ORDER IMBALANCES AND STOCK PRICE MOVEMENTS ON OCTOBER 19 AND 20

by

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(20-88)

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I. INTRODUCTION

There is no consensus as to what caused the market crash in October of 1987. Yet, according to the Brady report, program trading, or more precisely index related trading strategies, exacerbated the decline.[1] The critics of index related strategies, particularly of index arbitrage, have not articulated the precise mechanisms through which these strategies have had an adverse effect on the markets. However, both the Brady and SEC reports associate some of the drop in the S&P index on October 19 to selling programs from both index arbitrageurs and portfolio insurers.[2]

The purpose of this paper is to provide some background analyses on the relation of volume and price movements that may prove useful in forthcoming policy debates.

Since the S&P 500 index plays a crucial role in index related trading, it seems natural to compare the trading and return characteristics of stocks that are included in the S&P Index with those that are not. Confining the analysis to stocks listed on the New York Stock Exchange and controlling for firm size, the analyses indicate that there is more volume in S&P stocks than in non-S&P stocks.

Moreover, there are substantial differences in the time series of returns for these two groups of stocks on October 19 and 20. The S&P stocks decline more on October 19 than non-S&P stocks, but this greater decline is transitory and is almost eliminated by the morning of October 20.

Since both the SEC and Brady reports emphasize the role of order imbalances and their associated price pressures in the price movements of October 19 and 20, we propose a measure of such imbalances. Over time, there is a strong relation in the aggregate between this measure and the overall returns realized by both the S&P and non-S&P stocks. Cross-sectionally, there

is also a significant relation between this measure of order imbalance for an individual security and the concurrent return realized by that security. In addition, the analysis shows that those stocks that experienced the greatest losses in the last hours of trading on October 19 experienced the greatest gains in the opening hours on October 20.

The main conclusion of this paper is that there is a strong relation between buying and selling pressure and the returns realized by the market as a whole and by individual securities. What we have not established is whether the source of the order imbalance affects the strength of the relation. We do not know whether order imbalances generated by index related trading strategies produce a stronger relation than order imbalances generated in other ways.

II. SOME PRELIMINARIES

The primary data that this study uses are transaction prices, volume, and quotations for all stocks on the New York Stock Exchange for the week of October 19. The source of these data is Bridge Data. The data base itself contains only trades and quotations from the NYSE.[3] As such, the data differ somewhat from the trades reported on the Composite tape that includes activity on regional exchanges.[4]

A. The Source of the Data

In analyzing these data, it is important to understand how Bridge Data obtains its data. For the purposes of this paper, let us begin with the Market Data System of the NYSE. This system is an automated communication system that collects all new quotations and trading information for all activity on the floor of the NYSE.

One main input to this system is mark-sense cards that exchange employees known as recorders complete and that optical card readers read. In this non-

automated process, there is always the possibility that some cards are processed out of sequence. We have no direct information on the potential magnitude of this problem; however, individuals familiar with this process have suggested to us that this problem is likely to be more pronounced in periods of heavy volume and particularly with trades that do not directly involve the specialist. Also, when there is a simultaneous change in the quote and a trade based upon the new quote, there is the possibility that the trade will be reported before the new quote.

The Market Data System then transmits the quotation data to the Consolidated Quote System and the transaction data to the Consolidated Tape System, both operated by SIAC (Securities Industry Automation Corporation). These two systems collect all the data from the NYSE and other markets. SIAC then transmits these quotes and transactions to outside vendors and to the floor of the NYSE through IGS (Information Generation System). Except for computer malfunctions, this process is almost instantaneous. Up to this point, there are no time stamps on the transmitted data. Each vendor and IGS supply their own time stamps.

Two of the vendors of importance for this study are Bridge Data and ADP. ADP calculates the S&P Composite Index, so that any errors in prices transmitted by SIAC will affect the Index.

According to the studies of the GAO and the SEC, there were on occasion substantial delays in the processing of the mark-sense cards on October 19 and 20. In addition, the SEC reports that SIAC experienced computer problems in transmitting transactions to outside vendors with the result that there were no trades reported from 1:57 p.m. to 2:06 p.m. on October 19 and from 11:47 a.m. to 11:51 a.m. on October 20.[5] According to an official at the NYSE, all trades that should have been transmitted during these two periods were sent to

outside vendors as soon as possible after the computer problems were fixed. The computer problems experienced by SIAC did not delay the transmission of transactions to IGS.

There were no reported computer problems associated with the Consolidated Quote System, and outside vendors continued to receive and transmit changes in quotes during these two periods. Since an outside vendor uses the time at which it receives a quote or transaction as its time stamp, the time stamps of quotes and transaction provided by all outside vendors are out of sequence during and slightly after these two periods. These errors in sequencing may introduce biases in our analyses of buying and selling pressure during these periods, a subject to be discussed below.

An analysis of the data from Bridge discloses that, in addition to these two time intervals, there were no trades reported from 3:41 p.m. to 3:43 p.m. on October 19 and from 3:44 p.m. to 3:45 p.m. on October 20. We have not yet been able to establish the reason for this gap.

B. The Published Standard and Poor's Index

The published Standard and Poor's Composite Index is based upon 500 stocks. Of these 500 stocks, 462 have their primary market on the NYSE, 8 have their primary market on the American Stock Exchange, and 30 are traded on NASDAQ.

The first step in calculating the index for a specific point in time is to multiply the number of shares of common stock outstanding of each company in the index by the stock price to obtain the stock's market value. The number of shares outstanding comes from a publication of Standard and Poor's (1987).[6] The share price that S&P uses is almost always the price of the last trade on the primary market, not a composite price.[7]

The next step is to sum these 500 market values, and the final step is to divide this sum by a scale factor. This factor is adjusted over time to neutralize the effect on the index of changes in either the composition of the index or in the number of shares outstanding for a particular company. The initial value of this scale factor was set so that the index value was 10.0 as of 1941-1943.

Since this study had for the most part only access to NYSE prices, the subsequent analyses approximate the S&P index using only the 462 NYSE stocks. The market value of the 38 non-NYSE stocks as of the close on October 16 equals only 0.3 percent of the total market value of the index, so that this approximation might be expected to be quite accurate. Indeed, some direct calculations[8] and some of the subsequent analyses are consistent with this expectation.

In some of the subsequent analyses, the 462 NYSE stocks are partitioned into four size quartiles of roughly an equal number of companies each, based upon market values on October 16. The largest quartile contains 116 companies with market values in excess of 4.6 billion; the second largest quartile contains 115 companies with market values between 2.2 and 4.6 billion; the third contains 116 companies with values between 1.0 billion and 2.2 billion; and the fourth contains 115 companies with market values between 65.4 million and 1.0 billion.

In comparisons of companies included in the S&P with companies not included in the S&P, we exclude the 178 non-S&P companies with market values of less than 65.4 million--the smallest company listed in the S&P.[9] The remaining 929 companies are classified by the same break points as the quartiles of the S&P. This classification results in 16 non-S&P companies with assets in excess of 4.6 billion, 27 companies corresponding to the second

largest quartile of S&P stocks, 100 companies for the next S&P quartile, and 786 companies for the smallest S&P quartile.

III. TRADING VOLUME

In view of the emphasis placed upon index related strategies, the analysis in this section compares the trading volume of S&P stocks to that of non-S&P stocks. Since there is substantial range in the market value of these stocks, it is important to control for this variable in this comparison.

The first comparison attempts to hold market value constant by summing for each 15-minute interval the total dollar volume of all the 462 S&P stocks listed on the NYSE and dividing this sum by the total market value of these stocks. The estimate of the market value for each fifteen-minute interval is the closing value on Friday, October 16, adjusted for general market movements to the beginning of each 15-minute period. The same calculations are performed for the non-S&P stocks. The indexes used in making these adjustments are described in the Appendix.[10]

In every 15-minute interval on October 19 and 20, the dollar trading volume as a percent of outstanding is greater for the S&P stocks than for the non-S&P stocks (Figure 1). In addition, there is substantially greater volatility in the trading volume for the S&P stocks.

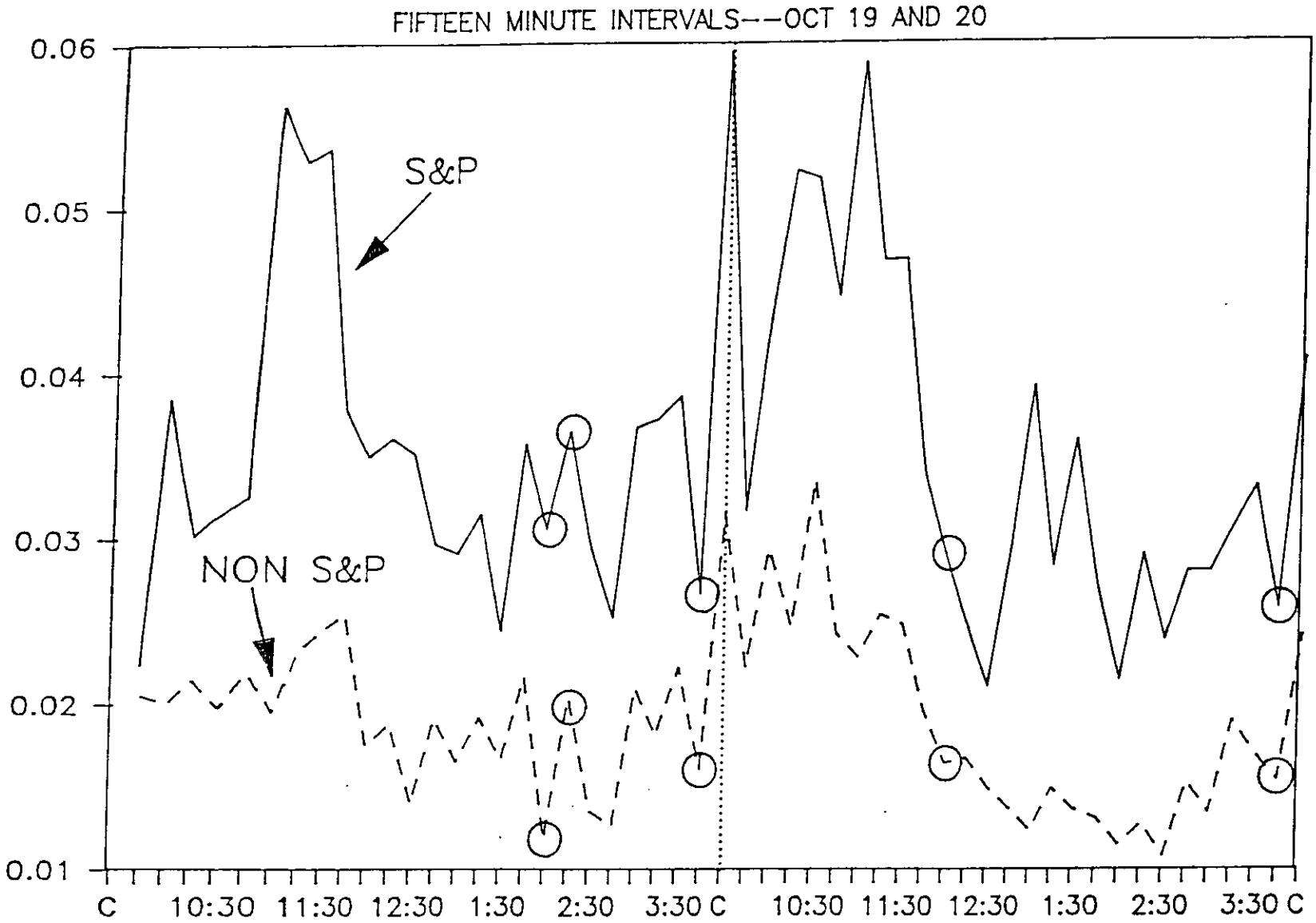
Another analysis regressed for each half hour t the half-hour trading volume of stock i, V_{it}, on the market value of stock i, M_{it}. Specifically,

$$\ln(V_{it}) = a_t + b_t \ln(M_{it}) + e_{it} , \qquad i = 1,2, \ldots ,N_t ,$$

where e_{it} is assumed to be a mean-zero disturbance term and N_t is the number of stocks included in the t^{th} interval.[11]

Over October 19 and 20, the coefficients b_t are remarkably stationary and range from 0.94 to 1.14 for S&P stocks and from 0.61 to 0.82 for non-S&P

DOLLAR VOLUME AS PERCENT OF OUTSTANDING



NOTE: Circled points indicate less reliable data--cf. text

FIGURE 1

TABLE 1

S&P 500 Stocks
Cross-sectional Regression of Logarithm of
Dollar Volume on Logarithm of Market Value
By Half Hour Intervals

Time Interval	Intercept			Slope			R^2
	value	t	z	value	t	z	
Monday							
Oct 19							
9:30-10:00	2.61	8.99	9.27	0.94	24.61	25.85	0.65
10:00-10:30	1.93	6.91	7.39	0.98	26.93	29.84	0.70
10:30-11:00	1.92	7.60	6.55	0.98	29.56	26.45	0.70
11:00-11:30	1.23	5.06	5.43	1.08	34.55	37.31	0.75
11:30-12:00	0.99	3.71	3.90	1.08	31.37	34.07	0.70
12:00-12:30	1.44	6.79	6.80	1.04	37.97	39.77	0.77
12:30- 1:00	1.69	7.86	7.79	0.98	35.45	36.65	0.74
1:00- 1:30	0.64	3.00	2.45	1.09	39.80	33.90	0.78
1:30- 2:00	0.94	4.18	3.76	1.09	37.48	35.53	0.76
2:00- 2:30	1.46	4.95	5.13	1.00	26.43	28.49	0.62
2:30- 3:00	0.88	3.42	3.19	1.06	32.22	31.20	0.70
3:00- 3:30	1.44	5.39	4.87	1.02	29.86	27.94	0.67
3:30- 4:00	1.86	7.01	6.39	0.99	29.12	27.55	0.67
Average	1.46	4.94	5.61	1.03	28.89	31.89	0.71
Tuesday							
Oct 20							
9:30-10:00	1.78	6.09	5.93	1.04	26.98	27.32	0.67
10:00-10:30	1.10	3.10	2.94	1.09	23.58	23.27	0.61
10:30-11:00	0.67	2.07	1.85	1.14	27.13	25.46	0.64
11:00-11:30	1.46	5.73	6.29	1.05	31.85	35.99	0.71
11:30-12:00	1.11	3.18	2.92	1.04	22.99	21.74	0.59
12:00-12:30	1.64	4.60	4.48	0.94	20.44	20.48	0.55
12:30- 1:00	1.17	3.28	3.62	1.02	22.14	24.97	0.59
1:00- 1:30	0.57	1.59	1.69	1.07	23.38	25.65	0.60
1:30- 2:00	0.71	2.47	2.62	1.04	28.65	31.50	0.68
2:00- 2:30	1.01	3.45	3.75	0.99	26.53	29.48	0.64
2:30- 3:00	0.56	1.81	1.73	1.06	27.06	26.42	0.64
3:00- 3:30	0.10	0.27	0.28	1.13	25.24	26.08	0.61
3:30- 4:00	1.04	3.05	3.47	1.04	23.90	28.03	0.57
Average	0.99	3.13	3.20	1.05	25.37	26.64	0.62

Notes: t denotes the OLS t-statsitic for the null hypothesis that the regression parameter is zero.

z denotes a heteroscedasticity consistent z-statistic for the null hypothesis that the regression parameter is zero. This statistic is calculated using the technique of White [Econometrica (1980)].

For the regression dollar volume is expressed in hundreds of dollars and market value is expressed in millions of dollars.

TABLE 2

Non-S&P Stocks
Cross-sectional Regression of Logarithm of
Dollar Volume on Logarithm of Market Value
By Half Hour Intervals

Time Interval	Intercept			Slope			R^2
	value	t	z	value	t	z	
Monday							
Oct 19							
9:30-10:00	3.15	13.33	10.43	0.77	19.01	14.62	0.37
10:00-10:30	2.70	8.90	7.29	0.75	14.69	11.85	0.30
10:30-11:00	3.03	11.31	9.41	0.69	15.49	12.57	0.29
11:00-11:30	2.77	10.91	9.12	0.73	17.23	13.79	0.32
11:30-12:00	2.42	8.22	6.73	0.76	15.55	12.36	0.30
12:00-12:30	2.78	9.07	7.63	0.68	13.47	10.91	0.25
12:30- 1:00	2.58	8.81	7.08	0.71	14.67	11.44	0.28
1:00- 1:30	2.05	6.02	5.02	0.74	13.16	10.48	0.27
1:30- 2:00	2.14	5.93	5.40	0.77	13.05	11.55	0.27
2:00- 2:30	2.39	7.21	5.74	0.76	13.99	10.77	0.28
2:30- 3:00	2.24	7.46	6.59	0.75	15.11	12.80	0.29
3:00- 3:30	3.02	10.15	8.87	0.67	13.56	11.56	0.25
3:30- 4:00	3.15	12.17	8.31	0.69	15.87	10.45	0.27
Average	2.65	8.51	7.51	0.73	14.99	11.93	0.29
Tuesday							
Oct 20							
9:30-10:00	3.57	15.59	10.38	0.68	17.63	11.17	0.31
10:00-10:30	2.61	9.33	7.28	0.77	16.48	12.34	0.32
10:30-11:00	2.36	8.56	6.55	0.80	17.47	12.92	0.33
11:00-11:30	2.28	7.92	7.34	0.82	17.23	15.44	0.33
11:30-12:00	3.50	12.99	10.83	0.61	13.61	10.91	0.24
12:00-12:30	2.68	9.90	8.14	0.72	15.80	12.85	0.30
12:30- 1:00	2.61	9.37	7.74	0.71	15.02	12.14	0.28
1:00- 1:30	2.33	7.82	7.70	0.73	14.44	14.32	0.27
1:30- 2:00	2.92	9.19	8.17	0.59	11.27	9.62	0.21
2:00- 2:30	2.43	7.66	7.25	0.67	12.97	12.04	0.27
2:30- 3:00	2.39	7.57	6.32	0.71	13.55	11.17	0.27
3:00- 3:30	2.21	7.18	6.29	0.76	15.03	12.90	0.30
3:30- 4:00	2.60	9.21	7.18	0.72	15.28	11.48	0.27
Average	2.65	9.41	7.78	0.71	15.06	12.25	0.28

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For the regression dollar volume is expressed in hundreds of dollars and market value is expressed in millions of dollars.

stocks (Tables 1 and 2). The intercepts vary from one period to the next as the average volume changes. Over the range of values of M_{it}, the regression line for the S&P stocks for any specific half hour is always above the regression line for the non-S&P stocks. In all intervals, for both the S&P stocks and non-S&P stocks, the relation of volume to size is highly significant as indicated by the large t-statistics and large (heteroscedasticity consistent) z-statistics.

IV. THE CONSTRUCTED INDEXES

Indexes, such as the S&P 500, utilize the price of the last trade in calculating market values. In a rapidly changing market, some of these past prices may be stale or old in that they no longer reflect current conditions. This problem is particularly acute for stocks that have not yet opened in which case the index is based upon the closing price of some prior day. As a result of such stale prices, the published S&P index may underestimate losses in a falling market and underestimate gains in a rising market. The appendix describes an approach to remove these biases by constructing indexes that utilize only prices from stocks that have traded in the prior fifteen minutes. After the first hour or so of trading each day, the analysis in the appendix indicates that this approach successfully eliminates the bias from stale prices.

Before describing in detail the approach used in this study to reduce the biases caused by stale prices, we present two of our constructed indexes that point to substantial differences in the returns realized by S&P and non-S&P stocks on October 19 and 20 (Figure 2). Both of these indexes have been standardized to 1.0 at the close of October 16.

To eliminate any confusion, we shall always refer to the index published by S&P as the published index. Without any qualifier, the term "S&P index"

INDEXES OF S&P AND NON-S&P STOCKS

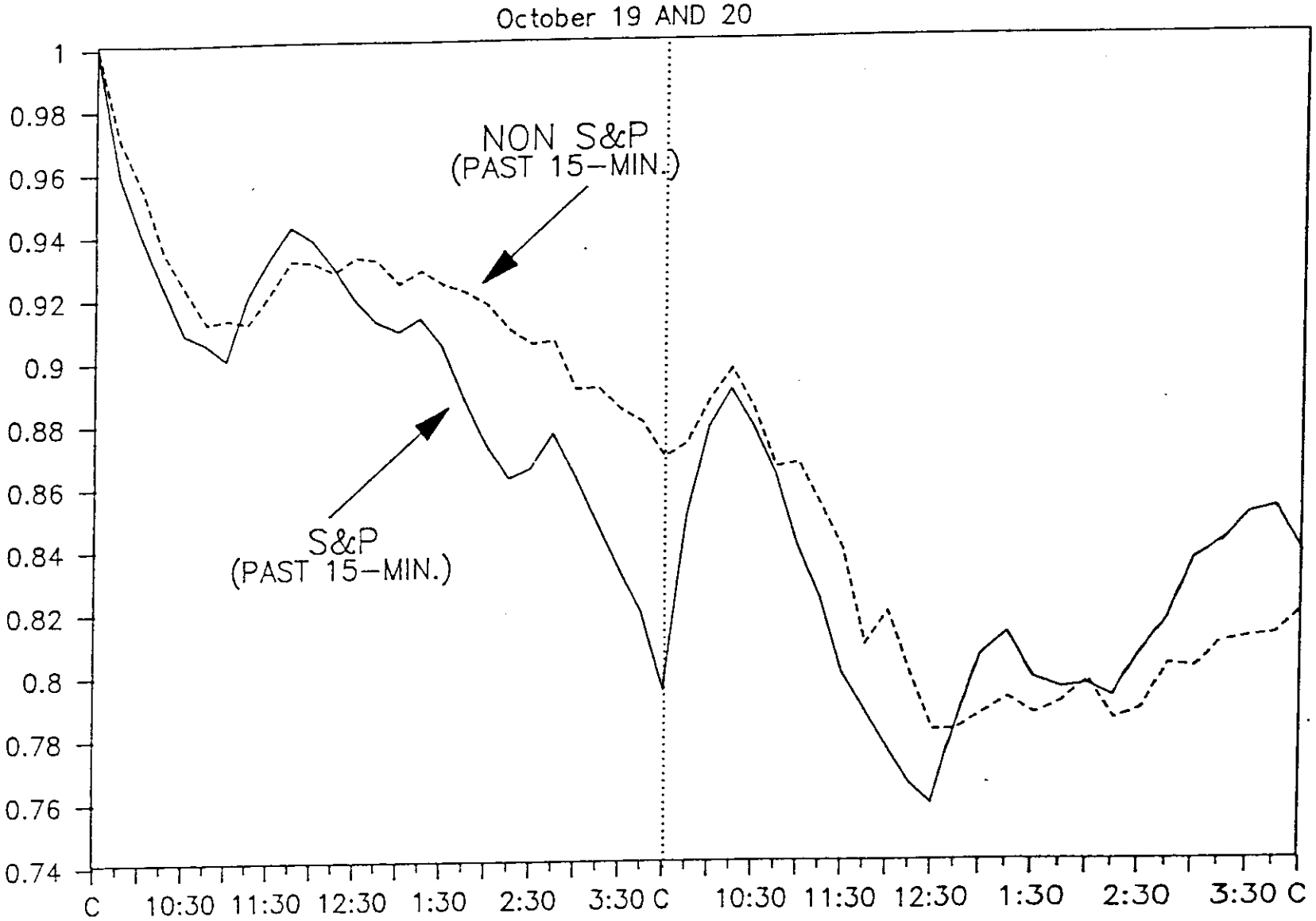


FIGURE 2

will refer to the calculated S&P index as shown in Figure 2.

On October 19, the S&P index dropped 20.5 percent. By the morning of Tuesday, October 20, the S&P index had recaptured a significant portion of this loss. Thereafter, the S&P index fell but closed with a positive gain for the day. In contrast, the non-S&P index declined steadily over the two-day period. The magnitude of the non-S&P index reversal is smaller than that of the S&P stocks.

Of particular note, the recovery of the S&P stocks on Tuesday morning brought the S&P index almost in line with the non-S&P index. One possible interpretation of this recovery is that there was considerably greater selling pressure on S&P stocks on October 19 than on non-S&P stocks. This selling pressure pushed prices of S&P stocks down further than warranted, and the recovery in the opening prices of S&P stocks on October 20 corrected this unwarranted decline.

In contrast, the Brady report suggests that some opening prices set by specialists on October 20 "may have been overly optimistic." Although the Brady report does not explicitly make this accusation, the report does contain an example that shows how a specialist with a large inventory of stock accumulated on Monday might benefit from setting the opening price too high on Tuesday and selling overpriced stock to the public.[12]

V. BUYING AND SELLING PRESSURE

In the last section, a comparison of the indexes for S&P and non-S&P stocks indicates that the prices of S&P stocks declined 6.4 percentage points more than the prices of non-S&P stocks on October 19. By the morning of October 20, the prices of S&P stocks had bounced back nearly to the level of non-S&P stocks.

This greater decline in S&P stocks and subsequent reversal is consistent with the hypothesis that there was greater selling and trading pressure on S&P stocks than on non-S&P stocks on Monday afternoon. But it is also consistent with other hypotheses such as the presence of a specific factor related to S&P stocks alone. Such a factor might be related to index arbitrage.

This section begins with the definition of a statistic to measure buying and selling pressure, or in short, order imbalance. At the aggregate level, there is a strong correlation between this measure of order imbalance and the return on the index. At the security level, there is significant correlation between the order imbalance for an individual security and its returns. Finally, the paper finds that those stocks that fell the most on October 19 experienced the greatest recovery on October 20. This finding applies to both S&P and non-S&P stocks.

A. A Measure of Order Imbalance

The measure of order imbalance that this study uses is the dollar volume at the ask price over an interval of time less the dollar volume at the bid price over the same interval. Implicit in this measure is the assumption that trades between the bid and the ask price generate neither buying nor selling pressure. A positive value for this measure indicates net buying pressure, and a negative value net selling pressure.

In estimating this measure of order imbalance, it is important to keep in mind some of the limitations of the data available to this study. As already mentioned, the procedures for recording changes in quotations and for reporting transactions do not always guarantee that the time sequence of these records is correct. Sometimes, when there is a change in the quotes and an almost immediate transaction, the transaction is recorded before the change in the offer prices and sometimes after. Although orders matched in the crowd

should be recorded immediately, they sometimes are not.[13] Finally, there are outright errors.[14]

In an attempt to cope with these potential problems, the estimate of the order imbalance uses the following algorithm: Let t be the minute in which a transaction occurs.[15] Let t_p be the minute which contains the nearest prior quote. If the transaction price is between the bid and the ask of this prior quote, the transaction is treated as a cross and not included in the estimate of the order imbalance. If the transaction price is at the bid, the dollar value of the transaction is classified as a sale. If the price is at the ask, the dollar value of the transaction is classified as a buy. A quote that passes one of these three tests is termed an acceptable quote.

If the quote is not acceptable, the transaction price is then compared in reverse chronological order to prior quotations, if any, in t_p to find an acceptable quote. If an acceptable quote is found, the quote is used to classify the trade as a buy, cross, or sell. If no acceptable quote is found, the quotes in minute t following the trade are examined in chronological order to find an acceptable quote to classify the trade. If no acceptable quote is found, the minute $(t_p - 1)$ is searched in reverse chronological order. If still no quote is found, the minute $(t + 1)$ is searched. This process is repeated again and again until minutes $(t_p - 4)$ and $(t + 4)$ are searched. If finally there are no acceptable quotes, the transaction is dropped.

On October 19, 82.8 percent of trades in terms of share volume[16] match with the immediately previous quote and 9.5 percent with a following quote in minute t. There are no acceptable quotes for 1.5 percent of the trades. Crosses represent 40.7 percent of the share volume. The corresponding percentages for October 20 are respectively: 81.6 percent, 12.3 percent, 1.6 percent, and 42.4 percent.

This estimate of order imbalance obviously contains some measurement error, caused by misclassification.[17] Despite the possibility of measurement error, this estimate of order imbalance does have substantial explanatory power. Nonetheless, in interpreting the following empirical results, the reader should bear in mind the potential biases that these measurement errors might introduce.

B. Time-series Results

In the aggregate, there is a strong positive relation between the 15-minute returns for the S&P stocks and the aggregate net buying and selling pressure (Figures 3 and 4). For October 19, the correlation is 0.71 and for October 20, 0.75. The relations for non-S&P stocks are somewhat weaker, but still positive (Figures 5 and 6).

The estimate of the returns for any 15-minute interval is the ratio of the value of the constructed S&P index at the end of the interval to the value at the end of the prior interval. The aggregate order imbalance is the sum of the order imbalances of the individual securities within the 15-minute interval.

These results are consistent with an inventory model in which specialists reduce their bid prices when their inventory increases and raise their ask prices when their inventories decrease. It should be noted that this phenomenon occurs in the aggregate for both S&P stocks and non-S&P stocks. The next part of this section shows that the same phenomenon occurs with individual securities, namely the returns of those securities with more selling pressure decline more than with less. The reverse holds with buying pressure.

S&P ORDER IMBALANCE VS 15-MIN RETURNS

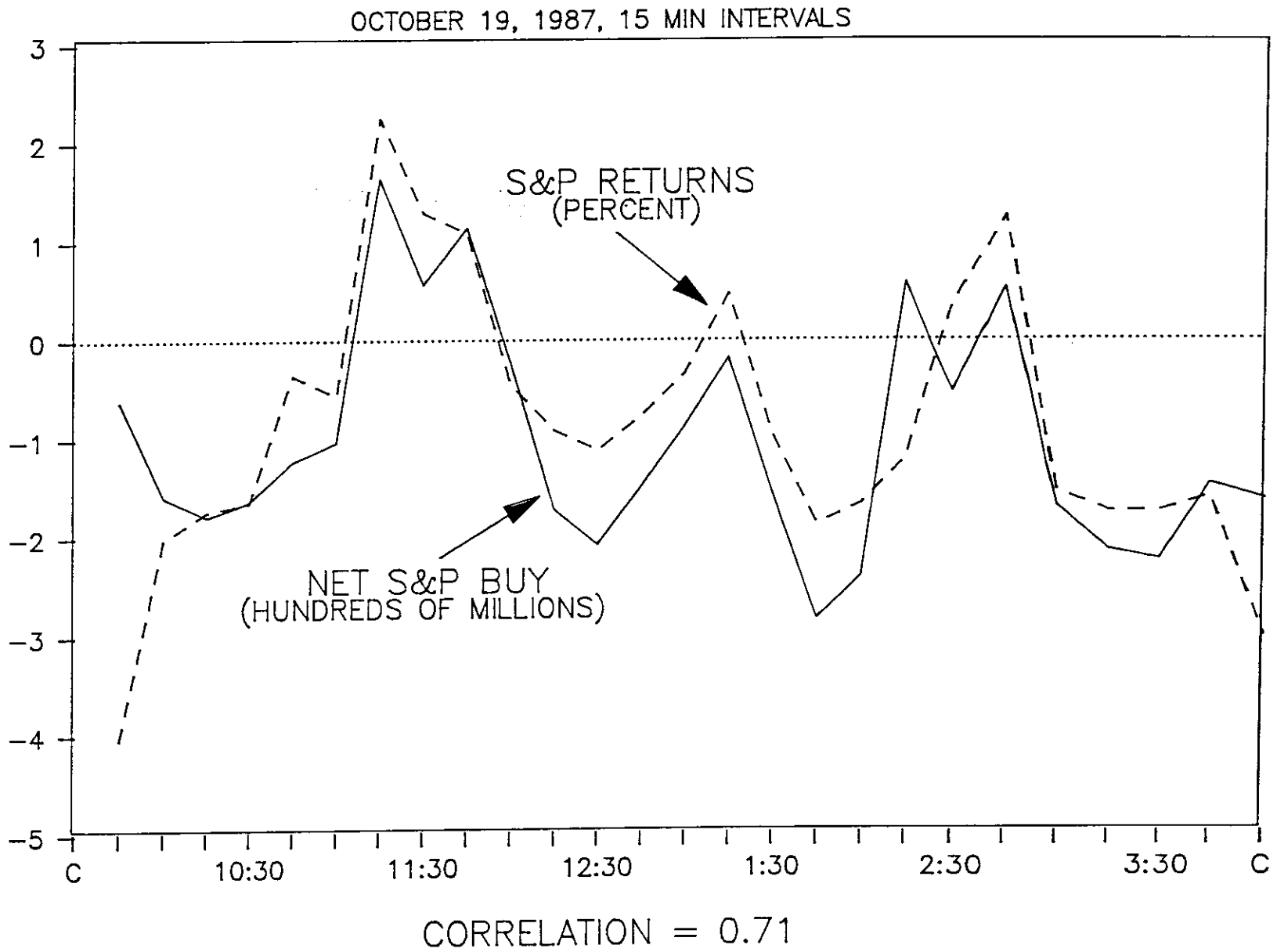


FIGURE 3

S&P ORDER IMBALANCE VS 15-MIN RETURNS

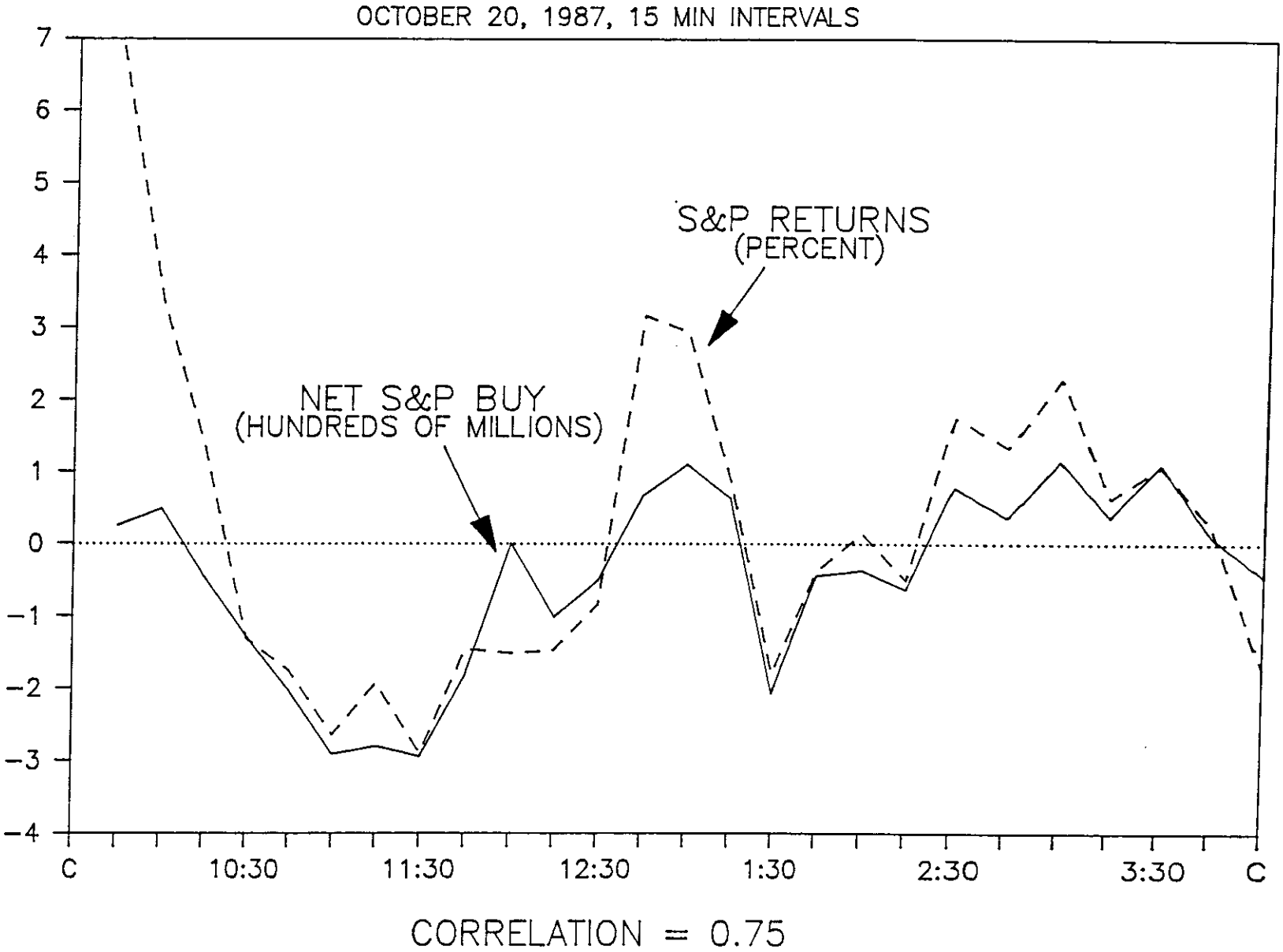


FIGURE 4

NON S&P ORDER IMBALANCE VS 15-MIN RETURNS

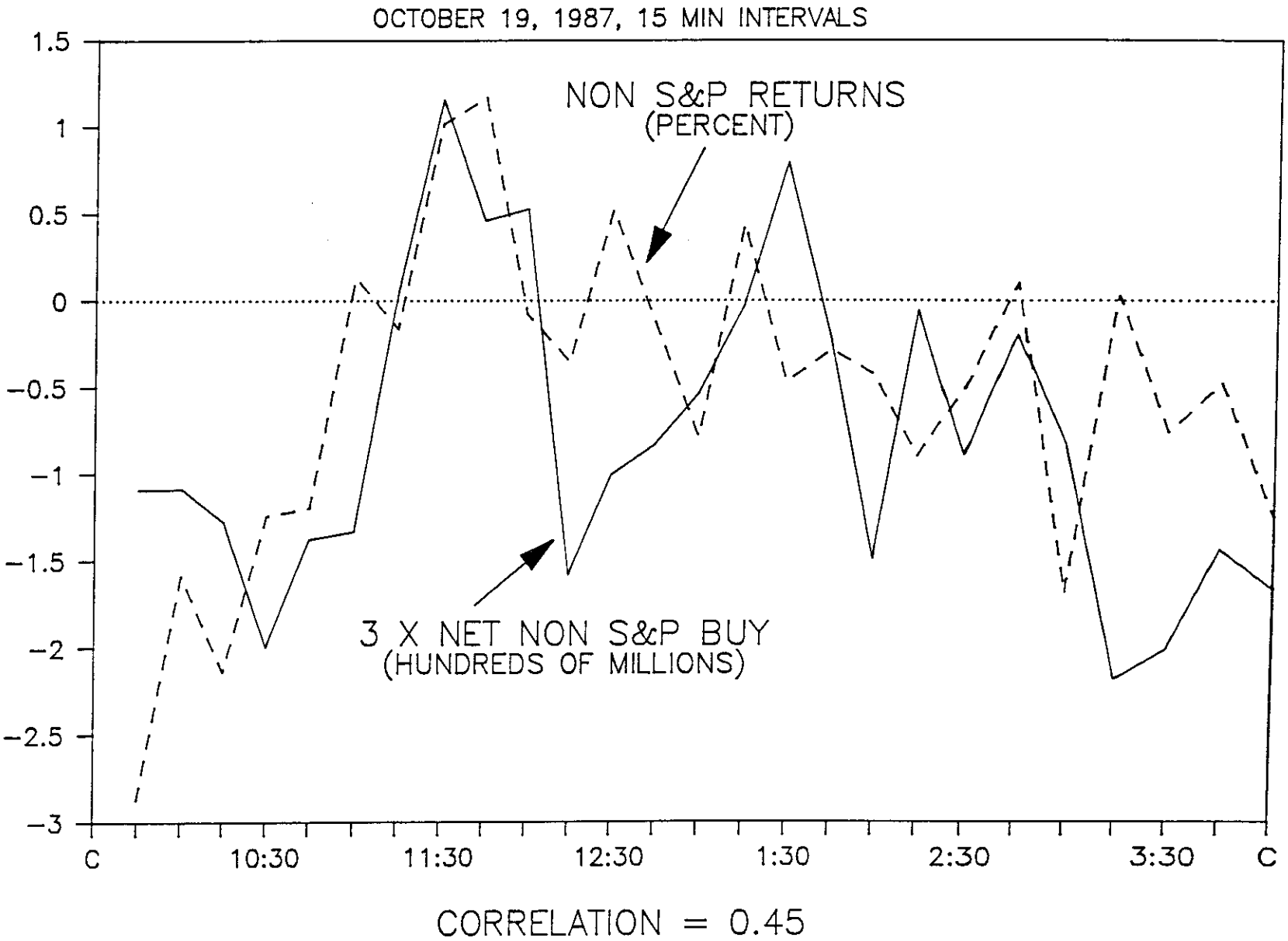
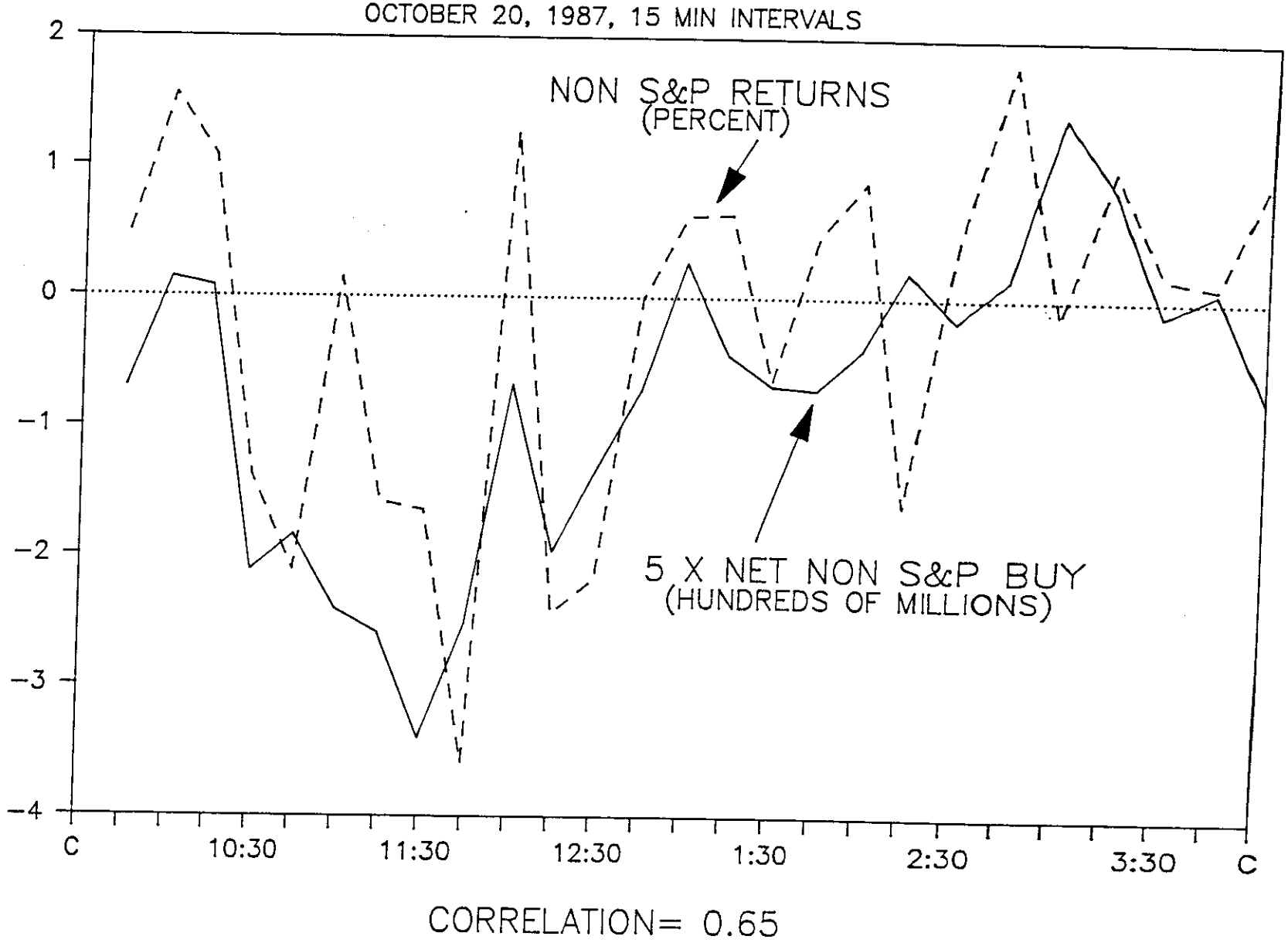


FIGURE 5

NON S&P ORDER IMBALANCE VS 15-MIN RETURNS



CORRELATION= 0.65

FIGURE 6

C. Cross-sectional Results

The aggregate time series analysis indicates a strong relation between order imbalance and stock returns. This finding, however, provides no guarantee that there will be any relation between the realized returns of individual securities and some measure of their order imbalances in any cross-section. In the extreme, if all trading is due to index related strategies and these strategies buy or sell all stocks in the index in market proportions, all stocks would be subject to the same buying or selling pressure. As a result, there would be no differential effects in a cross-section.

Let us for a moment continue to assume that all trading is due to index related strategies, but let us assume that these strategies buy or sell subsets of the stocks in the index and not necessarily in market proportions. Even in this case, it is theoretically possible that there would be no cross-sectional relations if, for instance, all stocks were perfect substitutes at all times.

As a result, finding no relation between realized returns and order imbalances in a cross-section of securities does not preclude a time series relation. Finding a relation in a cross-section indicates that, quite apart from any aggregate buying and selling pressure, the relative amount of buying and selling pressure is related to individual returns.

With this preamble, let us turn to the cross-sectional analysis. To begin, the trading hours of October 19 and October 20 are divided into half-hour intervals. The sample for a given half hour includes all securities that traded in the 15 minutes prior to the beginning of the interval and in the 15 minutes prior to the end of the interval. For each security, the order imbalance includes all trades following the last trade in the prior 15 minutes

through and including the last trade in the half-hour interval. The return for each security is measured over the same interval as the trading imbalance. To control for size, the order imbalance for each security is deflated by its market value as of October 16 to yield a normalized order imbalance (NOI).

The analysis of the cross-sectional relation uses two approaches. The first utilizes the rank order correlation coefficients and the second utilizes regression analysis.

The nonparametric rank (or Spearman) correlation coefficient does not require specific distributional assumptions. Further, it does not assume linearity, only monotonicity. For the S&P stocks, the rank correlation coefficient estimates are uniformly positive for the half hour intervals on Monday and Tuesday (Table 3). All the estimates, which range from 0.05 to 0.56, are statistically significant at the 5 percent level with the exception of the 2:00 to 2:30 interval on Monday afternoon, during part of which the SIAC system was inoperable. The rank order correlations for the non-S&P stocks are similar to those of the S&P stocks. The estimates range from 0.09 to 0.56. These rank correlations provide support for the hypothesis that there is a positive cross-sectional relation between the return and normalized order imbalance.

The regression analysis is preliminary in nature.[18] Since using 30 minute intervals, the order imbalance may be partly endogenous if the returns in the first part of any 30 minute interval lead to further imbalances in the same interval. Thus, the results should be interpreted with caution. Specifically, the simultaneity problem will lead to inconsistent estimators of the parameters using least-squares. However, since the results are very

TABLE 3

Cross-sectional Rank Correlation Results
Individual Security Return vs Normalized Order Imbalance
By Half Hour Intervals

Time Interval	S&P 500 Stocks		Non-S&P Stocks	
	rank correlation	# stocks	rank correlation	# stocks
Monday				
Oct 19				
9:30-10:00	0.25	316	0.16	615
10:00-10:30	0.33	308	0.38	508
10:30-11:00	0.30	362	0.35	573
11:00-11:30	0.49	393	0.55	609
11:30-12:00	0.56	413	0.56	559
12:00-12:30	0.50	425	0.51	536
12:30- 1:00	0.31	431	0.49	538
1:00- 1:30	0.37	428	0.45	463
1:30- 2:00	0.34	430	0.40	459
2:00- 2:30	0.05	424	0.09	510
2:30- 3:00	0.38	429	0.44	544
3:00- 3:30	0.23	427	0.40	554
3:30- 4:00	0.23	409	0.40	668
Average	0.33		0.40	
Tuesday				
Oct 20				
9:30-10:00	0.24	358	0.25	668
10:00-10:30	0.53	344	0.54	570
10:30-11:00	0.54	404	0.44	604
11:00-11:30	0.31	406	0.45	585
11:30-12:00	0.23	364	0.23	588
12:00-12:30	0.30	342	0.39	575
12:30- 1:00	0.51	340	0.50	573
1:00- 1:30	0.41	360	0.41	553
1:30- 2:00	0.36	379	0.48	464
2:00- 2:30	0.44	396	0.43	448
2:30- 3:00	0.45	401	0.52	497
3:00- 3:30	0.39	404	0.41	517
3:30- 4:00	0.40	426	0.40	607
Average	0.39		0.42	

Note: The asymptotic standard error of the rank correlation estimate is $1/\sqrt{\#\text{ stocks}}$.

stable across time periods, we do report these regressions despite their shortcomings.

The regression analysis uses two specifications. The first specification is a linear relation between the return on security i in the half-hour interval t, r_{it}, and the normalized order imbalance, NOI_{it}:

$$r_{it} = a_t + b_t \, NOI_{it} + e_{it} , \qquad i = 1,2, \ldots ,N_t ,$$

where N_t is the number of securities in the half-hour interval t and e_{it} is a mean-zero disturbance. The regression estimates provide evidence that b_t is greater than zero across the half-hour intervals for both the 19th and 20th of October for both the S&P and non-S&P stocks (Tables 4 and 5). However, regression diagnostics indicate that for extreme values of NOI_{it}, this regression is not well specified.

An analysis of the residuals suggests that with a transformation of NOI, the following regression would be linear:

$$r_{it} = a_t + b_t \, TNOI_{it} + e_{it} , \qquad i = 1,2, \ldots ,N_t ,$$

where $TNOI_{it} = NOI_{it}/|NOI_{it}|^{\frac{1}{2}}$ for $NOI_{it} \neq 0$ and $TNOI_{it} = 0$ for $NOI_{it} = 0$. Diagnostics of the residuals suggest that the linear specification of this model is adequate.[19]

For the S&P stocks, consistent with the rank correlation results, the regression results support a positive relation between the individual security return and the order imbalance variable (Table 6). The heteroscedasticity consistent z-statistics for the slope coefficient are all positive and statistically significant for all but two of the half-hour intervals. Overall, these results provide strong support for a positive relation between the returns of individual S&P 500 securities and this variant of the

TABLE 4

S&P 500 Stocks
Cross-sectional Regression of Realized Return
on Order Imbalance Standardized by Market Value
By Half Hour Intervals

Time Interval	Intercept			Slope			R^2
	value	t	z	value	t	z	
Monday							
Oct 19							
9:30-10:00	-5.59	-27.13	-23.85	0.85	0.29	0.24	0.00
10:00-10:30	-2.54	-12.16	-11.79	24.31	6.03	4.61	0.11
10:30-11:00	-1.33	-7.30	-7.04	23.59	5.12	3.57	0.07
11:00-11:30	2.77	14.17	14.24	36.24	8.50	5.45	0.16
11:30-12:00	1.15	8.77	8.48	32.23	10.80	5.15	0.22
12:00-12:30	-1.11	-9.60	-9.51	27.07	9.18	6.61	0.17
12:30- 1:00	-1.17	-10.08	-11.08	10.30	3.17	3.25	0.02
1:00- 1:30	-0.31	-3.92	-3.45	14.44	5.27	3.07	0.06
1:30- 2:00	-2.43	-17.13	-17.46	13.86	5.07	4.88	0.06
2:00- 2:30	-1.22	-11.31	-11.31	2.95	1.17	1.12	0.00
2:30- 3:00	-0.04	-0.39	-0.37	22.67	5.82	4.50	0.07
3:00- 3:30	-2.53	-16.13	-16.78	11.86	5.32	5.10	0.06
3:30- 4:00	-3.72	-16.07	-15.72	14.68	3.86	3.36	0.04
Average	-1.39	-8.33	-8.13	18.08	5.35	3.92	0.08
Tuesday							
Oct 20							
9:30-10:00	6.26	16.09	15.05	5.92	0.64	0.44	0.00
10:00-10:30	1.04	5.32	5.35	28.23	5.98	5.16	0.12
10:30-11:00	-2.69	-14.39	-14.87	28.60	9.23	6.88	0.17
11:00-11:30	-4.52	-19.43	-19.80	15.44	4.45	4.01	0.05
11:30-12:00	-3.52	-17.41	-18.37	28.58	4.92	4.78	0.06
12:00-12:30	-2.75	-11.17	-11.47	24.21	3.96	2.82	0.04
12:30- 1:00	5.01	13.67	11.99	56.23	5.97	2.82	0.10
1:00- 1:30	0.00	0.01	0.01	41.84	6.90	3.54	0.12
1:30- 2:00	-0.37	-2.78	-2.72	22.08	4.63	2.36	0.05
2:00- 2:30	0.83	6.90	6.95	8.76	3.04	1.93	0.02
2:30- 3:00	3.00	19.21	18.67	28.67	6.11	4.35	0.09
3:00- 3:30	1.74	13.01	12.03	30.56	8.00	3.47	0.14
3:30- 4:00	-0.04	-0.22	-0.22	19.01	5.01	2.35	0.06
Average	0.31	0.68	0.20	26.01	5.30	3.45	0.08

Notes: The slope coefficient value is scaled by 100.

t denotes the OLS t-statsitic for the null hypothesis that the regression parameter is zero.

z denotes a heteroscedasticity consistent z-statistic for the null hypothesis that the regression parameter is zero. This statistic is calculated using the technique of White [Econometrica (1980)].

For the regression dollar volume is expressed in hundreds of dollars and market value is expressed in millions of dollars.

TABLE 5

Non-S&P Stocks
Cross-sectional Regression of Realized Return
on Order Imbalance Standardized by Market Value
By Half Hour Intervals

Time Interval	Intercept			Slope			R^2
	value	t	z	value	t	z	
Monday							
Oct 19							
9:30-10:00	-3.06	-2.62	-2.51	13.03	0.85	1.81	0.00
10:00-10:30	-2.66	-15.69	-15.19	13.77	5.84	3.47	0.06
10:30-11:00	-2.02	-13.65	-14.08	11.57	5.24	4.02	0.05
11:00-11:30	1.08	8.15	8.27	28.82	11.28	7.49	0.17
11:30-12:00	1.28	9.56	9.85	21.79	10.42	3.45	0.16
12:00-12:30	-0.10	-1.06	-1.08	12.40	8.37	6.99	0.12
12:30- 1:00	-0.51	-5.76	-5.32	1.68	1.97	0.66	0.01
1:00- 1:30	-0.16	-2.08	-2.03	20.02	3.71	17.36	0.03
1:30- 2:00	-1.29	-14.29	-12.82	2.63	3.46	1.55	0.03
2:00- 2:30	-1.68	-15.68	-15.92	-2.13	-1.30	-1.30	0.00
2:30- 3:00	-0.33	-3.55	-3.56	12.50	6.76	4.59	0.08
3:00- 3:30	-1.68	-12.85	-12.90	10.29	6.05	4.23	0.06
3:30- 4:00	-2.10	-12.77	-12.82	13.33	6.35	3.55	0.06
Average	-1.02	-6.33	-6.16	12.28	5.31	4.45	0.06
Tuesday							
Oct 20							
9:30-10:00	0.01	0.02	0.02	1.93	0.81	0.69	0.00
10:00-10:30	1.01	7.13	7.21	16.53	7.73	2.74	0.10
10:30-11:00	-0.74	-5.53	-5.31	11.39	6.66	3.87	0.07
11:00-11:30	-2.37	-14.96	-15.23	7.95	4.65	2.00	0.04
11:30-12:00	-2.98	-16.42	-16.84	12.02	3.88	2.82	0.03
12:00-12:30	-3.45	-17.02	-17.14	4.42	1.99	1.29	0.01
12:30- 1:00	0.53	2.19	2.03	30.47	6.46	4.09	0.07
1:00- 1:30	0.13	0.82	0.82	30.23	6.88	4.73	0.08
1:30- 2:00	0.32	2.25	2.28	33.66	9.14	5.86	0.15
2:00- 2:30	0.30	2.07	2.07	1.66	1.51	1.26	0.01
2:30- 3:00	1.42	9.37	9.40	16.89	5.94	3.02	0.07
3:00- 3:30	1.65	10.30	10.46	26.86	6.97	4.97	0.09
3:30- 4:00	1.13	7.56	7.98	11.76	5.20	1.42	0.04
Average	-0.23	-0.94	-0.94	15.83	5.22	2.98	0.06

Notes: The slope coefficient value is scaled by 100.

t denotes the OLS t-statsitic for the null hypothesis that the regression parameter is zero.

z denotes a heteroscedasticity consistent z-statistic for the null hypothesis that the regression parameter is zero. This statistic is calculated using the technique of White [Econometrica (1980)].

For the regression dollar volume is expressed in hundreds of dollars and market value is expressed in millions of dollars.

TABLE 6

S&P 500 Stocks
Cross-sectional Regression of Realized Return on
Transformed Order Imbalance Standardized by Market Value
By Half Hour Intervals

Time Interval	Intercept			Slope			R^2
	value	t	z	value	t	z	
Monday							
Oct 19							
9:30-10:00	-5.62	-24.21	-19.92	-0.58	-0.05	-0.04	0.00
10:00-10:30	-1.75	-6.40	-6.19	102.29	7.18	6.07	0.14
10:30-11:00	-1.08	-5.52	-5.05	74.07	6.07	5.00	0.09
11:00-11:30	2.54	13.09	14.32	118.49	10.21	10.18	0.21
11:30-12:00	0.99	7.69	8.61	104.06	12.79	9.54	0.28
12:00-12:30	-0.78	-6.43	-6.48	87.72	11.65	10.88	0.24
12:30- 1:00	-0.94	-7.21	-8.75	42.47	4.89	5.23	0.05
1:00- 1:30	-0.15	-1.80	-1.61	46.46	7.29	5.79	0.11
1:30- 2:00	-2.02	-11.40	-12.39	57.17	6.05	6.62	0.08
2:00- 2:30	-1.20	-11.08	-11.00	13.36	1.71	1.73	0.01
2:30- 3:00	0.07	0.64	0.62	66.76	8.16	7.43	0.13
3:00- 3:30	-2.01	-9.82	-9.66	65.93	5.91	5.20	0.08
3:30- 4:00	-2.99	-11.36	-11.38	97.28	6.65	6.35	0.10
Average	-1.15	-5.68	-5.30	67.34	6.81	6.15	0.12
Tuesday							
Oct 20							
9:30-10:00	6.11	15.17	13.29	40.33	1.52	1.13	0.01
10:00-10:30	1.01	5.45	5.47	104.84	9.57	8.52	0.21
10:30-11:00	-2.26	-11.39	-11.56	107.96	10.49	9.30	0.21
11:00-11:30	-3.78	-12.51	-13.53	84.17	5.60	5.81	0.07
11:30-12:00	-3.36	-15.02	-15.69	66.66	4.61	4.21	0.06
12:00-12:30	-2.25	-8.59	-9.27	114.30	6.17	5.44	0.10
12:30- 1:00	4.19	11.18	10.77	218.99	8.47	6.58	0.18
1:00- 1:30	0.01	0.04	0.03	104.64	7.35	4.79	0.13
1:30- 2:00	-0.18	-1.35	-1.33	77.60	7.05	5.80	0.12
2:00- 2:30	0.84	7.32	7.37	65.92	6.93	5.54	0.11
2:30- 3:00	2.62	15.97	16.35	102.08	8.21	7.79	0.14
3:00- 3:30	1.49	10.87	9.56	96.94	9.46	6.22	0.18
3:30- 4:00	0.00	0.00	0.00	87.34	7.93	6.37	0.13
Average	0.34	1.32	0.88	97.83	7.18	5.96	0.13

Notes: The slope coefficient value is scaled by 100.

t denotes the OLS t-statsitic for the null hypothesis that the regression parameter is zero.

z denotes a heteroscedasticity consistent z-statistic for the null hypothesis that the regression parameter is zero. This statistic is calculated using the technique of White [Econometrica (1980)].

For the regression dollar volume is expressed in hundreds of dollars and market value is expressed in millions of dollars.

normalized order imbalance for both October 19 and 20. The regression results for the non-S&P stocks are similar to those for the S&P stocks (Table 7).

D. Return Reversals

The order imbalance argument suggests that some of the price movement for a given stock during the period of imbalance is temporary in nature. We would expect that if a negative order imbalance pushes a stock's price down, the price would rebound once the imbalance is eliminated. If on Monday afternoon those securities exhibiting the greatest losses were subject to the greatest order imbalances, these securities should have the greatest rebounds on Tuesday if the imbalance is no longer there. This cross-sectional prediction is the subject of this section.

The last hour of trading on October 20 and the first hour of trading on October 21 are considered in the analysis. The Monday return is calculated for all stocks which traded in the 2:45 to 3:00 interval, using the price of the transaction closest to 3:00 and the closing price. The Tuesday return is calculated for all stocks which traded in the 10:30 to 10:45 interval, using Monday's closing price and the Tuesday transaction closest to 10:30.[20]

For the S&P 500 stocks, all stocks with both Monday and Tuesday returns are included. The number of eligible stocks is 427. The cross-sectional relation between Tuesday's return and Monday's return is examined using the following linear regression

$$\text{Return Tuesday}_i = a + b\ \text{Return Monday}_i + v_i \qquad i = 1,2, \ldots ,N$$

The slope coefficient estimate is -0.72 with an associated heteroscedasticity consistent z-statistic of -8.38.[21] The unadjusted R^2 of the regression is 0.26.

TABLE 7

Non-S&P Stocks
Cross-sectional Regression of Realized Return on
Transformed Order Imbalance Standardized by Market Value
By Half Hour Intervals

Time Interval	Intercept			Slope			R^2
	value	t	z	value	t	z	
Monday							
Oct 19							
9:30-10:00	-2.34	-1.78	-1.51	105.64	1.43	2.17	0.00
10:00-10:30	-2.06	-10.27	-10.71	78.91	7.84	6.40	0.11
10:30-11:00	-1.50	-8.87	-9.02	71.94	7.89	6.39	0.10
11:00-11:30	1.08	8.53	8.72	108.84	14.11	11.92	0.25
11:30-12:00	1.09	8.62	9.58	109.13	14.37	8.14	0.27
12:00-12:30	-0.03	-0.37	-0.37	65.22	11.77	9.33	0.21
12:30- 1:00	-0.25	-2.87	-2.05	48.88	9.45	3.68	0.14
1:00- 1:30	-0.06	-0.86	-0.81	41.61	9.18	4.72	0.15
1:30- 2:00	-0.91	-8.92	-6.76	41.33	7.74	4.38	0.12
2:00- 2:30	-1.67	-14.77	-14.05	-2.81	-0.39	-0.34	0.00
2:30- 3:00	-0.12	-1.28	-1.31	62.03	9.97	9.45	0.15
3:00- 3:30	-1.21	-8.30	-8.67	68.24	8.77	7.75	0.12
3:30- 4:00	-1.65	-9.02	-10.23	77.18	8.23	6.69	0.09
Average	-0.74	-3.86	-3.63	67.40	8.49	6.21	0.13
Tuesday							
Oct 20							
9:30-10:00	-0.00	-0.01	-0.01	47.61	3.53	2.59	0.02
10:00-10:30	0.90	6.81	6.88	98.40	12.42	8.82	0.21
10:30-11:00	-0.53	-4.04	-3.65	73.10	10.04	7.32	0.14
11:00-11:30	-1.77	-10.53	-11.78	79.45	9.35	7.15	0.13
11:30-12:00	-2.79	-14.56	-15.19	55.80	4.90	4.14	0.04
12:00-12:30	-2.86	-12.79	-12.03	78.10	5.98	4.11	0.06
12:30- 1:00	0.80	3.40	2.90	155.53	9.76	6.20	0.14
1:00- 1:30	0.19	1.24	1.24	103.50	8.97	7.11	0.13
1:30- 2:00	0.41	3.01	3.01	120.42	11.53	8.48	0.22
2:00- 2:30	0.39	2.83	2.78	59.86	6.54	3.15	0.09
2:30- 3:00	1.29	9.10	9.27	109.28	10.59	6.61	0.18
3:00- 3:30	1.57	9.91	10.10	89.59	8.35	6.65	0.12
3:30- 4:00	1.07	7.49	7.86	91.24	9.37	4.73	0.13
Average	-0.10	0.14	0.11	89.38	8.56	5.93	0.12

Notes: The slope coefficient value is scaled by 100.

t denotes the OLS t-statsitic for the null hypothesis that the regression parameter is zero.

z denotes a heteroscedasticity consistent z-statistic for the null hypothesis that the regression parameter is zero. This statistic is calculated using the technique of White [Econometrica (1980)].

For the regression dollar volume is expressed in hundreds of dollars and market value is expressed in millions of dollars.

The same regression is repeated for non-S&P 500 stocks. The number of eligible stocks is 551. For this regression the slope coefficient estimate is -0.62 with a z-statistic of -6.19.[22] The unadjusted R^2 of the regression is 0.20.

These results provide support for the price pressure hypothesis and lead to the conclusion that some of the largest declines for individual stocks on Monday afternoon were temporary in nature and can partically be attributed to the inability of the market structure to handle the large amount of selling volume.

VI. CONCLUSION

The primary purpose of this paper was to examine order imbalances and the returns of NYSE stocks on October 19 and 20. The evidence shows that there are substantial differences in the returns realized by stocks that are included in the S&P Composite Index and those that are not. In the aggregate, the losses on S&P stocks on October 19 are much greater than the losses on non-S&P stocks. Importantly, by mid morning of October 20, the S&P stocks had recovered nearly to the level of the non-S&P stocks. Not surprisingly, the volume of trading in S&P stocks with size held constant exceeds the volume of trading in non-S&P stocks.

In the aggregate, there is a significant relation between the realized returns on S&P stocks in each fifteen minute interval and a concurrent measure of buying and selling imbalance. Non-S&P stocks display a similar, but weaker relation. Quite apart from this aggregate relation, the study finds a relation within half hour intervals between the returns and the relative buying and selling imbalances of individual stocks. Finally, those stocks with the greatest losses in the afternoon of October 19 tended to realize the greatest gains in the morning of October 20.

These results are consistent with, but do not prove, the hypothesis that S&P stocks fell more than warranted on October 19 because the market was unable to absorb the extreme selling pressure on these stocks.[23] If this hypothesis is correct, a portion of the losses on S&P stocks on October 19 is related to the magnitude of the trading volume and not real economic factors. A question of obvious policy relevance that this paper has not addressed is whether buying and selling imbalances induced by index related strategies have a differential relation to price movements from order imbalances induced by other strategies.

APPENDIX

This Appendix describes and evaluates the approach used in this paper to remove biases in indexes resulting from stale prices.

A. S&P Stocks

On October 19, the future price is often less than the Standard and Poor's Index, when arbitrage conditions suggest that the reverse should hold. The SEC in its report presents some evidence showing that part of this discount is artificial in that stale prices cause the calculated index to be greater than its true value.

Harris (1988) presents a complicated econometric approach to removing the effect of stale prices on the value of the index and reaches similar conclusions to those of the SEC. Harris' approach is to adjust the last traded price of a stock by an estimate of how the price of that stock would have changed given various econometric models. Underlying Harris's models is the assumption that the price movements in stocks that do not trade mirror price movements in stocks that do trade.

The approach used in this study is simpler and at the same time permits some validation of the empirical results. Every fifteen minutes, we calculate the return on the index as follows: To take a specific case, say 10:00 on October 19, we identify all stocks that have traded in the past fifteen minutes, insuring that no price is more than 15 minutes old. Using the closest trade price in the past fifteen minutes to 10:00, we calculate the market value of these stocks and also the value of these same stocks using the closing prices on October 16. The ratio of the 10:00 market value to the closing market value on October 16 gives an estimate of one plus the return on the index from Friday close to 10:00. Applying this return to the actual

closing value of the index on October 16 of 282.70 provides an estimate of the index at 10:00.

Alternatively, since the level of the index is arbitrary, one could set the index to one at the close of October 16 and interpret this ratio as an index itself. Much of the subsequent analyses utilizes this alternative.

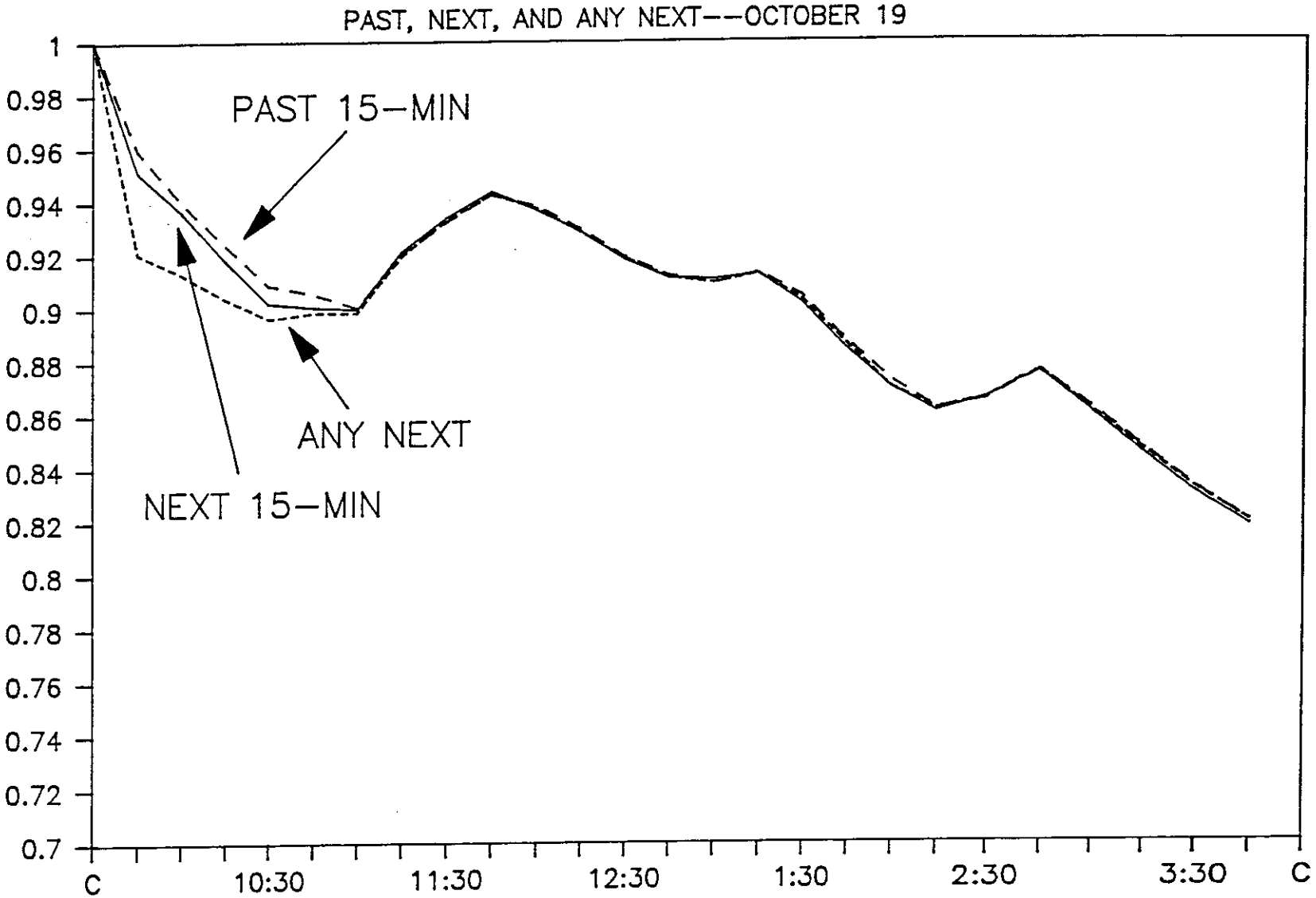
To validate this approach, we also calculate the return by identifying those securities that trade in the next 15 minutes and using the nearest price in the next fifteen minutes to calculate the market value. The set of stocks using the past 15 minutes will usually differ somewhat from the set of stocks using the next 15 minutes.

One criticism of this approach is that in the falling market of October 19, there may be some stocks that did not trade in either the past 15 minutes or the next 15 minutes because there was no one willing to buy. The argument goes that the returns on these stocks if they could have been observed would be less than the returns on those that traded. Excluding these stocks would then cause the index as calculated here to overstate the true index.

One way to assess this potential bias is to calculate the index using the first available next trade price, whenever it occurs. This index would correspond to a strategy of placing market orders for each of the stocks in the index. In some cases, this price would be the opening price of the following day. However, if the next trade price is too far distant, the market could have fallen and recovered, so that the next trade price might even overstate the true unopened price at the time.

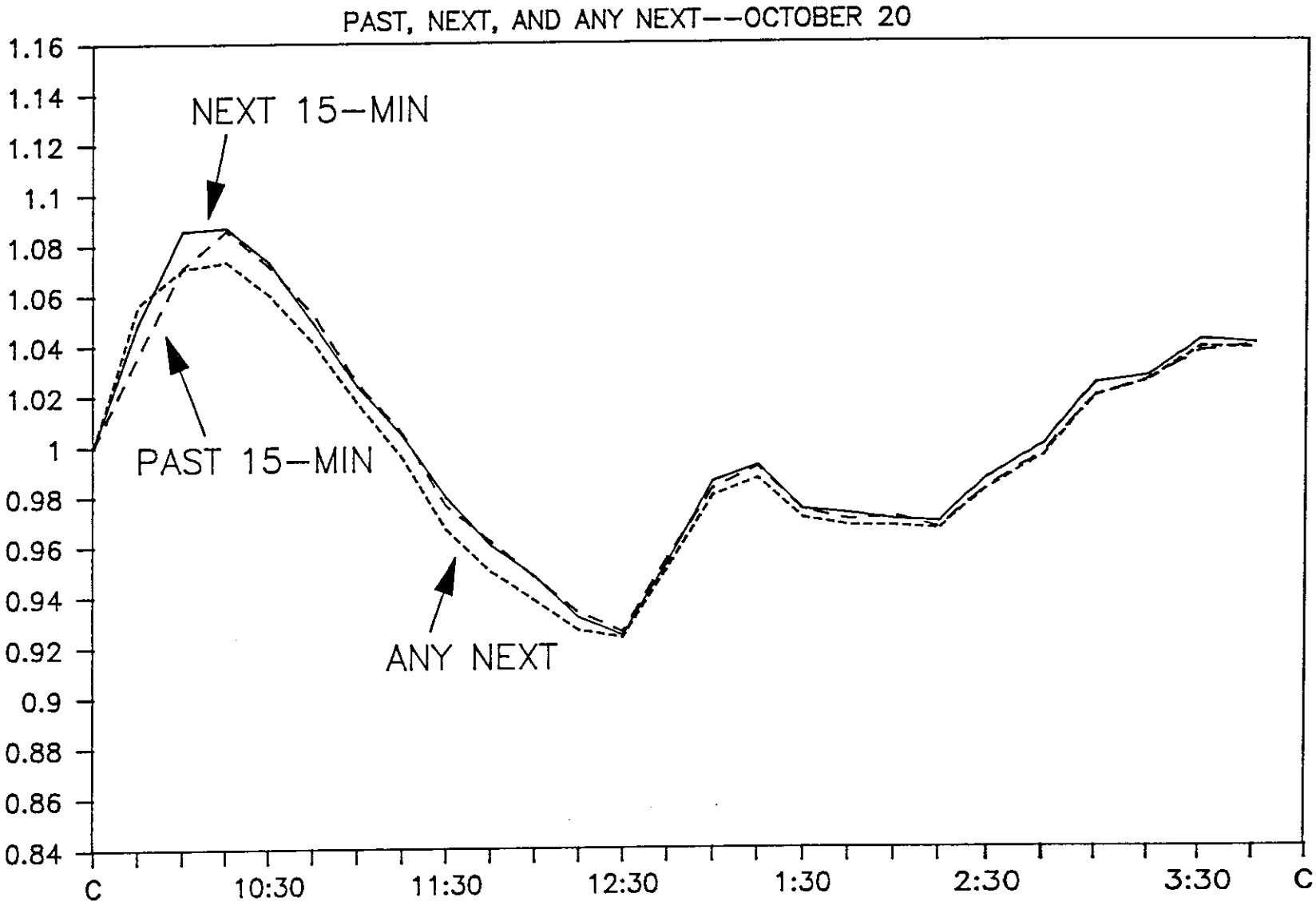
A comparison of the indexes for S&P stocks using the most recent price in the past 15 minutes, the first price in the next 15 minutes, and the next price at any point in the future shows little difference in the indexes except for the first hour and a half of trading (Appendix Figures 1 and 2).

CALCULATED S&P INDEX



APPENDIX FIGURE 1

CALCULATED S&P INDEX



APPENDIX FIGURE 2

Excluding this first hour and a half for both days, the index using the past 15-minute price differs from the index using the next 15-minute price by an absolute maximum of 0.0049 and by an average of -.0001. The corresponding numbers using the next price at any point in the future are .0130 and -0.0023.

The similarity of the three indexes after the first hour and half stems from the fact that the bulk of the S&P stocks had opened and then continued to trade. By 11:00 on October 19, stocks representing 87.1 percent of the market value of the 462 NYSE stocks in the S&P Composite had opened and had traded in the prior 15 minutes, and by 11:00 on October 20, 93.1 percent of the market value had opened and had traded in the prior 15 minutes (Appendix Tables 1 and 2). On both Monday and Tuesday, there was a tendency for the larger stocks to open later than the smaller stocks (Appendix Table 3). Thereafter, a substantial number of stocks traded in every fifteen minute interval (Appendix Figure 3). It is interesting to note that a large number of stocks continued to trade in midday on October 20 despite the well documented fact that there were many trading halts during this period.

The differences in the indexes in the first hour and a half of trading are partly related to the delays in opening and to the rapid drop in the market on October 19 and the rise on October 20. If the prices of stocks that have not opened move in alignment with the stocks that have opened, the true level of the market would be expected to fall within the index values calculated with the last 15-minute price and the next 15-minute price.

If in the falling market of October 19, the true losses on stocks that had not opened exceeded the losses on stocks that had opened, the true market index might even be less than the index calculated with the next 15-minute price. This argument may have some merit. For any specific 15-minute

Appendix Table 1

S&P 500 Stocks

Realized Returns from Friday Close, Number of Stocks, and Percentage of the Market Value of the Index Cross-Classified by Opening Time and Trading Interval Monday, October 19

Trading Interval	Variable	Opening Time 9:30-9:45	9:45-10:00	10:00-10:15	10:15-10:30	10:30-10:45	10:45-11:00	Overall
9:30-9:45	Return[a]	-4.0						-4.0
	Number[b]	201						201
	% of Value[c]	29.7						29.7
9:45-10:00	Return	-5.8	-6.2					-6.0
	Number	198	130					328
	% of Value	29.5	28.3					57.8
10:00-10:15	Return	-7.4	-7.6	-8.7				-7.6
	Number	197	129	36				362
	% of Value	29.4	28.2	4.8				62.5
10:15-10:30	Return	-8.6	-9.0	-10.1	-13.0			-9.1
	Number	194	128	35	19			376
	% of Value	29.3	28.2	4.8	3.8			66.1
10:30-10:45	Return	-8.7	-9.0	-10.4	-11.6	-11.1		-9.4
	Number	192	128	35	18	19		392
	% of Value	29.4	28.1	4.8	3.7	12.4		78.4
10:45-11:00	Return	-9.2	-9.5	-11.0	-12.3	-9.9	-12.3	-10.0
	Number	194	128	34	18	18	19	411
	% of Value	29.3	28.1	4.7	3.7	12.3	9.0	87.1

Notes: [a]Ratio of total market value of stocks using last prices in trading interval to total market value of same stocks using Friday closing prices, expressed as a percentage. The overall return is calculated in a similar fashion and is not a simple average of the returns in the cells.

[b]Number of stocks that opened at the designated time and traded in the trading interval.

[c]Ratio of total market value of stocks in cell to the total market value of all 462 stocks, both market values based upon Friday closing prices.

Appendix Table 2

S&P 500 Stocks

Realized Returns from Monday Close, Number of Stocks, and Percentage of the Market Value of the Index Cross-Classified by Opening Time and Trading Interval Tuesday, October 20

Trading Interval	Variable	Opening Time 9:30-9:45	9:45-10:00	10:00-10:15	10:15-10:30	10:30-10:45	10:45-11:00	Overall
9:30-9:45	Return[a]	5.0						5.0
	Number[b]	262						262
	% of Value[c]	36.9						36.9
9:45-10:00	Return	8.0	9.9					8.8
	Number	252	117					369
	% of Value	36.4	26.1					62.4
10:00-10:15	Return	8.5	11.0	17.2				10.8
	Number	254	115	40				409
	% of Value	36.7	24.7	12.0				73.4
10:15-10:30	Return	7.7	9.0	14.4	14.1			10.0
	Number	250	113	38	23			424
	% of Value	36.2	24.6	11.7	13.2			85.8
10:30-10:45	Return	5.9	7.5	11.4	11.2	10.5		8.0
	Number	252	112	37	23	6		430
	% of Value	36.2	24.6	11.7	13.2	1.8		87.6
10:45-11:00	Return	3.2	4.7	8.6	9.5	6.0	4.5	5.3
	Number	254	113	38	23	5	5	438
	% of Value	36.3	24.6	11.7	13.2	1.8	5.5	93.1

Notes: [a]Ratio of total market value of stocks using last prices in trading interval to total market value of same stocks using Monday closing prices, expressed as a percentage. The overall return is calculated in a similar fashion and is not a simple average of the returns in the cells.

[b]Number of stocks that opened at the designated time and traded in the trading interval.

[c]Ratio of total market value of stocks in cell to the total market value of all 462 stocks, both market values based upon Monday closing prices.

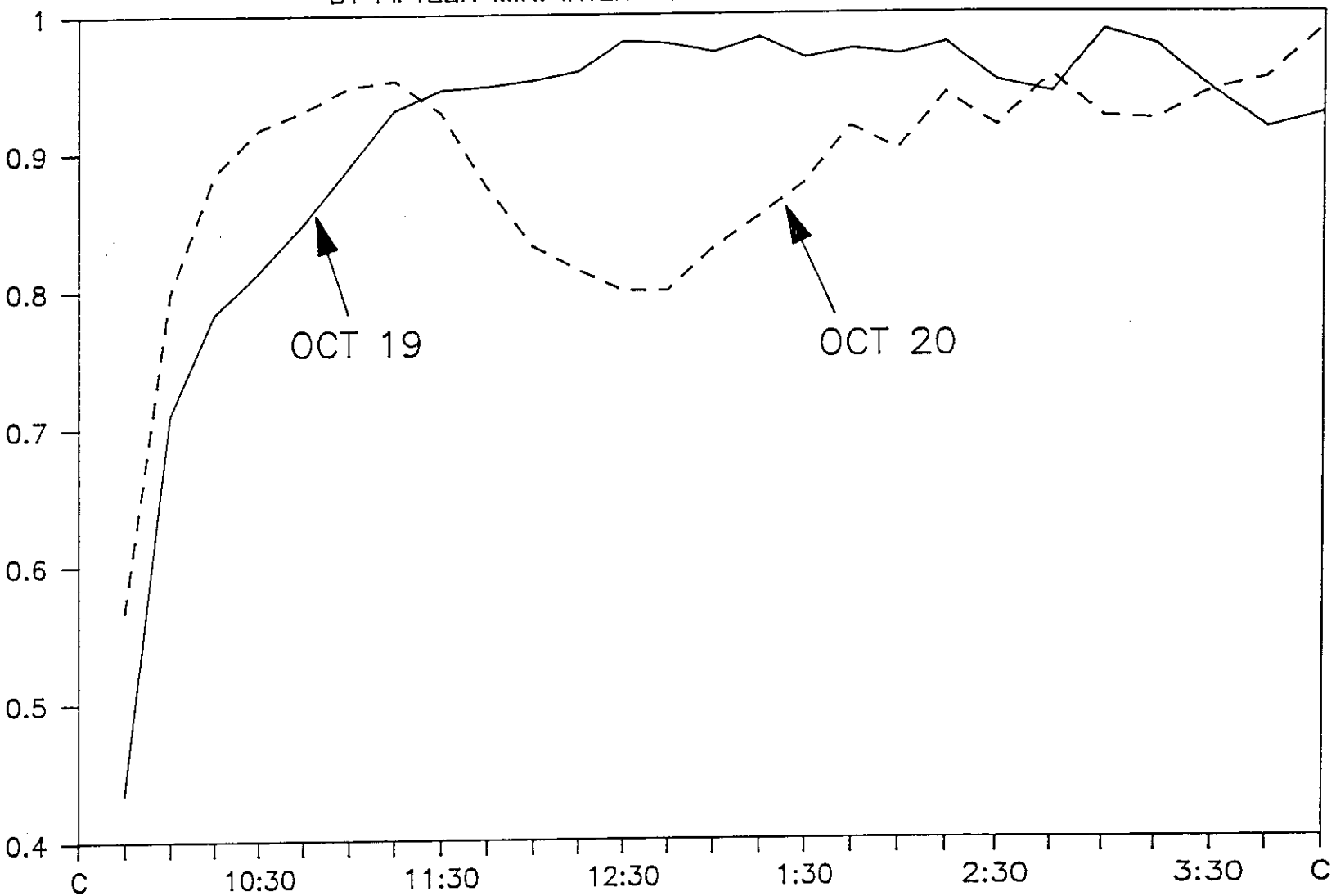
Appendix Table 3

Percentage of S&P Stocks Traded by Fifteen Minute Intervals
Opening Hour, October 19 and 20

Time Interval	9:30-9:45	9:45-10:00	10:00-10:15	10:15-10:30
Monday Oct. 19				
Overall	43.5	71.0	78.4	81.4
Large Quartile	31.9	61.2	65.5	69.8
2	36.5	67.8	74.8	81.7
3	44.8	70.7	82.8	85.3
Small Quartile	60.9	84.3	90.4	88.7
Tuesday Oct. 20				
Overall	56.7	79.9	88.5	91.8
Large Quartile	35.3	65.5	80.2	87.1
2	61.7	79.1	87.8	94.8
3	66.4	88.8	94.8	95.7
Small	63.5	86.1	91.3	89.6

PERCENTAGE OF S&P STOCKS TRADED

BY FIFTEEN MIN. INTERVALS--OCT 19 & 20



APPENDIX FIGURE 3

interval from 9:45 to 11:00, there is a strong negative relation between the returns realized from Friday close and the time of opening (Appendix Table 1).

On October 20, the market initially rose. If the true returns on the stocks that had not opened were greater than the returns on those that had opened, the index using the past 15 minute prices would overstate the true index. Indeed, the evidence shows that the returns on the stocks that had not opened did exceed the returns on those that had opened. For any specific 15-minute interval from 9:45 to 11:00, there is a strong positive relation between the returns realized from Monday's close and the time of opening (Appendix Table 2).

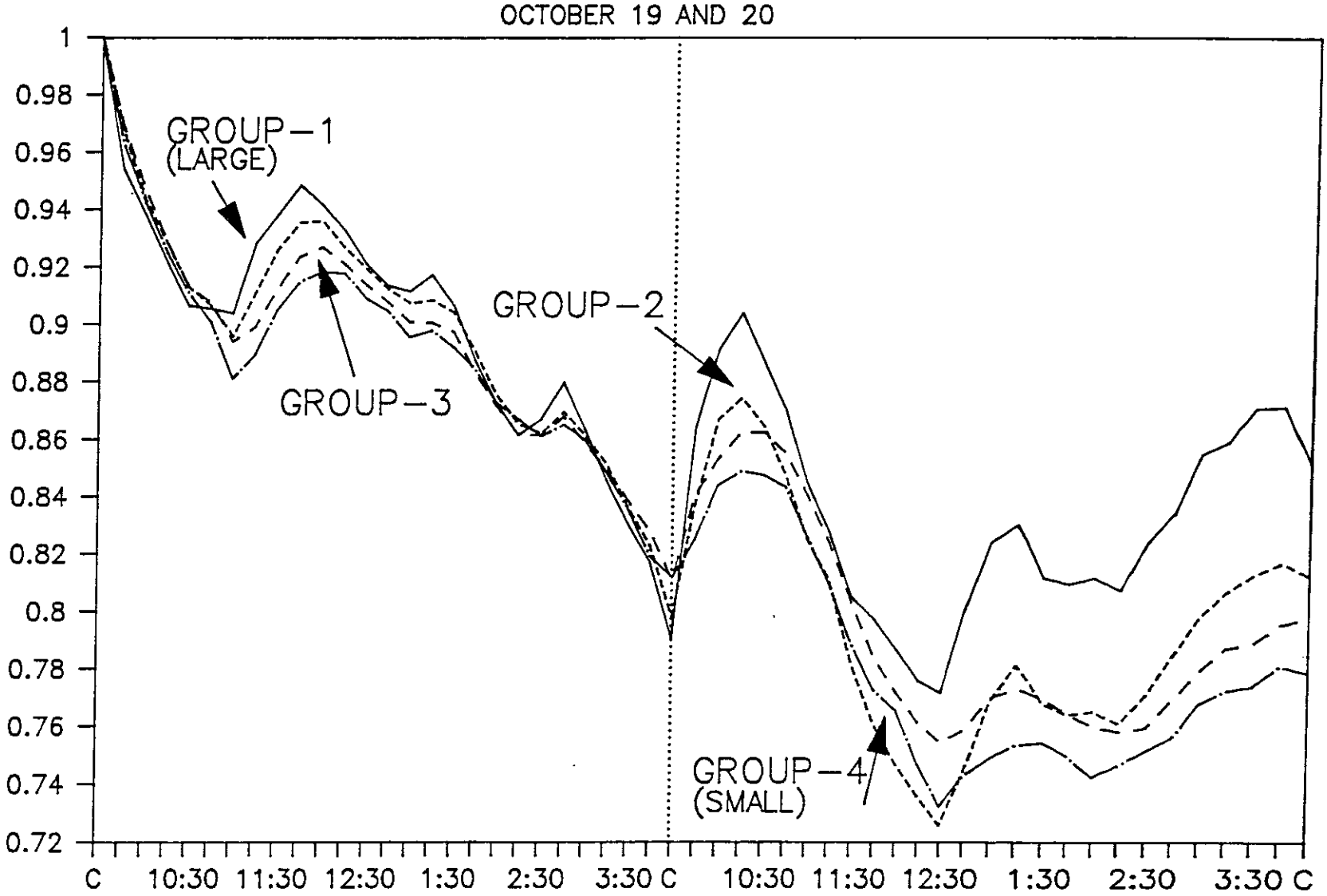
On Monday, there was little difference in realized returns of S&P stocks as a function of size. On Tuesday, the returns realized by stocks in the largest quartile exceeded the returns realized by stocks in the smaller quartiles (Appendix Figure 4).

Except for the first hour and a half of trading, the index constructed of S&P stocks listed on the NYSE that have traded in the past fifteen minutes tracks the published S&P index quite closely (Appendix Figure 5). The differences between the two indexes in the first hour and half of trading on both October 19 and 20 are due to the inclusion of stale prices in the published index. Since there is some evidence that the returns on stocks that had not opened on October 19 were more negative than those that had opened, the actual level of the market was probably somewhat less than the constructed index indicates. The reverse is probably true on October 20.

B. Non-S&P Stocks

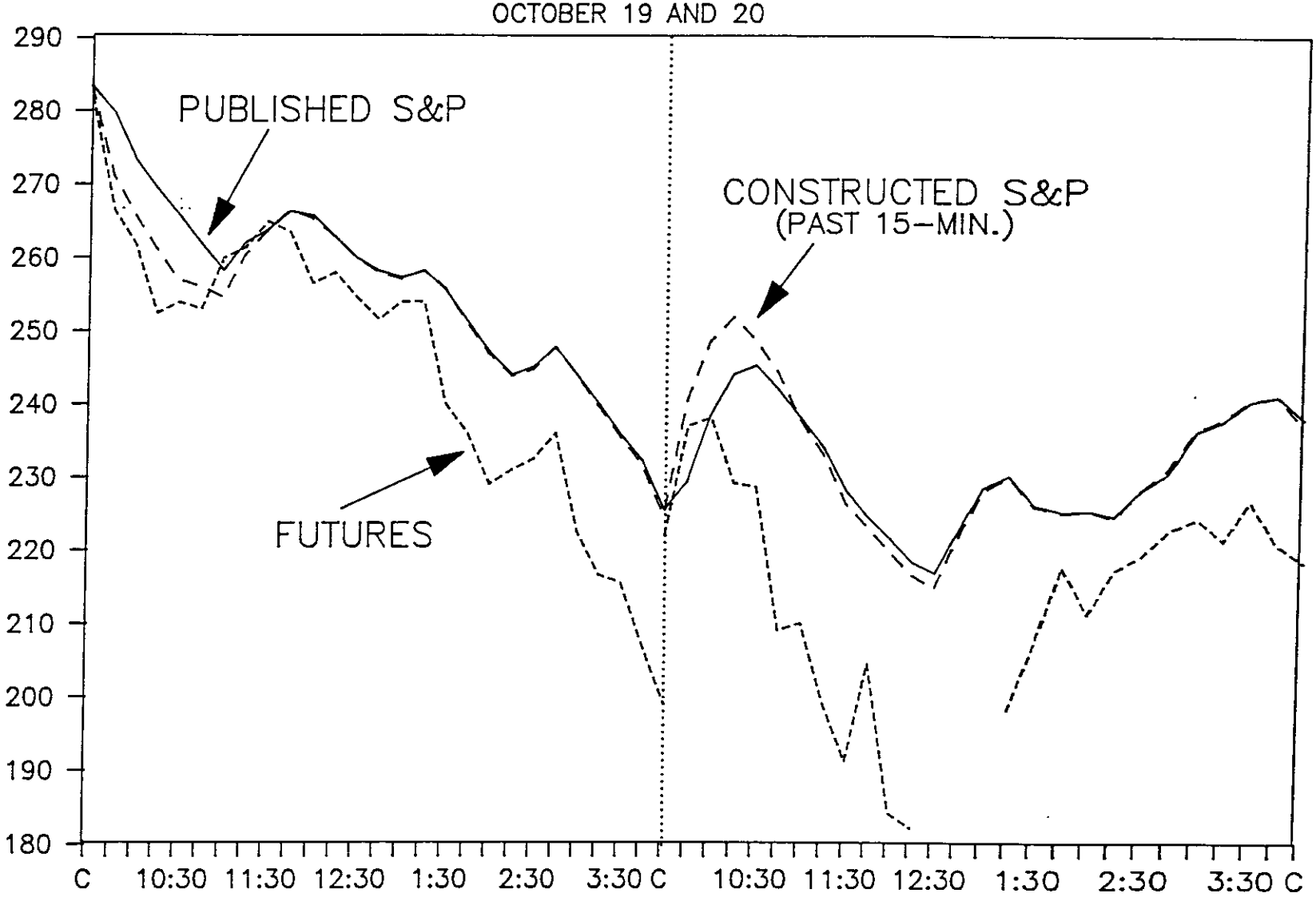
Construction of indexes for NYSE stocks that are not components of the S&P Composite Index follows the same basic approach as the S&P indexes. In comparison to the constructed S&P indexes, the indexes of non-S&P stocks

INDEXES OF S&P STOCKS BY SIZE



APPENDIX FIGURE 4

S&P INDEX AND FUTURES



APPENDIX FIGURE 5

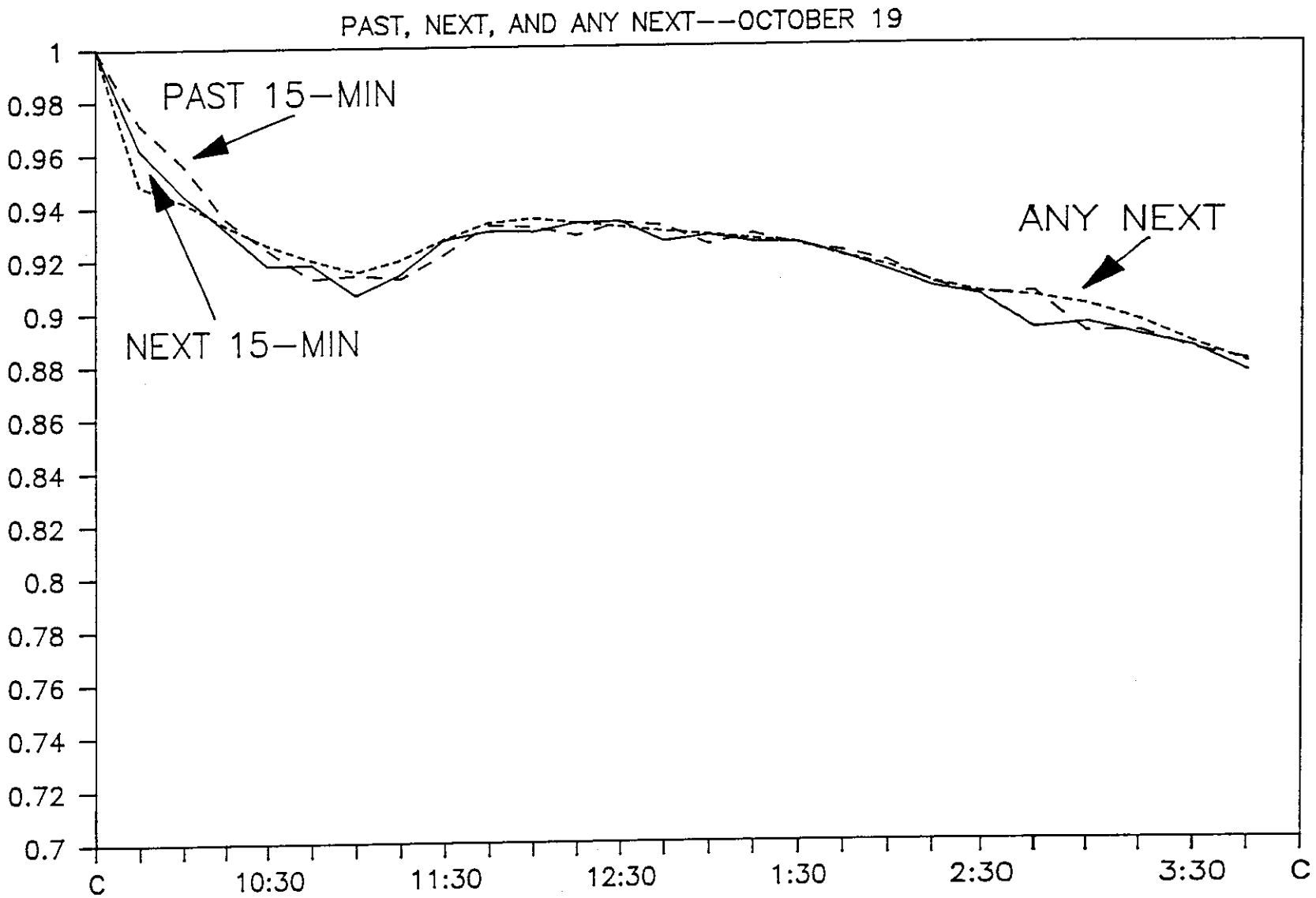
Note: The value of the published S&P index and the future are from Tick Data.

utilizing prices in the past fifteen minutes, prices in the next fifteen minutes, and the first price at any point in the future do not track each other as well (Appendix Figures 6 and 7).

There are two reasons for this difference. The first is that a lesser percentage of non-S&P stocks trade in each fifteen minute interval (Appendix Figures 3 and 8). The second is that there are only 16 stocks in the largest quartile. Since these stocks do not trade every fifteen minutes, the addition or deletion of any individual company can cause substantial changes in the levels of the calculated indexes, which are value weighted (Appendix Figure 9).

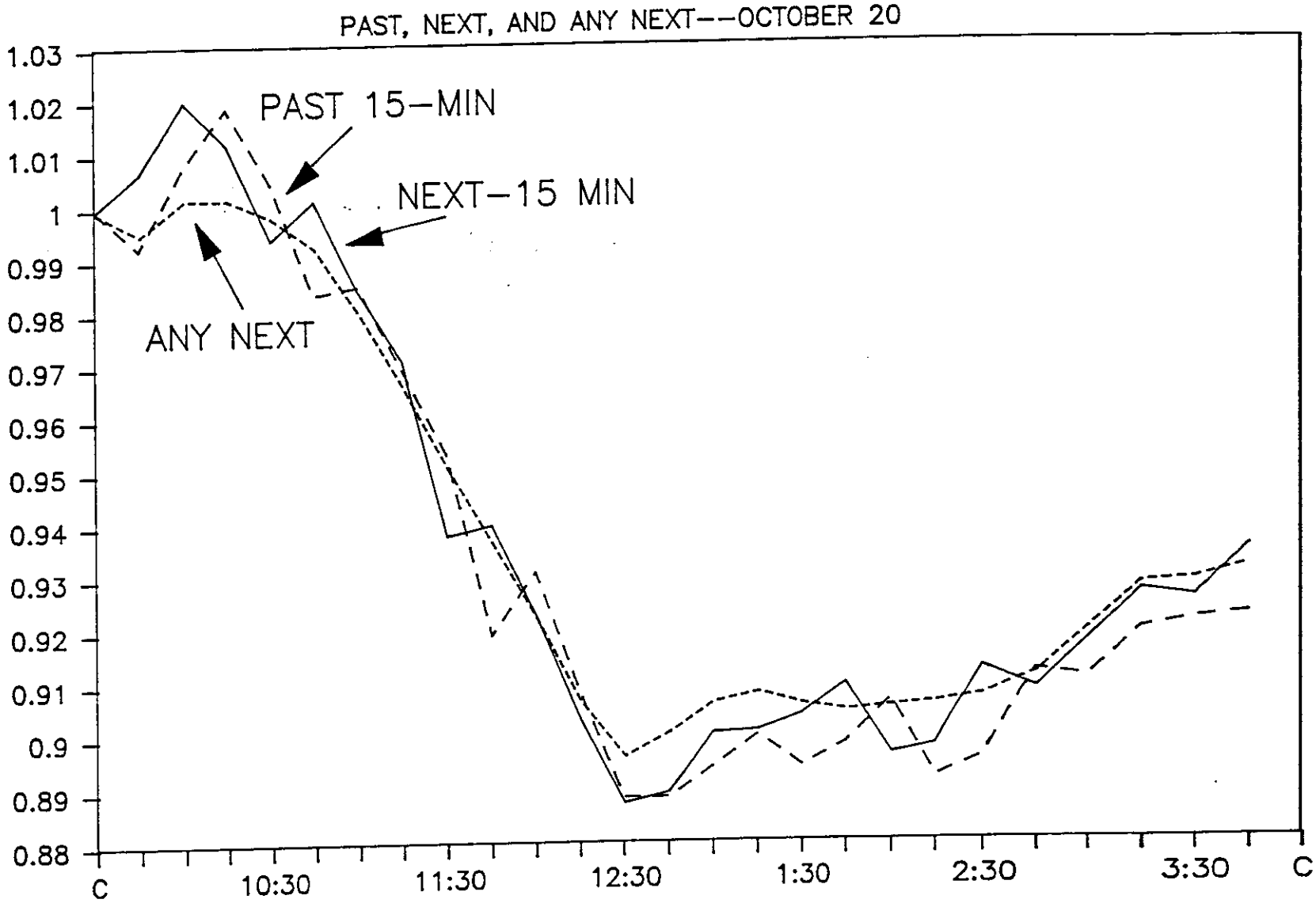
Again, there is evidence of stale prices at the opening (Appendix Tables 4 and 5). Similar to the findings for the S&P stocks, there is evidence that the returns on non-S&P stocks that have not opened are not the same as on those that have opened. Also, similar to the S&P stocks, there is less trading in the larger stocks in the opening hour (Appendix Table 6).

CALCULATED NON S&P INDEX



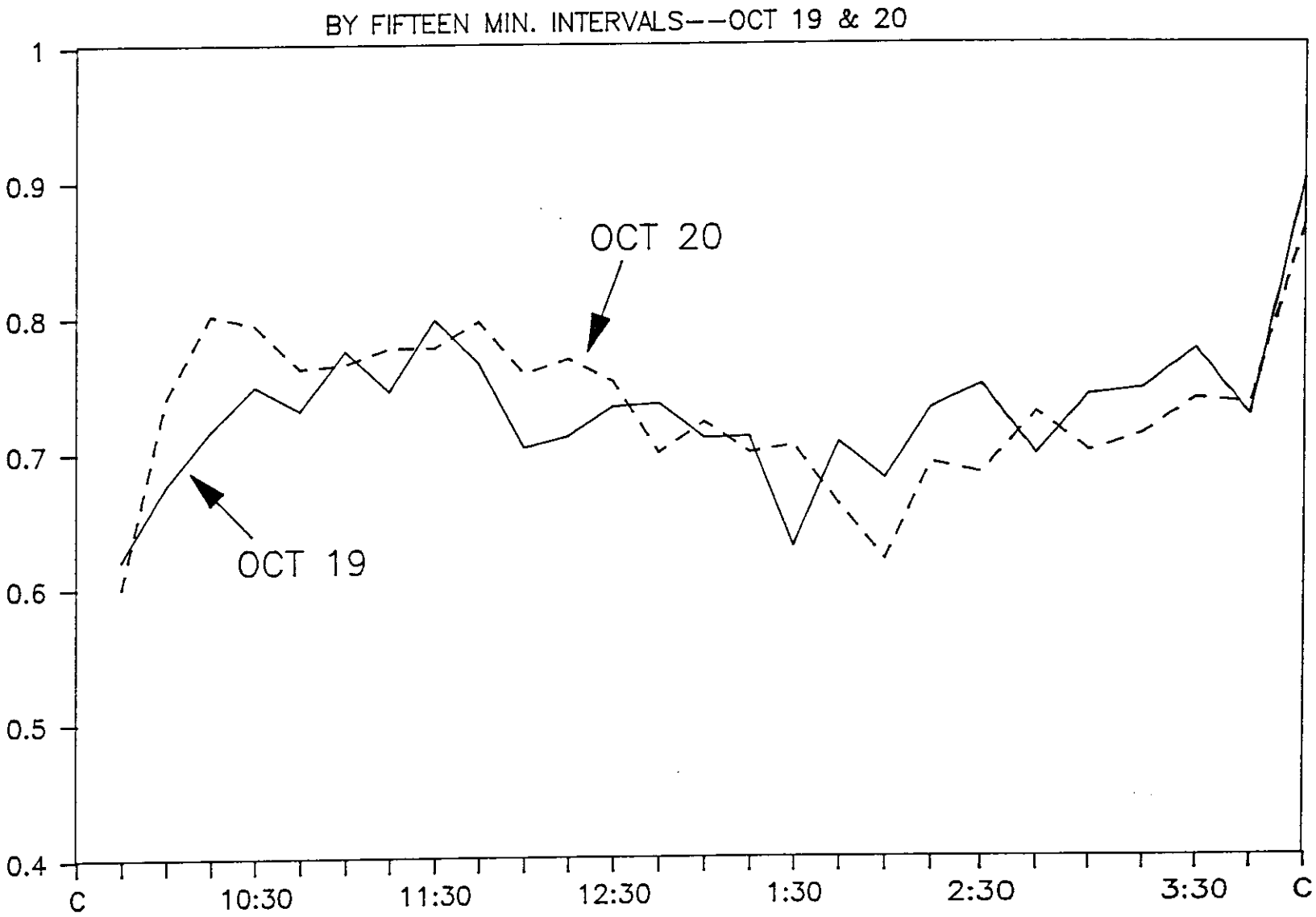
APPENDIX FIGURE 6

CALCULATED NON S&P INDEX



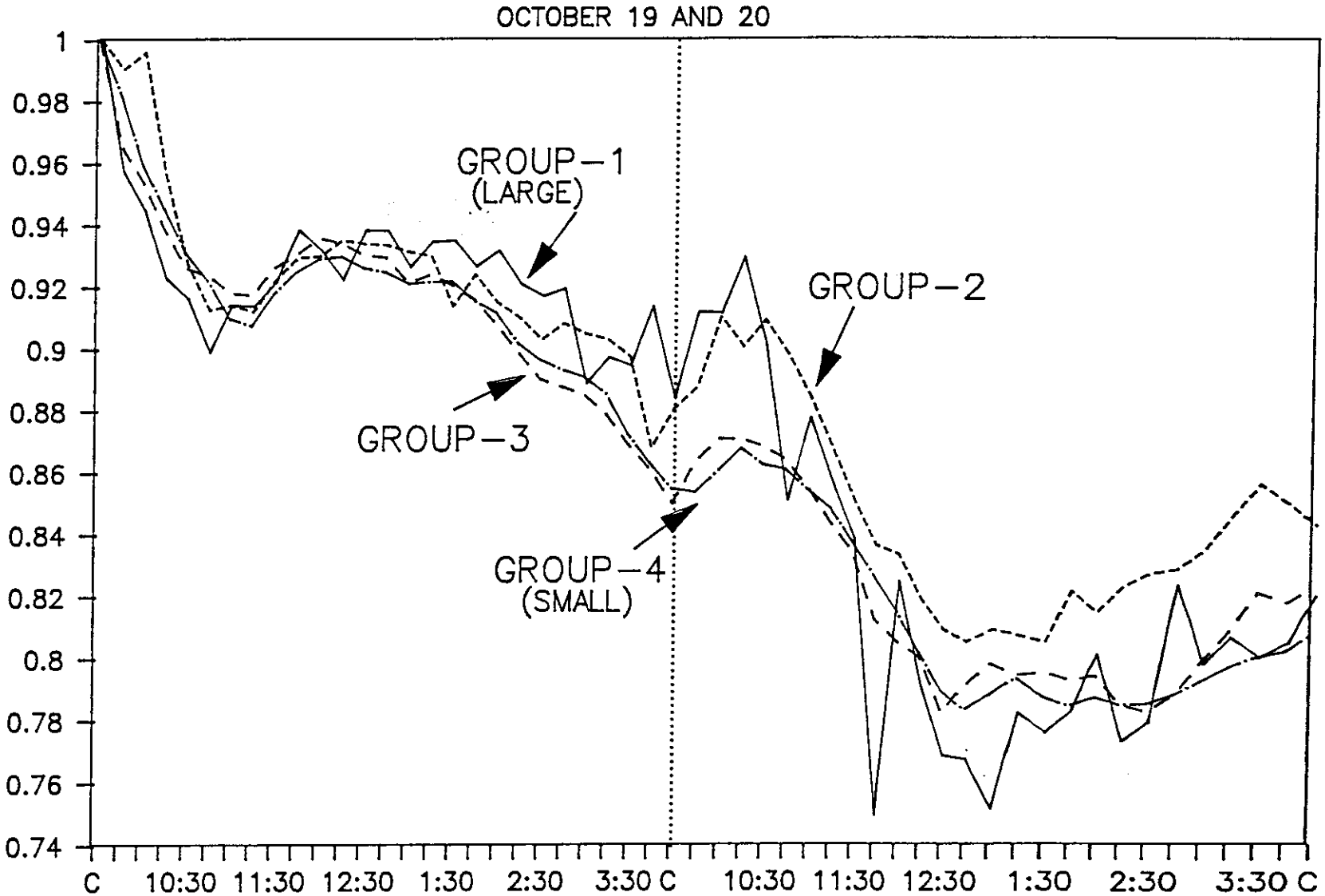
APPENDIX FIGURE 7

PERCENTAGE OF NON-S&P STOCKS TRADED



APPENDIX FIGURE 8

INDEXES OF NON S&P STOCKS BY SIZE



APPENDIX FIGURE 9

Appendix Table 4

Non-S&P Stocks

Realized Returns from Friday Close, Number of Stocks, and Percentage of the Market Value of the Index Cross-Classified by Opening Time and Trading Interval Monday, October 19

Trading Interval	Variable	Opening Time 9:30-9:45	9:45-10:00	10:00-10:15	10:15-10:30	10:30-10:45	10:45-11:00	Overall
9:30-9:45	Return[a]	-3.0						-3.0
	Number[b]	703						703
	% of Value[c]	46.3						46.3
9:45-10:00	Return	-4.2	-5.5					-4.6
	Number	493	212					705
	% of Value	38.9	17.2					56.1
10:00-10:15	Return	-5.7	-6.8	-8.6				-6.6
	Number	512	171	66				749
	% of Value	41.4	15.8	16.7				73.9
10:15-10:30	Return	-6.4	-8.2	-10.0	-12.2			-7.7
	Number	525	164	52	39			780
	% of Value	40.8	15.6	14.9	2.3			73.6
10:30-10:45	Return	-7.1	-9.5	-13.0	-14.9	-8.6		-8.8
	Number	507	171	49	18	23		768
	% of Value	39.5	15.3	10.8	2.0	1.8		69.3
10:45-11:00	Return	-7.5	-10.5	-9.6	-15.7	-9.6	-7.6	-8.7
	Number	538	174	52	24	14	14	816
	% of Value	41.4	15.9	16.1	1.8	1.3	7.6	84.1

Notes: [a]Ratio of total market value of stocks using last prices in trading interval to total market value of same stocks using Friday closing prices, expressed as a percentage. The overall return is calculated in a similar fashion and is not a simple average of the returns in the cells.

[b]Number of stocks that opened at the designated time and traded in the trading interval.

[c]Ratio of total market value of stocks in cell to the total market value of all 462 stocks, both market values based upon Friday closing prices.

Appendix Table 5

Non-S&P Stocks

Realized Returns from Monday Close, Number of Stocks, and Percentage of the Market Value of the Index Cross-Classified by Opening Time and Trading Interval Tuesday, October 20

Trading Interval	Variable	Opening Time 9:30-9:45	9:45-10:00	10:00-10:15	10:15-10:30	10:30-10:45	10:45-11:00	Overall
9:30-9:45	Return[a]	-0.3						-0.3
	Number[b]	655						655
	% of Value[c]	41.8						41.8
9:45-10:00	Return	1.6	2.5					2.0
	Number	537	260					797
	% of Value	35.8	33.7					69.5
10:00-10:15	Return	1.9	3.7	1.4				2.5
	Number	539	214	95				848
	% of Value	38.3	29.6	7.9				75.9
10:15-10:30	Return	2.1	3.2	0.4	3.4			2.5
	Number	501	206	74	55			836
	% of Value	34.3	27.3	6.8	7.4			75.7
10:30-10:45	Return	1.7	0.8	-1.2	2.4	-2.6		1.2
	Number	489	198	70	41	14		812
	% of Value	33.5	11.8	6.8	6.9	0.7		59.8
10:45-11:00	Return	0.7	1.8	-4.0	0.5	-1.7	-0.5	0.6
	Number	484	190	65	39	9	10	797
	% of Value	33.0	26.2	7.4	6.8	0.6	1.0	75.0

Notes: [a]Ratio of total market value of stocks using last prices in trading interval to total market value of same stocks using Monday closing prices, expressed as a percentage. The overall return is calculated in a similar fashion and is not a simple average of the returns in the cells.

[b]Number of stocks that opened at the designated time and traded in the trading interval.

[c]Ratio of total market value of stocks in cell to the total market value of all 462 stocks, both market values based upon Monday closing prices.

Appendix Table 6

Percentage of Non-S&P Stocks Traded by Fifteen Minute Intervals Opening Hour, October 19 and 20

Time Interval	9:30-9:45	9:45-10:00	10:00-10:15	10:15-10:30
Monday Oct. 19				
Overall	62.1	67.6	71.7	74.9
Large Quartile	31.3	31.3	75.0	62.5
2	44.4	40.7	66.7	81.5
3	47.0	74.0	76.0	75.0
Small Quartile	65.3	68.4	71.2	74.9
Tuesday Oct. 20				
Overall	60.1	74.1	80.2	79.4
Large Quartile	31.3	50.5	62.5	62.5
2	59.3	74.1	77.8	96.3
3	55.0	81.0	82.0	85.0
Small Quartile	61.3	73.7	80.4	78.5

FOOTNOTES

[1]There are many critics who share this view. Indeed, Donald Regan, former head of Merrill Lynch and former Chief of Staff at the White House, called on Congress to prohibit index arbitrage, one form of program trading.

[2]As part of its report (1988) the SEC collected information on specific index-related selling programs. On October 19, these selling programs represented 21.1 percent of the S&P volume. The actual percentage is undoubtedly greater. Moreover, there are some trading strategies involving large baskets of stocks in the S&P that the SEC would not include as index-related. Also of interest, the data collected by the SEC indicated that 81.0 percent of index-arbitage on October 19 involved the December future contract on the S&P Composite Index.

[3]Geewax Terker and Company collected these data on a real time basis from Bridge Data. Bridge Data also provides activity on other Exchanges, but the original collection process did not retain these data.

[4]On October 19, we found on occasion large differences between the price of the last trade on the NYSE and the last trade as reported in newspapers. For example, the price for the last trade for Texaco on October 19 on the NYSE was 30.875 and was reported at 4:03. In contrast, the closing price in the newspaper was 32.50. Some investigative work disclosed that a clerk on the Midwest Stock Exchange had recorded some early trades in Texaco after the markets had closed, but had failed to indicate that the trades were out of sequence.

[5]An analysis of the data from Bridge indicates that there were some trades reported during 2:05 p.m. and none during 2:07 p.m. on October 19. We have not determined the reason for this slight discrepancy.

[6]The number of shares outstanding that Standard & Poor's uses in the construction of its indexes sometimes differs from the number reported in other financial publications. These shares were properly adjusted for stock dividends and stock splits during the month of October.

[7]In reconstructing the S&P index, it would be ideal to have the NYSE closing prices of NYSE stocks on Friday, October 16. Not having these prices, we utilize for this date the closing prices as reported on the Composite tape. This substitution will introduce some error in reconstructing the index (Cf. footnote 8).

[8]As a test of the accuracy of our data, we tried to reconstruct the published S&P Composite Index. The published closing value for S&P index on Friday, October 16, was 282.70. The closing price the next Friday was 248.22--a percentage drop of 12.20 percent. Using the NYSE data and closing prices of the 38 non-NYSE stocks as reported in the newspaper, the percentage drop was 12.54 percent using all 500 stocks and 12.26 percent using only NYSE stocks. This small difference is attributable at least in part to the use of Composite prices on Friday rather than the last prices on the NYSE.

Although the differences for the week are not great, there are larger differences between the published index and the calculated index on Monday and Tuesday. On Monday, October 19, the published S&P Index declined 20.47

percent and on Tuesday increased 5.34 percent. In contrast, the data base available to this study yields a decline of 20.11 percent on Monday and an increase of 4.48 percent on Tuesday. The percentages using only NYSE stocks are respectively a decline of 20.22 percent and an increase of 4.88 percent. That the calculated index declined less than the published index on Monday and increased less on Tuesday suggests that the closing prices on Monday in our data base are on average greater than the closing prices used in calculating the closing value of the S&P Index on Monday. We have tried to find the cause of these minor discrepancies, but have not been successful. The calculated daily returns for Wednesday, Thursday, and Friday are within two basis points of the returns implied by the published values of the S&P Index.

[9]We also excluded foreign companies whose common stock are traded through ADRs.

[10]The adjustment is made for each quartile separately.

[11]An analysis presented below includes only stocks in the half-hour interval if they have a transaction in the 15 minutes prior to the interval and in the last 15 minutes of the interval. This same restriction applies to this analysis.

[12]This example assumes that on Tuesday there are more orders to buy at the open than to sell.

[13]Changes in offer prices and recording of transactions take place in part in different computers. If these computers at critical times are out of phase, there will be errors in sequences.

[14]As an example, an optical card may be smudged. As another example, there may be no indication that an order is out of sequence.

[15]Trades marked out of sequence are discarded.

[16]Trades marked out of sequence are excluded.

[17]An error might occur in the following scenario. Assume the prior quote was 20 bid and 20 1/8 ask and the next prior quote was 19 7/8 bid and 20 ask. The algorithm would classify a trade at 20 as a sell, even though it might be a buy.

[18]Currently, in work in progress, we are undertaking further analysis that will properly take account of the endogeneity issue.

[19]This is a peculiar specification and does not appear on the surface to be consistent with usual inventory models in which it might be conjectured that the realized return would be a convex function of the normalized order imbalance.

[20]The selection of these particular intervals is based on an examination of the indexes in Figure 2. Other time periods were tried and lead to similar results although the significance may not always have been as great.

[21]The usual OLS t-statistic is -12.3.

[22]The usual OLS t-statistic is -11.9.

[23]An alternative hypothesis consistent with the data is that S&P stocks adjust more rapidly to new information than non-S&P stocks and between the close on October 19 and the opening on October 20, there was a release of some favorable information. Under this hypothesis, the losses on non-S&P stocks on October 19 were not as great as they should have been.

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