THE JOURNAL OF FINANCE • VOL. XLIII, NO. 2 • JUNE 1988

Intradaily Price-Volume Adjustments of NYSE Stocks to Unexpected Earnings

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ABSTRACT

The speed and path of adjustment in stocks to the degree of earnings surprise in their quarterly announcements are studied using price-volume transactions data. A differential price-adjustment process was observed, with stocks having large, positive earnings surprises experiencing a faster adjustment compared with those stocks with negative earnings surprises. Volume, transaction frequency, and size were found to be directly related to the absolute degree of surprise, but very favorable earnings-surprise stocks experienced initially a large number of smaller trades while stocks with large unfavorable earnings surprises had relatively fewer transactions but higher volume per trade.

THE STOCK MARKET'S MICROSTRUCTURE has received increasing attention from researchers, especially from an empirical perspective, as transaction data on prices and volume have become more readily available.[1] An important subset of this research has been the study of stock price adjustments to significant news events. Specifically, publicly announced information with economic content should be quickly reflected in prices in an unbiased manner. This paper contains a study of the intradaily adjustment in stocks to the informational content of earnings reports using price changes, trading volume, and transaction frequency and size. We examine the transaction-to-transaction and time-series stock behavior associated with different degrees of earnings surprise embedded in earnings announcements. The "degree of surprise" is measured by a comparison of actual with forecasted earnings for 325 New York Stock Exchange (NYSE) firms. These firms are subdivided into five earnings-surprise categories in order to determine whether the speed and path of their price-volume adjustment processes are different. One question of interest is whether the adjustment process for favorable versus unfavorable earnings surprises is similar or different. Another is whether any adjustment is distinguished by a few large trades or a large number of smaller trades.

Our research is conducted in three stages. First, our analysis examines the speed of adjustment using the well-documented reversal tendency of intradaily price changes, where a reversal is defined as two consecutive price changes in

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[1] In addition to those empirical studies related to our study and detailed below, see also Cohen, Hawawini, Maier, Schwartz, and Whitcomb [3], Dann, Mayers, and Raab [7], Harris [9, 10], Harris and Gurel [11], Oldfield, Rogalski, and Jarrow [22], and Wood, McInish, and Ord [27].

opposite directions.[2] If price adjustments to new information are not rapid, then the normal reversal pattern should be interrupted by an above-average proportion of continuations during the adjustment period. A return to a more normal price behavior should therefore signal the end (duration) of the adjustment process.

Second, both the speed and time path of adjustment are analyzed by monitoring stock returns following an earnings announcement. Beginning with the last transaction price before announcement, the percentage of completion of the adjustment process for the five earnings categories is estimated by comparing prices at periodic intervals with the "fully adjusted" price on a clock-time and a transaction-time basis.

Our final analysis attempts to provide additional insights into the nature of the adjustment process by determining whether adjustments to new information are also reflected in other market attributes. Three important attributes are examined: trading volume, transaction frequency, and transaction size. The reversal and returns analyses describe the adjustment process in terms of price changes but say nothing about how much investor activity generates these changes. Price changes may reflect, for instance, the *market's* overall assessment of new information, while transaction behavior may reflect the *individual investor's* assessment. That is, it is generally accepted that disagreement should translate into increased trading, but elevated trading volume does not necessarily imply disagreement. Even when investors agree on the informational content, higher volume may arise because investors diverged in their prior expectations. Regardless of the reasons, one might expect that the greater the degree of earnings surprise, the greater should be the response in trading activity.[3]

We find that the average initial response to an earnings announcement is rapid, with the first trade occurring within fourteen minutes of an announcement. Furthermore, while our results indicate that the adjustment process was not instantaneous, they do suggest that the major portion of the adjustment occurred within a few hours following an earnings release. One implication is that most investors normally will not be able to participate profitably in the price reaction to positive/negative earnings surprises. In addition, the returns analysis indicated that the most favorable and most unfavorable earnings surprise categories had the largest price adjustments, with the largest overall adjustment experienced by stocks with negative earnings surprises. Interestingly, the most-favorable-earnings stocks had the quickest adjustment, with ninety-one percent of their price adjustment completed after three hours.

An analysis of trading activity revealed that the adjustment to earnings surprises was accompanied by above-average volume and number of transactions. In general, volume, transaction frequency, and transaction size were directly related to the absolute degree of surprise. While volume remained elevated following an announcement, transaction frequency peaked quickly in the first

[2] The individual as well as joint research of Niederhoffer and Osborne was the first to record this general tendency in intradaily stock price behavior. For example, in their 1966 paper [21], they found that a reversal was three times as likely to occur as a *continuation*, i.e., two consecutive price changes in the *same* direction. In earlier works by Smidt [25] and Working [28], negatively correlated price changes were also found in commodity futures prices.

[3] For example, see Bamber [1], Karpoff [17,18], and Kiger [19].

half hour following an announcement and rapidly declined thereafter. Moreover, the initial response to stocks with very favorable earnings surprises was a large number of smaller trades followed by relatively fewer trades with much higher share volume. In contrast, stocks with unfavorable earnings surprises initially had relatively fewer transactions but with higher share volume per trade.

Section I reviews related studies of the intradaily behavior of stock prices and volume. Section II describes our data sample, and the following three sections describe the methodology and results of our price-reversal, returns, and trading-activity analyses. The final section contains a summary of our findings and concluding comments.

I. Related Studies

Hillmer and Yu [12] argued that price adjustments to new information cannot be instantaneous, where speed of adjustment was defined as the time required for market prices to move from their existing equilibrium to a new one, given a change in demand and supply. They proposed a statistical method to estimate the speed of adjustment that depended upon price changes and transaction frequency and then empirically applied it to five stocks. While they provided a unique approach to the adjustment process, their small sample did not permit any general conclusions.

Patell and Wolfson [24] used *Value Line* earnings forecasts to represent investors' earnings expectations for ninety-six stocks. They then applied trading rules to intradaily transactions that involved buying (shorting) those stocks with positive (negative) forecast errors. Their trading rules' average returns were measured over thirty-minute holding periods during the announcement period, overnight, and over five thirty-minute periods of the next trading day. They found that the average return for the thirty-minute period beginning at the minute of the announcement was four to five times larger than those in surrounding periods. In contrast, the average return for the thirty-minute period beginning five minutes after the announcement was considerably smaller but still significant; however, returns measured over the next ten to sixty minutes were similar to the pre-announcement level. Moreover, overnight price changes and price changes in the first thirty minutes of the next day were significantly positive.

To determine the magnitudinal effect of earnings surprises on returns, Patell and Wolfson performed the same tests on those stocks that had reported earnings different from their *Value Line* forecasts by more then twenty percent. The results were not strikingly different from those reported for the full sample, but their "surprise sample" consisted of only twenty-four stocks. Finally, they tested the extent to which the reversal process was interrupted by the arrival of earnings announcements. They found that the frequency of continuations remained significantly higher through seven price changes when compared with the nonannouncement period. When considered over time, the frequency of continuations rose at the announcement, and, while it declined within fifteen minutes, it remained significantly higher than the nonannouncement level for ninety minutes after the announcement but only somewhat higher for the remainder of the announcement days.

Jennings and Starks [13] applied the Patell and Wolfson statistical tests to an expanded sample of stocks that was divided into two quarterly earnings announcement groups: those with high and those with low informational content. Their binary classification scheme was determined by the revisions of financial analysts' forecasts of fiscal year-end earnings in response to interim earnings announcements. They found a differential price-adjustment process, with high-informational-content stocks exhibiting longer adjustments than stocks with low informational content. For instance, high-content stocks' price adjustments continued through the fourth price change, with another elevated level of continuations between the eighth and sixteenth price changes. In contrast, the low-content stocks' adjustment appeared to end after three price changes.

In a follow-up study, Jennings and Starks [14] used a sample of stocks in which half had exchange-listed options traded on them while the other half did not. Their results indicated that these two types of stocks also displayed different adjustment processes to quarterly earnings announcements. That is, non-optioned stocks required substantially more time for their prices to adjust. While the major implication was that options markets appeared to expedite price adjustments, the authors did not discriminate among the stocks on the basis of their earnings' informational content.

Regarding the relationship between price changes and trading activity, a well-accepted theory does not appear to exist, but there have been numerous empirical studies of price changes and volume.[4] Theoretical work by Copeland [4, 5] and its extensions by Jennings, Starks, and Fellingham [15] and Morse [20] use a sequential information-arrival process that implies that trading volume and the absolute size of price changes should be positively correlated and that volume should become elevated during those time periods when price changes are serially correlated. Alternative models by Epps and Epps [8], Harris [9], and Tauchen and Pitts [26] rely on the mixture-of-distributions hypothesis and also imply a positive relationship between price changes and volume. The limited empirical research at the transactions level has provided support for a positive price-volume relationship (e.g., Epps and Epps [8] and Wood, McInish, and Ord [27]); however, apparently no one has examined the relationship among the degree of informational content in announcements, price changes, and transaction behavior.

While the current research draws upon these earlier studies, there are notable differences. First, prior studies did not attempt to control for the *degree* of new information (surprise) contained in earnings releases or to examine separately the adjustment processes for stocks with favorable or unfavorable earnings surprises. We control for informational content by categorizing unexpected earnings into five groups. Second, and most importantly, we provide new information on the relative adjustment processes as reflected in three other market attributes: trading volume, transaction frequency, and transaction size. Third, in contrast to earlier work, we include zero price changes in our reversal analysis and broaden significantly the sample of stocks in terms of size and the mix of non-optioned and optioned stocks. On the latter, for instance, Patell and Wolf-

[4] Karpoff [18] presents an excellent survey of the theoretical and empirical research on the price-volume relationship.

son's sample contained only optioned stocks, whereas only twenty-five percent of our sample contains stocks with tradable options. Finally, the announcement period is expanded to cover three days centered on the announcement date. This allows an examination of possible information leakages prior to the announcement as well as the possibility of a longer adjustment period.

II. Description of the Data and Announcement Period

Four sources of data were utilized. As with Patell and Wolfson, *expected* earnings were represented by quarterly earnings forecasts hand-collected from the *Value Line Investment Survey*. Prior research involving *Value Line* provided the basis for using it to estimate expected earnings. For example, Brown and Rozeff [2] argued that sophisticated investors rely on the most reliable source available to them in forming earnings expectations. They then tested the forecasting ability of *Value Line* against several time-series forecasting models and found *Value Line* to be superior. Copeland and Mayers [6] also came to a similar conclusion. Moreover, this publication is well known and widely available to investors, having over 100,000 subscribers and residing in most major libraries.[5] In addition, *Value Line*'s primary criterion for including a company in its coverage is that it have one of the more actively traded stocks. For instance, the 1,600 stocks it covered represented over ninety-five percent of the market value of all publicly traded U.S. stocks.

To further ensure that our sample consisted of actively traded companies, our earnings-announcement sample began with eight hundred New York Stock Exchange firms randomly selected from *Value Line*. The *Wall Street Journal Index* was consulted next to establish each company's reported earnings and the date of its release during the January 15 to April 15, 1980 time period.[6] Most firms had at least one announcement during the period; those that did not were eliminated. If more than one earnings announcement was found, only the first one was used. After the actual quarterly earnings were determined, *Value Line*'s main and supplementary reports were then checked to obtain the most recent forecast of each firm's earnings before those earnings were publicly announced. About forty stocks were eliminated because information either in *Value Line* or in the announcement itself was insufficient to allow a comparison between actual and forecasted earnings. In addition, another sixty firms were eliminated because their announcements were incomplete, were confounded by a dividend announcement, were corrected at a later date, or could not be located on the Dow Jones Broad Tape.

The Dow Jones News/Retrieval Service was used to pinpoint the exact time of day when an earnings release appeared on the Broad Tape. Francis Emory

[5] *Value Line*'s forecasts of earnings may be either primary, fully diluted, and/or based on average shares outstanding. The choice for each company depends on how the company typically reports earnings. For example, gains and losses from discontinued operations and tax credits/charges are usually included in *Value Line*'s forecasts. However, its forecasts usually exclude extraordinary credits/charges and gains/losses from securities transactions.

[6] While most firms' announcements also included an annual earnings figure, we focused only on their expected and actual fourth-quarter earnings.

Fitch, Inc., was the source for the transactions data, which included the price, the number of shares traded, and the time of day to the nearest minute of each transaction but excluded transactions that took place on regional exchanges or in the over-the-counter market.[7] Similar to other studies, the unexpected-earnings-component percentage was measured by

$$U = [EPS - \mathrm{E}(EPS)]/\mathrm{E}(EPS), \tag{1}$$

where EPS and $\mathrm{E}(EPS)$ were actual and forecasted earnings, respectively.[8]

The remaining seven hundred stocks were initially divided into three categories based upon their unexpected-earnings-component percentage. The basis for division and the number of stocks in each category were as shown in Table I. To ensure comparable sample sizes and low informational content in our control group's earnings announcement, i.e., the neutral stocks, the unexpected-earnings-component percentage's range was reduced to minus five to plus five percent. Then stocks were randomly selected from both the favorable and neutral categories until 110 stocks were in each category. Subsequent to the selection of the stocks, one day's worth of transaction data were found to be missing on the Fitch tapes, and five stocks with announcement dates that were affected had to be eliminated.

To determine whether the speed of adjustment was affected by the degree of earnings surprise, the favorable and unfavorable categories were further divided into two additional categories. The criteria for division and number of stocks in each category are given in Table II.[9] This table also indicates that very favorable earnings releases tended to occur earlier in the day whereas the very unfavorable news tended to be released late in the day, especially after the market's close.

Additional descriptive information on our sample is given in Table III.[10] The

[7] These tapes provide no information on how trades are handled. For example, a market order to buy 1,000 shares of XYZ stock may be filled as follows: three hundred shares from the floor, five hundred shares from the specialist's book, and two hundred shares from the specialist's own account. In this example, three transactions will be recorded on the tapes even though there was only one market order on the buy side. The three transactions may or may not be at the same price. Moreover, odd-lot trades are not included on the Fitch tapes. Information on these trades is aggregated each day and recorded separately.

[8] When the *expected* EPS was negative, the formula was modified to $U' = -(U)$. In addition, a potential drawback to using this formula is that the magnitude of the unexpected earnings component is sensitive to extremely small $\mathrm{E}(EPS)$. That is, the percentage of forecast error approaches infinity as $\mathrm{E}(EPS)$ approaches zero. To assess this problem, the extreme earnings categories were examined closely. In the most-favorable-earnings category, nine of the seventy-seven stocks had $\mathrm{E}(EPS) < |\$0.20|$, while ten of the sixty-two most-unfavorable-earnings stocks had $\mathrm{E}(EPS) < |\$0.20|$. While the market may have responded differently to percent changes of very small dollar amounts, we decided to leave these stocks in our sample because they represented a suitably small percentage of the samples.

[9] A twenty percent forecast error was assumed to be large enough to cause a measurable reaction among investors. A forty percent forecast error was chosen as the second cutoff because it was believed to be sufficiently greater than twenty percent to allow for a meaningful comparison of categories. Twenty and forty percent cutoffs were used by Joy, Litzenberger, and McEnally [16] in their study of stock price adjustments.

[10] This information was obtained from *Value Line*. In particular, the market value of equity was calculated by multiplying the number of common shares outstanding by the price per share given in each stock's latest *Value Line* report.

Table I

Sample of Stocks Categorized by Degree of Earnings Surprise

Earnings-Surprise Category	Unexpected-Earnings-Component Percentage	Number of Stocks
Favorable	> 20%	168
Neutral	−20% to 20%	422
Unfavorable	< −20%	110

median and range of the market values of equity for the five earnings-surprise categories are presented first. As indicated, firm size was negatively related to the degree of unexpected earnings. That is, whether it was a positive or negative surprise, firms reporting unexpected earnings were more likely to be much smaller companies than those with an earnings release that held little informational content. The implication is that smaller firms' earnings were more difficult to predict, and hence, their earnings reports contained more frequent and bigger surprises. One explanation is that smaller firms' earnings announcements constituted a greater proportion of the totally available information on such firms when compared with larger, more frequently monitored companies.

With regard to the latter, Table III also reveals that neutral-earnings stocks were heavily owned by institutions, with the median percentage of shares owned by such investors being 41.1 percent. In contrast, stocks exhibiting an earnings surprise tended to have a median institutional ownership of only ten to sixteen percent, with the most-favorable-earnings stocks being the lowest at 10.2 percent. Finally, the extent to which stocks in the five earnings categories had tradable options was also inversely related to the degree of unexpected earnings. For instance, only fourteen percent of the extreme-earnings-surprise stocks had tradable options, whereas nearly half (forty-five percent) of the no-surprise stocks had listed options. In sum, a distinct pattern emerged when stocks in the five earnings categories were examined with regard to three firm-specific characteristics: the larger a company's unexpected earnings component, the greater the chances that it was a small firm with low institutional sponsorship and no tradable options.

Analyzing market reaction to an earnings report usually involves comparing a time period surrounding the announcement with a normal or "nonannouncement" period. Prior earnings studies have typically used daily or weekly data and have selected announcement periods varying in length from one to several months. The current study also divided the data into announcement-nonannouncement periods but defined the announcement period to be the three trading days centered on each stock's announcement day. The reason was that Patell and Wolfson found that, while most of the price activity occurred within minutes after an information event, there was evidence of price activity continuing into the beginning of the next trading day. Moreover, there is the possibility that "information leakages" may also affect price behavior *before* an announcement.

Table II

Earnings-Surprise Categories and Distribution of Announcement Times

Earnings-Surprise Category	Degree of Surprise Criterion	Number of Stocks	Distribution of Announcements by Time of Day[a]						
			10–11	11–12	12–1	1–2	2–3	3–4	Overnight
1. Most Favorable	> +40%	77	17%	12%	13%	8%	17%	13%	21%
2. Less Favorable	+21% to +40%	33	9%	18%	12%	18%	12%	9%	21%
3. Neutral	−5% to +5%	107	18%	18%	14%	7%	14%	7%	22%
4. Less Unfavorable	−40% to −21%	46	20%	7%	7%	4%	17%	7%	39%
5. Most Unfavorable	< −40%	62	8%	6%	15%	8%	15%	11%	37%
Total		325	15%	13%	13%	8%	15%	9%	27%

[a] Rows and columns may not sum to one hundred percent due to rounding.

Table III

Market Attributes of Stocks Classified by Degree of Earnings Surprise

Earnings-Surprise Category	Market Value of Equity ($ Millions)			Institutional Holdings			Percentage of Stocks Optioned
	Min	Median	Max	Min	Median	Max	
Most Favorable	$ 4	$109	$ 3,947	0.0%	10.2%	87.4%	14%
Less Favorable	$44	$216	$ 2,093	0.8%	14.2%	56.2%	18%
Neutral	$61	$731	$14,914	2.1%	41.1%	73.4%	45%
Less Unfavorable	$ 7	$130	$ 5,057	1.2%	16.4%	45.1%	25%
Most Unfavorable	$14	$128	$ 4,752	0.7%	15.1%	73.3%	14%

As long as an announcement occurred before 4:00 P.M. EST, the time of day of the announcement did not affect the selection of the announcement period. If the announcement occurred later than 4:00 P.M. EST, the following trading day was designated the announcement day, with the announcement period centered on that day.[11]

That part of an announcement period occurring *before* an announcement was designated the "pre-announcement" time segment. That part of the announcement period *after* the announcement but before the end of trading was designated the "post-announcement" time segment, and the trading day following the announcement date was designated the "next-day" time segment. By the next day, usually an earnings report would have appeared in the *Wall Street Journal*, and informed investors would have had ample time to react to any news.

III. Price Reversal and Speed of Adjustment

The analysis in this section documents the reversal tendency found in intradaily transaction prices and then uses this process to provide a measure of the speed of adjustment in prices to unexpected earnings. The arrival of new information may result in an equilibrium price change. If the adjustment to a new equilibrium price is instantaneous, little or no change in the normal reversal tendency in the time path of price changes should be observed. On the other hand, if the adjustment is not instantaneous, the reversal process should be disrupted until a new equilibrium level is reached. That is, the percentage of continuations (reversals) should remain above (below) average during the adjustment. Therefore, a comparison of the reversal process during the announcement with that in the nonannouncement period should provide a measure of the adjustment process.

A. Nonannouncement Period

As noted earlier, a *reversal* is defined as two successive price changes occurring in opposite directions, while a *continuation* is two successive price changes in the same direction. A *zero change*, on the other hand, is two consecutive transactions at the same price. Panel A of Table IV contains the relative frequencies of continuations, reversals, and zero price changes for all stocks during the nonannouncement period. As shown, a reversal was more than twice as likely to occur as a continuation, and about one half of all transactions involved no price change. To illustrate, for "All Categories", continuations and reversals comprised 14.4 and 33.0 percent, respectively, while the remaining 52.6 percent of the transactions involved no price change.

Although the percentage of reversals is similar for all earnings categories, the percentage of continuations (zeroes) decreased (increased) steadily by about four percentage points from the most favorable to the most unfavorable category,

[11] The Broad Tape operates during the hours of 8:00 A.M. to 6:30 P.M. EST; therefore, there is a period of four and one half hours *after* the market's close at 4:00 P.M. EST that an earnings announcement can hit the tape. Because trading on this news must wait until the market's opening on the following day, this was used as the "announcement day". Refer to Patell and Wolfson [23] for a detailed discussion of the Broad Tape's operations.

with the biggest decline being between the less-favorable and neutral categories. There was no apparent reason for these occurrences. A χ^2 goodness-of-fit test was performed to test the null hypothesis of equal frequencies across earnings categories. In every category, the test statistic was significant at greater than the 0.001 level, indicating that the probabilities of a continuation, reversal, and zero change were not equally likely. This also applied when probabilities of a continuation or reversal were considered separately.

B. Announcement Period

Panel B of Table IV presents similar information for the three time segments within as well as over the entire announcement period. For the individual earnings-surprise categories and the total sample, the percentage of continuations was significantly higher in the post-announcement segment than in the other two time segments. For example, the post-announcement percentage of continuations for "All Categories" was 15.7 percent in contrast to only 13.5 percent and 13.4 percent in the pre-announcement and next-day time segments, respectively. This compares with the 14.4 percent continuations found during the nonannouncement period. Thus, when stocks are not separated by their informational content, the effect of the announcement in the post-announcement period appeared to be slight. However, when the earnings-surprise categories are considered individually, the differences become more pronounced. In the most-unfavorable category, for example, the percentages of continuations were 10.9, 16.8, and 12.0 percent for the pre-announcement, post-announcement, and next-day segments, respectively, while the comparable nonannouncement percentage was 12.9.

C. Announcement versus Nonannouncement Periods

C.1. Reversal Behavior for All Transactions

The first group of tests compared the percentage of continuations in the announcement versus the nonannouncement periods. In Table IV, the percentage of continuations varied considerably for each category within the three time segments, i.e., increasing from the pre-announcement to post-announcement time segments but then decreasing markedly in the next-day segment. There was, however, little difference between the *entire* announcement and nonannouncement periods. The biggest difference was found in the less-favorable category, which experienced 16.0 percent continuations in the nonannouncement period versus 15.1 percent in the announcement period.

A χ^2 statistic was computed to test for equality between the relative frequencies of continuations in the *entire* announcement and the nonannouncement periods. This test indicated no statistical differences for the most-favorable and the two unfavorable earnings categories. In the less favorable and neutral categories, a statistically significant difference was found, but curiously there were *lower* proportions of the continuations in the announcement periods. On the other hand, when the announcement period's three time segments were compared individually with the nonannouncement period, a different picture emerged. The

Table IV

Relative Frequency Distributions of Continuations, Reversals, and Zero Changes in Nonannouncement Period, Entire Announcement Period, and the Three Time Segments of the Announcement Period

Earnings-Surprise Category	Continuations	Reversals	Zero Changes	Number of Transactions
A. Nonannouncement Period[a]				
Most Favorable	16.9%	33.3%	49.8%	142,307
Less Favorable	16.0%	32.5%	51.5%	109,159
Neutral	13.8%	32.7%	53.5%	393,811
Less Unfavorable	13.6%	33.0%	53.4%	121,494
Most Unfavorable	12.9%	33.8%	53.3%	126,737
All Categories	14.4%	33.0%	52.6%	893,508
B. Announcement Period[a, b]				
1. Pre-Announcement				
Most Favorable	15.9%**	30.7%	53.4%	3,582
Less Favorable	15.9%	34.0%	50.1%	2,426
Neutral	12.6%**	33.8%	53.6%	9,695
Less Unfavorable	14.1%	34.4%	51.5%	2,596
Most Unfavorable	10.9%***	34.3%	54.9%	3,177
All Categories	13.5%	33.4%	53.1%	21,476
2. Post-Announcement				
Most Favorable	18.5%**	32.8%	48.7%	2,173
Less Favorable	16.7%	31.5%	51.9%	1,462
Neutral	13.5%	36.1%	50.4%	4,719
Less Unfavorable	15.8%**	32.0%	52.2%	2,152
Most Unfavorable	16.8%***	35.3%	47.9%	2,068
All Categories	15.7%	34.1%	50.2%	12,574

3. Next Day				
Most Favorable	17.0%	33.0%	50.0%	3,166
Less Favorable	13.2%***	32.1%	54.7%	2,274
Neutral	13.0%*	34.1%	53.0%	7,516
Less Unfavorable	11.3%***	34.2%	54.5%	2,380
Most Unfavorable	12.0%	31.6%	56.4%	2,650
All Categories	13.4%	33.3%	53.4%	17,926
4. Entire Period				
Most Favorable	17.0%	32.0%	51.0%	8,921
Less Favorable	15.1%*	32.6%	52.3%	6,162
Neutral	13.0%***	34.4%	52.7%	21,930
Less Unfavorable	13.7%	33.6%	52.7%	7,128
Most Unfavorable	12.9%	33.5%	53.6%	7,895
All Categories	14.0%	33.5%	52.5%	52,036

[a] The χ^2 statistics for a goodness-of-fit test of equality of frequencies were all significant at greater than the 0.001 level.

[b] Significance levels of the χ^2 statistics (adjusted for continuity) for a two-by-two contingency-table test of equality between the relative frequencies of continuances for the nonannouncement versus the announcement periods are indicated as follows:

* Significant at the 0.05 level.

** Significant at the 0.01 level.

*** Significant at the 0.001 level.

extreme earnings-surprise categories generally showed statistically significant differences between the two periods. First, in the pre-announcement time segment, the proportion of continuations was *lower* than in the nonannouncement period. This might imply a lack of significant information "leakages" right before announcement. Next, because they should contain stocks with the largest unexpected earnings component, the most-favorable and the two unfavorable earnings-surprise categories had a significantly elevated proportion of post-announcement continuations. By the next day, however, there was no significant elevation of continuations in the two extreme earnings categories, but the other earnings categories had a significantly *lower* proportion of continuations. Thus, these results seem to indicate that most of any expected adjustment occurred within the post-announcement segment, although there is no apparent explanation for the reduced level of continuations in the other two time segments.

C.2. Reversal Behavior by Transactions

In another attempt to measure the speed of adjustment, a second group of tests involved numbering the sequence of transactions according to their proximity to the announcement time and their location within this time segment. Numbering the transactions permitted measurement of the speed of adjustment on a transaction-by-transaction basis. For each earnings category, the number of continuations, reversals, and zero changes were tabulated for the cross-section of transactions associated with each transaction number. Table V reports the relative frequencies of continuations for all stocks by individual transactions following their earnings announcements. For this table, the stocks were regrouped into three earnings-surprise categories in order to provide sufficiently large sample sizes, and only the first fifteen transactions are reported.

Table V indicates that, in general, all three earnings categories had an elevated number of continuations. In particular, the relative frequencies in the favorable category had a sharp increase over the first nine transactions; however, only the first six were statistically higher than the norm during the nonannouncement period (16–17 percent). This was then followed by another increase with transactions 12 and 13. On the other hand, a different pattern emerged for the unfavorable-earnings category. The relative frequencies became significantly elevated over only the first four transactions, but another spurt was experienced again around transactions 12, 13, and 15. The neutral-earnings stocks behaved as expected, with no statistically significant change in their usual price pattern. The exception was a reaction on the first trade following their earnings release. Finally, a closer examination found that the first trade (average reaction time) occurred 13.5, 12.9, and 13.4 minutes after announcement for the favorable-, neutral-, and unfavorable-earnings categories, respectively.

This test suggests that the major portion of an adjustment to unexpected earnings was within the first four to six transactions. Although these results may be viewed as being inconsistent with the hypothesis of an instantaneous adjustment, they do indicate a very rapid adjustment. It appeared as if, after a strong initial reaction, prices drifted only gradually toward a new equilibrium level, with another brief flurry appearing later in the adjustment process. Any such gradual movement may go undetected in our cross-sectional aggregation of stocks.

Table V

Proportion of Continuations by Individual Transactions in the Post-Announcement and Next-Day Time Segments by Earnings Category[a]

Transaction Number following Announcement	Favorable-Earnings Category	Neutral-Earnings Category	Unfavorable-Earnings Category
+1	24.0%*	22.4%*	20.4%*
+2	35.6%***	18.4%	31.1%***
+3	25.0%*	20.0%	26.2%***
+4	28.2%**	15.7%	29.4%***
+5	25.2%*	17.3%	15.8%
+6	28.2%**	16.3%	12.9%
+7	22.2%	15.3%	17.8%
+8	23.7%	22.7%*	15.8%
+9	24.0%	18.6%	18.2%
+10	19.4%	19.6%	13.1%
+11	17.1%	13.4%	16.5%
+12	30.3%***	14.4%	23.7%**
+13	23.3%	14.4%	20.0%
+14	16.5%	15.8%	12.8%
+15	14.1%	13.8%	21.5%*

[a] Significance levels of the χ^2 statistics (adjusted for continuity) for a two-by-two contingency-table test of equality between the relative frequencies of continuations in each cross-section of transactions and in the nonannouncement period are indicated as follows:

* Significant at the 0.05 level.

** Significant at the 0.01 level.

*** Significant at the 0.001 level.

Our results are not inconsistent with those reported by Patell and Wolfson [24] and Jennings and Starks [13]. Patell and Wolfson found that the relative frequencies of continuations remained significantly higher through seven price changes. Because their study was not segregated by informational content, a direct comparison of our results with theirs is not possible. Jennings and Starks found that their high-information-content stocks had an elevated level of continuations through the fourth trade following an announcement and then another elevated number of continuations between the eighth and sixteenth transactions. On the other hand, their low-information-content stocks' price adjustment process appeared to end after three price changes.

IV. Return Behavior and Speed of Adjustment

In this section, we measure the speed of adjustment by examining the stock returns associated with unexpected earnings. The results so far indicate that most of the adjustment occurred within a few hours during the announcement day. Therefore, the next set of tests focuses only on the time period immediately following the announcement. Although the analysis also represents an attempt

to measure how fast prices adjust, it does provide new information on the time path of adjustment.

Conceptually, the overall adjustment to new information can be measured by comparing the last price before the information arrival with the "fully adjusted" price. Empirically, it is not easy to determine the fully adjusted price. On one hand, the passage of time leads to a higher probability that the information has been reflected in the price, but there is also a greater chance that the price will become "contaminated" by other information and general market effects. Given the conclusions of earlier work and our own results, we chose the closing price of the trading day following the announcement day (next-day time segment) to be the fully adjusted price.

The total price adjustment was defined as the percent return a hypothetical investor could have earned by buying a stock on the last transaction before its earnings report was released and then selling it on the last transaction of the following day.[12] The following formula was used to calculate the total price adjustment for each stock in the sample:

$$R_{ij} = \frac{P_{ij}^{ND} - P_{ij}^{-1}}{P_{ij}^{-1}}, \tag{2}$$

where

R_{ij} = total price adjustment or return on stock i in earnings-surprise category j.
P_{ij}^{ND} = the next day's closing transaction price for stock i in category j, and
P_{ij}^{-1} = stock i's price on the last transaction *before* the earnings announcement.

Within each earnings-surprise category, the average total price adjustment, $\bar{R}_j$, was calculated as

$$\bar{R}_j = \sum_{i=1}^{n} \frac{R_{ij}}{n}, \qquad j = 1, 2, \cdots, 5, \tag{3}$$

where n was the number of stocks in earnings category j. Once the total adjustment was known for each stock from equation (2), the time path of adjustment on a clock-time basis was then tracked by comparing transaction prices at one-half-hour, one-hour, two-hour, and three-hour intervals after the announcement with their next-day closing price using a formula similar to equation (2). These results were then cross-sectionally aggregated by earnings category at the end of each time interval using equation (3). This allowed us to

[12] This method of measuring returns is similar to that used by Dann, Mayers, and Raab [7], who tested a trading rule on large block trades. The rule was to buy at the block price and sell at the closing price that same day for those stocks that met certain criteria. They then examined the effect on returns as the lag time of investor response increased from one to fifteen minutes. Our method differs slightly in that the investment position was closed out on the day following the new release. This was done to allow for the possibility that prices are not fully adjusted by the end of the announcement day. In addition, our time-based analysis provides a measure of the portion of adjustment completed as the time interval lengthens. Patell and Wolfson [24] used a similar methodology to test their trading rules.

determine what percentage of the adjustment had been completed at various points in time.

The first line in Table VI presents the average total return, $\bar{R}_j$, for each earnings category. The most-unfavorable-earnings category had the largest total price adjustment of −2.83 percent, while the less-unfavorable- and most-favorable-earnings categories were next with −2.10 and +1.78 percent, respectively.[13] Except for the neutral category, returns declined rapidly toward zero as the time interval increased. Regarding the percentage of adjustment completed, the percentage ranged from nine to twenty-six percent on the first transaction following the announcement. The most-favorable-earnings stocks clearly exhibited the most rapid adjustment. That is, within one half hour, sixty-nine percent of the total adjustment was realized, ninety-one percent after three hours. In contrast, the unfavorable-earnings' adjustments were notably slower but similar. In part, the differential adjustment in the two extreme earnings stocks may have reflected the differential cost and other constraints on short selling for NYSE stocks.

Table VII presents information similar to that in Table VI except that the adjustment process is couched in terms of *transaction time.* These findings indicate that the two extreme earnings-surprise categories had a rapid and relatively unbiased adjustment process compared with the other earnings-surprise categories. Once again, the most-favorable stocks seemed to adjust more quickly, with an eighty-three percent completion compared with the most-unfavorable stocks' seventy-five percent completion through ten transactions. On the other hand, the less extreme earnings-surprise stocks displayed a much slower adjustment. The extreme earnings-surprise stocks' returns path also steadily declined toward zero through the first nine transactions, whereas the smaller earnings-surprise stocks displayed a slightly more erratic path that was not evident in the Table VI results.

V. Trading Activity and the Adjustment Process

The next tests attempted to determine whether adjustments to new information were reflected in three other market attributes: trading volume, transaction frequency, and transaction size. Our analyses of the reversal process and percentage of completion of adjustment did not indicate how price changes occurred or what types of investors were involved in these changes. In addition, while higher trading volume may be associated with earnings surprises, increases in volume could be the result of a few or many trades. Transaction frequency therefore should provide additional insights not available from examining only volume.

The first set of hypotheses to be tested was that above-average volume per

[13] A partial explanation of the smaller percentage adjustment with the most-favorable vis-à-vis the most-unfavorable stocks is that the favorable stocks' *median* degree of surprise was plus seventy percent (range = 41 to 472%) while the most-unfavorable stocks' median was minus eighty-three percent (range = −41 to −3543%). The extremely large negative surprise was produced by Macmillan, Inc., whose forecasted earnings per share was $0.16 but whose actual earnings were reported as a $5.55 per share deficit on March 13.

Table VI

Time Path of Returns and Percentage of Adjustment Completed at Selected Time Intervals

Closing Price of "Next-Day" Segment Compared with:	Earnings-Surprise Category[a]				
	Most Favorable	Less Favorable	Neutral[b]	Less Unfavorable	Most Unfavorable
Price on Last Transaction before Announcement	+1.78%	+1.52%	−0.10%	−2.10%	−2.83%
Price on First Transaction after Announcement	1.32% (26%)	1.38% (9%)	−0.12%	−1.64% (22%)	−2.24% (21%)
Price at One Half Hour after Announcement	0.55% (69%)	0.75% (51%)	−0.16%	−1.30% (38%)	−1.75% (38%)
Price at One Hour after Announcement	0.53% (70%)	0.70% (54%)	−0.11%	−1.14% (46%)	−1.43% (49%)
Price at Two Hours after Announcement	0.25% (86%)	0.56% (63%)	−0.11%	−0.85% (60%)	−1.04% (63%)
Price at Three Hours after Announcement	0.16% (91%)	0.36% (76%)	−0.02%	−0.69% (67%)	−0.87% (69%)

[a] Percentages of adjustment completed appear in parentheses.

[b] Percentages of adjustment completed are not meaningful.

Table VII

Path of Returns and Percentage of Adjustment Completed on a Transaction-by-Transaction Basis

Closing Price of "Next-Day" Segment Compared with Transaction Price:	Earnings-Surprise Category[a]				
	Most Favorable	Less Favorable	Neutral[b]	Less Unfavorable	Most Unfavorable
−1	1.78%	1.52%	−0.10%	−2.10%	−2.83%
	(100%)	(100%)		(100%)	(100%)
+1	1.32%	1.38%	−0.12%	−1.64%	−2.24%
	(26%)	(9%)		(22%)	(21%)
+2	1.25%	1.12%	−0.21%	−1.27%	−1.79%
	(30%)	(26%)		(40%)	(37%)
+3	1.02%	1.06%	−0.18%	−1.19%	−1.64%
	(43%)	(30%)		(43%)	(42%)
+4	0.71%	1.10%	−0.17%	−1.21%	−1.53%
	(60%)	(28%)		(42%)	(46%)
+5	0.56%	0.87%	−0.16%	−1.20%	−1.51%
	(69%)	(43%)		(43%)	(47%)
+6	0.49%	0.73%	−0.17%	−1.18%	−1.34%
	(72%)	(52%)		(44%)	(53%)
+7	0.32%	0.74%	−0.23%	−0.92%	−1.09%
	(82%)	(51%)		(44%)	(61%)
+8	0.27%	0.80%	−0.13%	−0.94%	−0.87%
	(85%)	(47%)		(55%)	(69%)
+9	0.25%	0.66%	−0.17%	−0.99%	−0.91%
	(86%)	(56%)		(53%)	(68%)
+10	0.30%	0.81%	−0.24%	−0.87%	−0.71%
	(83%)	(47%)		(41%)	(75%)

[a] Percentages of adjustment completed appear in parentheses.

[b] Percentages of adjustment completed are not meaningful.

unit of time should be observed immediately following an earnings surprise and that the ratio of post-announcement volume per unit of time to nonannouncement volume per unit of time should increase with the degree of surprise. The second set of hypotheses was that a greater frequency of transactions should occur immediately following an earnings surprise and that the ratio of post-announcement to nonannouncement transaction frequencies should increase with the degree of surprise. Similar to the returns analysis, these hypotheses were tested over the first half hour, second half hour, second hour, and third hour following the earnings announcement.

The volume and transaction frequency ratios were aggregated across all stocks in each earnings category to determine the average ratio and standard deviation of ratios. These statistics are reported in Table VIII. In Panel A, the volume analysis reveals that the lowest ratios were in the neutral category for each time interval considered. In the first half hour, for example, the average volume traded on a neutral-earnings stock was 2.02 times its average volume in the nonannouncement period. This ratio is considerably lower than those experienced in the other four earnings-surprise categories. During this time period, almost five times and over six times the average nonannouncement volume occurred in the first half hour of the most-favorable and most-unfavorable categories, respectively.

In general, trading volume tended to be directly related to the degree of surprise, and, although volume tapered off over time, it still remained well above average throughout the three-hour time period. Except for the first half hour, the most-favorable stocks experienced a relatively higher level of activity, especially in the third hour. This may help to explain their more rapid adjustment noted earlier. In addition, although unfavorable stocks' adjustments were found to be slower, notice that these stocks also exhibited relatively high levels of trading activity.

In Panel B, the transaction-frequency ratios essentially mirrored what was happening to the volume ratios. For both ratios, an analysis of variance was conducted to determine whether they were statistically different across earnings categories. The F-statistics' significance levels in Table VIII indicate that none of the volume ratios were statistically different from each other, the reason being the high variability in these ratios. In contrast, three of four transaction-frequency ratio comparisons were statistically different at the five percent level.

Next, while elevated investor interest was quite evident, it was not clear whether we were observing an above-average number of small or large trades. To address this issue, the volume ratios were divided by the transaction-frequency ratios and reported in Panel C of Table VIII. If this new ratio is greater than one, for example, this means that the post-announcement *volume per transaction* was higher than that found in the nonannouncement period. As shown, the higher volume and transaction frequencies were associated with an above-average number of shares per trade. In particular, unfavorable stocks tended to have larger trades in the first half hour, while most-favorable stocks exhibited much higher volume per trade later in the time period. On the latter, as the time interval lengthened, perhaps larger investors, having had sufficient time to receive and analyze the new information, were more likely to take a position. Nevertheless, a closer examination of the data yielded very little evidence of institutional

activity because only three block trades (10,000 shares or more) were found in this category.[14]

VI. Summary and Concluding Comments

This study used three sets of tests to examine the intradaily speed and path of adjustment in NYSE stock prices to the degree of unexpected earnings. It was found that, while the adjustment was not "instantaneous", it did occur rapidly within the first few hours following an earnings announcement. The average reaction time was relatively quick, with the first trade taking place within fourteen minutes on average. One implication is that the rapid adjustment provides floor traders with a comparative advantage because they can react more quickly than off-exchange traders, and this represents a means of compensating them for their efforts.

In addition, not only did stocks with high- versus low-informational-content announcements experience a differential adjustment process, but, more importantly, stocks with extremely favorable earnings surprises exhibited a more rapid adjustment than those with extremely unfavorable unexpected earnings. In this regard, companies with extreme earnings surprises typically had a small market capitalization, low institutional ownership, and no tradable options compared with those stocks with no surprises. While this may help to explain the differential-adjustment process in the high- versus low-informational-content announcements, the similarities in these firm-specific characteristics for the two extreme-surprise stocks did not offer much explanation for their differential price adjustments. Rather, it could be conjectured that the adjustment process was more a function of market microstructure; e.g., the uptick rule makes it harder to short a stock on unfavorable news than to buy on favorable news.

Volume and transaction-frequency tests found an initial flurry of investor activity in the first half hour following an announcement, but, in general, this activity appeared to dissipate quickly within three hours, except in the case of the most-favorable-earnings stocks. In addition, there appeared to be a general lack of institutional activity in the adjustment process. In part, this may reflect floor traders and individual professional investors who typically anticipate and can react more quickly to earnings reports and who are more inclined to speculate on positive surprises than to speculate on negative surprises by selling short.

The current study has some potential drawbacks. Our results may apply only to the time period analyzed, and this time period was relatively short. Furthermore, the ability of our analysis to identify the new information in the earnings announcements depended on how well the *Value Line* forecasts reflected investor expectations. In addition, our initial definition of the adjustment process lasting only two days may be incorrect because it may in fact occur over a much longer

[14] Specialists and floor brokers seeking to execute large market orders frequently split the orders among the limited price quotations of several competing market participants. This may have been especially true in the case of the most-favorable and unfavorable stocks because they were smaller and less actively traded and, hence, less liquid. Such activity may have "disguised" the presence of institutional investors in the adjustment process and increased the transaction frequency.

Table VIII

Average Volume and Transaction Frequency Ratios for the First Three Hours following an Earnings Announcement[a]

Earnings-Surprise Category	First Half Hour	Second Half Hour	Second Hour	Third Hour
A. Volume Ratios				
Most Favorable	4.96	4.06	3.04	5.36
	(7.32)	(12.92)	(8.23)	(27.57)
Less Favorable	3.07	2.06	1.79	1.62
	(3.11)	(4.32)	(2.43)	(2.08)
Neutral	2.02	1.57	1.20	1.53
	(3.62)	(2.06)	(2.57)	(4.70)
Less Unfavorable	8.94	2.12	2.14	1.98
	(33.53)	(3.15)	(4.03)	(5.88)
Most Unfavorable	6.29	3.39	2.42	2.20
	(25.27)	(7.45)	(7.31)	(2.18)
F-Ratio Significance Level[b]	0.19	0.19	0.22	0.36
B. Transaction-Frequency Ratios				
Most Favorable	3.01	2.22	1.69	1.76
	(3.53)	(2.32)	(1.71)	(1.69)
Less Favorable	2.35	1.59	1.28	1.13
	(2.38)	(1.81)	(1.06)	(1.46)
Neutral	1.48	1.52	1.22	1.17
	(1.13)	(1.25)	(0.81)	(0.86)
Less Unfavorable	2.07	1.91	1.74	0.94
	(1.82)	(1.64)	(1.49)	(0.94)
Most Unfavorable	2.41	2.01	1.64	1.36
	(2.27)	(2.10)	(1.35)	(1.11)
F-Ratio Significance Level[b]	0.00	0.10	0.04	0.00

C. Volume/Transaction-Frequency Ratios				
Most Favorable	1.65	1.83	1.80	3.05
Less Favorable	1.57	1.30	1.40	1.43
Neutral	0.85	1.03	0.98	1.31
Less Unfavorable	4.32	1.11	1.23	2.11
Most Unfavorable	2.61	1.69	1.48	1.62

[a] Standard deviations appear in parentheses.

[b] Levels of significance for the F-statistics computed for an analysis of variance, where F is the ratio of the estimated population variance based on variation among the sample means to the estimated population variance based on variation within samples. The null hypothesis is that there was no statistical difference among the mean ratios of the five earnings-surprise categories.

time period, e.g., as security analysts digest the new information, revise their expectations, and issue new recommendations. However, considering a longer time period incurs the confounding problem of *other* events affecting stock prices, which would obscure the true adjustment process, e.g., market effects, industry news, unrelated portfolio adjustments by investors, etc.

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