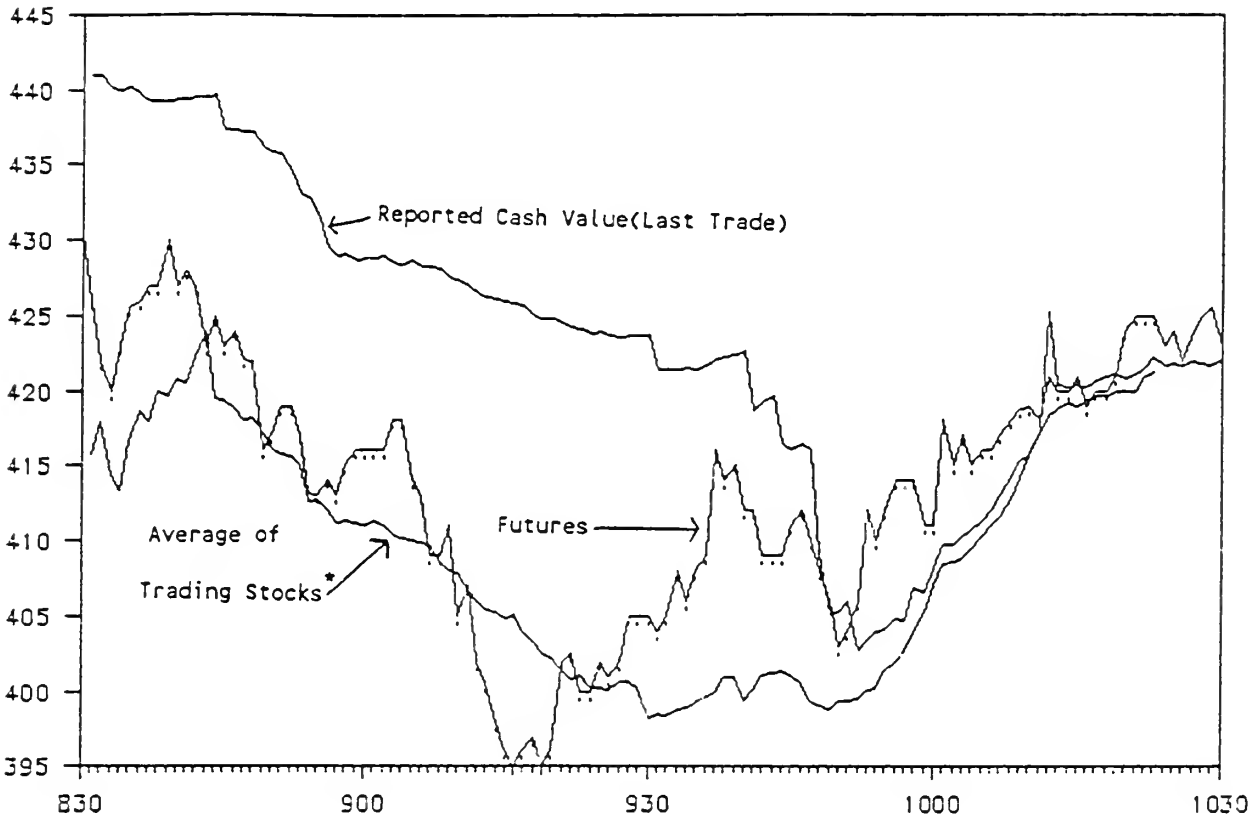


Figure 5
MMI Spread at the Open
Last Trade and Average of Trading Stocks



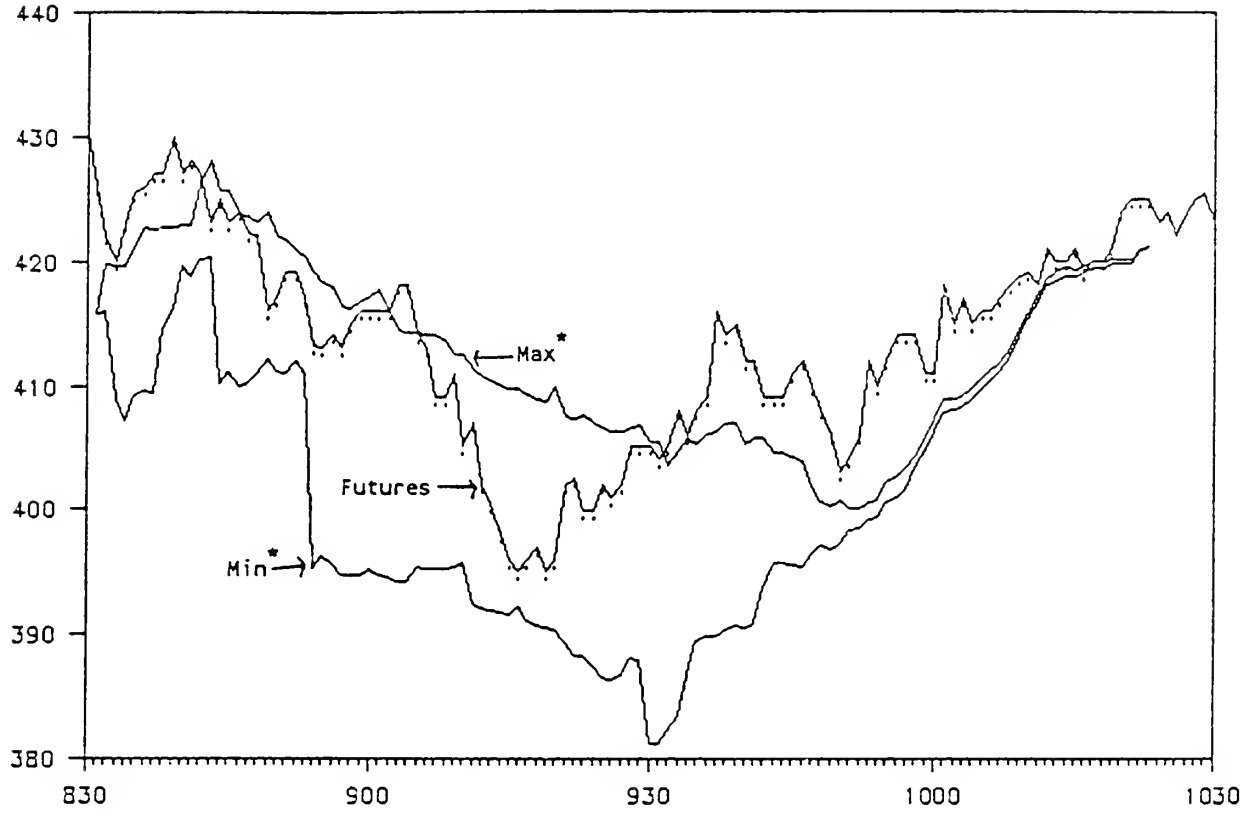
*SEE DESCRIPTION IN TEXT

Figure 6
MMI Estimated Cash Value at the Open
Using the Average of
Trading Stocks



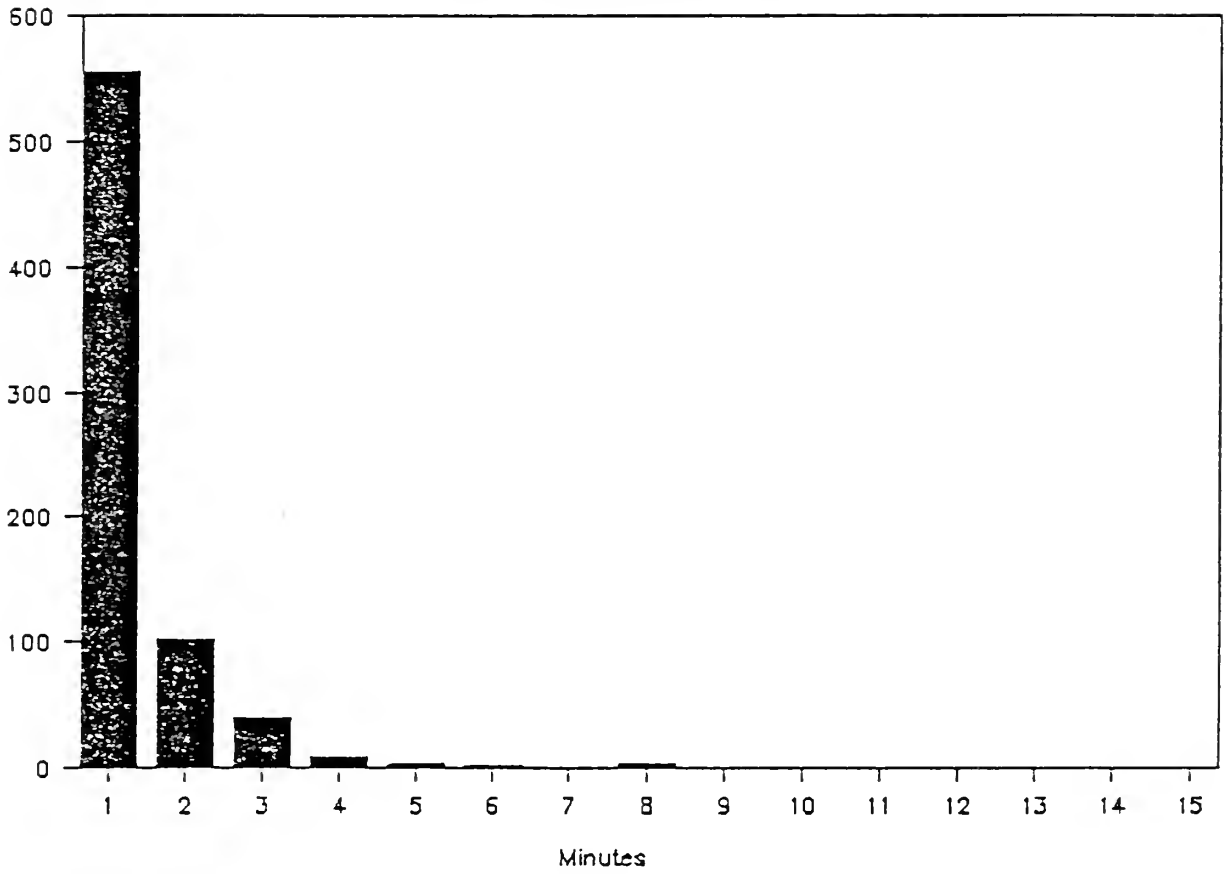
*See description in text

Figure 7
MMI Estimated Cash Value
Using the Max and Min of
Trading Stocks



*See description in text

Figure 8
Gap Length Frequency



THERE WAS ONE GAP OF 28 MINUTES

Figure 9
The Difference Between
Next and Last Trade Indices

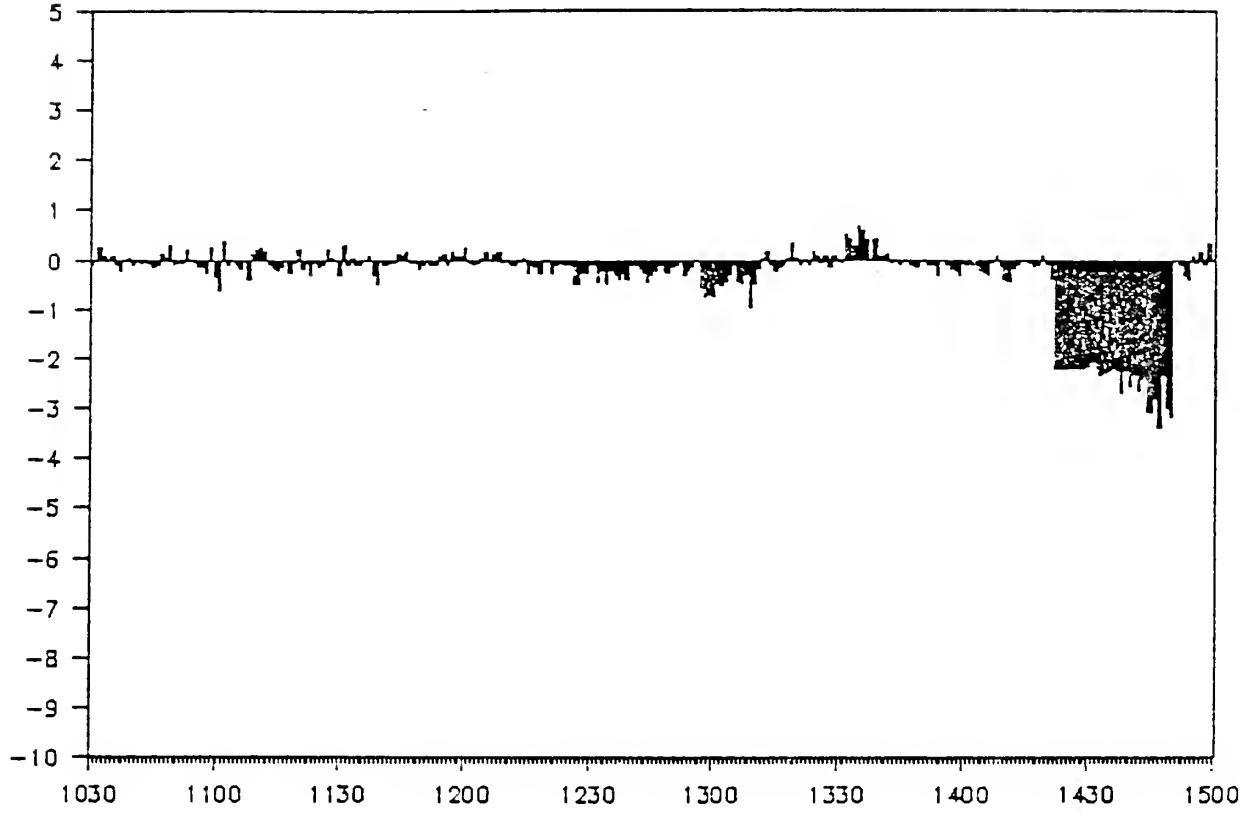


Figure 10
MMI Estimated Spread
Using Only Recent Prices of All Stocks

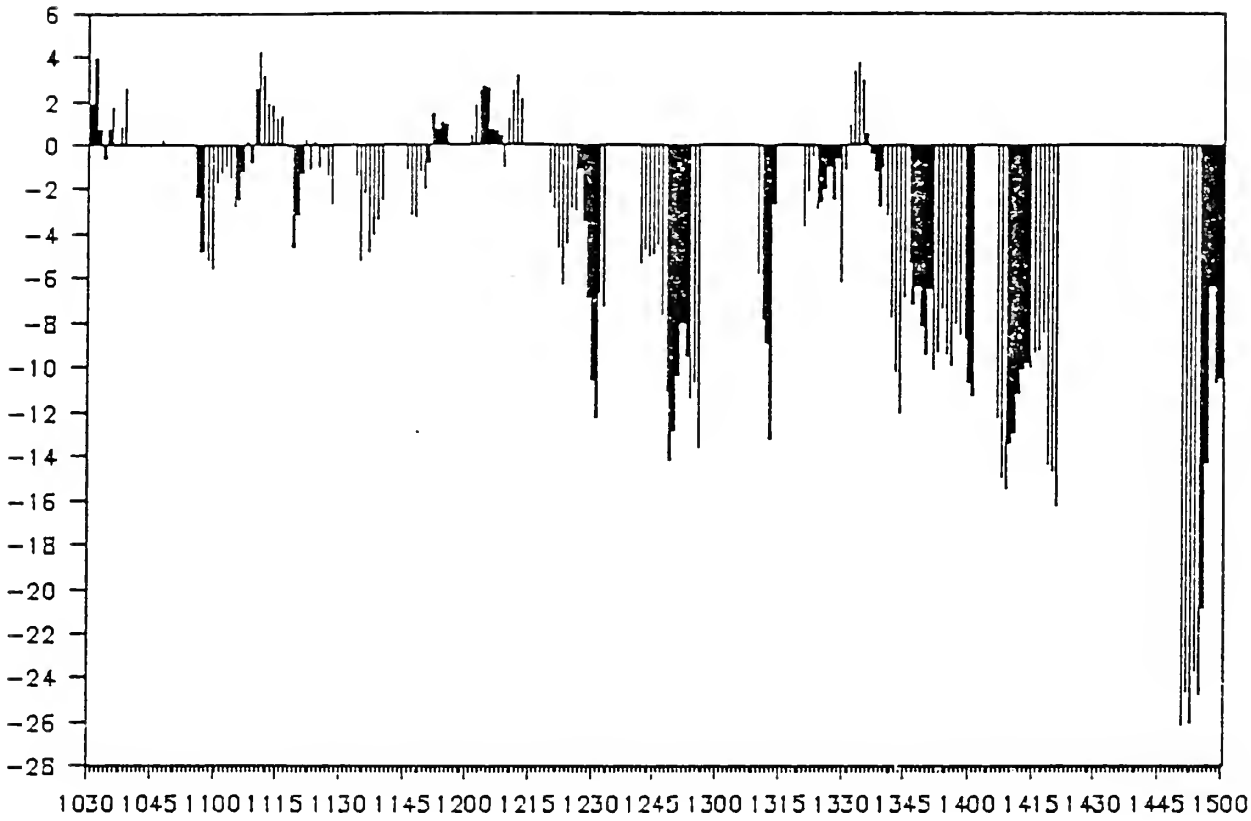


Figure 11
Window Width Spread
5 Minutes

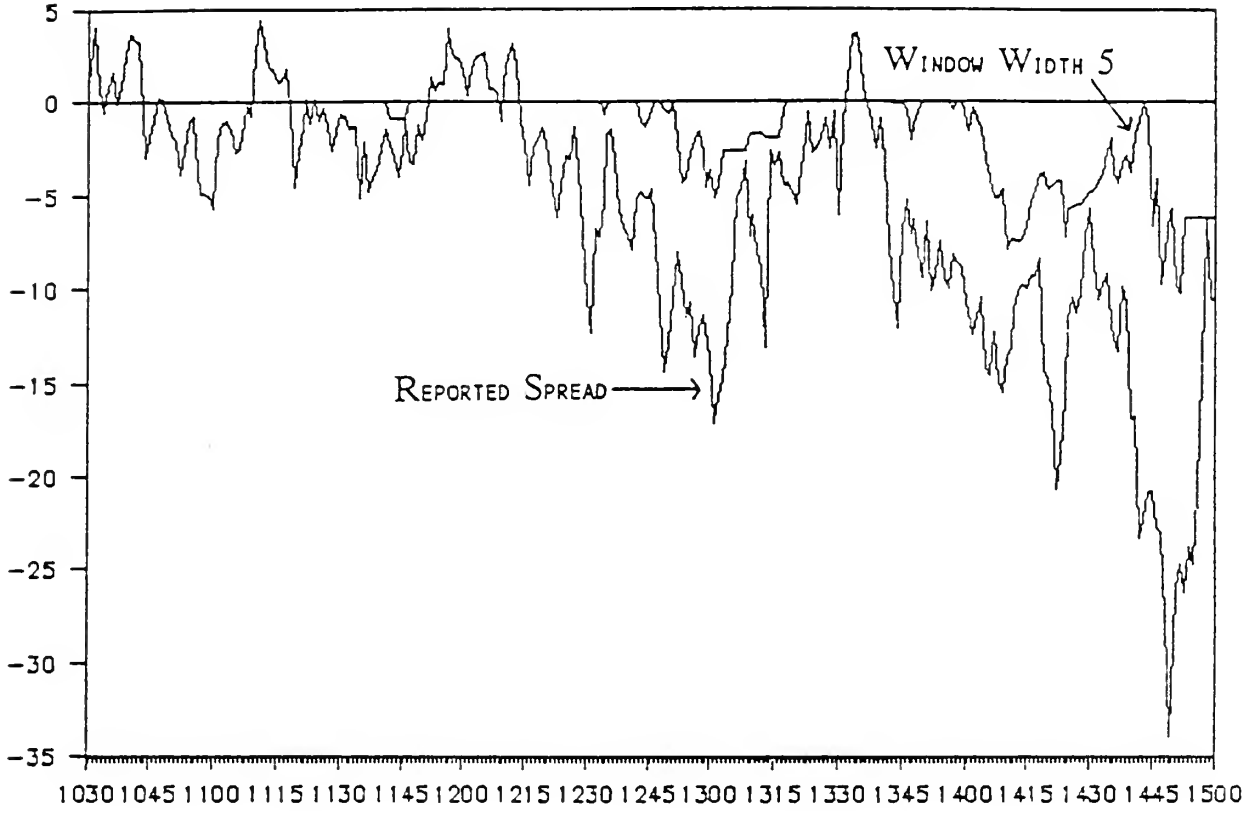


Figure 12
Window Width Spread
10 Minutes

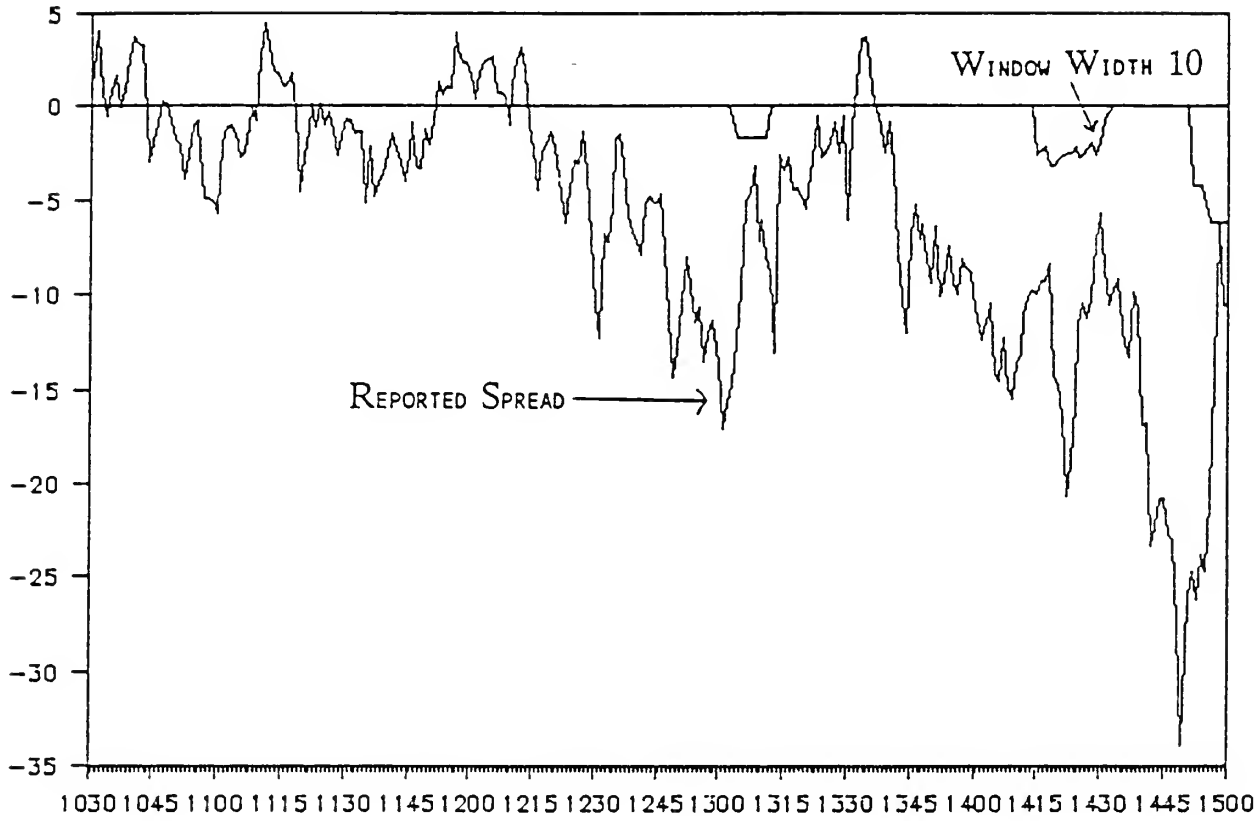


Table 1
MMI Stocks

COMPANY NAME	SYMBOL	FIRST TRADE Time-Oct19	FIRST TRADE Price-Oct19	LAST TRADE Price-Oct16
MERCK & CO	MRK	9:47	162.00	184.00
INTERN. BUS. MACH.	IBM	9:43	124.00	135.00
PHILLIP MORRIS	MO	9:48	90.00	102.63
DU PONT	DD	9:51	90.00	98.50
DOW CHEMICAL	DOW	8:48	85.50	88.00
GEN. MOTORS	GM	8:49	65.38	66.00
PROCTER & GAMBLE	PG	8:51	82.00	85.00
JOHNSON&JOHNSON	JNJ	8:52	75.00	79.00
MINNESOTA MNG&MFG	MMM	8:55	64.00	69.25
CHEVRON	CHV	8:47	47.50	49.50
MOBIL	MOB	8:32	40.88	42.75
EXXON	XON	10:23	40.00	43.50
EASTMAN KODAK	EK	9:40	76.00	92.13
GENERAL ELEC	GE	9:30	42.00	50.75
INTERN. PAPER	IP	8:44	41.00	45.75
COCA COLA	KO	8:54	36.25	39.75
SEARS ROEBUCK	S	9:58	36.88	41.00
USX	USX	8:35	32.25	34.00
AMERICAN TEL&TEL	T	8:36	28.38	30.25
AMERICAN EXPRESS	AXP	8:31	28.88	32.00

Table 2
Example

(A) Price Data

PERIOD	STOCK A	STOCK B	STOCK C	INDEX VALUE
prv.close	52	105	77	78.00
1	50	--	--	77.33
2	49	--	--	77.00
3	48	100	--	75.00
4	46	98	--	73.67
5	47	95	75	72.33
6	45	94	75	71.33

(B) Price Changes
Relative to Period Five

PERIOD	STOCK A	STOCK B	STOCK C
1	50/47	--	--
2	49/47	--	--
3	48/47	100/95	--
4	46/47	98/95	--
5	47/47	95/95	75/75

(C) Distribution of Price Changes

PERIOD	STOCK A	STOCK B	STOCK C	MIN	AVE	MAX
1	1.06	--	--	1.06	1.06	1.06
2	1.04	--	--	1.04	1.04	1.04
3	1.02	1.05	--	1.02	1.035	1.05
4	0.98	1.03	--	0.98	1.005	1.03
5	1.00	1.00	1.00			

Table 2
Continued

(C) Estimated Stock Values*

PERIOD	STOCK A	B	C
1	50	1.06*95	1.06*75
2	49	1.04*95	1.04*75
3	48	100	1.035*75
4	46	98	1.005*75
5	47	95	75

(D) Estimated Index Values*

PERIOD	STOCK A	B	C	INDEX VALUE
1	50	100.7	79.5	76.73
2	49	98.8	78	75.27
3	48	100	77.625	75.21
4	46	98	75.375	73.13
5	47	95	75	72.33
6	45	94	75	71.33

* Using the average of the price change distribution

Estimated Index Values

PERIOD	MIN	AVE	MAX	LAST TRADE
1	76.73	76.73	76.73	77.33
2	75.27	75.27	75.27	77.00
3	74.83	75.21	75.58	75.00
4	72.50	73.13	73.75	73.67
5	72.33	72.33	72.33	72.33

Table 3
Nontrading Minutes by Half Hour

TIME	MRK	IBM	MO	DOW	PG	DD	JNJ	MMM	GM	EK	GE	IP
10:30-10:59	3	0	4	4	2	4	9	6	8	3	4	2
11:00-11:29	4	0	2	2	5	7	2	6	3	3	4	7
11:30-11:59	8	1	5	8	4	7	1	4	3	1	1	9
12:00-12:29	4	0	4	4	5	5	5	5	5	3	1	7
12:30-12:59	9	2	4	4	3	10	10	5	5	4	6	1
1:00-1:29	7	1	7	7	12	11	12	7	3	15	4	5
1:30-1:59	3	0	3	3	4	10	4	8	3	2	5	3
2:00-2:30	12	1	3	6	2	8	6	1	2	3	3	2
2:30-3:00	22	2	4	3	7	5	3	2	0	8	2	5

TIME	XON	KO	CHV	MOB	S	X	T	AXP	TOTAL	PCT.
10:30-10:59	5	9	7	19	9	7	5	2	112	18.7
11:00-11:29	8	11	7	6	14	7	8	1	107	17.8
11:30-11:59	7	7	8	11	18	12	11	2	128	21.3
12:00-12:29	5	5	9	9	15	10	4	2	107	17.8
12:30-12:59	15	14	3	5	11	4	1	3	119	19.8
1:00-1:29	10	6	14	15	18	5	5	4	168	28.0
1:30-1:59	4	5	6	5	7	3	1	3	82	13.7
2:00-2:30	2	6	7	3	12	1	0	4	84	14.0
2:30-3:00	9	2	9	3	9	6	0	4	105	17.5

References

CFTC(1988a). "Analysis of Trading on the Chicago Board of Trade's Major Market Index Futures Contract on October 20, 1987", Commodity Futures Trading Commission, January 4, 1988, mimeo.

CFTC(1988b). "Final Report on Stock Index Futures and Cash Market Activity During October 1987", Commodity Trading Futures Commission, January, 1988, mimeo.

Edwards,F.R.(1988). "Studies of the 1987 Stock Market Crash: Review and Appraisal. Center for the study of Futures Markets. Working Paper CSFM-#168.

Harris,L.(1987). "Nonsynchronous Trading and the S&P 500 Stock-Futures Basis in October 1987", mimeo.

Kleidon A.W.(1988). "Arbitrage, Nontrading, and Stale Prices: October 1987", mimeo.

SEC(1988). "The October 1987 Market Break", A Report by the Division of Market Regulation U.S. Securities and Exchange Commission, February, 1988.

Stoll H.R. and R.E. Whaley(1988). The Dynamics of Stock Index and Stock Index Futures Returns, Futures and Options Research Center, Duke University, Working Paper No.88-101.