Do Analyst Stock Recommendations Piggyback on Recent Corporate News? An Analysis of Regular-Hour and After-Hours Revisions

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ABSTRACT

Analysts often update their recommendations following corporate news. Questions have been raised regarding analysts' ability to generate new information beyond recent corporate events. Employing a comprehensive database on corporate news we show that only a small minority of 27.9% of all recommendation revisions directionally confirm the information in the preceding corporate events and even these "confirming revisions" facilitate the information discovery of corporate events and thus cannot simply be dismissed as "piggybacking." Our analysis further shows that analysts not only facilitate price discovery to corporate news through issuing trending revisions but also help reverse prevailing market sentiments following corporate news by issuing contrarian revisions. Our study is the first to investigate short-window intraday market reactions to revisions issued after hours, which account for 70% of all recommendation revisions. Analysts' incentives to issue revisions after hours appear to reflect demands from large institutional clients who dominate after-hours trading. More importantly, we show that the after-hours revisions are associated with significantly greater price reactions and different price reaction patterns than revisions issued during regular trading hours. Collectively, our evidence indicates that analysts are a significant source of new information beyond recent corporate news and they also help shape the market's assessment of corporate disclosures.

Keywords: Stock recommendation, After-hours revisions, Piggybacking, Security analysts
JEL classification: G11, G12, G14, G24, M41

1. Introduction

Analysts often update their recommendations following corporate news. For example, Ivković and Jegadeesh (2004) show that the frequency of recommendation revisions increases sharply following earnings announcements. A natural question arises about the incremental information content of recommendation revisions beyond the preceding corporate news. Even though many prior studies such as Womack (1996), Francis and Soffer (1997), and Asquith, Mikhail and Au (2005) show that recommendation revisions generate significant price reactions, their reliance on daily instead of intraday stock returns makes it difficult to disentangle the price effects from recommendation revisions versus price reactions to prior corporate events. More recent work by Altınkılıç and Hansen (2009) suggests that the vast majority of recommendation revisions come closely after corporate news. Their intraday price reaction analysis documents disproportionately large price reactions in the pre-announcement window of the revisions, which these authors attribute to analysts piggybacking on prior corporate news.

The goal of our study is to provide a better understanding of the interactions between recommendation revisions and corporate news and to speak directly to the piggybacking hypothesis. Our study is uniquely fitted for this purpose for two reasons. First, we use a large and comprehensive database from Thomson Reuters on corporate news between 2003 and 2010. This database not only allows us to directly assess the incidence of analyst recommendation revisions that closely follow corporate news but also makes it feasible for us to measure the price reactions to the corporate events and link them to the directions of the revisions. An analysis of the price reactions to the corporate events themselves is important for making inferences regarding analyst piggybacking but such an analysis is missing from prior literature. Second, we employ intraday returns data to study both regular-hour revisions as well as after-hours revisions.

After-hours revisions are excluded from prior literature's intraday price reaction tests although they account for an increasing proportion of all revisions and consist of 70% of all revisions during our sample period. Inferences regarding recommendation revisions cannot be complete without a careful analysis of the after-hours revisions.

Investigating how recommendations interact with prior corporate news is important for understanding the roles financial analysts play in the capital markets – whether they generate new information with their stock recommendations or mainly serve other roles, such as marketing, for their employers. Brokerage firms spend billions of dollars each year to produce sell-side equity research with the goals of generating trading commissions and facilitating corporate advisory services (e.g., Lin and McNichols, 1998; Irvine, 2000).[1] A cynical view of analyst research is that it is primarily a marketing tool for the brokerage houses' other services. Academic research has documented optimistic biases in analyst research and calls into question its objectivity and informativeness (e.g., Lin and McNichols, 1998; Bradshaw, 2004). Further compounding the perception that analyst research lacks substance, the Institutional Investor rankings of sell-side equity analysts routinely put "soft" measures such as industry knowledge, accessibility/responsiveness, and timely calls/visits to clients above the quality of analysts' written reports and stock recommendations. Some researchers argue that analyst recommendations mostly "regurgitate" recent corporate news and the price reactions observed around recommendation revisions are in fact attributable to the corporate news immediately preceding the revisions themselves (e.g., Altınkılıç and Hansen, 2009).

On the other hand, there are reasons to believe that analysts generate new information through their stock recommendations. The significance of stock recommendations to investors and to the brokerage houses that produce them is illustrated by a 2006 lawsuit brought by several

[1] See, for example, "Analyse this: The economics of equity research." *The Economist*, September 21, 2013.

prominent brokerage firms (Barclays Capital, formerly Lehman Brothers, Morgan Stanley, and Merrill Lynch) against TheFlyOnTheWall.com, a subscription-based internet news gathering service ("Fly"). The brokerage houses allege, among other things, "hot news misappropriation," which involves unauthorized distribution by Fly of the brokerage firms' newly issued stock recommendations to parties that are not the firms' clients. The court opinion issued in 2010 describes the great lengths the brokerage firms go to, including taking legal actions against Fly, in order to prevent the immediate distribution of their newly issued stock recommendations to non-clients. The brokerage firms argue that Fly's actions erode the investment value of the stock recommendations to the brokerage firms' clients who pay for the research through soft dollar trading commissions.[2] The fact that investors are willing to pay for the stock recommendations either directly (e.g., through subscriptions in the case of Fly's subscribers) or indirectly (e.g., through trading commissions in the case of the brokerage houses' clients) suggests that investors expect to benefit from the information contained in the recommendations.

To better understand the relation between recommendation revisions and corporate news, we link recommendation revisions to corporate news articles extracted from Thomson Reuters News Archive (TRNA), which covers both corporate-issued press releases and third-party releases identified as news alerts and commentaries primarily from Reuters News. Our analysis of the Thomson Reuters corporate news database reveals that 61.1% of the recommendation revisions follow corporate events in a three-day window, among which 45.6% are confirming, i.e., in the same direction as the price reactions to, the preceding corporate events (pre-events).

[2] The U.S. District Court for the Southern District of New York ruled in favor of the brokerage firms in 2010 requiring Fly to delay its distribution of the brokerage firms' stock recommendations (Barclays Capital Inc. et al. v. TheFlyOnTheWall.com, Inc. 06Civ. 4908, March 18, 2010). However, the District Court's decision was reversed in 2011 by the Second Circuit Court (Barclays Capital Inc. et al. v. TheFlyOnTheWall.com, Inc. 2d Cir., June 20, 2011). Specifically, the Second Circuit Court concluded that while analyst firms "make news" by issuing recommendations, they do not have the right "to control who breaks that news and how." Interestingly, the Court suggested that if the equity analyst firms themselves had a service that broke the "news" of analyst recommendations, Fly could have been held liable for copying such a news dissemination service.

This suggests that a small minority of 27.9% (61.1% × 45.6%) of all recommendation revisions are suspects for piggybacking.

To gain further insight into the interactions between these "confirming" revisions and their pre-events, we analyze the price discovery process of the pre-events. We document significant incremental price discovery around recommendation revisions following the pre-events. For revisions issued during regular trading hours, price discovery is observed starting from around 330 minutes prior to the recommendation revision to 90 minutes after the revision. The magnitude of the incremental price discovery peaks at the 30-minute interval right before the revision at 6.1%. For comparison, the pre-event itself brings a peak incremental price discovery of 9.4% in the first 30-minute window following the news release. We also find substantial incremental price discovery following after-hours recommendations. We conclude that even confirming revisions serve an important information role by facilitating the market's price discovery related to the pre-events and thus cannot simply be dismissed as piggybacking. Further analysis shows that analysts not only facilitate price discovery to corporate news through issuing trending revisions, but also help reverse prevailing market sentiments following corporate news by issuing contrarian revisions.

We conduct intraday analyses of the market reactions to revisions released during regular trading hours and those issued after hours. After removing confounding events we find statistically and economically significant price and volume reactions in both samples, suggesting that the revisions have information content beyond confounding corporate news. Furthermore, our analysis of recommendation revisions issued after hours, which represent the vast majority of all recommendation revisions (70%) but are excluded from prior studies' intraday short-window market reaction tests, reveals a markedly different price and volume reaction pattern from that of

the regular-hour revisions. Our analysis of the *regular-hour* recommendation revisions shows large *pre-announcement* returns and trading volume in the [-1 day, -21 minute] window although we also find statistically and economically significant returns and trading volume in the announcement window [-20 minute, +20 minute] and in the post-announcement window [+21 minute, +1 day]. In contrast, our analysis of the *after-hours* revisions shows that most of the price and volume reactions occur in the *post-announcement* window, inconsistent with the piggybacking hypothesis that predicts pre-announcement reactions to outweigh post-announcement reactions.

Interestingly, we also find that the after-hours revisions are associated with measurably greater overall price reactions than regular-hour revisions. An analysis of the timing of the revisions is consistent with analysts having incentives to issue revisions after hours to benefit large institutional clients who dominate after-hours trading (Barclay and Hendershott, 2003). These findings suggest that after-hours revisions have different information characteristics from regular-hour revisions and that focusing on regular-hour revisions alone as in previous studies can lead to incomplete and biased inferences regarding the informativeness of recommendation revisions.

We make several contributions to the literature. We answer the call of Beyer et al. (2010) to examine "the interplay between the information provided by sell-side security analysts …, and firms' mandatory and voluntary disclosures (p. 335)." Our use of a comprehensive corporate news database that was not used in prior research allows us to study more precisely the relation between analyst recommendation revisions and the preceding corporate events and to speak directly to the piggybacking hypothesis. Our study is also the first to analyze the differential incentives faced by analysts to issue revisions after hours versus in the regular trading hours and

their differential market reactions. We find that after-hours revisions exhibit systematic differences in intraday price reaction magnitudes and patterns from those of regular-hour revisions. Overall our findings suggest that analysts play important information roles in the capital markets and are inconsistent with the notion that analyst recommendations primarily piggyback on recent corporate news. In fact, analysts not only provide new information, but also help shape the market's assessment of corporate disclosures.

The rest of the paper is organized as follows. Section 2 discusses related literature. Section 3 describes our data and methodology. Section 4 presents the results and Section 5 concludes.

2. Related research

There is a large literature documenting strong stock price reactions to recommendation revisions and interpreting this as evidence of investment value in the recommendations (e.g., Womack, 1996 and Asquith, Mikhail and Au, 2005). However, these studies are based on *daily stock returns* and thus cannot pinpoint the effects of the recommendation revisions as precisely as with intraday data. The use of daily stock returns in combination with multi-day event windows also makes it difficult to disentangle the revision price effects from price reactions to corporate news around the time of the revisions. These studies address the issue of confounding events by removing them from their samples, where confounding events are identified via two different approaches. The first and most common approach is to focus on select types of corporate news collected through machine-readable data sources. For example, Loh and Stulz (2011) drop 25% of the revisions that fall into a 3-day window around an earnings announcement (collected from COMPUSTAT) or management forecast (from First Call). The advantage of this approach is that recommendations confounded by these select types of events

can be systematically removed for a large sample of recommendations. The drawback, however, is that only the selected categories of events are removed, leaving behind a variety of other events, such as mergers and acquisitions, management changes, product changes, and lawsuits, etc., that can still confound inferences. The second approach is to remove a comprehensive set of confounding events that are identified through machine-readable as well as *hand-collected* data sources. Asquith et al. (2005) exemplifies this approach where they rely on Zacks and CRSP databases to identify earnings announcements and dividend changes, respectively, and hand collect from Dow Jones Newswire for other corporate events such as mergers and divestitures, equity and debt financing, lawsuits, product changes, management changes, etc. In all they find that 53% of their sample has confounding events. While this approach captures a comprehensive set of corporate news, the need for hand collection means that it is only practical for small sample sizes, which in the case of Asquith et al. (2005) comprises 1,126 analyst reports. Therefore, even though many earlier studies show strong price movements around the time of the recommendation releases, their research design choices – the use of daily instead of intraday stock returns and the tradeoffs they have to make regarding confounding events (removing either a partial list of events for a large sample of recommendation revisions or a comprehensive set of events for a small sample of revisions) – still leaves the concern that the price reactions to revisions are affected by confounding events.

More recent work by Altınkılıç and Hansen (2009) differs from prior studies in that they employ intraday stock returns and show that for regular-hour revisions most of the market reactions occur prior to the actual release of the recommendations and the 40-minute announcement window is associated with negligible price movements. Further, they claim that the vast majority (80%) of recommendation revisions are preceded by corporate news releases

within a short window and therefore argue that it is the preceding corporate events not the recommendation revisions that are the triggers of the substantial price reactions before the release of the revisions and the revisions themselves are information-free. To estimate the frequency of the preceding corporate events (pre-events), Altınkılıç and Hansen (2009) rely on machine-readable data as well as extrapolation from hand-collected news items for a small subsample. Specifically, they use I/B/E/S, First Call, and SDC to identify earnings news and major transactions and conclude that 40% of the recommendation revisions are preceded by earnings announcements and management earnings guidance combined and 7% are preceded by major transactions such as securities issuances and corporate restructuring.[3] For the remainder of the 19,582 recommendation revisions (or 53% of their sample) for which they are not able to identify pre-events from these machine-readable sources, the authors sample one in every 15 of these recommendations revisions, or a total of 1,305 observations, and search Factiva.com for news articles released before these revisions. They are able to find corporate events in the [-2 day, 0 day] window for 822, or 63%, of the 1,305 revisions. They then extrapolate the 63% from these 1,305 observations to the 19,583 revisions and conclude that 80% of all revisions are associated with pre-events (i.e., 40% with earnings announcements and guidance + 7% with major transactions + 33% other events which is calculated from 63% of the remaining 53% of the sample). Similar to prior studies, Altınkılıç and Hansen (2009) have to rely on hand collection of news releases for a small sample of recommendation revisions. Their extrapolation of the news frequency from this small sample of revisions to the overall sample can obviously introduce measurement errors.

[3] Altınkılıç and Hansen (2009) do not specify the length of their pre-event window for identifying the earnings-related events from I/B/E/S and First Call or major transactions from SDC (even though they do define the pre-event window as [-2 day, 0 day] for their Factiva search).

In summary, prior literature has produced conflicting evidence and conclusions regarding the effect of preceding corporate news on the information content of recommendation revisions. Compared to these previous studies, our use of TRNA (Thomson Reuters News Archive), a large and machine-readable database of corporate news from a comprehensive set of firms over a long period of time, allows detailed analysis of the interactions between revisions and pre-events and to a large extent takes the guesswork out of assessing the pre-event frequency for recommendation revisions. And perhaps more importantly, we are able to directly measure the price reactions to the preceding corporate news and link them to the directions of recommendation revisions. This is an important step in evaluating the information content in revisions beyond confounding corporate news.

Another critical issue in evaluating the information content in recommendation revisions is the interpretation of the large pre-announcement price effects of the regular-hour recommendation revisions — whether they are attributable to the preceding corporate events or the revisions themselves. Altınkılıç and Hansen (2009) interpret this as analyst piggybacking on pre-events. However, another possible reason for the large pre-announcement returns of recommendation revisions is information leakage. A substantial body of work provides evidence of analyst tipping select clients (e.g., Green, 2006; Irvine, Lipson and Puckett, 2007; Christophe, Ferri and Hsieh, 2010; Markov, Muslu and Subasi, 2011; and Anderson and Martinez, 2012). Irvine et al. (2007) find that institutional buying starts to pick up from five days prior to the release of buy recommendation initiations and the trading patterns by institutions suggest knowledge of the characteristics and content of the analyst reports. In addition, Christophe et al. (2010) provide both anecdotal and empirical evidence that short sellers are tipped off before analyst downgrades of stocks.

Two recent papers, Bradley et al. (2014) and Hoechle, Schaub and Schmid (2012), raise delayed I/B/E/S timestamps in as a possible reason for the large pre-announcement returns of recommendation revisions. It is worth noting that our data source of recommendation timestamps is First Call, not I/B/E/S. In fact, Hoechle et al. (2012) make their inferences of delayed I/B/E/S recommendation timestamps by benchmarking them with the First Call timestamps. Loh and Stulz (2011) also directly compare I/B/E/S and First Call recommendation timestamps and find that when they are different, I/B/E/S timestamps lag First Call ones in the vast majority of the cases. This is not to say that First Call timestamps are not subject to delays, although the evidence in the literature suggests that systematic problems with First Call timestamps, if they exist, are likely less severe. However, to the extent there *are* delays in the First Call recommendation timestamps, it can be another explanation for the large pre-announcement returns of regular-hour recommendation revisions.

Note that the prior studies documenting large pre-announcement returns focus exclusively on regular-hour revisions, which make up of a small portion of all revisions. For example, Altınkılıç and Hansen (2009) conduct tests of short-window intraday price reaction exclusively on regular-hour revisions even though they also report summary statistics on after-hours revisions. Bradley et al. (2014) also include after-hours revisions in their overall sample. However, they treat the extended and non-trading hours from 4 p.m. to 9:30 a.m. as a single trading period and compute the announcement returns for after-hours revisions using the close-to-open prices. Therefore, the extant literature is silent on short-window intraday price reactions to the vast majority of recommendation revisions that are released after hours. To the extent the after-hours revisions exhibit different price reaction magnitudes and patterns it can affect the overall assessment of the information content of analyst recommendation revisions.

3. Data description and methodology

Thomson Reuters News Archive (TRNA) is a historical database of news stories issued by Reuters and an array of other news providers/disseminators such as Business Wire, PR Newswire, Equity Stories (EQS), etc. As discussed in Section 2, in prior studies comprehensive coverage of corporate news is limited to certain types of events such as earnings releases, management guidance, and securities issuances in which machine-readable data are available; while information on other types of corporate news has to be hand collected for small subsamples (e.g., Asquith et al., 2005; and Loh and Stulz, 2011). In addition, even for the events with machine-readable data, the timestamps can be either unavailable or inaccurate (e.g., Bradley et al., 2014). TRNA affords a major advantage in analyzing corporate events because we are able to construct from it a machine-readable data source for a comprehensive set of corporate news with precise timestamps. The dataset we obtained from Thomson Reuters covers the period of 2003-2010. The First Call recommendation revisions sample contains 5,052 unique U.S. firms during this time period, out of which 44 (0.87%) are not covered in TRNA and therefore dropped from the analysis. The intersection of the First Call analyst recommendation revision sample and TRNA during 2003-2010 consists of 5,008 U.S. firms and 22,237 firm/years, for which we obtain 1,777,263 corporate press releases issued by these firms via five news sources: Business Wire, PR Newswire, Prime Newswire, GlobeNewswire (formerly Prime Newswire), and Marketwire and 2,398,586 third-party news articles identified as news alerts and commentaries primarily from Reuters News.[4] We use PERL to extract the following key information from each news article: firm identifier (ticker and exchange listing, which we match to CRSP's PERMNO through the CRSP's link file), timestamp (Thomson Reuters timestamps each news article to the

[4] Business Wire, PR Newswire, Marketwire, and GlobeNewswire are the four primary press release services in North America. Together they have close to 100 percent share of the press release market during our sample period.

millisecond) and news categories. Based on TRNA-provided article topic codes we categorize each press release as follows: (i) "res" – financial results, (ii) "resf" – financial results forecasts, (iii) "div" – dividends, (iv) "mrg" – merger and acquisition, (v) "mngiss" – management issues, and (vi) "ipo" – IPOs. Press releases not classified in any of the above categories are included in the category "oth."[5] When the same press release is issued by multiple press release services or in several parts (both rare events), we keep only the first one. The third-party news articles are labeled as non-press release news.

Earlier studies using Reuters as the news source generally rely on limited news data. More recently several working papers utilize large samples of news articles provided by Thomson Reuters News Archive (TRNA).[6] Since TRNA is a relatively new database, we conduct several validity checks of the comprehensiveness of its coverage. First, for a random sample of 20 firms, we manually verify their news coverage in TRNA with the coverage in Factiva and find that TRNA includes 98% of the news articles in Factiva. Second, using our full sample, we match the earnings announcement press releases in TRNA to those in Compustat and find matches in TRNA for 92.7% of the Compustat earnings announcements. Note that some of the Compustat earnings announcements not matched with TRNA will be included in the "oth"

[5] The news categories are not mutually exclusive, e.g., an earnings press release can be classified as "res", "resf" and "div" if the press release also includes management forecast and dividend announcement. Furthermore, the TRNA-assigned topic codes are not always precise. For example, an earnings announcement may not have the TRNA topic code "res" and as a result is assigned by us to the "oth" category. Conversely, a press release announcing an upcoming earnings conference may have a TRNA topic code of "res" even though the press release itself does not contain an earnings announcement. Because our concern is with *the existence of any* corporate event prior to a stock recommendation, how the events are classified is not critical for our analyses. However, as discussed in Appendix A, in our validation test against Compustat earnings announcements, we do run into the issue of errors in TRNA news classifications with regard to earnings announcements and we take steps to address this issue.

[6] Berry and Howe (1994) study the relation between overall public news flow and aggregate intraday market activities in trading volume and price volatility using Reuter's news articles from May 1990 to April 1991. Riordan et al. (2013) analyze how the tone of news affects price discovery, liquidity and trading intensity for a sample of 33 firms traded on Toronto Stock Exchange from 2005 to 2008. Using TRNA news data from 2003 to 2005 Hendershott, Livdan and Schürhoff (2014) study how institution trading leads news sentiments. Heston and Sinha (2014) study the predictability of stock returns based on the tone of a large sample of TRNA news articles during 2003-2010. Overall, our study focuses on a topic different from those examined in prior or concurrent studies using TRNA.

category if they are misclassified as non-earnings news and not picked up by our keyword searches. Finally, we present the frequencies of earnings announcements and management guidance in the three-day window leading up to recommendation revisions based on commonly used databases (I/B/E/S for identifying earnings announcements and First Call for management guidance). We then cross-check these frequencies with those calculated based on TRNA (see Appendix A for identification of earnings announcements and management forecasts from TRNA). We find that the frequencies obtained from TRNA are comparable to those from I/B/E/S and First Call. Appendix A provides further details on the TRNA database and the above validation checks. Taken together, our validation tests suggest that TRNA provides reasonably comprehensive news coverage. Still, we caution that our analysis of the pre-events of recommendation revisions is subject to the caveat that some corporate releases may not be covered by TRNA or may be excluded by our news source filters.

We obtain intraday data on stock returns from the Trade and Quote (TAQ) trade files to investigate stock market reactions to analyst recommendation revisions and corporate news. The regular trading hours (RTH) are 9:30 a.m. to 4 p.m. EST. The extended trading hours (ETH) include a pre-market session and an after-market session, which are 4 a.m. to 9:30 a.m. and 4 p.m. to 8 p.m., respectively, by the end of our sample period.[7] The time periods outside the regular and extended trading hours are non-trading hours (NTH), when we do not observe stock trades but may still observe releases of recommendation revisions or corporate news. We keep only valid trades based on the criteria in Ng et al. (2008) for trades during regular trading hours and use the appropriate TAQ COND and EX codes to identify valid trades during extended

[7] The extended trading hours vary by time period and exchange during our sample period, as summarized in the Table 1 notes. We define each firm's extended trading hours based on its exchange listing and the specific time period.

trading hours (Dong et al. 2014).[8] We note that at the monthly level, the incidence of any ETH trading is around 90 percent in NASDAQ stocks and 70 percent in NYSE/AMEX stocks by the end of our sample period.

Table 1 presents the calendar year distribution of recommendation revisions by trading hours for our sample period of 2003-2010. There are in total 54,947 recommendation downgrades and 47,982 upgrades. The percentage of recommendations released during regular trading hours declines almost monotonically over the years. In 2003, 42.1% of downgrades (40.2% of upgrades) were released during RTH and the numbers are 27.2% downgrades (28.8% upgrades) for ETH and 30.7% of downgrades (31.0% upgrades) for NTH. By 2010, however, regular trading hours only see 22.8% of the downgrades (19.9% of the upgrades). Over half of all recommendations now come out during the extended trading hours (51.5% of downgrades and 52.2% of upgrades) with the rest being released in non-trading hours (25.7% of downgrades and 27.9% of upgrades). Overall, this table suggests that focusing on RTH recommendations alone likely paints an incomplete picture of the informativeness of recommendation revisions.

4. Main results

4.1. Roadmap

The goal of our study is to provide fresh evidence on the information content in recommendation revisions in relation to the preceding corporate news. We therefore begin our analysis by documenting the following: 1) the frequency of revisions that are preceded closely by

[8] For trading occurring during regular trading hours, we keep only trades that meet all of the following criteria: (1) trades occurring on the NYSE, AMEX or NASDAQ; (2) trades made under regular market conditions (i.e., COND codes *, @, E, F, and blank); (3) trades without subsequent cancellations; and (4) the transaction price and the number of shares traded were both positive. For trades during extended trading hours, we include trades with COND codes that include T or F, which represent the bulk of all extended hour trades. In terms of EX codes, we exclude "extended hour trades" in NYSE and AMEX as they are likely to represent regular session closing transactions that are reported after 4:00 p.m. Most extended hour trades are reported through the NASDAQ trade/quote systems, NYSE Arca, and NSX. We thank Steve Poser of NYX for his help in identifying the appropriate COND and EX codes.

corporate news, 2) the price reactions to the preceding corporate news, and 3) how frequently analysts revise their recommendations in the same direction as the news in the preceding corporate event. These analyses help us establish the frequency of "confirming revisions" that are suspects for piggybacking on corporate news. In step 4) we focus on these "confirming revisions" to investigate if they facilitate the information discovery process for the preceding corporate news because if that is the case, these confirming revisions cannot be simply dismissed as "piggybacking." An important element of our analyses concerns the after-hours revisions. We conduct the following tests while taking into account confounding corporate news: 5) we compare the characteristics of after-hours revisions relative to regular-hour revisions and document the importance of client demand in the timing of the revisions, and 6) we present evidence on the intraday price and volume reactions to regular-hour and after-hours revisions and document differences in the reaction magnitudes and patterns. Figure 1 presents timelines of the various measurement windows we use in our tests.

4.2. Pre-events

Table 2 reports the frequency of corporate news before recommendation revisions (pre-events) and the market reactions to the pre-events over our sample period of 2003-2010 (i.e., steps 1, 2 and 3 in the Section 4.1 roadmap). Information on recommendation revisions and pre-events is from First Call and TRNA, respectively. Panel A presents the percentage of revisions with pre-events and the number of pre-events per revision for upgrades and downgrades released in RTH, ETH, and NTH, respectively. We define the announcement window for a recommendation revision as the 41-trading-minute time interval [-20 minute, +20 minute] around the revision's release. Pre-events are then identified in the previous three days, specifically, 12:00 a.m. on calendar day -3 to 21 calendar minutes before the release of the recommendation

revision [-3 day, -21 minute].[9] In Panel A, the "All Events" row shows that 66.7% of the downgrades and 64% of the upgrades released during regular trading hours are preceded by corporate news in the previous three days. The percentages are somewhat lower in ETH (62.1% for downgrades and 58.4% for upgrades) and NTH (58.4% for downgrades and 56.6% for upgrades). In all 61.1% of the recommendation revisions are preceded by corporate news in the previous 3 days. We further show that 52.7% of revisions follow corporate press release news while 48.5% follow non-press release news. Looking across the different press release news categories based on the TRNA topic codes, roughly 23% of the recommendation revisions are preceded by earnings-related news and around 12% by management guidance. Lower percentages are associated with dividends, M&A, and management-related announcements. As discussed earlier in Section 3 and in Appendix A, these frequencies are comparable to those obtained from the commonly used databases (I/B/E/S for earnings announcements and First Call for management guidance). The breakdown by topic codes for non-press release news is similar. In addition, Panel A of Table 2 shows that the mean number of pre-events is around 3.5 across upgrades/downgrades and the different trading hours, with standard deviations of around 7.

To test the piggybacking hypothesis it is critical to know the nature of the news contained in the pre-events and link it to the direction of the subsequent recommendation revisions. In other words, a recommendation revision may follow a corporate event, but unless the revision is in the same direction as the news in the pre-event, there is really no evidence of piggybacking. None of the earlier studies examines the market reactions to the confounding events themselves. We first

[9] We use the 41-trading-minute announcement window following Altınkılıç and Hansen (2009). We measure all market reaction windows surrounding recommendation revisions or corporate events using *trading* days and/or minutes, while we measure all pre- and post-event windows using *calendar* days and/or minutes. This is because recommendation revisions could be issued during weekends. In the case of the pre-event window, if we chose 21 *trading*, instead of *calendar*, minutes before recommendation revisions as the ending point for a revision issued during weekends, the pre-event window would end at 21 trading minutes before the end of the prior Friday's extended trading hours, resulting in an understatement of the incidence of pre-events.

present summary statistics on market reactions to the pre-events in Panel B of Table 2 and then investigate their consistency with the subsequent recommendation revisions in Panel C. Consistent with our definition of the announcement window for recommendation revisions, we use a 41-trading-minute window to capture market reactions to the pre-events [-20 minute, +20 minute]. For pre-events released during non-trading hours the 41-minute time interval includes the last 20 trading minutes of the previous extended hours trading period and the first 21 trading minutes of following extended hours trading period; in other words, we exclude the non-trading hours from the announcement window. Panel B of Table 2 shows that on average pre-events generate significantly negative market reactions ahead of recommendation downgrades and significantly positive market reactions ahead of recommendation upgrades. While it is not surprising that analysts update their recommendations based on new information (e.g, Ivković and Jegadeesh, 2004; Ljungqvist et al., 2007), it can also be interpreted as evidence of analyst piggybacking on the news. Further analysis is thus warranted.

Panel C of Table 2 investigates how frequently recommendation revisions confirm the news in the pre-events. The sample sizes in Panel C are smaller than those in Panel A because Panel C includes only the recommendation revisions with corporate news in the previous 3-day window. We define a bad news (good news) pre-event as one with a negative (positive) announcement window return. In cases where there are multiple pre-events for a recommendation revision, we sum up the announcement window returns for all the pre-events without double counting any overlapping windows. Confirming revisions are downgrades (upgrades) that follow bad (good) news pre-events. We find that for the 11,398 recommendation downgrades issued during regular trading hours that follow corporate news, 45.7% (5,205) have negative pre-event returns, which suggests that the revisions confirm the news in the pre-events.

For 32.3% of the downgrades the pre-event returns are positive and the remaining 22.0% of the downgrades have zero pre-event returns. Thus considering all downgrades released in regular trading hours with and without pre-events (17,097 reported in Panel A), the number of confirming downgrades amounts to 30.4% (5,205/17,097) of the total observations. Similar inferences can be drawn from the other columns in Table 2 Panel C, where confirming revisions cells are shaded. In all, the 28,675 confirming revisions (sum of all shaded cells) account for 45.6% of the revisions with pre-events (28,675/62,870) and 27.9% of all revisions (28,675/102,929). These numbers suggest that relying simply on the *existence* of pre-events without considering their market reactions will lead to incorrect inferences regarding the prevalence of piggybacking by financial analysts.

To give more texture to the interactions between pre-events and recommendation revisions, Figure 2 presents, in each of the 96 calendar hours leading up to the recommendation revisions, the percentage of revisions with at least one pre-event disclosed within the hour.[10] There is a concentration of recommendations with pre-events from hour -26 to hour -12 relative to the recommendation timestamp. The peak value of 7.8% occurs at hour -16, i.e., 7.8% of the revisions experienced a pre-event in the 16th hour prior to the release of the revision. Although the incidence of pre-events is skewed somewhat closer to the time of the revision announcement, the typical time lag between a pre-event and the revision arguably allows time for analysts to process the information contained in the preceding news event.[11]

[10] Because our pre-event window starts from 12:00 a.m. of calendar day -3 (see Figure 1), the total number of calendar hours from the pre-event timestamp to the revision timestamp can approach four calendar days or 96 hours. To calculate the percentage of revisions with pre-events in an hour, we use the total number of revisions in our sample (102,929) as the denominator and the number of revisions with at least one pre-event within that hour as the numerator. Revisions with multiple pre-events within the same hour are counted as one observation in that hour. Revisions with pre-events in different hours are entered as separate observations into each of those one-hour intervals during which the pre-events occur.

[11] Similar inferences are drawn for both trending and contrarian revisions. As defined in Figures 3 and 4, a trending (contrarian) revision is one in the same (opposite) direction as the pre-announcement return of the revision.

4.3. Price discovery test

From the previous section we know that 61.1% of the recommendations follow pre-events in a three-day window, among which 45.6% are in the same direction as (i.e. confirming) the news in the pre-events. In this section we investigate if these confirming recommendations, or presumably "piggybacking" revisions, can nonetheless help with the information discovery of the pre-events (i.e., step 4 in the Section 4.1 roadmap). The sample for this analysis is the confirming recommendation revisions reported in the shaded cells in Table 2 Panel C. For each revision we keep its most recent pre-event, and then calculate the cumulative returns for each 30-trading-minute interval over three trading days starting from the timestamp of the latest pre-event (see Figure 1). We construct a ratio of price discovery measure (*RPD*) for each of the 30-minute interval:

$$RPD_{30m} = \frac{\log(1 + ret_{30\_trading\_min})}{\log(1 + ret_{3\_trading\_day})} \qquad \text{Eq. (1)}$$

We use the natural logarithm of return to capture its compounding nature. We run the following regression to examine the price discovery in the 16 30-minute intervals (in total 480 minutes) immediately following the pre-event and the 16 30-minute intervals immediately before and after the subsequent recommendation revision:

$$RPD_{30m} = \beta_0 + \sum_{i=30m}^{480m} \beta_{1,i} Post\_Event_i + \sum_{j=-480m}^{-30m} \beta_{2,j} Pre\_\Delta REC_j + \sum_{k=+30m}^{+480m} \beta_{3,k} Post\_\Delta REC_k + \varepsilon \qquad \text{Eq. (2)}$$

where $Post\_Event_i$ equals to 1 for the i^{th} 30-minute interval "post-event". Similarly, $Pre\_\Delta REC_j$ and $Post\_\Delta REC_k$ equals to 1 for the j^{th} 30-minute interval "pre-revision" and k^{th} 30-minute interval "post-revision", respectively.

We expect to observe significant price discovery in the 480 minutes after the disclosure of the pre-event, especially in the time intervals soon after the pre-event. In other words, we expect to see significantly positive coefficients on $Post\_Event_i$, especially when i is smaller. If the recommendation revisions are important in facilitating the price discovery process for the pre-events, the $Post\_\Delta REC_k$ (post revision) coefficients are expected to be positive and significant, especially when k is smaller, i.e., soon after the release of the revisions. If there is leakage of analyst revisions (e.g., Irving et al., 2007) or delayed First Call timestamps (e.g., Bradley et al., 2014), we may also observe positive $Pre\_\Delta REC_j$ (pre-revision) coefficients, especially in the time intervals closer to the release of the revision. Table 3 presents the regression results for RTH, ETH, and NTH revisions separately.

Focusing first on column (1) for RTH revisions, the constant of 0.007, which is highly significant, implies a base price discovery of 0.7% per 30-minute interval in the three trading days after the corporate event. The coefficient on $Post\_Event_{+30m}$, the first 30 minutes after the corporate event has an incremental price discovery of 9.4% over the baseline of 0.7% and is highly significant. In other words, roughly 10% of the information in the three-day window is reflected in the 30-minute window immediately following the pre-event disclosure for RTH revisions. We find significant and declining price discoveries in the next few 30-minute intervals ended 60, 90, and 120 minutes after the corporate event. Price discovery is generally insignificantly different from the baseline over the following time intervals. The time intervals surrounding the subsequent recommendation revisions are associated with significant incremental price discovery starting from around 330 minutes prior to the revision to 90 minutes after the revision. The magnitude of the incremental price discovery peaks at the 30-minute interval right before the revision ($Pre\_\Delta REC_{-30m}$) at 6.1%, with an additional price discovery of

4.7% during the ensuing 90 minutes. Note that the pre-announcement returns could be consistent with leakage of analyst recommendations (Irvine et al., 2007) or delayed recommendation timestamps (Bradley et al., 2014). Regardless, the significant post-revision returns are consistent with information in analyst recommendations.

The analysis on revisions released in ETH in column (2) leads to similar inferences in that the recommendation revisions are associated with significant price discoveries for the pre-event. Here significant price discovery comes primarily in the time intervals after the revision with the magnitude peaking at the 90-minute intervals right after the revision ($Post\_\Delta REC_{+90m}$ at 6.8%). The price discovery pattern for NTH revisions is less clear cut. While there appears to be significant price discovery shortly after the revision ($Post\_\Delta REC_{+60m}$ at 1.4%), there are also delayed reactions starting from 90 minutes and 210 minutes after the revision. The delayed reaction for NTH revisions is consistent with price discovery occurring after regular trading begins. Overall the results in Table 3 suggest that even revisions that confirm the news in the pre-events serve, at a minimum, to facilitate the market's price discovery related to the pre-events and cannot simply be dismissed as "piggybacking." These findings are consistent with the conclusion in Yezegel (2014) that analysts revise their recommendations after corporate events to assist investors with the interpretation of the news and meet their information demands.

4.4. Timing of revisions -- regular-hour versus after-hours revisions

Table 1 shows that in recent years analysts increasingly release their recommendations after hours. Overall after-hours revisions make up 70% of all recommendation revisions. To better understand the timing of analyst recommendation revisions, we explore the relation between intraday revision timing choice and various broker, recommendation, and firm

characteristics by running the following probit regression (i.e., step 5 in the Section 4.1 roadmap).

$$\text{Prob}(RTH) = \beta_0 + \beta_1 GRAS + \beta_2 Small\_Regional + \beta_3 Research + \beta_4 Log(MVE) + \beta_5 Inst\_Own + \beta_6 First\_Rec + \beta_7 Downgrade + \beta_{8,T} \sum_{T=2004}^{2010} YT + \varepsilon \quad \text{Eq. (3)}$$

RTH is an indicator that equals one for analyst recommendations released during regular trading hours, and zero otherwise. On the right hand side, we include the following broker-level variables -- *GRAS* (an indicator for brokers involved in the Global Research Analyst Settlement), *Small_Regional* (small regional brokers according to Nelson's Dictionary of Investment Research), and *Research* (an indicator for independent research firms according to Nelson's). Large brokers as proxied by *GRAS* likely have large institutional/professional clients who trade frequently after hours and can have greater incentives to release recommendations in those periods. We thus expect a negative β_1 coefficient, i.e., lower likelihood of regular-hour revisions. On the other hand, smaller regional brokers may have fewer large institutional clients who trade after hours and are less likely to release revisions after hours, so we expect a positive β_2 coefficient, i.e., higher likelihood of regular-hour revisions. Independent research firms by definition do not face such demands from brokerage clients and are more likely to release revisions during regular hours, which could also enable them to attract greater attention in the marketplace, so we predict a positive β_3 coefficient. We also include firm size, *Log(MVE)*, and institutional ownership (*Inst_Own*). If larger firms and firms with greater institutional ownership have more active after-hours trading, we may see more revisions released after hours, which predicts negative β_4 and β_5 coefficients. Finally, we include an indicator for first revisions (those with no other revisions in the same direction on the same firm within the previous 24 hours) and an indicator for downgrades but do not have directional predictions on these variables. Detailed

variable definitions are provided in Table 4 notes. In Panel A we present the summary statistics of the regression variables for the full sample and the after-hours and regular-hour revisions. Panel B presents the correlation matrix and Panel C reports the Eq. (3) regression results.[12]

Column (1) of Panel C in Table 4 shows that large brokers (proxied by *GRAS*) are less likely to release revisions during regular hours whereas small regional brokers and independent research firms are more likely to issue RTH revisions. We also find that larger firms and firms with more institutional ownerships are less likely to have regular-hour revisions. These results are consistent with our expectations and suggest that the release of after-hours revisions likely reflects institutional clients' demand for tradable information after hours. Finally, the first revisions are more likely to be released after hours. And downgrades are more likely to be issued during regular hours.[13] Because analyst revision timing is likely affected by the timing of preceding corporate news, we next report in column (2) regression results for the sample of revisions not confounded by corporate news in the [-3 day, +3 day] window and come to similar inferences.

4.5. Market reactions to recommendation revisions

In this section we present evidence on the intraday price reactions to recommendation revisions (the last step in the Section 4.1 roadmap). Table 5 reports stock returns around recommendation revisions released during RTH, ETH, and NTH for our sample period. We focus on a three-day window surrounding recommendation revisions (-1, +1) from 4:00 p.m. of

[12] Given that the probit coefficients are not directly interpretable, we report the marginal effects, calculated as the average partial effect, in Panel C.

[13] Similar conclusion can be inferred from Table 2 Panel A in Altınkılıç and Hansen (2009). Specifically, 40% of their sample downgrades are released during the daytime hours (24,718/62,869), higher than the 38% of upgrades released during the day (18,889/50,052). The higher frequency of downgrades during regular trading hours contrasts with the finding in some earlier studies that *managers* have incentives to use after hours to selectively disseminate bad news (e.g., Patell and Wolfson, 1982). We note that analysts face different incentives than managers. Furthermore, the incidence of earnings releases during regular trading hours has declined drastically in the recent decade with after-hours earnings announcements now becoming the norm for the vast majority of firms regardless of the nature of the earnings news (e.g., Dong et al., 2014; Doyle and Magilke, 2009).

trading day -2 to 4:00 p.m. of trading day +1 of the recommendation revision, and split it into announcement window (0^-, 0^+), pre-announcement window (-1, 0^-), and post-announcement window (0^+, +1). R(0^-, 0^+) is cumulative return measured over [-20 minute, +20 minute] window to capture market reactions to the revisions.[14] For revisions released during non-trading hours we construct the announcement window as the 41-minute time interval that includes the last 20 trading minutes of the previous extended hours trading period and the first 21 trading minutes of following extended hours trading period, thus excluding the non-trading hours from the announcement window.[15] The pre-announcement window return, R(-1,0^-), is return cumulated from 4:00 p.m. of trading day -2 to 21 trading minutes before the release of the revision. The post-announcement return R(0^+,+1) refers to the return cumulated from 21 trading minutes after the release of the revision to 4:00 p.m. of trading day +1. We report both the mean and the median (in italic font below the mean) returns. With a few exceptions all mean and median returns are significantly different from zero at the two-tailed 5% level and are highlighted in bold. We focus most of our discussions below on the mean returns as inferences from the medians are similar.

Panel A of Table 5 reports the market reactions for our entire sample of recommendation revisions. For the 17,097 downward revisions released during regular trading hours, we observe a statistically and economically significant mean market reaction of -4.06% over the entire [-1

[14] It is calculated as ($PRICE_{end}$ - $PRICE_{beg}$)/$PRICE_{beg}$, where $PRICE_{end}$ is the trading price of the last transaction within the [-20, +20] minutes window and $PRICE_{beg}$ is the trading price of the immediately previous transaction before the [-20, +20] minutes event window. If no transaction occurs within the [-20, +20] minutes window, the return is set to zero. If we use the average price of the first and last 10 minutes of the announcement window to define $PRICE_{beg}$ and $PRICE_{end}$ (similar to Altınkılıç and Hansen, 2009), all inferences from the market reaction tests remain the same. For the beginning of the pre-announcement window and the end of the post-announcement window, we use the CRSP daily closing price if there is no trade at the exact minute.

[15] Note that if a revision and a pre-event are both released during the same non-trading-hour period, their announcement, pre-announcement and post-announcement windows are the same. For NTH revisions with pre-events, only a small proportion (9%) of downgrades/upgrades are released during the same non-trading-hour period as the pre-events. Excluding these recommendation revisions does not change the tenor of our findings.

day, +1 day] window with most of reactions occurring in the pre-announcement window (-2.67%, or 66% of -4.06%), consistent with Altınkılıç and Hansen (2009) and Bradley et al. (2014). Importantly, we also find an announcement window return of -64 basis points, which is statistically and economically significant given the short 41-minute window. Moving on to the 13,813 upgrades released during regular trading hours, we find a similar pattern, in that most of the 3.10% price reaction in the [-1 day, +1 day] window occurs pre-announcement (1.69%, or 55% of 3.10%). Again, the announcement window return of 64 basis points is statistically and economically significant.

The second row in Panel A corresponds to revisions issued during extended trading hours. The average price reaction in the [-1 day, +1 day] window for downgrades is -4.42%. In contrast to RTH downgrades, here most of the price reactions occur in the post-announcement window (-2.59%, or 59% of -4.42%). A similar pattern is observed for ETH upgrades, where the price reaction over the [-1 day, +1 day] window is 3.81% with 2.37% coming in the post-announcement window. Similar patterns are observed for revisions released during NTH. The fact that price reactions concentrate in the post-announcement window for ETH and NTH revisions, which account for 70% of all revisions, is inconsistent with the piggybacking hypothesis.

In Panel B, we repeat the analysis in Panel A for "first revisions", which are recommendation revisions that have no other revision in the same direction for the same firm within the previous 24 hours. The purpose of this analysis is to assess the extent to which the pre-announcement window returns are due to the effect of previous recommendation revisions. We indeed find that for revisions issued in the regular trading hours, the pre-announcement returns account for a smaller portion of the overall price reactions, 55% (-1.69%/-3.09%) for

upgrades and 49% (1.34%/2.75%) for downgrades, than those reported in Panel A. For revisions released in ETH and NTH, we continue to find that most of the price reactions occur in the post-announcement window.

One concern with the analysis of ETH and NTH revisions is that the market may react to pre-events slowly (Barclay and Hendershott, 2003), thus the post-announcement returns of recommendation revisions may in fact be delayed price reactions to the preceding corporate events. Another concern is that the post-announcement returns of recommendation revisions may be due to the corporate news disclosed after the recommendation revisions (post-events).[16] To investigate this possibility, we examine first revisions that are not preceded or followed by any corporate news per TRNA in the [-3 day, +3 day] window (12:00 a.m. on calendar day -3 to 11:59 p.m. on calendar day +3 of the recommendation revision) and report the results in Panel C. Here we find that pre-announcement returns are smaller than those reported in Panel B across RTH, ETH, and NTH, suggesting that part of the pre-announcement returns are likely due to the effects of pre-events. We also find that the post-announcement returns are largely unaffected. For ETH and NTH revisions, we continue to find that most of the price reactions come after the release of the revisions. The analysis in this panel suggests that it is likely the recommendation revisions, and not confounding events, that are responsible for the statistically and economically significant price reactions in the [-1 day, +1 day] window. Comparing the price reactions across the different trading hours, RTH (-1.78%/2.34% for down/upgrades), ETH (-2.48%/3.09%), and NTH (-2.28%/3.02%), we see that the after-hours revisions come with stronger market reactions than regular-hour revisions for both downgrades and upgrades. This is confirmed later in regression analyses reported in Table 7.

[16] Post-events are defined as any corporate news within the three-day window from 21 calendar minutes following the release of the recommendation revision to calendar day +3 (see Figure 1 for the timeline).

We next examine the circumstances in which recommendation revisions might facilitate the market's processing of information in corporate news versus the circumstances in which they might reverse the prevailing market trend that follows the release of corporate news. To test for these effects, we follow Altınkılıç and Hansen (2009) and define trending (contrarian) revisions as those in the same (opposite) direction as the pre-announcement return, which is cumulated from 4:00 p.m. of trading day -2 to 21 trading minutes before the release of the revision. By construction, trending upgrades and contrarian downgrades have positive pre-announcement returns and trending downgrades and contrarian upgrades have negative pre-announcement returns. While our Table 3 results are suggestive that trending revisions would help accelerate the prevailing price trend, we expect that the contrarian revisions would shift the trend in the opposite direction. To examine the disparate effects of trending versus contrarian revisions, we plot their average cumulative returns over 301 10-minute intervals starting approximately two trading days before to two trading days after the revision announcement for all revisions (the sample in Table 5 Panel A) in Figure 3 and first revisions without confounding events (i.e., the sample in Table 5 Panel C) in Figure 4.

Figure 3 Panel A presents revisions released during regular trading hours. The visual representation and inferences from this figure are consistent with those in Figure 1 of Altınkılıç and Hansen (2009), i.e., for RTH revisions most of the price reaction occurs prior to the release of the recommendations. However, we do observe price reactions at time interval 0 in the direction of the revisions for both contrarian downgrades and contrarian upgrades and price drifts in the subsequent two trading days, consistent with investors reacting to the information in these revisions. Even for the trending revisions, there are clear inflection points at the time 0,

suggesting that the releases of the revisions affect the price discovery process, which confirms the results in Table 3.

Figure 3 Panel B plots the cumulative returns for revisions released during the extended trading hours (ETH). Here revisions are associated with strong price reactions in the directions of the revisions for all four categories from time interval 0 to +20 (i.e., around 3 hours following the revision). Similar price movement patterns are observed in Panel C for revisions released during non-trading hours (NTH).[17] This suggests that the market reacts strongly at the time of or immediately following the announcement of ETH and NTH revisions, which is different from the price reaction to RTH revisions, and consistent with the findings in Table 5. In Table B1 of Appendix B, we present formal regression tests to show that the changes in price trajectory at minute zero are statistically significant in all four categories and three trading time zones of Figure 3. In addition, the regression tests show that the ETH and NTH trending (contrarian) revisions substantially alter the cumulative return lines by tilting their slopes in the direction of (opposite to) the prevailing market sentiments.

In Figure 4 we plot the cumulative returns excluding subsequent revisions or revisions with confounding events according to TRNA. We find that generally the magnitudes of the cumulative returns are smaller in Figure 4.[18] For example, trending upgrades see an average 9% pre-announcement return in Figure 3 Panel A and 5.8% return in Figure 4 Panel A for first revisions without confounding events, which suggests that a portion of the pre-announcement returns are likely due to pre-events. The test result in Table B2 of Appendix B shows that the

[17] The upward and downward shifts in the cumulative return plots of NTH reflect the heightened price discovery at the beginning of regular trading hours (i.e., 9:30 a.m.).

[18] Given that firms are assigned to pre-revision good/bad news groups based on actual returns leading up to time zero, by construction we observe positive and negative cumulative returns prior to the release of analyst recommendations. The trending/contrarian downgrades/upgrades in Figure 4 are, therefore, benchmarked against the prevailing price momentum.

declines in return magnitudes are all statistically significant.[19] However, we continue to observe in Figure 4 substantial post-announcement returns for both trending and contrarian recommendation revisions that are unlikely due to corporate events. The general price movement patterns in Figure 4 are similar to those in Figure 3 across all three Panels. Overall, not only do analysts facilitate price discovery due to corporate news through issuing trending revisions, but also they help reverse prevailing market sentiments following corporate news by issuing contrarian revisions.

To more clearly visualize the pre- and post-announcement market reactions to recommendation revisions, we next plot the minute-by-minute abnormal absolute returns over the window of 1,920 trading minutes centered on the release of the revision or approximately one trading day before to one trading day after the revision announcement, for all revisions in Figure 5 and first revisions without confounding events in Figure 6.[20] Panel A of Figure 5 shows that for RTH revisions there are elevated return reactions in the approximately (-360 minute, +360 minute) window around the release of the revisions and minute 0 corresponds with a sharp spike in absolute returns. The ETH revisions reported in Panel B of Figure 5 see market reactions that are more concentrated around and following the release timestamp of the revisions.[21] The graphs in Figure 6 for first revisions with no confounding events are similar to those in Figure 5.

[19] In un-tabulated tests, we conduct a replication of Womack (1996) using data from our sample period of 2003-2010. We find significant reductions in the 3-day announcement window returns after the removal of confounding events according to TRNA. However, announcement returns without confounding events remain statistically and economically significant.

[20] Following Brown et al. (1992, 77–78), we identify a pseudo revision (defined as one occurring at the same hour and minute as the recommendation revision of interest and on the same weekday of the week that immediately follows the revision of interest) and calculate abnormal intraday returns (volume in Table 6) by subtracting the pseudo revision return (volume) from the actual revision return (volume) to control for market microstructure effects.

[21] We do not plot the minute-by-minute returns for revisions released in NTH because the price reactions are observed in the subsequent (and possibly previous) extended trading hours.

Finally, we analyze abnormal intraday trading volume around recommendation revisions and present the results in Table 6. The inferences from Table 6 are similar to those based on the return reactions in Table 5. Specifically, we find strong pre-announcement volume reactions for RTH revisions. For ETH and NTH revisions, however, the reactions are mostly in the post-announcement window. Further, we find significant volume reactions to recommendation revisions even after the removal of confounding events (Panel C of Table 6).

In summary, this section presents evidence that analyst recommendation revisions have information content. We find economically significant price and volume reactions to regular-hour (RTH) revisions within the short 41-minute announcement window. Further, the large pre-announcement returns associated with RTH revisions likely partially reflect the information in the revisions themselves and cannot all be attributed to pre-events. We also document strong market reactions at the time of and immediately after the release of the after-hours (ETH and NTH) revisions, which account for the vast majority of all revisions. These results suggest that after-hours revisions have different price reaction patterns than regular-hour revisions. Therefore, studying after-hours revisions, in addition to regular-hour revisions, is important for achieving a more complete understanding of the information content of analyst recommendations.

4.6. Differential price reactions to regular-hour and after-hours revisions

The evidence in the earlier Table 5 Panel C suggests that after-hours revisions in ETH and NTH are associated with stronger market reactions. One possible reason for the release of more informative revisions after hours is that brokerage houses may want to give an information advantage to their larger clients, who tend to be professional/institutional investors that dominate the after-hours trading (Barclay and Hendershott, 2003). The brokerage houses may also need time to reach out to their large clients and encourage them to trade on the recommendations

before the markets open. In this section we formally test the differential informativeness of regular-hour and after-hours revisions with the following regression:

$$R(-1,+1) = \beta_0 + \beta_1 ETH + \beta_2 NTH + \beta_3 Downgrade + \beta_4 ETH \times Downgrade + \beta_5 NTH \times Downgrade + \beta_6 R\_pre + \beta_7 R\_post + \varepsilon$$

Eq. (4)

where *R(-1,+1)* is defined the same as in Table 5 — the intraday cumulative return from 4:00 p.m. of trading day -2 to 4:00 p.m. of trading day +1 of the recommendation revision. We include indicators for ETH and NTH revisions, recommendation downgrades and their interactive terms. *R_pre* (*R_post*) is the 41-trading minute cumulative returns centered on the timestamp of pre-events (post-events).[22] When a corporate event is released during non-trading hours, the announcement window consists of the last 20 minutes of the previous extended trading session and the first 21 minutes of the next extended trading session. When there are multiple events in the pre- or post-event window we sum up their announcement returns. If there are overlaps in the announcement windows of multiple events, the cumulative return is calculated from minute -20 of the first overlapping event to minute +20 of the last overlapping event. The coefficient on the intercept, β_0, captures the market reaction to RTH upgrades and β_3 (*Downgrade*) captures the incremental market reaction to RTH downgrades. The coefficients β_1 (*ETH*) and β_2 (*NTH*) then capture the incremental market reaction to ETH and NTH upgrades relative to RTH upgrades and the interactive terms β_4 (*ETH* × *Downgrade*) and β_5 (*NTH* × *Downgrades*) capture the incremental market reaction to ETH and NTH downgrades relative to RTH downgrades. *R_pre* and *R_post* are included to control for confounding corporate events. If

[22] To be comparable to the dependent variable, pre-events are limited to those released from 4:00 p.m. of trading day -2 to trading minute -21 of the revision and post-events are limited to those released from trading minute +21 of the revision to 4:00 p.m. of trading day +1 (see Figure 1 for the timeline).

the after-hours revisions are more informative than regular-hour ones we expect positive coefficients of β_1 and β_2 and negative coefficients of β_4 and β_5.

Column 1 of Table 7 reports the Eq. (4) regression results. We find a positive and significant coefficient on the intercept, implying mean return of around 2.53% in the [-1 day, +1 day] window for RTH upgrades. The coefficient on *ETH* is positive and highly significant, as is that on *NTH*, suggesting that upgrades released after hours are associated with more positive returns or greater information content. The coefficient on *Downgrade* is negative and significant as expected. We also find a negative and significant coefficient on the interactive term *ETH* × *Downgrade*, suggesting that extended-hour downgrades generate more negative returns than regular-hour downgrades. The coefficient on *NTH* × *Downgrade* is negative, although insignificant. As expected, the coefficients of *R_pre* and *R_post* are both positive and highly significant.

In column (2) we run median regression to mitigate the effects of outliers and find similar results. In addition, the coefficient on *NTH* × *Downgrade* is now negative and significant. In column (3) and (4) we repeat our analysis for first revisions without any confounding events in [-3 day, +3 day] window and drop the return controls for corporate events, *R_pre* and *R_post*, and find similar results to those for the full sample. The evidence in Table 7 indicates that compared to regular-hour revisions, after-hours revisions are associated with stronger market reactions. Therefore, focusing on regular-hour revisions alone underestimates the overall informativeness of recommendation revisions.

5. Conclusions

Financial analysts are important information intermediaries in the capital markets. Earlier findings in the literature indicate substantial investment value in analyst research (e.g., Womack,

1996, Asquith Mikhail and Au, 2005). However, this information role of analysts was recently challenged by Altınkılıç and Hansen (2009), who argue that analysts piggyback on preceding corporate news and that their recommendation revisions are free of information content. In this paper, we use a large and comprehensive database on corporate news to gain a better understanding of the interplay between the information provided by recommendation revisions and corporate news. We provide two primary findings. First, we find that only a small minority of revisions confirm the news in pre-events and even these confirming revisions facilitate market price discovery associated with the pre-events. We further show that analysts not only facilitate price discovery to corporate news through issuing trending revisions but also help reverse prevailing market sentiments following corporate news by issuing contrarian revisions.

Second, we conduct intraday market reaction analysis of revisions released during the regular trading hours and those issued after hours. After removing confounding events we find statistically and economically significant price reactions in both samples, suggesting that the revisions have information content beyond surrounding corporate news. Perhaps more importantly, we show that after-hours revisions, which now account for over 70% of all revisions, have significantly greater information content and different price reaction patterns than regular-hour revisions. This result suggests that analysts likely face different incentives when issuing after-hours revisions versus regular-hour revisions.

We contribute to the literature on the information role of financial analysts by speaking directly to the piggybacking hypothesis. Our evidence suggests that the Altınkılıç and Hansen (2009) estimate of the frequency of confounding events is likely subject to large measurement errors. Further, the large pre-announcement returns that they document for regular-hour revisions do not extend to the vast majority of revisions that are issued after hours. More importantly, our

analysis suggests that simply relying on the *existence* of confounding events without considering their market reactions will lead to incorrect inferences regarding the prevalence of piggybacking by financial analysts.

Our study also contributes to a more complete understanding of the characteristics, incentives, and functions of financial analysts by extending the scope of intraday analysis to after-hours revisions. The percentage of recommendation revisions issued after hours observes a significant increase from less than 60% in 2003 to nearly 80% in 2010. This trend in timing, coupled with the measurably greater overall price reactions associated with after-hours revisions, suggests that after hours have become the center stage for analysts to release their research. Therefore, future research on financial analysts cannot provide a complete picture without an adequate account of the after-hours recommendation releases.

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Appendix A
Thomson Reuters News Archive (TRNA)

Thomson Reuters News Archive includes both corporate press releases and third-party news articles (i.e., news alerts and commentaries primarily from Reuters News). Our corporate press release sample comes from the following sources: BSW (Business Wire), PRN (PR Newswire), PNW (Prime Newswire), GNW (GlobeNewswire, formerly Prime Newswire), and MKW (Marketwire). Business Wire, PR Newswire, GlobeNewswire and Marketwire are the four primary press release services in North America. Together they have close to 100 percent share of the press release market during our sample period.[23]

We conduct several checks of the comprehensiveness of TRNA coverage. First, we manually compare the corporate news identified by TRNA with those in Factiva using the following sources: Business Wire (all sources), PR Newswire (all sources), GlobeNewswire (Prime), and MarketWire. The comparison is based on a random sample of 20 firms with corporate news from TRNA in +/-3 days surrounding analyst recommendations. When TRNA reports a corporate news article, we try to match the article with one from Factiva. When TRNA does not report any articles in the search window, we check Factiva to ensure there are no articles in that window. Our manual verification indicates that TRNA includes 98% of the news articles in Factiva, which suggests that TRNA provides a comprehensive coverage of corporate news.

Second, we use the Compustat earnings announcement dates to validate the earnings press releases in TRNA. The reason we focus on earnings announcements is because they are among the most high-profile and frequent corporate announcements. In addition, TRNA has a

[23] Recently some companies switched from newswires to their own investor relations websites to distribute earnings releases (e.g., "Microsoft Outlines New Process for Publishing its Earnings Announcements; Company to now post quarterly results to its Investor Relations Website," October 27, 2010; "Google moves to Web Disclosure for Reg. FD," April 16, 2010; "Web Disclosure Q1 Trends: Google, Expedia and 4 Others leading the pack," April 21, 2010). However, these companies typically issue advisory press releases to inform investors that the earnings press release for a given quarter has been made available in their website. The TRNA database appears to cover such advisory press releases as these are issued through one of the press release firms (e.g., 10/28/2010, "Microsoft Earnings Press Release Available on Investor Relations Website" (PR Newswire); 4/15/2010, "Google Announces Availability of First Quarter 2010 Financial Results" (Marketwire); 2/11/2010, "Expedia, Inc. Earnings Press Release Available on Company's IR Site" (PR Newswire)). Given our focus is on the existence of a pre-event, not the exact content of the related disclosure, the use of the TRNA database should not result in any bias. One caveat is that, to the extent a company decides to stop issuing such advisory press releases, the TRNA database may be incomplete in capturing all pre-events. We believe that such practices are few and far between and would, in the worst case, result in the omission of a few earnings releases in 2010 when some companies began using their websites to release earnings reports.

specific topic code ("res") for reported financial results and it is relatively easy for us to verify the TRNA code and correct any misclassifications through common earnings release-related keyword searches. The intersection of the analyst recommendation revision sample from First Call and TRNA consists of 5,008 U.S. firms and 22,237 firm/years during 2003-2010. For this joint sample we obtain 86,757 earnings release dates from Compustat. As Compustat defines earnings release date (RDQ) as the earlier of earnings announcement date or SEC 10-K/Q filing date, there may or may not be an earnings press release when RDQ is the same as the SEC 10-K/Q filing date.[24] To ensure that RDQ is the earnings announcement date, we delete 14,333 observations when RDQ is the same as or later than the SEC filing date, resulting in 72,424 earnings announcements. We next match these earnings announcements with press releases in TRNA where the earnings release date is within days [-1, 0] of RDQ. As discussed earlier the TRNA news topics are not always precise. We identify earnings announcements in TRNA from the "res" category after eliminating news articles not believed to be earnings announcements.[25] We also search news articles not classified as "res" to identify additional earnings announcements.[26] In the end, we are able to match 67,153 (92.7%) of the Compustat earnings announcements with press releases in TRNA, which suggests that TRNA provides reasonably comprehensive news coverage. Note that some of the 7.3% Compustat earnings announcements not matched with TRNA may still exist in TRNA if they are misclassified as non-earnings news and not picked up by our keyword searches.

Finally, we cross-check the pre-event frequencies based on TRNA (similar to what we report in Panel A of Table 2) using earnings announcements identified from the I/B/ES database and management guidance from the First Call database. Table A1 below reports the findings for our sample period of 2003-2010. In Panel A of Table A1 we find that 26.8% of the

[24] When RDQ is the same as the 10K/Q filing date, it is one of the following three scenarios: (a) earnings announcement is made after 10K/Q filing; (b) there is no earnings announcement at all; and (c) earnings announcement is released on the same day as 10K/Q filing.

[25] In the category "res" (financial results-related press releases), we use keywords in the headlines to eliminate press releases on announcements of dates of upcoming earnings announcements ("to host," "to announce," "to hold," "to report," "to present," "to speak," "to release," "to broadcast," "date and time of," "earnings release date," "earnings release schedule," "sets release date," "will report...results," "will release...results," "will announce...results," etc.), conference calls or Webcasts ("conference," "earnings calls," "webcast," etc.), and corrections or updates ("correcting and replacing" and "correction"). We assume that the rest of the press releases in "res" are earnings announcements.

[26] From press releases not categorized by TRNA as "res", we use keywords ("reports/announces/ delivers/presents/releases/records" and "results/sales/revenue/net income/net loss/earnings/profit/EPS") to identify additional earnings announcements.

recommendation revisions issued during regular trading hours follow earnings announcements per I/B/E/S and 11.3% follow management guidance per First Call for a combined 30.6% of the revisions following either type of events in a three-day window (i.e., 12:00 a.m. on calendar day -3 to 21 calendar minutes before the release of the recommendation revision). The percentages are lower for revisions issued during extended trading hours (26.6%) and non-trading hours (22.7%).

We cross-check these frequencies with those calculated based on TRNA as reported in Panel B of Table A1, with earnings announcements from TRNA identified as discussed above and topic code "resf" used for management forecasts.[27] The percentages of RTH recommendation revisions following earnings announcements and management guidance are 26.2% and 13.9%, respectively. These numbers are comparable to those based on I/B/E/S and First Call. The slightly higher percentages on guidance per TRNA could be due to the limited coverage of First Call (Chuk et al., 2013).

[27] We apply a similar procedure to clean the category "resf" as for "res" (footnote 25). In addition, we use keywords (e.g., "announces/updates/projects/provides/issues/affirms/confirms/reiterates/revises/increases/raises/ lowers" and "outlook/guidance/estimates/expectation/forecast/projection/update/preliminary", or "announces/ reports/expects/projects/anticipates/pre-announces" and "results/performance/earnings") to identify additional management guidance from press releases not categorized by TRNA.

TABLE A1
Earnings Announcement and Management Guidance before Recommendation Revisions (ΔRECs):
I/B/E/S and First Call versus TRNA

	[Day -3, Minute -21]		
	ΔRECs in RTH	ΔRECs in ETH	ΔRECs in NTH
Number of ΔRECs	30,910	42,302	29,717
Percentage of ΔREC with pre-events:			
Panel A. Frequency of pre-events per I/B/E/S and First Call			
Earnings Announcement per I/B/E/S	26.8%	23.8%	20.0%
Management Guidance per First Call	11.3%	9.1%	8.3%
Combined frequency of pre-events	30.6%	26.6%	22.7%
Panel B. Frequency of pre-events per TRNA			
Earnings Announcement per TRNA	26.2%	23.6%	19.3%
Management Guidance per TRNA	13.9%	11.9%	10.5%
Combined frequency of pre-events	29.8%	26.1%	21.6%

This table reports the frequency of earnings announcements and management guidance issued before recommendation revisions (ΔRECs) . Panel A reports the frequencies per I/B/E/S and First Call, and Panel B is for frequencies calculated per Thomson Reuters News Archive (TRNA). ΔRECs are classified into RTH, ETH, and NTH recommendation revisions as defined in Table 1.

Appendix B
Statistical Tests Related to Figure 3 and Figure 4

I. Analysis of changes in price trajectory

To test the significance of changes in price trajectory at minute 0 in Figure 3 and 4, we estimate the following regression:

$$CUMRET_t = \alpha + \beta TIME_t + \gamma TIME_t \times Post\_Minute0_t + \varepsilon_t ,$$

where -20 ten-minute interval ≤ t ≤ +20 ten-minute interval. *CUMRET* is buy-and-hold cumulative return starting from -150 ten-minute interval, which is approximately two trading days before the recommendation revision (ΔREC), to t. *TIME* ranges from -20 to +20 ten-minute intervals relative to the recommendation revision announcement (minute 0), and *Post_Minute0* is an indicator for cumulative returns at or after minute 0. We report the regression results in Table B1 by four categories of recommendation revisions and by full sample (as in Figure 3) and non-confounding sample (as in Figure 4), respectively. For brevity, we omit the intercept α from Table B1. The coefficient of interest is gamma (γ), which reflects the change in price trajectory at minute 0. We observe significant changes in price trajectory in all cases except for RTH contrarian downgrades in the non-confounding sample.

TABLE B1
Test of Changes in Price Trajectory around Recommendation Revision Announcements

	Full Sample (Figure 3)		Non-confounding Sample (Figure 4)	
Panel A: Recommendation Revisions Announced within Regular Trading Hours (RTH)				
	[-20, +20] ten-minute intervals		[-20, +20] ten-minute intervals	
Category	β (in %)	γ (in %)	β (in %)	γ (in %)
Trending downgrade	-0.284	0.252	-0.173	0.145
Trending upgrade	0.250	-0.214	0.188	-0.151
Contrarian downgrade	0.029	-0.058	-0.036	*0.006*
Contrarian upgrade	0.019	0.011	0.044	-0.016
Panel B: Recommendation Revisions Announced within Extended Trading Hours (ETH)				
	[-20, +20] ten-minute intervals		[-20, +20] ten-minute intervals	
Category	β (in %)	γ (in %)	β (in %)	γ (in %)
Trending downgrade	-0.078	-0.166	-0.023	-0.132
Trending upgrade	0.067	0.173	0.041	0.170
Contrarian downgrade	-0.015	-0.164	-0.013	-0.164
Contrarian upgrade	0.022	0.182	0.020	0.195

(Continued on the next page)

(TABLE B1 Continued)

Panel C: Recommendation Revisions Announced within Non-Trading Hours (NTH)

Category	[-20, +20] ten-minute intervals β (in %)	[-20, +20] ten-minute intervals γ (in %)	[-20, +20] ten-minute intervals β (in %)	[-20, +20] ten-minute intervals γ (in %)
Trending downgrade	-0.042	-0.064	-0.008	-0.083
Trending upgrade	0.028	0.113	0.010	0.126
Contrarian downgrade	*0.002*	-0.100	*0.001*	-0.101
Contrarian upgrade	*0.003*	0.107	*0.002*	0.127

Numbers that are insignificant at the two-tailed 10% level are presented in italics.
This table reports the analysis results of changes in price trajectory estimated from the following regression:

$$CUMRET_t = \alpha_t + \beta TIME_t + \gamma TIME_t \times Post\_Minute0_t + \varepsilon,$$

where -20 ten-minute interval ≤ t ≤ +20 ten-minute interval. *CUMRET* is buy-and-hold cumulative return starting from -150 ten-minute interval, which is approximately two trading days before the recommendation revision (ΔREC), to t. *TIME* ranges from -20 to +20 ten-minute intervals relative to the recommendation revision announcement (minute 0), and *Post_Minute0* is an indicator for cumulative returns at or after minute 0. We present the coefficients of general time trend (β) and coefficients of changes in time trend at minute 0 (γ) for brevity. ΔRECs are classified into RTH, ETH, and NTH recommendation revisions as defined in Table 1. Downgrade (upgrade) refers to lowered (raised) recommendations. Trending (Contrarian) refers to ΔRECs in the same (opposite) direction as the pre-announcement returns from 4:00 p.m. of trading day -2 to trading minute -21 prior to the revisions.

II. Analysis of changes in cumulative returns due to removal of confounding events

Table B2 presents significance tests of the differences in cumulative returns leading up to the recommendation revisions between the full sample (Figure 3) and the non-confounding sample (Figure 4). We restrict this analysis to trending revisions only as piggybacking is more of a concern in those cases. The table indicates significant declines in the magnitudes of cumulative returns in all cases due to the removal of confounding events.

TABLE B2
Comparisons of Cumulative Returns at Recommendation Revision Announcements: Full Sample (Figure 3) versus Non-confounding Sample (Figure 4)

	Full Sample (1)		Non-confounding Sample (2)		Test of the Difference (1) - (2)	
	N	Mean	N	Mean	(1) - (2)	T-stat.
RTH Revisions:						
Trending downgrade	10,412	-10.84%	1,882	-5.20%	-5.64%	-30.50***
Trending upgrade	8,755	9.11%	1,894	5.82%	3.29%	17.48***

(Continued on the next page)

(TABLE B2 continued)

ETH Revisions:						
Trending downgrade	12,162	-6.47%	2,258	-2.67%	-3.80%	-28.44***
Trending upgrade	11,106	5.44%	2,440	3.21%	2.23%	16.62***
NTH Revisions:						
Trending downgrade	8,053	-5.71%	1,736	-2.58%	-3.13%	-22.44***
Trending upgrade	7,882	5.05%	1,727	3.18%	1.87%	11.35***

***, **, * represent two-tailed statistical significance at 0.01, 0.05, and 0.1 levels respectively.

Cumulative return refers to the buy-and-hold cumulative return over 151 ten-minute intervals (i.e., [-150, 0]), starting from approximately two trading days before the recommendation revision (ΔREC) to the revision announcement time (minute 0). Downgrade (upgrade) refers to lowered (raised) recommendations. ΔRECs are classified into RTH, ETH, NTH as defined in Table 1. Downgrade (upgrade) refers to lowered (raised) recommendations. Trending refers to ΔRECs in the same direction as the pre-announcement returns from 4:00 p.m. of trading day -2 to trading minute -21 prior to the revisions.

FIGURE 1
Timelines of Measurement Windows

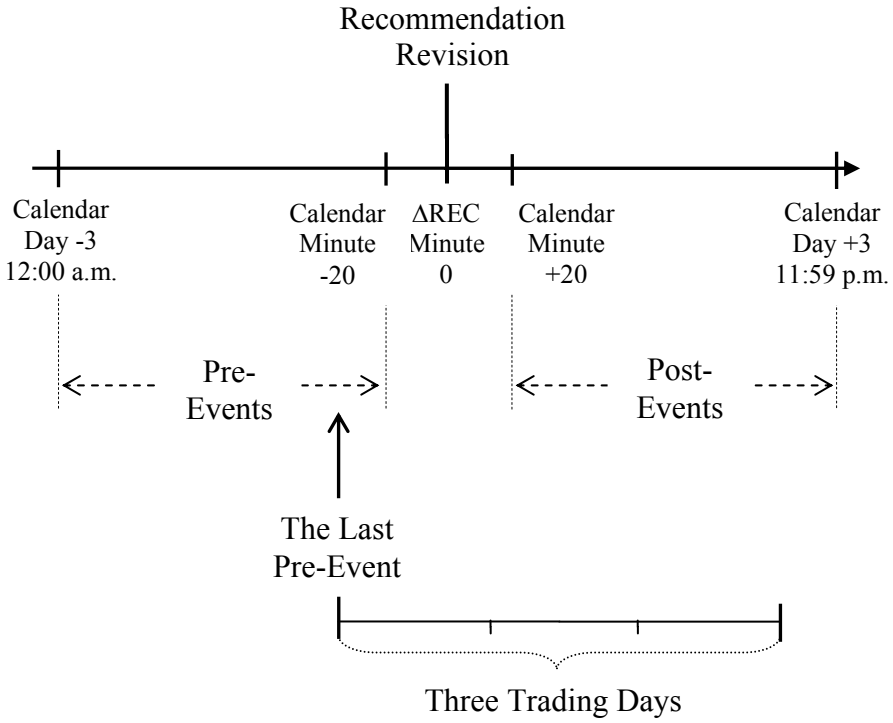
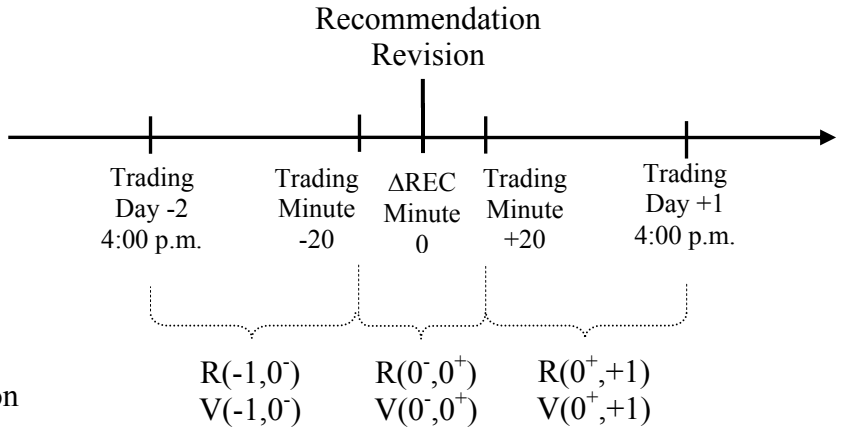


Table 2: Corporate Events Disclosed before/after Recommendation Revisions

Table 3: Price Discovery of Corporate Events and Subsequent Confirming Recommendation Revisions



Tables 5 & 6: Price Reaction/Abnormal Trading Volume around Recommendation Revisions

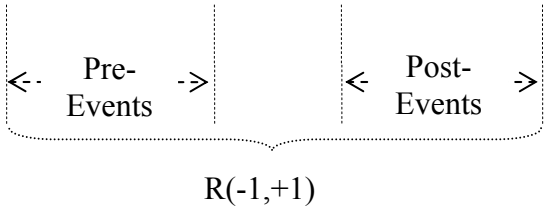
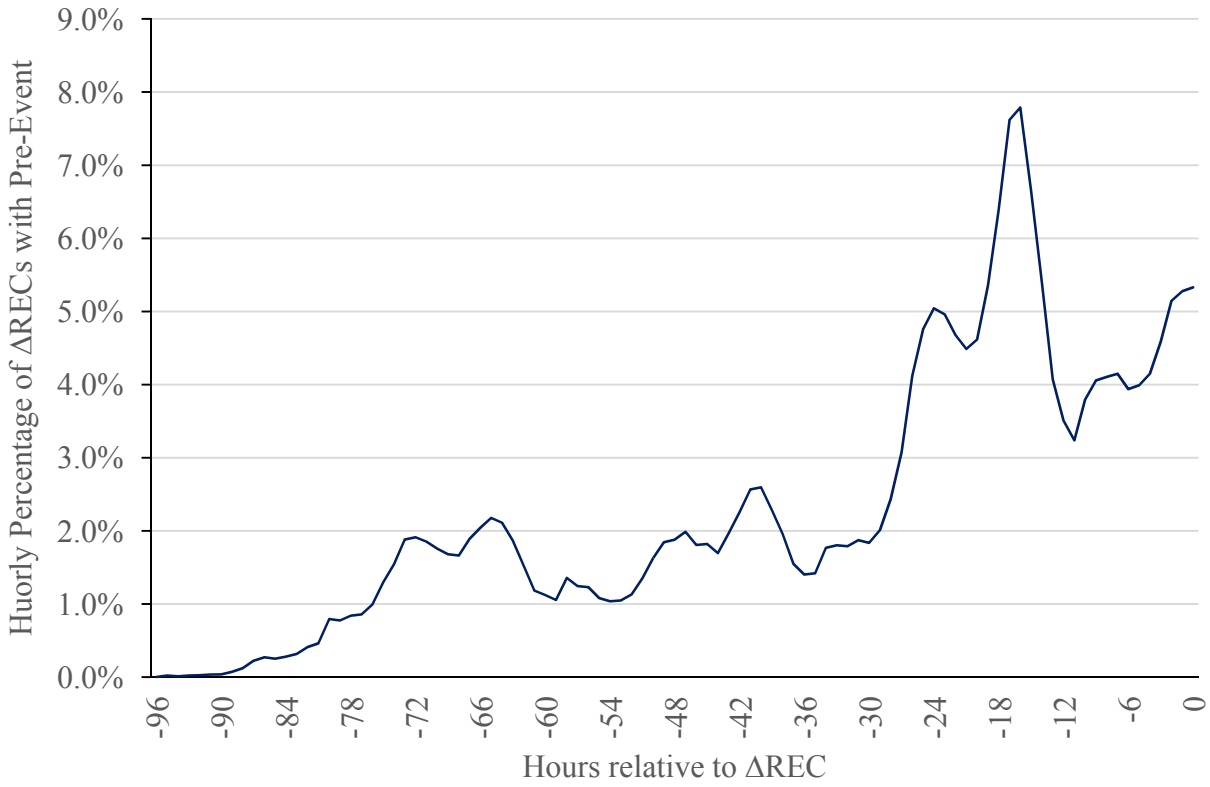


Table 7: Regression Analysis of Three-Day Cumulative Returns Surrounding Recommendation Revision Release in Different Trading Hours

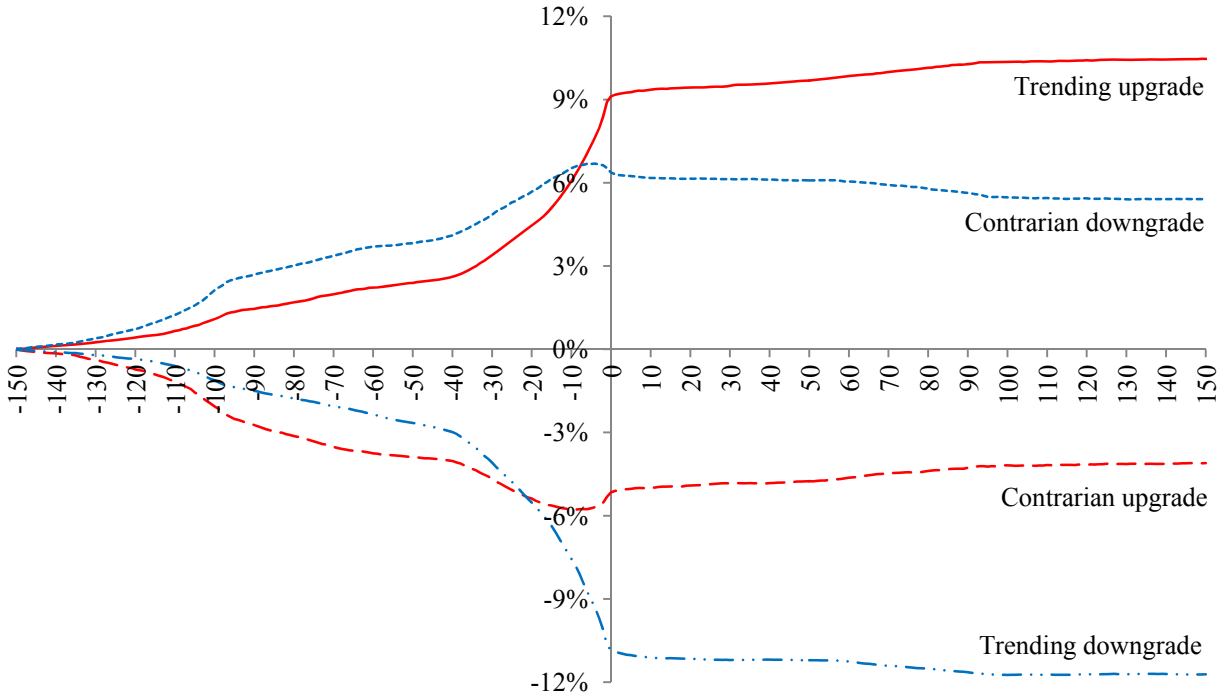
FIGURE 2
Timing of Pre-Events Relative to Recommendation Revisions



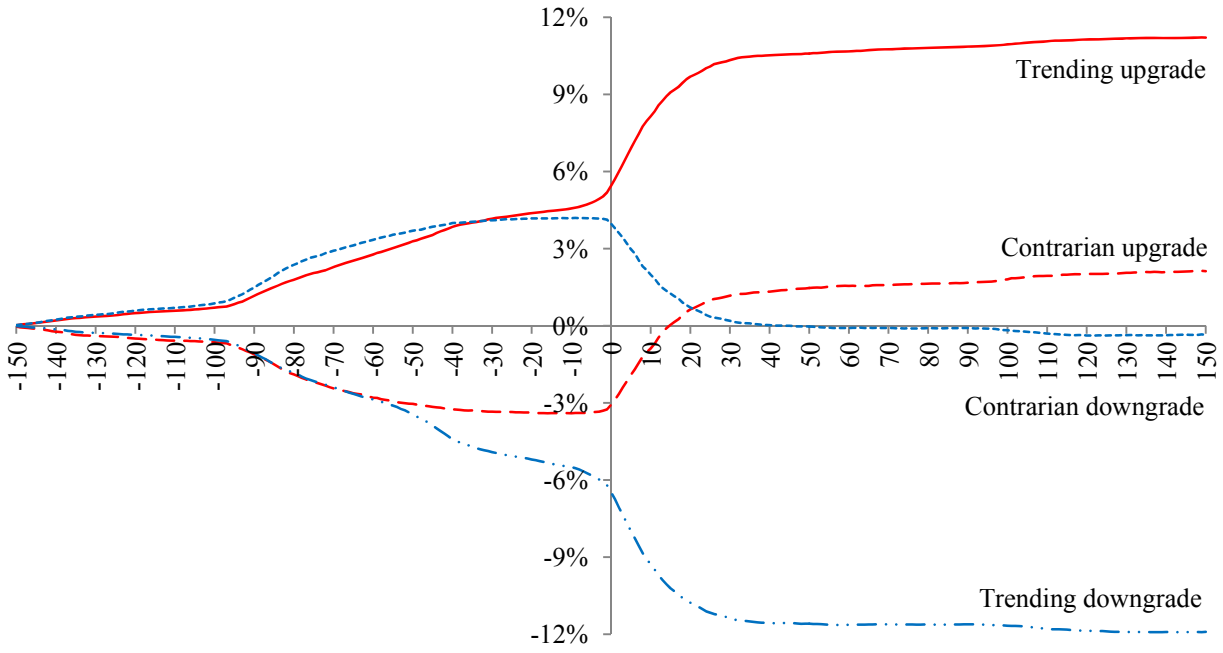
This figure is based on 102,929 recommendation revisions (ΔRECs) released over 2003-2010. It presents, in each of the 96 calendar hours leading up to the recommendation revisions, the percentage of revisions with at least one pre-event disclosed within the hour. Pre-events are corporate news per Thomson Reuters News Archive (TRNA) database.

FIGURE 3
Average Cumulative Return Around Recommendation Revision Announcements

Panel A: Recommendation Revisions Announced within Regular Trading Hours (Obs=30,910):



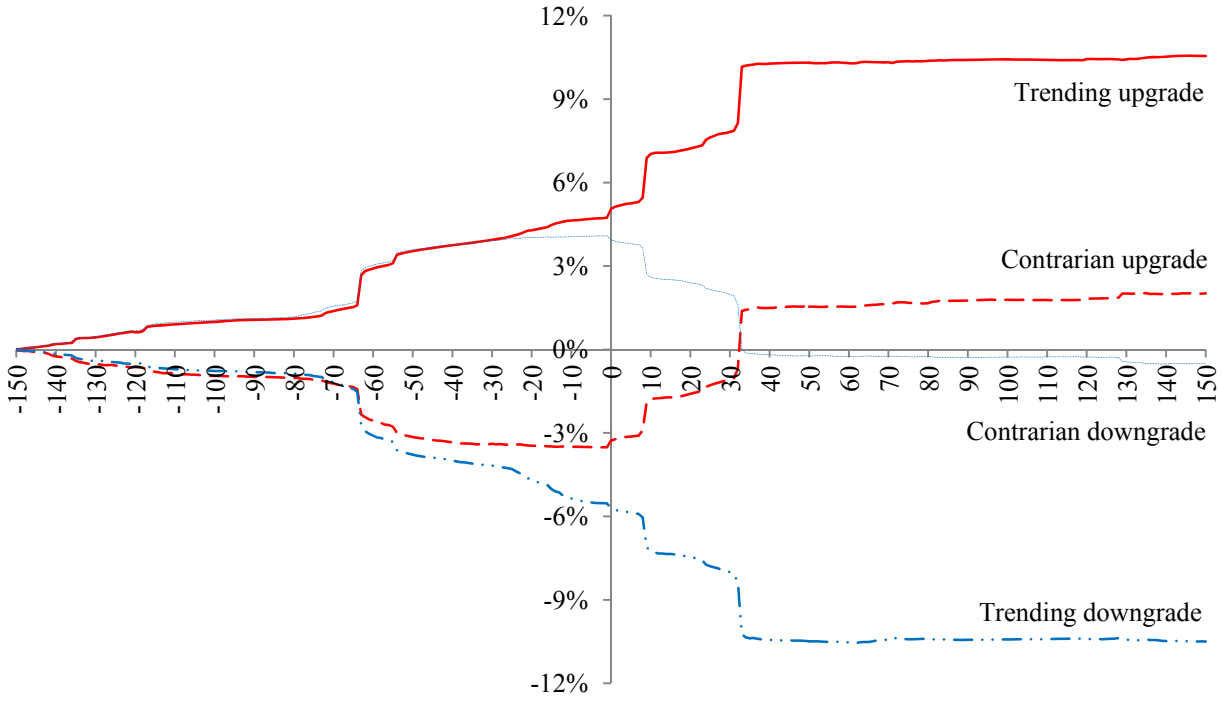
Panel B: Recommendation Revisions Announced within Extended Trading Hours (Obs=42,302):



(Continued on the next page)

(FIGURE 3 continued)

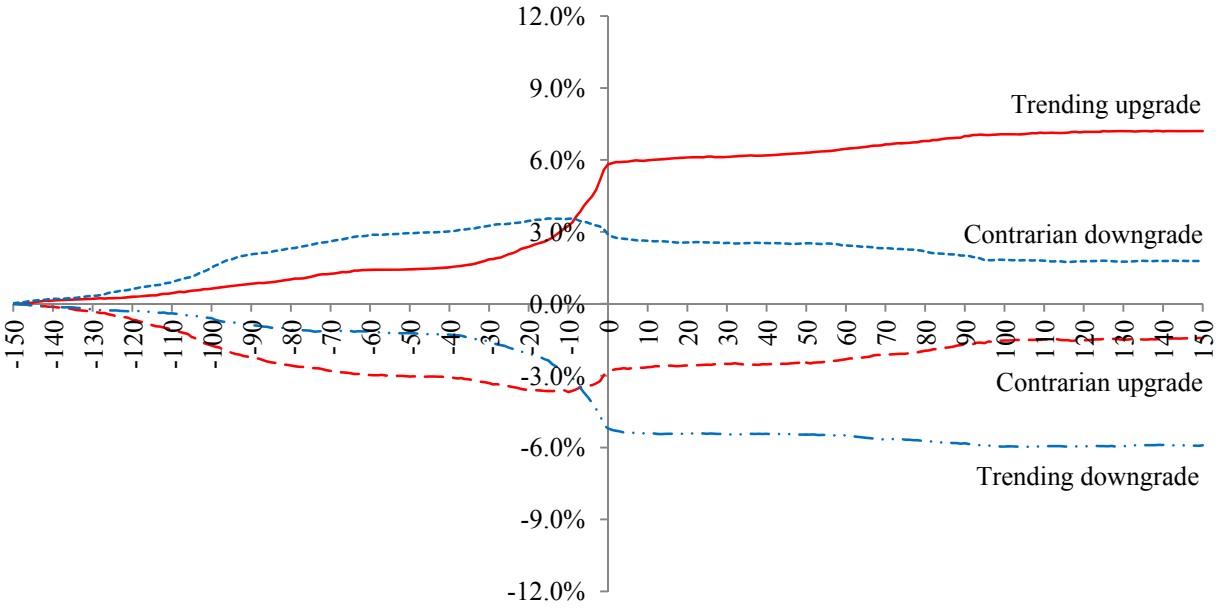
Panel C: Recommendation Revisions Announced within Non-Trading Hours (Obs=29,717):



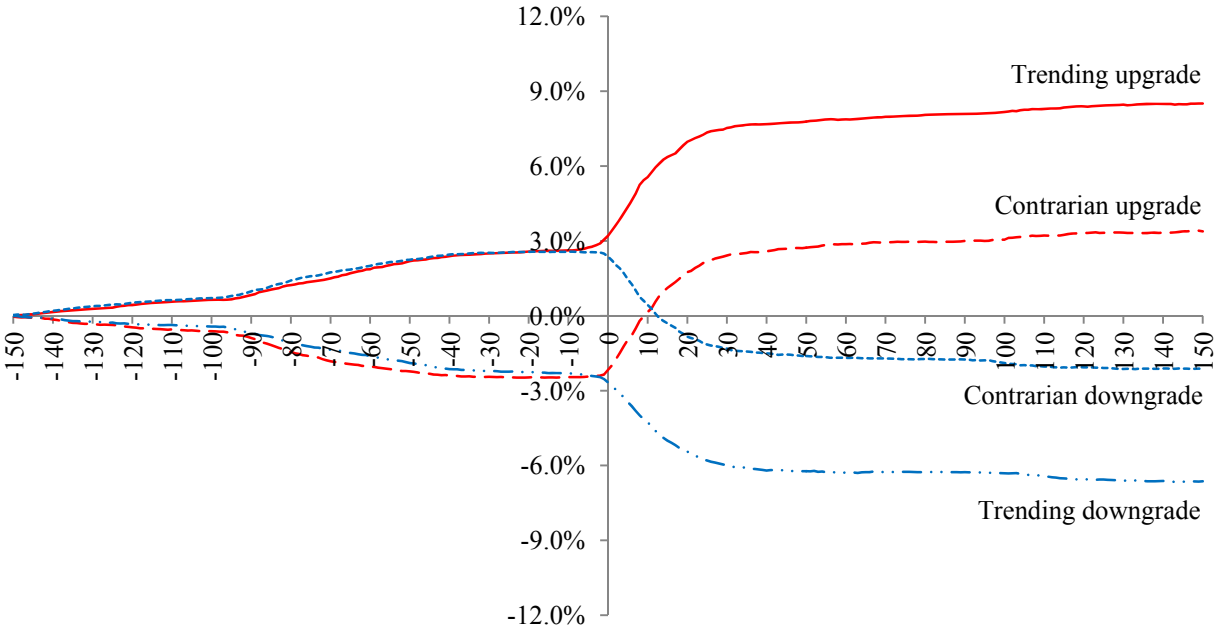
These figures are based on 102,929 recommendation revisions (ΔRECs) released over 2003-2010. Average cumulative returns are shown for 301 ten-minute intervals, starting from approximately two trading days before to two trading days after the revision announcement. Downgrade (upgrade) refers to lowered (raised) recommendations. Return for minute t is calculated as $(PRICE_t - PRICE_{t-1})/PRICE_{t-1}$, where $PRICE_t$ is the trading price of the last transaction within minute t and $PRICE_{t-1}$ is the trading price of the immediately previous transaction before minute t. If no transaction occurs within minute t, return is set to zero. ΔRECs are classified into RTH, ETH, and NTH by their respective announcement trading hours. Detailed definitions of trading hours are provided in Table 1. Trending (Contrarian) revisions refers to ΔRECs in the same (opposite) direction as the pre-announcement returns from 4:00 p.m. of trading day -2 to trading minute -21 prior to the revisions.

FIGURE 4
Average Cumulative Return Around First Recommendation Revision Announcements without Pre- or Post-Events

Panel A: Recommendation Revisions Announced within Regular Trading Hours (Obs=6,910):



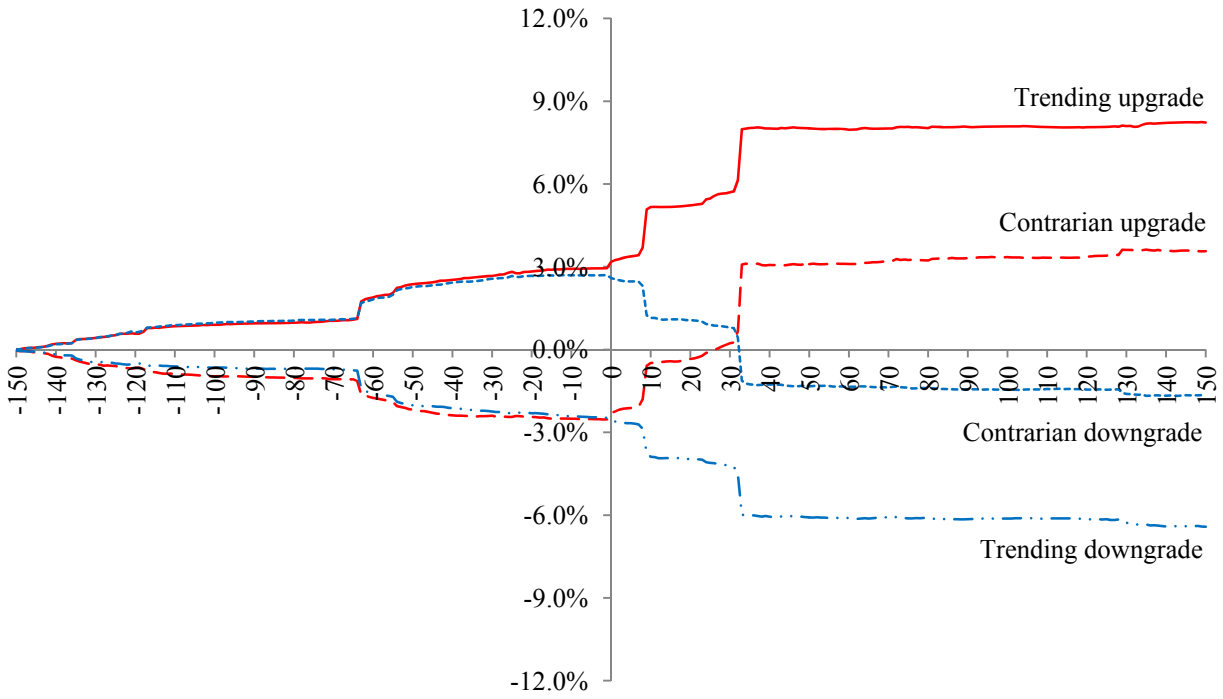
Panel B: Recommendation Revisions Announced within Extended Trading Hours (Obs=9,716):



(Continued on the next page)

(FIGURE 4 continued)

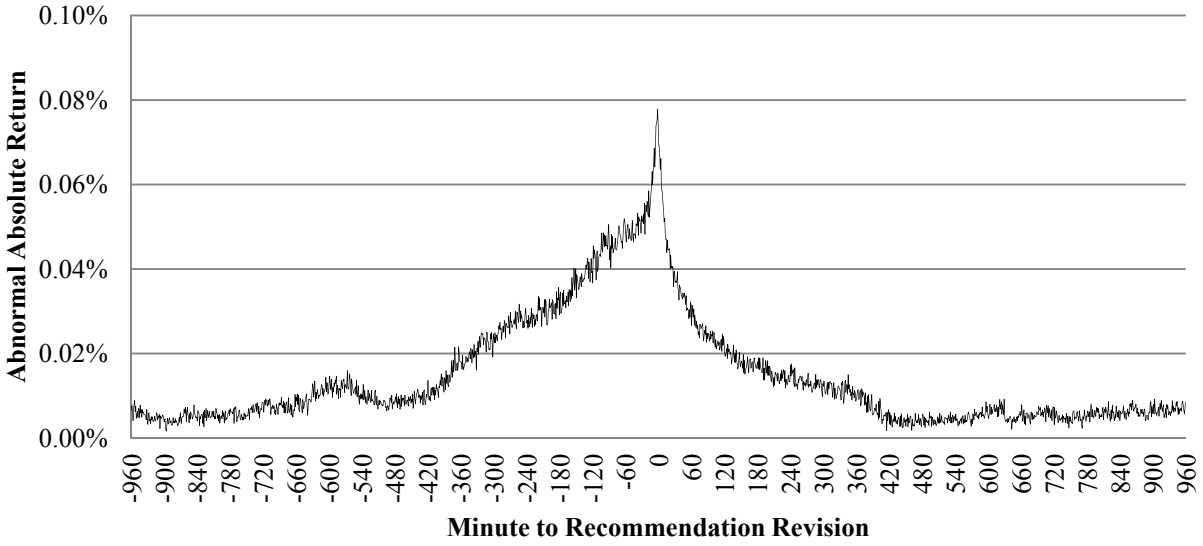
Panel C: Recommendation Revisions Announced within Non-Trading Hours (Obs=7,047):



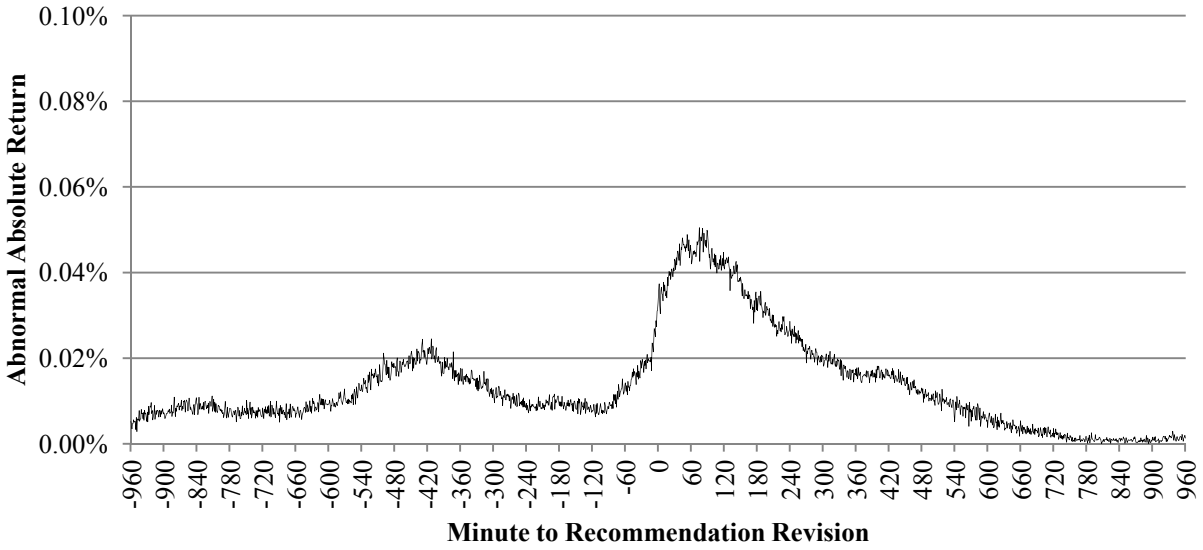
These figures are based on 23,673 first recommendation revisions (ΔRECs) without pre- or post-events. First ΔRECs refer to recommendation revisions that have no other revision of the same direction for the same firm within the previous 24 hours. Pre-events (post-events) are corporate news per Thomson Reuters News Archive (TRNA) from calendar Day -3 to calendar minute -21 before (from calendar minute +21 to calendar day +3 after) the recommendation revision. Average cumulative returns are shown for 301 ten-minute intervals, starting from approximately two trading days before to two trading days after the revision announcement. Downgrade (upgrade) refers to lowered (raised) recommendations. Return for minute t is calculated as $(PRICE_t - PRICE_{t-1})/PRICE_{t-1}$, where $PRICE_t$ is the trading price of the last transaction within minute t and $PRICE_{t-1}$ is the trading price of the immediately previous transaction before minute t. If no transaction occurs within minute t, return is set to zero. ΔRECs are classified into RTH, ETH, and NTH by their respective announcement trading hours. Detailed definitions of trading hours are provided in Table 1. Trending (Contrarian) revisions refers to ΔRECs in the same (opposite) direction as the pre-announcement returns from 4:00 p.m. of trading day -2 to trading minute -21 prior to the revisions.

FIGURE 5
Abnormal Absolute Returns to Recommendation Revision Announcements

Panel A: Recommendation Revisions Announced within Regular Trading Hours (Obs=30,910):



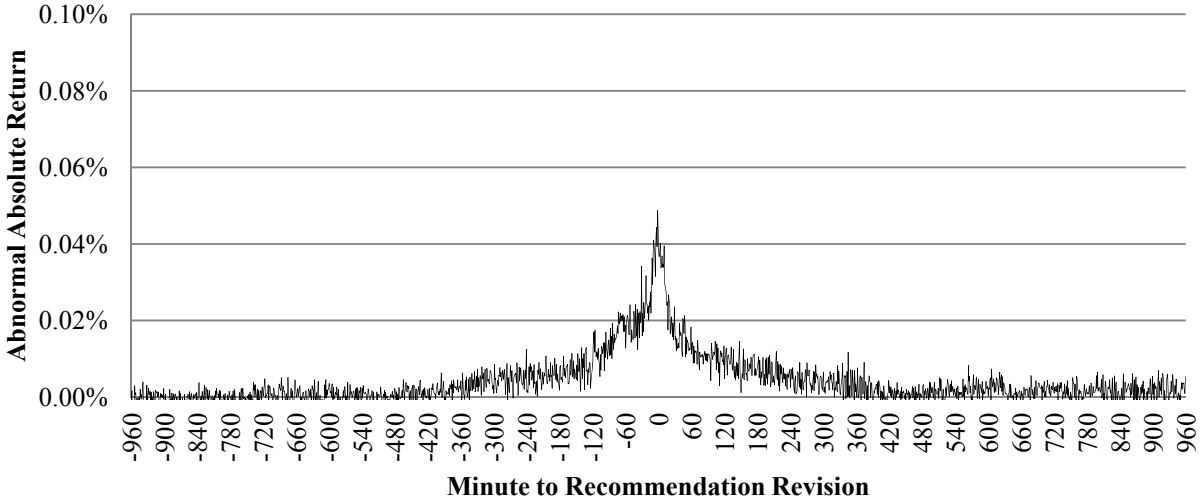
Panel B: Recommendation Revisions Announced within Extended Trading Hours (Obs=42,302):



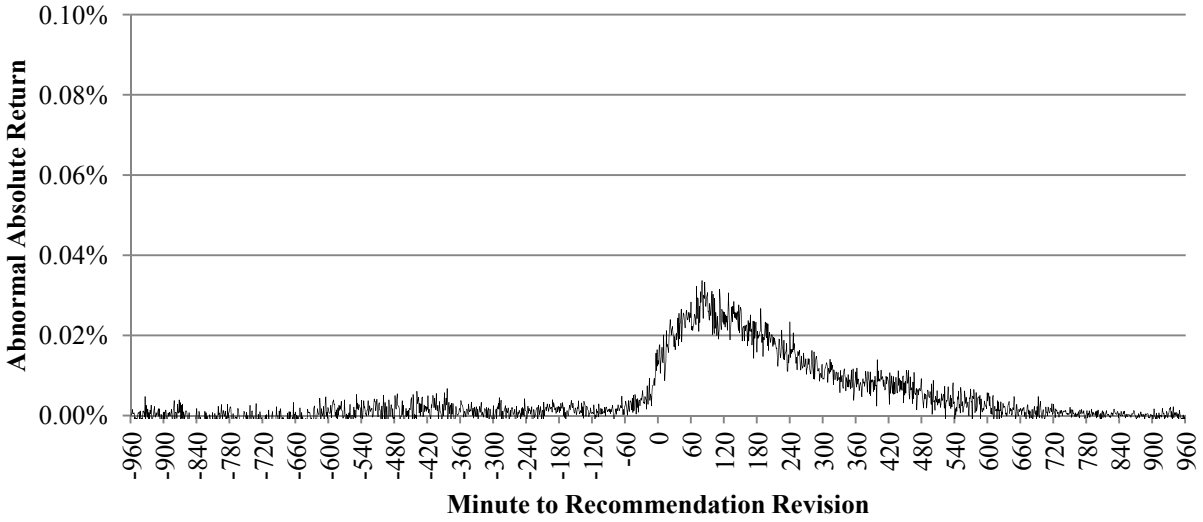
These figures are based on 30,910 RTH and 42,302 ETH recommendation revisions (ΔRECs) released over 2003-2010. Each figure shows the abnormal absolute return of 1,920 trading minutes centered on ΔREC announcement. Abnormal absolute return is calculated as the *ABSRET* of the actual ΔREC in excess of that of the corresponding pseudo ΔREC, which is defined as occurring at the same hour and minute as the ΔREC of interest and on the same weekday of the week that immediately follows the ΔREC of interest. *ABSRET* is calculated as the absolute value of $(PRICE_t - PRICE_{t-1})/PRICE_{t-1}$, where $PRICE_t$ is the trading price of the last transaction within minute t and $PRICE_{t-1}$ is the trading price of the immediately previous transaction before minute t. If no transaction occurs within minute t, *ABSRET* is set to zero. *ABSRET* is winsorized at the top 0.1 percentile. Recommendation revisions (ΔRECs) are classified into RTH, ETH, and NTH by their respective announcement trading hours. Detailed definitions of trading hours are provided in Table 1.

FIGURE 6
Abnormal Absolute Returns to First Recommendation Revision without Pre- or Post-Events

Panel A: Recommendation Revisions Announced within Regular Trading Hours (Obs=6,910):



Panel B: Recommendation Revisions Announced within Extended Trading Hours (Obs=9,716):



These figures are based on first recommendation revisions (ΔRECs) released over 2003-2010 without any pre- or post-events. First ΔRECs and pre- and post-events are as defined in Figure 4. Each figure shows the abnormal absolute return of 1,920 trading minutes centered on ΔREC announcement. Abnormal absolute return is calculated as the *ABSRET* of the actual ΔREC in excess of that of the corresponding pseudo ΔREC, which is defined as occurring at the same hour and minute as the ΔREC of interest and on the same weekday of the week that immediately follows the ΔREC of interest. *ABSRET* is calculated as the absolute value of $(PRICE_t - PRICE_{t-1})/PRICE_{t-1}$, where $PRICE_t$ is the trading price of the last transaction within minute t and $PRICE_{t-1}$ is the trading price of the immediately previous transaction before minute t. If no transaction occurs within minute t, *ABSRET* is set to zero. *ABSRET* is winsorized at the top 0.1 percentile. Recommendation revisions (ΔRECs) are classified into RTH, ETH, and NTH by their respective announcement trading hours. Detailed definitions of trading hours are provided in Table 1.

TABLE 1
Calendar Year Distribution of the Number of Recommendation Revisions (ΔRECs) by Trading Hours

Calendar Year	***Downgrade***				***Upgrade***			
	Number of ΔRECs	ΔRECs in RTH (%)	ΔRECs in ETH (%)	ΔRECs in NTH (%)	Number of ΔRECs	ΔRECs in RTH (%)	ΔRECs in ETH (%)	ΔRECs in NTH (%)
2003	7,044	42.1	27.2	30.7	5,886	40.2	28.8	31.0
2004	6,724	33.7	26.1	40.2	5,880	33.4	25.6	41.0
2005	6,407	29.7	43.5	26.8	6,101	27.6	41.4	31.1
2006	7,419	27.6	47.7	24.7	5,746	24.9	48.3	26.8
2007	7,148	30.5	47.2	22.3	6,481	27.0	46.8	26.2
2008	8,593	30.8	41.7	27.5	6,751	30.8	43.5	25.7
2009	6,264	29.7	43.0	27.3	5,877	25.4	45.7	28.8
2010	5,348	22.8	51.5	25.7	5,260	19.9	52.2	27.9
Total	54,947	31.1	40.8	28.1	47,982	28.8	41.5	29.7

This table reports the calendar year distribution of recommendation revisions (ΔRECs) released during 2003-2010, along with the percentage of ΔRECs released during different trading hours. RTH is regular trading hours (9:30 a.m.- 4:00 p.m.), and ETH is extended trading hours. Within our sample period, the time schedule of ETH of NYSE/AMEX and NASDAQ stocks evolves as follows:

NYSE/AMEX			NASDAQ		
Period	Pre-market Session	After-market Session	Period	Pre-market Session	After-market Session
1/1/2003-4/7/2005	8:00-9:30	16:00-20:00	1/1/2003-4/7/2005	8:00-9:30	16:00-18:30
4/8/2005-12/31/2010	4:00-9:30	16:00-20:00	4/8/2005-9/19/2006	4:00-9:30	16:00-18:30
			9/20/2006-12/31/2010	4:00-9:30	16:00-20:00

ΔRECs not in RTH or ETH are released during non-trading hours (NTH). Downgrade (upgrade) refers to lowered (raised) recommendations.

TABLE 2
Corporate Events Disclosed before Recommendation Revisions (ΔRECs)

Panel A: Frequency of pre-events

	ΔRECs in RTH		***ΔRECs in ETH***		***ΔRECs in NTH***		Total
	Down	Up	Down	Up	Down	Up	
N of ΔRECs:	17,097	13,813	22,398	19,904	15,452	14,265	102,929
% of ΔREC with pre-events:							
All Events	66.7%	64.0%	62.1%	58.4%	58.4%	56.6%	61.1%
Press Release News	60.0%	57.0%	53.9%	49.1%	49.2%	46.6%	52.7%
Earnings	*26.0%*	*26.5%*	*24.7%*	*22.3%*	*19.7%*	*18.9%*	*23.1%*
Guidance	*14.6%*	*13.1%*	*13.2%*	*10.6%*	*11.2%*	*9.9%*	*12.1%*
Dividend	*3.1%*	*3.3%*	*2.9%*	*3.0%*	*3.1%*	*2.5%*	*3.0%*
M&A	*8.0%*	*5.5%*	*5.6%*	*3.9%*	*5.0%*	*4.0%*	*5.4%*
Management	*2.2%*	*2.2%*	*2.6%*	*2.3%*	*1.9%*	*1.9%*	*2.2%*
Other Press Release	*34.4%*	*34.5%*	*31.1%*	*30.6%*	*30.3%*	*30.8%*	*31.9%*
Non-Press Release News	54.1%	48.9%	50.8%	46.1%	45.9%	44.0%	48.5%
Earnings-related	*35.7%*	*32.5%*	*32.9%*	*27.7%*	*27.4%*	*24.1%*	*30.3%*
Guidance-related	*33.9%*	*29.5%*	*31.2%*	*25.7%*	*25.7%*	*22.0%*	*28.2%*
Dividend-related	*2.6%*	*2.6%*	*2.4%*	*2.2%*	*2.2%*	*2.1%*	*2.3%*
M&A-related	*12.2%*	*9.0%*	*9.5%*	*7.8%*	*8.7%*	*8.1%*	*9.2%*
Management-related	*3.8%*	*3.4%*	*4.1%*	*3.4%*	*3.7%*	*3.3%*	*3.7%*
Other Non-Press Release	*30.9%*	*26.7%*	*28.8%*	*27.1%*	*28.9%*	*28.3%*	*28.5%*
N of pre-events per ΔREC:							
Mean	3.4	3.9	3.2	3.5	3.2	3.4	3.4
Std	6.3	8.5	6.5	7.0	6.3	6.7	7.0
Q1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Median	2.0	2.0	1.0	2.0	1.0	1.0	1.0
Q3	4.0	5.0	4.0	4.0	4.0	4.0	4.0
P90	8.0	9.0	8.0	9.0	9.0	9.0	9.0

Panel B: Market reaction to pre-events

	ΔRECs in RTH		***ΔRECs in ETH***		***ΔRECs in NTH***		Total
	Down	Up	Down	Up	Down	Up	
N of total pre-events	66,276	46,758	78,086	63,140	52,445	45,265	351,970
Mean (in %)	**-0.59**	**0.37**	**-0.62**	**0.37**	**-0.48**	**0.29**	**-0.17**
Std (in %)	5.04	3.55	4.47	3.25	3.83	2.99	4.02
Q1 (in %)	-0.65	-0.19	-0.53	-0.19	-0.54	-0.22	-0.37
Median (in %)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Q3 (in %)	0.18	0.54	0.18	0.49	0.22	0.48	0.32

(Continued on the next page)

(TABLE 2 continued)

Panel C: Frequency of ΔRECs with a consistent sign to pre-event return

	ΔRECs in RTH		***ΔRECs in ETH***		***ΔRECs in NTH***		Total
	Down	Up	Down	Up	Down	Up	
ΔRECs with pre-events	11,398	8,836	13,902	11,633	9,020	8,081	62,870
%	*(100.0%)*	*(100.0%)*	*(100.0%)*	*(100.0%)*	*(100.0%)*	*(100.0%)*	*(100.0%)*
Bad news pre-events	5,205	2,769	6,356	3,805	4,211	2,812	25,158
%	*(45.7%)*	*(31.3%)*	*(45.7%)*	*(32.7%)*	*(46.7%)*	*(34.8%)*	*(40.0%)*
Good news pre-events	3,683	3,899	4,528	5,257	3,153	3,747	24,267
%	*(32.3%)*	*(44.1%)*	*(32.6%)*	*(45.2%)*	*(35.0%)*	*(46.4%)*	*(38.6%)*
No news pre-events	2,510	2,168	3,018	2,571	1,656	1,522	13,445
%	*(22.0%)*	*(24.5%)*	*(21.7%)*	*(22.1%)*	*(18.4%)*	*(18.8%)*	*(21.4%)*

This table reports the frequency of corporate events disclosed before recommendation revisions and market reactions to the pre-events during 2003-2010. RTH, ETH, OTH, downgrades and upgrades are as defined in Table 1. Pre-events are corporate news per Thomson Reuters News Archive (TRNA) from 12:00 a.m. on calendar Day -3 to 21 minutes before the recommendation revision. In Panel A, Earnings, Guidance, Dividend, M&A, Management, and Other refer to earnings announcements, management earnings guidance, dividend announcements, merger and acquisition news, management issues, and other news, respectively, based on TRNA topic codes. In panel B, market reaction to pre-events is the 41 trading minutes ([-20 min, +20 min]) cumulative return centered on the timestamp of pre-events. Return in minute t is calculated as $(PRICE_t - PRICE_{t-1})/PRICE_{t-1}$, where $PRICE_t$ is the trading price of the last transaction within minute t and $PRICE_{t-1}$ is the trading price of the immediately previous transaction before minute t. If no transaction occurs within minute t, the return is set to zero. Means or Median returns that are significant at two-tailed 1% level per t tests and Wilcoxon signed rank tests are shown in bold. In panel C, Bad news, Good news, and No news pre-event refer to revisions with negative, positive, and zero sign of the aggregate announcement returns of all pre-events. Market reaction to pre-events is the 41 trading minutes ([-20 min, +20 min]) cumulative return centered on the timestamp of pre-events. Return in minute t is calculated as $(PRICE_t - PRICE_{t-1})/PRICE_{t-1}$, where $PRICE_t$ is the trading price of the last transaction within minute t and $PRICE_{t-1}$ is the trading price of the immediately previous transaction before minute t. If no transaction occurs within minute t, the return is set to zero. In cases where there are multiple pre-events for a recommendation revision, we sum up the announcement window returns for all the pre-events without double counting any overlapping windows. Means or Median returns that are significant at two-tailed 1% level per t tests and Wilcoxon signed rank tests are shown in bold. Downgrade revisions with bad news pre-events and upgrade revisions with good news pre-events are labeled as confirming revisions and highlighted in shaded cells.

TABLE 3
Price Discovery of Corporate Events and Subsequent Confirming Recommendation Revisions (ΔRECs)

Dependent Variable: RPD	ΔRECs in RTH (# of ΔRECs = 9,057)			ΔRECs in ETH (# of ΔRECs = 11,529)			ΔRECs in NTH (# of ΔRECs = 7,895)		
	Coef.	t-stat		Coef.	t-stat		Coef.	t-stat	
Constant	0.007	24.49	***	0.006	26.21	***	0.006	20.32	***
Post_Event$_{+30m}$	0.094	8.70	***	0.068	9.29	***	0.075	8.69	***
Post_Event$_{+60m}$	0.035	4.62	***	0.023	4.43	***	0.020	3.73	***
Post_Event$_{+90m}$	0.017	2.52	**	0.014	3.72	***	0.007	2.11	**
Post_Event$_{+120m}$	0.017	2.84	***	0.006	1.27		0.010	2.21	**
Post_Event$_{+150m}$	-0.003	-0.69		0.006	1.49		0.005	1.26	
Post_Event$_{+180m}$	0.000	-0.06		-0.002	-0.65		0.006	1.41	
Post_Event$_{+210m}$	-0.003	-1.02		0.001	0.31		0.011	3.33	***
Post_Event$_{+240m}$	0.008	1.87	*	0.001	0.20		0.008	2.19	**
Post_Event$_{+270m}$	-0.001	-0.24		0.004	1.21		0.004	1.14	
Post_Event$_{+300m}$	0.000	-0.12		-0.005	-1.65	*	-0.003	-0.77	
Post_Event$_{+330m}$	0.000	0.14		0.002	0.44		0.004	1.16	
Post_Event$_{+360m}$	-0.001	-0.33		0.007	2.42	**	-0.003	-0.85	
Post_Event$_{+390m}$	0.001	0.27		0.000	-0.09		-0.004	-1.18	
Post_Event$_{+420m}$	-0.007	-1.81	*	0.004	1.14		0.005	1.32	
Post_Event$_{+450m}$	0.000	-0.09		0.003	0.72		-0.001	-0.14	
Post_Event$_{+480m}$	0.006	1.43		0.011	2.78	***	0.006	1.25	
Pre_ΔREC$_{-480m}$	-0.002	-0.49		0.000	0.06		-0.006	-1.23	
Pre_ΔREC$_{-450m}$	-0.005	-1.38		0.013	2.23	*	0.000	-0.09	
Pre_ΔREC$_{-420m}$	-0.004	-0.97		0.000	-0.08		0.006	1.18	
Pre_ΔREC$_{-390m}$	0.004	0.64		-0.002	-0.32		0.000	0.01	
Pre_ΔREC$_{-360m}$	0.000	0.08		-0.004	-0.98		0.001	0.23	
Pre_ΔREC$_{-330m}$	0.016	2.89	***	-0.007	-1.87	*	-0.002	-0.40	
Pre_ΔREC$_{-300m}$	0.008	1.25		-0.006	-1.74	*	-0.004	-0.73	
Pre_ΔREC$_{-270m}$	0.022	2.89	***	-0.004	-1.02		-0.020	-3.14	***
Pre_ΔREC$_{-240m}$	0.007	1.04		-0.004	-1.13		-0.012	-2.12	**
Pre_ΔREC$_{-210m}$	0.012	1.89	*	-0.004	-1.43		-0.009	-1.74	*
Pre_ΔREC$_{-180m}$	0.020	3.75	***	-0.007	-2.99	***	-0.005	-0.78	
Pre_ΔREC$_{-150m}$	0.028	4.00	***	-0.009	-3.31	***	0.007	1.07	
Pre_ΔREC$_{-120m}$	0.023	3.93	***	-0.005	-2.38	**	-0.011	-2.54	**
Pre_ΔREC$_{-90m}$	0.031	4.46	***	-0.003	-1.13		-0.017	-5.29	***
Pre_ΔREC$_{-60m}$	0.044	7.78	***	0.004	0.93		-0.010	-4.13	***
Pre_ΔREC$_{-30m}$	0.061	7.51	***	0.011	2.66	***	-0.010	-4.22	***

(Continued on the next page)

(TABLE 3 continued)

$Post\_\Delta REC_{+30m}$	0.022	3.98	***	0.048	8.15	***	-0.001	-0.17	
$Post\_\Delta REC_{+60m}$	0.015	3.79	***	0.055	7.48	***	0.014	3.16	***
$Post\_\Delta REC_{+90m}$	0.010	2.79	***	0.068	9.29	***	0.075	8.69	***
$Post\_\Delta REC_{+120m}$	0.002	0.66		0.040	7.31	***	0.062	8.02	***
$Post\_\Delta REC_{+150m}$	-0.003	-0.86		0.046	8.64	***	0.006	1.60	
$Post\_\Delta REC_{+180m}$	-0.001	-0.30		0.032	7.36	***	0.002	0.63	
$Post\_\Delta REC_{+210m}$	0.001	0.50		0.019	3.99	***	0.008	1.99	**
$Post\_\Delta REC_{+240m}$	0.003	0.86		0.017	3.89	***	0.012	3.29	***
$Post\_\Delta REC_{+270m}$	-0.004	-1.18		0.013	4.21	***	0.040	5.19	***
$Post\_\Delta REC_{+300m}$	-0.006	-1.78	*	0.016	3.41	***	0.011	2.38	**
$Post\_\Delta REC_{+330m}$	0.002	0.87		0.006	1.83	*	0.050	5.67	***
$Post\_\Delta REC_{+360m}$	-0.001	-0.44		0.009	2.97	***	0.097	10.54	***
$Post\_\Delta REC_{+390m}$	-0.009	-2.80	***	0.005	2.04	**	0.024	4.67	***
$Post\_\Delta REC_{+420m}$	-0.005	-1.87	*	0.001	0.32		0.006	1.60	
$Post\_\Delta REC_{+450m}$	-0.005	-2.36	**	-0.002	-0.72		0.007	1.75	*
$Post\_\Delta REC_{+480m}$	-0.003	-1.12		0.002	0.79		0.004	1.15	
Obs	514,328			725,360			504,315		
R^2	0.40%			0.31%			0.43%		

***, **, * represent two-tailed statistical significance at 0.01, 0.05, and 0.1 levels respectively. We report t-statistics based on broker-clustered standard errors.

This table presents the results of the Eq. (2) regression analysis on price discovery during the three-trading-day window after pre-events. The analysis is based on a sample of pre-events with confirming ΔRECs during 2003-2010. Pre-events refer to a corporate press release per Thomson Reuters News Archive (TRNA) database issued during the three calendar days prior to recommendation revisions (ΔRECs). A pre-event and confirming ΔREC pair is included in the sample if (1) there is no other pre-event disclosed between them; (2) the ΔREC is a first revision (i.e., a revision that has no other revision of the same direction on the same firm within the previous 24 hours); (3) the absolute value of the cumulative return over the three-day window after pre-event is greater than 1%; and (4) revisions are either downgrade ΔRECs with negative pre-event return or upgrade ΔRECs with positive pre-event return. ΔRECs are classified into RTH, ETH, and NTH by their respective announcement trading hours. Detailed definitions of trading hours are provided in Table 1. The three-trading-day window after the pre-event is divided into a series of 30-trading-minute intervals. The dependent variable *RPD* is the percentage of price discovery in each of the 30-minute intervals, calculated as $\log(1+ret_{30\ trading\ min})/\log(1+ret_{3\ trading\ day})$, where $ret_{30\ trading\ min}$ and $ret_{3\ trading\ day}$ refer to the cumulative return during the 30-minute interval and the cumulative return over the three trading days after the pre-event. *RPD* is winsorized to -1 and +1 to mitigate the influence of outliers. Return in minute t is calculated as $(PRICE_t - PRICE_{t-1})/PRICE_{t-1}$, where $PRICE_t$ is the trading price of the last transaction within minute t and $PRICE_{t-1}$ is the trading price of the immediately previous transaction before minute t. If no transaction occurs within minute t, the return is set to zero. The 16 $Post\_Event_i$ (i ranges from +30m to +480m) are indicators for the 30-minute intervals after the pre-event timestamp. Similarly, the 16 $Pre\_\Delta REC_j$ (j ranges from -480m to -30m) are indicators for the 30-minute intervals prior to the release timestamp of ΔREC, and the 16 $Post\_\Delta REC_k$ (k ranges from +30m to +480m) indicate the 30-minute intervals after the timestamp of ΔREC.

TABLE 4
Timing Choice of Analyst Recommendation Revisions

Panel A. Summary statistics of factors influencing analyst recommendation timing choice

	All				After-Hours				RTH			
	N	*Mean*	*Median*	*Std*	*N*	*Mean*	*Median*	*Std*	*N*	*Mean*	*Median*	*Std*
RTH	102,929	0.300	0.000	0.458								
GRAS	102,929	0.199	0.000	0.399	72,019	0.252	0.000	0.434	30,910	0.076	0.000	0.265
Small Regional	102,929	0.010	0.000	0.099	72,019	0.007	0.000	0.083	30,910	0.017	0.000	0.128
Research	102,929	0.056	0.000	0.230	72,019	0.036	0.000	0.185	30,910	0.104	0.000	0.305
Log(MVE)	102,551	7.502	7.382	1.638	71,761	7.624	7.516	1.606	30,790	7.218	7.054	1.678
Inst_Own	102,916	65.782	75.157	31.200	72,010	67.059	76.428	30.757	30,906	62.807	71.784	32.013
First_Rec	102,929	0.904	1.000	0.294	72,019	0.915	1.000	0.279	30,910	0.879	1.000	0.326
Downgrade	102,929	0.534	1.000	0.499	72,019	0.526	1.000	0.499	30,910	0.553	1.000	0.497

Panel B. Pearson/Spearman correlation coefficients below/above the diagonal

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
(1) RTH		-0.202	0.045	0.136	-0.120	-0.064	-0.055	0.025
		(<.0001)	(<.0001)	(<.0001)	(<.0001)	(<.0001)	(<.0001)	(<.0001)
(2) GRAS	-0.202		-0.050	-0.121	0.186	0.053	0.025	-0.013
	(<.0001)		(<.0001)	(<.0001)	(<.0001)	(<.0001)	(<.0001)	(<.0001)
(3) Small Regional	0.045	-0.050		-0.024	-0.025	-0.016	0.008	0.006
	(<.0001)	(<.0001)		(<.0001)	(<.0001)	(<.0001)	(0.0089)	(0.0573)
(4) Research	0.136	-0.121	-0.024		0.151	-0.031	-0.055	-0.004
	(<.0001)	(<.0001)	(<.0001)		(<.0001)	(<.0001)	(<.0001)	(0.2549)
(5) Log(MVE)	-0.114	0.175	-0.021	0.022		-0.023	-0.007	-0.054
	(<.0001)	(<.0001)	(<.0001)	(<.0001)		(<.0001)	(0.0297)	(<.0001)
(6) Inst_Own	-0.062	0.053	-0.012	-0.024	0.172		-0.020	-0.013
	(<.0001)	(<.0001)	(<.0001)	(<.0001)	(<.0001)		(<.0001)	(<.0001)
(7) First_Rec	-0.055	0.025	0.008	0.023	-0.035	-0.020		-0.090
	(<.0001)	(<.0001)	(0.0089)	(<.0001)	(<.0001)	(<.0001)		(<.0001)
(8) Downgrade	0.025	-0.013	0.006	-0.004	-0.054	-0.013	-0.090	
	(<.0001)	(<.0001)	(0.0573)	(0.2549)	(<.0001)	(<.0001)	(<.0001)	

(Continued on the next page)

(TABLE 4 continued)

Panel C. Probit regression results of analyst recommendation timing choice:

Dependent Variable: Prob(RTH)	*Pred. sign*	(1) Full Sample	(2) No Confounding Corp. News
GRAS	(-)	-0.2054***	-0.2309***
		(-6.543)	(-6.153)
Small_Regional	(+)	0.1724***	0.1396**
		(4.682)	(2.512)
Research	(+)	0.2321***	0.2661***
		(2.937)	(3.075)
Log(MVE)	(-)	-0.0209***	-0.0333***
		(-3.568)	(-3.632)
Inst_Own	(-)	-0.0003**	-0.0002
		(-2.550)	(-0.779)
First_Rec		-0.0836***	-0.0921***
		(-8.753)	(-4.734)
Downgrade		0.0113***	0.0097
		(2.724)	(1.594)
Year dummies		Yes	Yes
Observations		102,551	24,218
Pseudo R^2		0.0698	0.0892

***, **, * represent two-tailed statistical significance at 0.01, 0.05, and 0.1 levels respectively.

Panel A presents the summary statistics of broker, firm, and recommendation characteristics that influence the timing choice of analyst recommendation revisions. The variables are defined as follows:

RTH = 1 if the analyst recommendation is released during regular trading hours, and 0 otherwise.

GRAS = 1 if the broker is in the Global Research Analyst Settlement, and 0 otherwise.

Small_Regional = 1 if the brokerage house is classified as "Small Regional Broker" in the 2007 Edition of Nelson's Dictionary of Investment Research, and 0 otherwise.

Research = 1 if the brokerage house is classified as "Independent Research Firm" or "Research Firm" in the 2007 Edition of Nelson's Dictionary of Investment Research, and 0 otherwise.

Log(MVE) = Natural logarithm of market value of equity of the firm at the end of the fiscal quarter immediately preceding the recommendation revision.

Inst_Own = the percentage of stock ownership (winsorized to 100) held by institutions at the end of the calendar quarter immediately preceding the recommendation revision. We obtain institutional ownership from Thomson Reuters 13f dataset.

First_Rec = 1 for the initial recommendation revision of a firm with no other revision of the same direction on the same firm within the previous 24 hours, and 0 otherwise.

Downgrade = 1 for downgrade revision and 0 for upgrade revision.

Panel B presents the Pearson and Spearman correlation coefficients with two-tailed p values in parentheses. We omit the number of observations for brevity. Panel C reports the Eq. (3) probit regression results of analyst recommendation timing choice for (1) the full sample of revisions and (2) the revisions without any confounding corporate news per Thomson Reuters News Archive (TRNA) from 12:00 a.m. on calendar Day -3 to 11:59 p.m. on calendar Day +3 of the revision. All variables are as defined above. Given that the probit coefficients are not directly interpretable, we report marginal effects (calculated as the average partial effect) and t statistics based on broker-clustered standard errors in parentheses.

TABLE 5
Price Reaction around Recommendation Revisions (ΔRECs)

	Downgrade					*Upgrade*				
	N	R(-1, 0$^-$)	R(0$^-$, 0$^+$)	R(0$^+$, +1)	R(-1, +1)	N	R(-1, 0$^-$)	R(0$^-$, 0$^+$)	R(0$^+$, +1)	R(-1, +1)
Panel A: Price Reaction to All Revisions										
RTH	17,097	**-2.67**	**-0.64**	**-0.82**	**-4.06**	13,813	**1.69**	**0.64**	**0.74**	**3.10**
		-1.23	***-0.21***	***-0.48***	***-2.41***		***1.16***	***0.23***	***0.48***	***2.36***
ETH	22,398	**-1.50**	**-0.44**	**-2.59**	**-4.42**	19,904	**0.96**	**0.45**	**2.37**	**3.81**
		-0.47	***0.00***	***-1.69***	***-2.82***		***0.37***	***0.00***	***1.75***	***2.87***
NTH	15,452	**-1.05**	**-0.22**	**-2.43**	**-3.64**	14,265	**0.71**	**0.36**	**2.41**	**3.50**
		-0.26	***0.00***	***-1.67***	***-2.31***		***0.30***	***0.00***	***1.82***	***2.69***
Panel B: Price Reaction to First Revisions										
RTH	14,561	**-1.69**	**-0.66**	**-0.78**	**-3.09**	12,619	**1.34**	**0.65**	**0.74**	**2.75**
		-0.87	***-0.23***	***-0.48***	***-1.94***		***0.98***	***0.24***	***0.48***	***2.16***
ETH	19,530	**-0.82**	**-0.38**	**-2.50**	**-3.63**	18,612	**0.73**	**0.44**	**2.35**	**3.53**
		-0.27	***0.00***	***-1.68***	***-2.47***		***0.29***	***0.00***	***1.75***	***2.73***
NTH	14,226	**-0.69**	**-0.19**	**-2.42**	**-3.27**	13,519	**0.55**	**0.33**	**2.43**	**3.32**
		-0.19	***0.00***	***-1.70***	***-2.16***		***0.24***	***0.00***	***1.84***	***2.60***
Panel C: Price Reaction to First Revisions without Pre- or Post-Events										
RTH	3,718	**-0.52**	**-0.55**	**-0.70**	**-1.78**	3,192	**0.82**	**0.65**	**0.88**	**2.34**
		-0.21	***-0.20***	***-0.53***	***-1.20***		***0.68***	***0.23***	***0.57***	***1.93***
ETH	4,990	0.05	**-0.25**	**-2.26**	**-2.48**	4,726	**0.22**	**0.38**	**2.49**	**3.09**
		0.00	***0.00***	***-1.77***	***-1.95***		***0.07***	***0.00***	***1.96***	***2.59***
NTH	3,676	-0.04	**-0.14**	**-2.10**	**-2.28**	3,371	**0.16**	**0.29**	**2.58**	**3.02**
		0.00	***0.00***	***-1.59***	***-1.70***		***0.06***	***0.00***	***1.94***	***2.35***

(Continued on the next page)

(TABLE 5 continued)

This table reports the mean and median price reaction around recommendation revisions (ΔRECs). First revisions refer to recommendation revisions that have no other revisions of the same direction on the same firm within the previous 24 hours. First Revisions without Pre- or Post-events refer to first revisions that have no corporate news per Thomson Reuters News Archive (TRNA) from 12:00 a.m. on calendar day -3 to 11:59 p.m. on calendar day +3 of the revision. ΔRECs are classified into RTH, ETH, and NTH by their respective announcement trading hours. Detailed definitions of trading hours are provided in Table 1. Downgrade (upgrade) refers to lowered (raised) recommendations. R(-1,0^-) refers to the return cumulated from 4:00 p.m. of trading day -2 to 21 trading minutes before the ΔREC. R(0^-,0^+) refers to the return cumulated from 20 trading minutes before to 20 trading minutes after the ΔREC. R(0^+,+1) refers to the return cumulated from 21 trading minutes after to 4:00 p.m. of trading day +1 of the ΔREC. Return in minute *t* is calculated as $(PRICE_t - PRICE_{t-1})/PRICE_{t-1}$, where $PRICE_t$ is the trading price of the last transaction within minute *t* and $PRICE_{t-1}$ is the trading price of the immediately previous transaction before minute *t*. If no transaction occurs within minute *t*, the return is set to zero. Mean (median) returns (in percentage) are reported on top (bottom in italics), and are highlighted in bold if significant at the two-tailed 5% level.

TABLE 6
Abnormal Trading Volume around Recommendation Revisions (ΔRECs)

	Downgrade					***Upgrade***				
	N	V(-1, 0^-)	V(0^-, 0^+)	V(0^+, +1)	V(-1, +1)	N	V(-1, 0^-)	V(0^-, 0^+)	V(0^+, +1)	V(-1, +1)
Panel A: Volume Reaction to All Revisions										
RTH	17,097	**1.50**	**0.26**	**1.42**	**3.18**	13,813	**0.77**	**0.15**	**0.72**	**1.64**
		0.24	***0.05***	***0.36***	***0.77***		***0.21***	***0.04***	***0.28***	***0.63***
ETH	22,398	**0.80**	**0.05**	**1.75**	**5.23**	19,904	**0.43**	**0.02**	**0.93**	**1.39**
		0.09	***0.00***	***0.46***	***2.60***		***0.09***	***0.00***	***0.40***	***0.58***
NTH	15,452	**0.79**	**0.00**	**1.42**	**2.21**	14,265	**0.46**	**0.00**	**0.87**	**1.33**
		0.08	***0.00***	***0.42***	***0.61***		***0.10***	***0.00***	***0.41***	***0.58***
Panel B: Volume Reaction to First Revisions										
RTH	14,561	**0.86**	**0.19**	**0.98**	**2.02**	12,619	**0.65**	**0.13**	**0.63**	**1.42**
		0.17	***0.04***	***0.27***	***0.56***		***0.17***	***0.04***	***0.25***	***0.56***
ETH	19,530	**0.43**	**0.03**	**1.19**	**1.65**	18,612	**0.36**	**0.02**	**0.84**	**1.22**
		0.07	***0.00***	***0.37***	***0.54***		***0.08***	***0.00***	***0.37***	***0.53***
NTH	14,226	**0.42**	**0.00**	**1.16**	**1.58**	13,519	**0.39**	**0.00**	**0.82**	**1.21**
		0.06	***0.00***	***0.38***	***0.53***		***0.08***	***0.00***	***0.39***	***0.54***
Panel C: Volume Reaction to First Revisions without Pre- or Post-Events										
RTH	3,718	**0.15**	**0.05**	**0.23**	**0.43**	3,192	**0.19**	**0.06**	**0.26**	**0.51**
		0.07	***0.02***	***0.12***	***0.23***		***0.07***	***0.02***	***0.13***	***0.28***
ETH	4,990	**0.06**	**0.00**	**0.38**	**0.44**	4,726	**0.12**	**0.00**	**0.42**	**0.53**
		0.03	***0.00***	***0.20***	***0.24***		***0.04***	***0.00***	***0.27***	***0.34***
NTH	3,676	**0.09**	**0.00**	**0.45**	**0.54**	3,371	**0.10**	0.00	**0.48**	**0.58**
		0.02	***0.00***	***0.22***	***0.27***		***0.03***	***0.00***	***0.30***	***0.39***

(Continued on the next page)

(TABLE 6 continued)

This table reports the mean and median volume reaction around recommendation revisions (ΔRECs). First revisions refer to recommendation revisions that have no other revisions of the same direction on the same firm within the previous 24 hours. First Revisions without Pre- or Post-events refer to first revisions that have no corporate news per Thomson Reuters News Archive (TRNA) from 12:00 a.m. on calendar day -3 to 11:59 p.m. on calendar day +3 of the revision. ΔRECs are classified into RTH, ETH, and NTH by their respective announcement trading hours. Detailed definitions of trading hours are provided in Table 1. Downgrade (upgrade) refers to lowered (raised) recommendations. $V(-1,0^-)$ refers to the abnormal shares turnover cumulated from 4:00 p.m. of trading day -2 to 21 trading minutes before the ΔREC. $V(0^-,0^+)$ refers to the abnormal shares turnover cumulated from 20 trading minutes before to 20 trading minutes after the ΔREC. $V(0^+,+1)$ refers to the abnormal shares turnover cumulated from 21 trading minutes after to 4:00 p.m. of trading day +1 of the ΔREC. Shares turnover in minute *t* is calculated as $VOL_t/SHROUT$, where VOL_t is the total number of shares traded within minute *t* and *SHROUT* is the total number of shares outstanding. If no transaction occurs within minute *t*, the shares turnover is set to zero. Abnormal shares turnover is calculated as the shares turnover of the actual ΔREC in excess of that of the corresponding pseudo ΔREC, which is defined as occurring at the same hour and minute as the ΔREC of interest and on the same weekday of the week that immediately follows the ΔREC of interest. Mean (median) shares turnover (in percentage) are reported on top (bottom in italics), and are highlighted in bold if significant at the two-tailed 5% level.

TABLE 7
Regression Analysis of Three-Day Cumulative Returns Surrounding Recommendation Revisions Released in Different Trading Hours

Dependent Variable: R(-1,+1)	Full Sample (Obs = 102,929)		Sample of First Revisions without Pre- or Post-Events (Obs = 23,673)	
	(1)	(2)	(3)	(4)
Constant	0.0253***	0.0196***	0.0234***	0.0193***
	(30.989)	(30.355)	(19.298)	(17.090)
ETH	0.0060***	0.0048***	0.0075***	0.0066***
	(6.475)	(6.537)	(4.836)	(4.676)
NTH	0.0034***	0.0030***	0.0068***	0.0041***
	(3.428)	(3.848)	(4.171)	(2.815)
Downgrade	-0.0552***	-0.0378***	-0.0412***	-0.0313***
	(-44.126)	(-39.441)	(-25.180)	(-20.438)
ETH×Downgrade	-0.0087***	-0.0088***	-0.0145***	-0.0141***
	(-6.429)	(-8.591)	(-6.977)	(-7.547)
NTH×Downgrade	-0.0007	-0.0029***	-0.0118***	-0.0091***
	(-0.500)	(-2.691)	(-5.379)	(-4.604)
R_pre	1.0809***	1.0991***		
	(52.480)	(113.694)		
R_post	0.8906***	0.8664***		
	(25.030)	(42.591)		
R^2/*Pseudo* R^2	0.4007	0.3954	0.1434	0.1432

***, **, * represent two-tailed statistical significance at 0.01, 0.05, and 0.1 levels respectively.

This table presents the Eq. (4) regression results of three-day cumulative returns of regular- and after-hours revisions with t statistics based on firm-clustered standard errors in parentheses. The dependent variable *R(-1,+1)* is the intraday cumulative return from 4:00 p.m. of trading day -2 to 4:00 p.m. of trading day +1 of the recommendation revision. *R_pre* (*R_post*) is the sum of 41-trading-minute cumulative returns centered on the timestamp of pre-events (post-events). If a corporate event is released during non-trading hours, the 41-minute window consists of the last 20 minutes of the previous extended trading session and the first 21 minutes of the next extended trading session. When there are multiple events in the pre- or post-event window, we sum up their announcement returns. If there are overlaps in the announcement windows of multiple events, the cumulative return is calculated from minute -20 of the first overlapping event to minute +20 of the last overlapping event. To be comparable to the dependent variable, pre-events (post-events) are limited to any corporate events occurring from 4:00 p.m. of trading day -2 to trading minute -21 of the revision (from trading minute +21 of the revision to 4:00 p.m. of trading day +1). All other variables are as defined in the previous tables. We report in column (1) the OLS regression results for the full sample. To mitigate the influence of outliers, in column (2) we report the median regression results for the full sample. Column (3) and (4) repeat the regressions in (1) and (2) for the first revisions without any confounding corporate news per Thomson Reuters News Archive (TRNA) from 12:00 a.m. on calendar Day -3 to 11:59 p.m. on calendar Day +3 of the revision. As a result, *R_pre and R_post* are automatically dropped.