DETERMINATION OF THE APPROPRIATE EVENT WINDOW LENGTH IN INDIVIDUAL STOCK EVENT STUDIES

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It is common practice to assess the average effect of some type of announcement on stock prices by performing event studies on a large sample of firms and then averaging or otherwise combining the results. One benefit of this procedure is that the event window length can be standardized across observations because the errors from having too long or short an event window should have a small impact on the average by the Law of Large Numbers. Here, we examine various potential rules for determining the length of an event window when looking at a limited number of observations. We find that rules based on continuing price movements yield window lengths that correlate with the “size” of the news, as measured by the magnitude of earnings surprises, while a rule based on abnormally high volume does not have this property.

I. INTRODUCTION

Event studies have become standard tools for economists attempting to measure the effect of a particular announcement or category of announcement. The basic event study technique is by now well known and used in a number of fields. As with many modern economic analyses, the event study is an attempt to quantify some variable (in this case, the response of a stock price to some event) in an objective manner that is standard and replicable, and thus would have measurable statistical properties. With a given event to be studied, the standard event study technique leaves a limited number of choices to the analyst, thereby reducing the potential for subjective decisions and bias. Probably the most prominent of these choices are as follows: (1) the determination of the estimation window over which to measure the stock’s normal movements and correlation with an outside index or indices; (2) the index or

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indices to use to measure normal movements in the estimation window; (3) the determination of the event window over which to measure the stock’s abnormal return; (4) the frequency of data to be studied; and (5) the specification of price measurement (e.g., trading price v. bid-asked midpoint).

Of these five choices, the first is generally unlikely to greatly impact the results in any predictable way or even with too great a magnitude. For example, there is little reason to expect a large difference in the relationship between returns to a stock and returns to the selected market or industry indices if an estimation window runs for sixty days or one year before the event, assuming that the company in question did not undergo a major change in its profitability or line of business. There is of course a trade-off between windows extending back farther, and thus providing a larger data sample, and windows that start soon before the event window, and thus are less likely to include periods when the parameters of the market model were different.

Given an estimation window, the choice of a proper index would seem to be the least controversial, at least if a limited universe of indices exists. Unless special circumstances dictate otherwise, the index that has the strongest explanatory power in the estimation window would be the obvious candidate to use in the event study. In cases where one is running event studies for a large number of stocks, however, it may be more economical to stick to a broad market index rather than test the proper index for each case.

The principal focus of this paper will be on the third choice: how to determine the proper length of the event window. We focus on the case where the event itself occurs at a known time, so that the start of the event window is generally not an issue. What is unknown is when the market fully incorporates that news into the stock price.

This paper is organized as follows. Section II discusses the academic literature on event windows and the speed of market reaction. Section III considers the differences between studies of similar events over a number of stocks and a study of one particular event in one stock, and presents three proposed approaches to determining the length of an event window in a single-company study. Section IV discusses the data used in testing the three proposed
approaches and the implementation of the methodology. Results are presented in Section V, and discussed in Sections VI and VII. Section VIII concludes.

II. LITERATURE REVIEW

While there is a fairly extensive literature on event studies, there are only a few papers that deal with the length of time over which to measure the price reaction. One of the early papers in this area is Hillmer and Yu (1979). Hillmer and Yu develop a theory on the assumption that there are two types of return processes, one during a period of adjustment to the event and one outside the reaction period. While this is a rather strong assumption, it may be necessary for tractability. That is, one of the easiest ways to distinguish the period of reaction to an event is to assume that that period has some uniform characteristic different from the uniform characteristic of non-event periods. Hillmer and Yu test their model and find that there is no difference in mean price changes during the event window, but that there is an increased variance. These results are consistent with the efficient market hypothesis: there can be an initial jump to an expected change, after which future price changes during the event window would be expected to be uncorrelated. However, as long as the market is still absorbing the new information, the variance within the event window should be higher than in non-news periods outside the window. Using intraday data and five case studies, Hillmer and Yu find that the event window should end within hours of the initial announcement.

The Hillmer and Yu methodology is applied using daily data by Chang and Chen (1989). Chang and Chen find that event windows should go on for a number of days as the market keeps responding to news. Their results raise an interesting question about whether the time measured is related to the frequency of the data sampled, since their use of daily periods rules out finding an intraday event window and also makes finding even an event window of a single day difficult since there would really be no variance to measure within the event window.

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Recent papers often deal with the question of when the market reaches efficiency, which is defined as the time after which future price movements are not predictable from past information. While this is helpful in establishing a minimum period for the event window, it need not define the proper end of the window, as discussed in Section VI, below. Chordia, Roll, and Subrahmanyam (2001)\(^4\) show that order imbalances are corrected for within periods from five minutes to an hour. This signals the start of the period over which arbitrageurs have entered the market to ensure that there is no more predictable price movement. Busse and Green (2002)\(^5\) find that stocks react immediately to CNBC Morning and Midday Call reports. Busse and Green claim settlement occurs within fifteen minutes, which does represent a plateau in some of their figures. However, their Table 4 also shows some statistically significant price reactions occurring up to ten days later. Again, the results may be related to the period of observation.

III. PROPOSED SOLUTIONS

We now propose three ways to assess the proper length of the event window. In each case, we depart from the Hillmer and Yu assumption that some variable has a constant distribution in the event window that is different from its distribution outside the window. Doing so allows us to have a more flexible rule for determining the end of the event window. The drawback to this is that the rule will be a little more \textit{ad hoc} than the Hillmer and Yu methodology.

One could characterize the possible approaches to determining the length of an event window as belonging to one of three categories: using a fixed length of time, taking an \textit{ad hoc} approach, or following a rule based on the trading behavior of the stock during the potential event window.


An approach followed in most academic event studies is to allow a predetermined number of days for the stock price to react to an announcement. Lev (1989) reports the event window lengths used in a sample of 19 cross-sectional returns/earnings studies published in three major accounting journals over from 1980 to 1988. All but one of the studies he surveys use fixed-length windows, ranging from two days to one year. This method is often used in studies that measure the reaction of a large number of stocks to an event or events, in which case it might not be practical to determine event window length separately for each stock in the sample. Moreover, where the reaction of many companies to an event is being averaged, it is likely that, if the market initially misinterprets the event's effect on some of the individual companies, these miscalculations will offset one another. Say, for example, that the announcement of a stock split should cause a stock to rise either by five or fifteen percent, depending on what the split says about the underlying condition of the company, with fifty percent of announcements ultimately falling into each category. Before the market has time to figure out which category is appropriate in a particular instance, the stock price would rise by ten percent, so that the expected future increase is zero and there are no (risky) arbitrage opportunities available. If one is attempting to measure the average effect of a split announcement, the point estimate of the average effect will not depend on whether she counts one hundred returns of ten percent each or fifty returns of five percent and fifty returns of fifteen percent.

A fixed-length event window may be less appropriate for studies that focus on just a few securities or a single security. For one thing, the smaller the sample, the less likely that an initial over- or underreaction in the price of one security will be offset by an under- or overreaction in the price of another, because the Law of Large Numbers will not apply. Also, if the sample of companies is relatively small, it becomes feasible to measure each event window individually. If so, one possibility is to decide on an ad hoc basis how long to allow for the market to react to an event. A researcher might look at certain indicators that the market is

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6 Baruch Lev, “On the usefulness of earnings and earnings research: Lessons and directions from two decades of empirical research,” *Journal of Accounting Research Supplement*, 27 (1989), pp. 153-192. Even the one study in Lev’s sample that does not fix event window length does not determine length based on a statistical test; rather, the window ends in March of the following year regardless of when it begins.
reacting to news – such as unusually high or low returns, unusually high trading volume or unusually high fluctuations in price – and base a judgment about how long the market took to react on how long these indicators persisted. If on the three trading days following an event, for example, there were unusually high negative returns to the security affected, but on the fourth trading day the return was close to zero, a researcher might suspect that the reaction to the event lasted three days. If trading volume was also unusually high over the first three trading days, but returned to a typical level on the fourth day, this might confirm the judgment based on abnormal returns.

One advantage of the *ad hoc* approach over using a fixed-length window is that the latter approach makes use of information about the price movement and/or trading volume of a stock. A shortcoming of the *ad hoc* approach is that it is potentially inconsistent: two researchers observing data for the same security could come to different conclusions about the duration of the market’s reaction to an event. A more consistent approach is to formulate a rule to determine event window length, in which the reaction to an event is considered to persist as long as certain criteria, involving price movements or trading volume, are met. Like the *ad hoc* method, a rule uses information about the security being studied to determine event window length, rather than simply picking an arbitrary number of days. A rule, however, also applies a consistent set of criteria to determine when the stock price reaction to an event has ended.

We test three rules, based on the persistence of (i) abnormal returns to the stock price, (ii) abnormally high trading activity in the stock, and (iii) abnormally high volatility in the stock price. For our purposes here, looking at a large number of events, we do not consider other reasons to end an event window. It is important to note that when examining a single event, one has to also look at whether other news, besides the event under consideration, enters the market during the proposed event window. When the confounding news enters simultaneously, one must be aware that any price movement will show the combined effects of all of the news, and one cannot attribute that movement in whole or part to one news item or another without some form of additional analysis. When the confounding news enters the market after the news about the event being studied, one option is to end the event window before the later information arrives. While the measurement of the effects of the original news
is then potentially less precise because the full effect of the information may not be included, the excluded portion of the price reaction has an expected value of zero; the benefit is that other news, which may have a clear but unquantifiable directional impact, is excluded from the event window.

**Rule 1: Significant Abnormal Returns**

The first rule we test bases event window length on how long significant daily abnormal returns to the security price continue. According to this rule, the market’s reaction to an event persists until the first day with no statistically significant abnormal return. If statistically significant abnormal returns to a stock price persist, we assume that the market is still reacting to that event. Take the case of a stock with a statistically significant negative abnormal return on the first trading day after news was revealed to the market. On the second day, the reaction is measured as continuing if the abnormal return is again statistically significant, whether the abnormal return is again negative – indicating that investors believed the market had underreacted on the first day – or positive, indicating that investors believed there had been an overreaction the first day.

The logic behind this rule is simple: if significant abnormal returns persist, then the statistical evidence suggests that the market is continuing to incorporate the new information. There are, however, at least two reasons why this rule might incorrectly measure the length of the market’s reaction to an event. First, by relying only on daily closing prices, the rule could miss intraday fluctuations. Suppose, for example, that on the first trading day after an event that affects a particular stock (Day 1), there is a statistically significant 20 percent drop in the price of that stock. On the following trading day, Day 2, the stock price at first continues to drop, but then reverses course sometime during the day, as investors decide that the market has overreacted to the news. At the end of Day 2, the price is the same as the closing price on Day 1. On the next trading day, Day 3, the price continues to rise and ends up a statistically significant 10 percent higher than at the end of Day 2. The rule based on abnormal daily returns would measure a one-day event window and an abnormal return of negative 20%,
whereas based on what we know about the intraday price movements on Day 2, we would conclude that the market took three days to fully react to the event, and in the end fell by about 12%.

Another reason a rule based on abnormal returns might produce an incorrect measure of event window length is simple Type II error: an observed abnormal return is within the range in which the null hypothesis is not rejected, though the market is still working to incorporate the effects of the news. This potential problem is not specific to the abnormal returns rule.

**Rule 2: Significant Abnormal Trading Activity**

The second rule we test measures event window length based on the persistence of abnormally high trading activity in a security following a disclosure. The idea behind this rule is that as the market adjusts to the new information, market participants buy and sell at significantly higher volume than under normal circumstances. For reasons that will be explained below, it is more useful to measure trading activity in terms of turnover, the percent of a company's shares that are traded on a given day.

**Rule 3: Significant Abnormal Intraday Volatility**

The third rule we test measures event window length based on the persistence of significant abnormal intraday volatility. The intuition behind this rule is similar to in the case of the abnormal daily returns rule: we expect the price of a stock to be more volatile when it is adjusting to new information than otherwise. As noted above, however, a rule based on daily abnormal returns does not capture intraday price movements; this is exactly what the rule based on intraday volatility is designed to do. According to this rule, the event window continues as long as volatility – the range over which prices fluctuate over the course of a day (including the previous day's close) – is statistically significantly higher than would be expected given the volatility of the market as a whole.
IV. DATA AND METHODOLOGY

To test the methodology, we examined two types of announcements that one would expect to have potentially different event window lengths associated with them. First, earnings announcements are among the most anticipated announcements that could still be expected to have an effect on price. Market participants are often informed about the timing of the announcement and form expectations about the financial figures that are generally the key pieces of information in those announcements. Moreover, due to the high frequency of these announcements, market participants have tremendous experience in interpreting those announcements that principally indicate that earnings have exceeded or fallen short of expectations by some modest margin.

At the other extreme, we would like announcements that the market considered to be unusual in nature. One source for this would be shareholder class action lawsuits, where at least some parties allege that market participants were strongly misled about the operations of a company, over a period of time defined in the lawsuit and known as the “class period.” In nearly every shareholder class action, the class period ends with an announcement or other disclosure that, it is alleged, reveals to the market the truth about the fraud that is the subject of the litigation. Our hope is that due to the presumably unexpected nature of these disclosures we will find a large number of cases where the market did take more than one day to fully incorporate the relevant news.

Our dataset is comprised of companies that had securities fraud class action lawsuits filed against them in February, April, June, August, October, or December of 2001. Data on class action filings were obtained from monthly issues of Securities Class Action Alert and from Securities Class Action Clearinghouse (http://securities.stanford.edu/index.html).

For each company, we considered up to three events: 1) the class period-ending disclosure, 2) the previous earnings announcement, and 3) the following earnings announcement. We then performed news searches to determine the time of day in which the information was first released. Because our proposed methodologies for determining the event window length would potentially not work well for intra-day events (i.e., the predicted levels and standard deviations of daily returns, volume, and volatility would have to be adjusted to
consider the length of the trading day involved and to account for the presence or absence of the time between close and open), we exclude from our sample any events that occurred during the trading day. All non-intra-day events are included if 1) we can find a press release giving information about the event, 2) we can find price and volume data (from FactSet Research Systems, Inc. [FactSet]) and shares outstanding data (from FactSet or SEC filings), and 3) trading of the company’s stock is not halted shortly after any of the events.\footnote{We considered trading to have been halted if there was zero volume on the first trading day after an announcement, or on any day before the end of the event window, as measured by any of the three methods.} As 120 companies had shareholder class action lawsuits filed against them in February, April, June, August, October, or December of 2001, there are potentially 360 observations. Because not every company had an earnings announcement before and after the class period-ending disclosure, and because some observations were discarded due to the above-described reasons, our actual sample consists of 221 observations.

For all earnings announcements, we also collect from FactSet earnings surprise data published by the Institutional Brokers' Estimate System (IBES). We obtain data on the daily high, low, and closing values of the S&P 500 from FactSet as well. Additionally, we obtain daily NYSE turnover from the NYSE.

We are aware of a few imperfections in the data we are using. For some companies, there are trading days with no reported trading volume. We include these days in our estimation window, since the fact that there is no trading volume is relevant to our abnormal turnover method. However, even on days for which there is no reported trading volume, FactSet sometimes does report different high, low, and closing prices, generally based on trading quotations. We use these values in the estimation windows for our abnormal stock return and abnormal stock price volatility methods, although there were no shares reported traded at these prices.

As in most academic event studies, we do not remove days with news stories from the estimation windows. We also do not test whether there is other news, in addition to the earnings announcement or the disclosure for a shareholder class action, during the event window. Ideally, one would like an estimation window free of news and an event window free of news other than the announcement being considered. While excess news could affect the
overall results, there is no reason to believe the relative effects across the different methodologies will be significant.

Another data issue concerns turnover. Due to data constraints, we use a definition of turnover that is a proxy for a better measure. We define turnover as trading volume divided by shares outstanding. A more appropriate calculation would be trading volume divided by shares available to trade, defined as shares outstanding plus short interest less insider holdings. This would make the turnover calculation more standard across companies that have different percentages of shares held by insiders (and therefore not traded) or short interest. However, we do not have an easy way to obtain those data for our sample, so there is no practical way to modify our turnover calculation.

Moreover, our data on shares outstanding are also not perfect. While in reality, shares outstanding change daily or almost daily, shares outstanding data are available only on a quarterly basis. We treat the change in shares outstanding as occurring on the first trading day of the final month of each calendar quarter (March, June, September, and December).

**Methodologies:**

**Abnormal Daily Stock Price Return Method:**

In this method, we calculate daily natural log returns to each company’s closing stock price and regress those returns on the daily log returns of the S&P 500 over an estimation window of one year before the company’s first event. If data are not available for the entire one-year period before the event, we limit the estimation window to the sub-period of the year before the first event during which data are available. If the company had an IPO during the proposed estimation window, we exclude the first five returns from the estimation window to eliminate any stock price reaction immediately following the IPO. Using this market model, we are able to predict returns for the company’s closing stock price from the closing price before the event to the next closing price after the event, and for several subsequent days. We define the abnormal daily return of the company as the difference between the actual return and the predicted return. We then calculate a t-statistic on each daily abnormal return. We let the
event window extend through the last consecutive day at which the daily t-statistic is significant at the 5% level.\footnote{As noted above, more refined analyses could be made by also ending the event window if another major news event occurred in the period of the window. To avoid considerations of what other type of event would be considered major, we did not attempt to limit the event windows due to other news. This applies to all three of the methodologies we examine.}

**Abnormal Stock Price Volatility Method:**

We define volatility as the natural log of daily high price divided by daily low price, where “daily high price” is the maximum of the daily intra-day prices and the previous day’s closing price, and “daily low price” is the minimum of the daily intra-day prices and the previous day’s closing price. We include the previous day’s closing price to capture any change in price from the previous close to the open. We use an identically defined volatility on the S&P 500 as the independent variable and run a regression over the estimation window as defined above. We are then able to calculate abnormal daily volatility for the day following the event and for several subsequent days. We calculate a t-statistic for each day’s abnormal volatility and let the event window extend through the last consecutive day at which the daily t-statistic is significant at the 5% level.

**Abnormal Turnover Method:**

We calculate daily turnover as the ratio of trading volume to shares outstanding. Our independent variable is turnover on the New York Stock Exchange, which we take as a proxy for market turnover as a whole. Again, we run a regression over the estimation window and calculate abnormal daily turnover for the day following the event and several subsequent days. We again let the event window extend through the last day in which the turnover is larger, by a statistically significant amount at the 5% level, than the prediction based on the estimation window analysis.

**Additional Analysis:**

For each security, up to three of the events we are studying are earnings announcements (in some cases, the class period-ending disclosure is an earnings announcement). For these
events, we calculate an “adjusted surprise” as the absolute value of the earnings surprise (defined as the actual surprise less the consensus analyst estimate obtained from IBES) divided by the closing stock price before the event. Then for each of our three methods, we regress the event window lengths on the adjusted surprise for all earnings announcements for which we were able to acquire reliable surprise data.

V. RESULTS

Table 1 breaks the announcements up into three groups: those announcements that are earnings announcements only, those that are the end of a class period, and those that are both an earnings announcement and the end of a class period. The table shows the correlations of the length of the event window across the three methods, with the goal of seeing whether the choice of methodology matters.

A. Correlations In the Length of the Event Window Under Different Methodologies

<table>
<thead>
<tr>
<th>Announcements That are Earnings Announcements Only</th>
<th>Abnormal Volatility Method</th>
<th>Abnormal Turnover Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abnormal Return Method</td>
<td>0.5632</td>
<td>0.3011</td>
</tr>
<tr>
<td>Abnormal Volatility Method</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Observations: 159</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Correlation of Measured Event Window Lengths
Announcements That are Ends of Class Periods

<table>
<thead>
<tr>
<th>Method</th>
<th>Abnormal Volatility Method</th>
<th>Abnormal Turnover Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abnormal Return Method</td>
<td>0.8815</td>
<td>0.6415</td>
</tr>
<tr>
<td>Abnormal Volatility Method</td>
<td></td>
<td>0.6360</td>
</tr>
</tbody>
</table>

Number of Observations: 62

Correlation of Measured Event Window Lengths
Announcements That are both an Earnings Announcement and the End of Class a Period

<table>
<thead>
<tr>
<th>Method</th>
<th>Abnormal Volatility Method</th>
<th>Abnormal Turnover Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abnormal Return Method</td>
<td>0.9413</td>
<td>0.6805</td>
</tr>
<tr>
<td>Abnormal Volatility Method</td>
<td></td>
<td>0.7869</td>
</tr>
</tbody>
</table>

Number of Observations: 14

The strongest correlations are always between the abnormal return and abnormal volatility measures. This result is not unexpected, as both of these measures rely on price data. When one considers abnormal turnover, the results are least similar to the other two methodologies for the pure earnings announcements, or the announcements that are least likely to be surprises to the market. Table 2 below examines whether the average lengths of the windows for each of the three classifications of announcements follows a similar pattern. In particular, Table 2 shows summary data on the average event window length under each
method. In each case, the average estimated event window length is smallest for the abnormal return methodology, followed by the abnormal volatility methodology, and is longest for the abnormal turnover methodology.

The three types of announcements also display the same ordering as with the correlations: the pure earnings announcements have the smallest average window, and announcements that are both earnings announcements and the end of a class period have the longest average window. One interpretation of this is that there is some noise in all of the measurement periods and that more significant events have a higher signal-to-noise ratio. That is, for event windows that are a day or two long, as may be the case with earnings announcements that do not surprise the market, the estimated window length may be a function of chance. When an event window stretches out for multiple days, as is more likely with more significant events like those at the end of a class period, the different methodologies are more likely to all pick up the longer window and hence be correlated.

Table 2
Average Lengths of Event Windows For Three Groups of Announcements

<table>
<thead>
<tr>
<th>Number of Observations</th>
<th>Average Event Window Length (Days)</th>
<th>Abnormal Return Method</th>
<th>Abnormal Volatility Method</th>
<th>Abnormal Turnover Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Announcements That are Earnings Announcements Only</td>
<td>159</td>
<td>0.321</td>
<td>0.522</td>
<td>0.862</td>
</tr>
<tr>
<td>Announcements That are Ends of Class Periods</td>
<td>62</td>
<td>1.113</td>
<td>1.532</td>
<td>2.565</td>
</tr>
<tr>
<td>Announcements That are Both an Earnings Announcement and the End of Class a Period</td>
<td>14</td>
<td>1.571</td>
<td>2.000</td>
<td>3.214</td>
</tr>
</tbody>
</table>
B. Relating the Length of the Event Window to the Size of the Earnings Surprise

For the two announcements for each security that are earnings announcements, we next consider the relationship between the estimated event window lengths and the absolute magnitude of the earnings surprise. Our hypothesis is that larger surprises will take longer for the market to process since these are more likely to contain some form of unexpected information.

In Table 3, we present simple regressions that examine the relationship between the calculated event window length under each methodology and a standardized measure of the earnings surprise for the earnings announcements for each issuer, showing estimated coefficients and t-statistics. The earnings surprises are normalized by taking the absolute magnitude of the per-share surprise and dividing each by the pre-announcement stock price of the relevant company. The regressions examine the relationship between the event window length and the normalized earnings surprise both with and without a dummy for whether the event is the end of a class period.

Both the abnormal return and volatility methods yield a statistically significant positive relationship between the magnitude of the surprise and the estimated length of the event window, which matches our hypothesis. The two coefficients are reasonably close to each other, both with and without the end-of-class-period dummy, which is not surprising given the high degree of correlation in the estimates of the two event window lengths. The turnover or volume method, however, yields a statistically insignificant and negative relationship between the estimated days in the event window and the absolute magnitude of the earnings surprise. Viewed in isolation, this might be taken to mean that our measure of the magnitude of the earnings surprise was either noisy or had no relation with the time it takes the market to absorb news. However, the strong statistical relationship found for the abnormal return and volatility measures argues against these interpretations. Instead, while one should not overemphasize the

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9 To the extent that previously discussed data imperfections exist (e.g., days in the estimation window that might be part of a trading halt or other news events in the proposed event window), this would likely bias our results toward not finding a statistically significant relationship.
results of a single test, the data here suggest that continuing price movements are good measures of the time that the market takes to impound information because the period of abnormal price movements is positively correlated with the “size” of the news. Turnover, on the other hand, does not correlate with the size of the news, meaning that at least the tests here provide no evidence that higher volume or turnover is a good indicator that the market is still adjusting valuations in response to new information.

Table 3
Relationship Between Event Window Length and Size of Earnings Surprise

*Abnormal Return Method*

<table>
<thead>
<tr>
<th>Days in Event Window</th>
<th>0.2766 + 1.5432 * Adjusted Surprise + 1.1056 * End of Class Period Dummy</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-statistic</td>
<td>4.1705 2.4284 5.1789</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.2336</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Days in Event Window</th>
<th>0.3558 + 2.5194 * Adjusted Surprise</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-statistic</td>
<td>5.0568 3.8081</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.0891</td>
</tr>
</tbody>
</table>
**Volatility Method**

\[
\text{Days in Event Window} = 0.4805 + 1.7231 \times \text{Adjusted} + 1.3083 \times \text{End of Class Period Dummy}
\]

T-statistic: \[ \begin{array}{ccc} 5.6905 & 2.1300 & 4.8136 \end{array} \]

Adjusted \( R^2 \) = 0.2025

\[
\text{Days in Event Window} = 0.5742 + 2.8782 \times \text{Adjusted Surprise}
\]

T-statistics: \[ \begin{array}{c} 6.4833 \end{array} \]

Adjusted \( R^2 \) = 0.0735

**Turnover Method**

\[
\text{Days in Event Window} = 0.8796 - 3.1218 \times \text{Adjusted} + 2.7174 \times \text{End of Class Period Dummy}
\]

T-statistics: \[ \begin{array}{ccc} 3.8395 & -1.4223 & 3.6851 \end{array} \]

Adjusted \( R^2 \) = 0.0781

\[
\text{Days in Event Window} = 1.0742 - 0.7226 \times \text{Adjusted Surprise}
\]

T-statistics: \[ \begin{array}{c} 4.6116 \end{array} \]

Adjusted \( R^2 \) = -0.0065
VI. **Determining Overall Materiality or Statistical Significance**

One question that then arises is what methodology should be used to determine whether there has been a material or statistically significant change in the stock price as a result of the event under consideration. The most obvious answer is that one should test the entire price movement over the estimated event window for statistical significance, to see if the total price effect can be distinguished from random movements of the stock price.

We first note that an event window could appear to extend for one or more days, even though the net effect of the event is statistically insignificant, and that this is not a violation of the efficient market hypothesis. Under the efficient market hypothesis, it is not necessary for a stock price to *fully* incorporate all information immediately, but only for it to provide the best estimate of the value of that information, given the current state of computing ability, at any point in time. For example, if a company announced that its business plan was unchanged but that all cash flows would be 10% higher for the infinite future, the stock price should go up by 10% immediately. However, if the company announced changes in the structure of its operations such that investors and analysts were required to build new valuation models (or if the company announced that cash flows would change by x% where x was the solution to a complicated mathematical formula it provided), nothing in the theory of efficient markets requires that the new correct valuation be arrived at immediately.

There is then the question of what to do when the price movement on the first day of the event window is statistically insignificant, but looking at another measure, such as volume or volatility, leads one to look at a larger event window and the cumulative price movement in that window is statistically significant. The difficulty comes from the apparent contradiction of ignoring the statistical significance of the price movements for determining the length of the event window but using those same data and tests when determining the statistical significance of the overall price movement. While this tension occurs whenever the price movement

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10 Technically, this does not violate the no-arbitrage formulation of the efficient market hypothesis if one cannot predict the direction of later price movements while in the middle of the event window. If one interprets the efficient market hypothesis to say that the stock price reflects all information at all points in time, and therefore impounds information the second after a news announcement, then an event window longer than a single trade would of course violate this formulation.
methodology and another result in different event window lengths, it seems more apparent when the price movement methodology suggests that there was no significant event at all. One concern is that the announcement itself changed the typical volatility or volume for the stock, so that more post-event days are likely to appear significant under these tests, even though the price or average valuation impact of the event may be close to zero. Researchers may take different tacks at this point, but at the very least, one should exercise caution in these circumstances. For example, a careful investigation on whether there is another reason for the stock to move after the first day, but not by a statistically significant amount on the first day, would be warranted.

VII. CASE STUDY

Our methodology and results are illustrated by a case study of one company included in the study: Critical Path (ticker CPTH). Critical Path was included in our sample because it was listed in Securities Class Action Alert as having had a securities fraud class action lawsuit filed against it in February 2001.

According to Securities Class Action Alert, the lawsuit was filed on February 2, 2001, for a class period beginning January 19, 2001 and ending February 2, 2001. On the class period end date, according to news reports, Critical Path announced that it might restate its most recently reported quarter, that its board of directors was investigating company revenue recognition practices, and that two top officers had been placed on administrative leave. Our other two observations for Critical Path were the earnings announcements immediately before and after the end-of-class period announcement, on January 18, 2001 and May 14, 2001.

News articles for all three announcements showed that none of the three announcements was made during the trading day, which would cause an announcement to be excluded from the sample. The February 2, 2001 announcement ending the class period was made before the beginning of trading, so the stock price reaction to it was measured beginning on that date. Each of the earnings announcements was made after the close of trading, so the stock price reaction to each was measured from the next trading day after the announcement. We then calculated an event window by each of our three methods for each of the three announcements. Next, we performed one final data check: we used the volume data to test whether trading was
likely halted after any of the announcements. In the case of Critical Path, the FactSet data show nine consecutive trading days with zero volume beginning February 2, 2001, the day of the class period-ending announcement. Based on this, we excluded that observation.

In the January 18, 2001 after-hours announcement, earnings were reported 17 cents below the consensus estimate reported by IBES. Critical Path shares fell from a $20 closing price on January 18 to a $9 closing price on January 19. Over the following three days, Critical Path's stock price remained fairly stable, trading between $8.56 and $9.88. The event window, as measured using both the abnormal return and the abnormal volatility methods, was one day. Using the abnormal turnover method, however, the event window was measured as seven days. Trading volume on January 19, 2001, the first trading day after the announcement, was 38 million shares. As a point of comparison, average daily volume during the estimation window (January 19, 2000 through January 18, 2001) was 1.2 million shares. Average trading volume over the six trading days following January 19 was 6.7 million shares per day, over five times the average level over the estimation window. The abnormally high trading volume over the six days following January 19 may have been due to investors rebalancing their portfolios; in light of the stability of the stock price it does not seem likely that during that time the market was continuing to interpret the implications of the earnings surprise for future earnings and cash flows.

In the case of the stock price reaction to the earnings announcement following the class period, on May 14, 2001, the event window was measured as one day by each of the three methods. This was the case despite a -$0.44 earnings surprise on that date, which might have been expected to take longer to absorb. The stock price fell from a closing price $1.65 on May 14, 2001 to $0.98 the following day. After two very negative announcements in the prior four months, during which time the stock price had lost over 90 percent of its value, it may be that the market had become conditioned to expect large, negative earnings surprises from Critical Path and could process them more quickly.
VIII. CONCLUSION

While a no-arbitrage analysis under the efficient market hypothesis states that stock price movements should be unpredictable, this does not mean that new information has to be incorporated instantaneously. Rather, the market must incorporate information as quickly as it can be processed. Furthermore, the risk-adjusted expected movement for the remainder of the processing time must be zero. This latter point means that in event studies covering many events, one can adopt a simple rule such as fixed event window period, because the movements after the fixed period should roughly average to zero by the Law of Large Numbers. However, when one is concerned with examining the particular effects of an event or a small number of events, it would make sense to consider how long the event window should be.

One interesting finding is that announcements that were the end of a shareholder class action period had an average estimated event window length over one day. Because these are considered unusual announcements (at least by the lawyers who file such suits), one would expect that the information could take longer than usual to process. The average estimated event window being over a day long is therefore not a wholly unexpected result, as long as one recognizes that the no-arbitrage formulation of the efficient market hypothesis requires that the market begin to impound information immediately, not that it complete the process even within the course of a trading day.

We have proposed and examined three potential rules for determining the length of an event window. Without some knowledge of the true length of the event window, it is of course impossible to perform a perfect test of how well the rules perform. That said, we were able to perform a proxy of such a test by comparing the lengths of the predicted windows to a normalized measure of earnings surprises, under the assumption that the larger the surprise the longer it would take, on average, for the market to fully impound the information in the announcement. The results showed that methodologies based on abnormal daily returns and abnormal daily volatility were strongly correlated with the size of the surprise, while the methodology based on abnormal turnover was not. Results under the abnormal return and volatility methodologies also were similar and strongly correlated with each other, though this is due in part to the fact that both rely on price data. While this is only one set of possible tests,
it does suggest that volume is not necessarily a good proxy for materiality, whereas continuing price movements are related to the extent of information that the market is processing.