Earnings Announcements and Attention Constraints: The Role of Market Design[◊]

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Abstract

We identify a new channel – market makers' attention constraints – through which earnings announcements for one stock affect the liquidity of other stocks. When some stocks handled by a designated market maker have earnings announcements, liquidity is lower for non-announcement stocks handled by the same market maker, with the largest effects coming from earnings surprises and stocks with high earnings response coefficients. Half of the liquidity decline reflects attention constraints binding on the individual market maker, and the other half is explained by the market maker's inventory. We further find that a market design change that increases automation alleviates the liquidity effect of attention constraints, despite an increase in the number of stocks allocated to each market maker.

1. Introduction

Kim and Verrecchia (1994) predict that trading volume should be higher and liquidity lower (bid-ask spreads wider) for stocks around their earnings announcements dates, predictions borne out by empirical studies such as Lee, Mucklow, and Ready (1993). Stocks with earnings announcements also generally attract more attention (Aboody, Lehavy, and Trueman, 2010), which can have implications for other stocks as well as those making announcements. A large and growing body of literature documents that because attention is a scarce cognitive resource (Kahneman, 1973), financial market participants' attention constraints affect asset pricing. Studies that focus on the investor as the decision-maker show that the speed of price adjustment (Peng, 2005) and under-reaction to earnings announcements (Hirshleifer, Lim, and Teoh, 2009), profits and losses (Balakrishnan, Bartov, and Faurel, 2010), and long-term information (DellaVigna and Pollet, 2009) can all be explained in models that incorporate investor attention constraints.

In this paper we draw on both the extensive literature on earnings announcements and the more recent literature on attention constraints to examine another channel through which earnings announcements affect stock liquidity. We analyze the effect of one stock's earnings announcements on the liquidity of the otherwise unrelated stocks that are traded by the same designated market maker. Each designated market maker is contractually bound to provide liquidity for a defined set of securities, generally diversified across industries.[1] In recent years many financial markets have reintroduced designated market makers to increase liquidity for their listed stocks.[2]

We find that designated market makers' attention constraints on earnings-announcement days affect the liquidity of the non-announcement stocks they handle. These effects are strongest for announcements containing the largest earnings surprises and for stocks with the highest earnings response coefficients, and they occur even if the designated market maker does not have or acquire a large inventory position. We control for inventories because the increase in trading activity accompanying earnings announcements

[1] See Section 3 for a discussion of designated market maker portfolio composition.
[2] Charitou and Panayides (2009) find that all but one major international equity markets rely on some form of designated market maker to facilitate trading.

may absorb both the designated market maker's attention and his inventory capacity. Both factors can lead him to provide less liquidity for his assigned stocks. We also examine how increasing automation can ease the effects of designated market makers' attention constraints.[3]

Designated market makers on the New York Stock Exchange (NYSE) are called specialists, and each individual specialist is responsible for a set of stocks called a panel.[4] For each stock on his panel, the specialist's responsibilities are to bring buyers and sellers together, provide liquidity, and serve as a point of accountability for the smooth functioning of the market (NYSE Group, 2006a). The NYSE's Hybrid market introduction in 2006-2007 ushers in several changes, mostly related to increasing automation and execution speed. Hybrid gives the specialist additional electronic tools for managing his stocks (potentially easing the attention constraint) and makes it easier for public limit-order submitters including off-floor market makers to compete with the specialist on the NYSE (potentially mitigating the effects of the specialist's attention constraint as well as his inventory risk management).[5] However, specialist firms also increase the number of stocks assigned to each specialist, potentially worsening his attention constraint despite the automation. Our hypothesis is that the net effect of the Hybrid market's increased automation is to reduce the impact of the specialist's attention constraint on stock liquidity.

There are two main reasons that earnings announcements on a specialist's panel of stocks may attract his attention. First, stocks typically have higher trading volume on their earnings-announcement days, as predicted by Kim and Verrecchia (1994) and documented by Lee, Mucklow, and Ready (1993). Second, earnings-announcement days are times of increased information in the market (Beaver, 1968; Brown, Hillegeist, and Lo, 2009). With higher volume and an increased risk of trading with informed traders on

[3] Our study can be viewed as providing evidence on human processing constraints in general, including attention as well as manual and cognitive processing constraints. We follow the literature in adopting the term "attention constraints," although we cannot distinguish the precise nature of the processing constraint.

[4] Throughout this paper our focus is on individual specialists, the people who manage panels of stocks, not the firms that employ them, since attention constraints primarily affect individual humans.

[5] Off-floor market makers are not required to provide liquidity for a particular set of stocks; unlike the specialist, they can choose in which stocks, if any, to provide liquidity at any time. Hybrid's faster execution eliminates many of the advantages specialists had over off-floor traders, gives off-floor traders more up-to-date information about the state of the market, and enables off-floor traders to act on this information more quickly. Taken together, these changes make it easier for off-floor market makers to compete with specialists on the NYSE (see Boni and Rosen, 2006; Hendershott and Moulton, 2011; and NYSE Group, 2006b).

earnings announcement days, stocks that have earnings announcements are likely to demand more of the specialist's attention. Since the stocks assigned to a specialist generally have earnings announcements on different days, we can examine the effects of a specialist's attention being absorbed by a subset of his assigned stocks, those making earnings announcements.

We begin by analyzing the effect of earnings announcements on the liquidity of non-announcement stocks on each specialist's panel for the year surrounding the rollout of the Hybrid market, including controls for changes in public order submission strategies. We find that the liquidity of the non-announcement stocks handled by a specialist worsens (spreads widen) when some of the stocks on his panel have earnings announcements, and this effect is greater when the announcement contains a large earnings surprise or pertains to a stock with a high earnings response coefficient. Part of the liquidity deterioration is explained by the specialist's inventory risk management, but about half of the spread widening remains after controlling for inventory. For example, when half the stocks on a panel have earnings announcements, the effective spread of non-announcement stocks on the same panel widens by about 18 percent of its average. After controlling for inventories, the attention effect from half the stocks on a panel having earnings announcements drops to about nine percent of its average. Furthermore, we find that the impact of earnings announcements on the liquidity of non-announcement stocks drops substantially after Hybrid, consistent with our hypothesis that the Hybrid market design changes alleviate the effects of the attention constraint. These results are robust to the inclusion of controls for industry and market-wide earnings announcements, which allow us to distinguish attention constraints from information spillover effects.

We next examine how the Hybrid market mitigates the effect of a specialist's attention constraint. Do specialists find their constraint lowered (for example, because of their additional electronic tools), allowing them to participate more in the trading of non-announcement stocks on earnings announcement days? Or do off-floor market makers increase their participation in non-announcement stocks, making the specialist's attention constraint less consequential for the liquidity of non-announcement stocks? To answer these questions we analyze specialist and off-floor market maker participation in the trading of

non-announcement stocks on days when other stocks on the same panel have earnings announcements. Over the full sample period, we find that the specialist participates less in the trading of non-announcement stocks when some of the stocks on his panel have earnings announcements, consistent with his attention constraint binding. Notably, the specialist's participation in non-announcement stocks actually falls *more* on earnings-announcement days *after* Hybrid, as the specialist increases his participation in stocks with earnings announcements. In contrast, off-floor market makers participate more in non-announcement stocks on earnings announcement days and even more so after Hybrid. The introduction of the NYSE's Hybrid market thus appears to alleviate the effect of the specialist's attention constraint on stock liquidity by facilitating greater participation from off-floor market makers, who are not limited to trading a particular set of stocks, rather than by directly reducing the specialist's attention constraint.

Our main findings that specialist attention constraints on earnings announcement days affect non-announcement stock liquidity and that increased automation alleviates the liquidity effect are important for several reasons. Ours is the first study of attention constraints to control for inventory risk management as an explanation for reduced liquidity of some stocks when other stocks handled by the same specialist are unusually active. Corwin and Coughenour (2008) show that when volume is unusually high for some stocks handled by a specialist, spreads widen for other stocks on the same panel, but they do not consider the possibility of inventory risk management leading to the same outcome. Our study shows that the specialist's attention constraint matters even after controlling for inventory risk management. A further difference between the two studies is that our attention-demanding event, an earnings announcement, is clearly exogenous to the specialist. Corwin and Coughenour (2008) designate stocks as attention-demanding if they have high volume or returns over a 30-minute period, which could be endogenous if the specialist's attention causes stocks to trade more (e.g., if the specialist induces more trading in a stock by providing more aggressive quotes). While investor attention constraints have also been shown to affect stock trading on earnings announcement days (Hirshleifer, Lim, and Teoh, 2009), our analysis of the introduction of Hybrid automation suggests that the specialist's attention constraint is

distinct from investors' attention constraints. Our finding that the introduction of the Hybrid system alleviates the liquidity effect of earnings announcements on non-announcement stocks suggests that the spread widening on earnings-announcement days is driven by disruptions in liquidity supply, not by investors' liquidity demands. This result provides further evidence that automated electronic trading can improve liquidity.

The remainder of the paper is organized as follows. Section 2 reviews related literature and develops our hypotheses. Section 3 describes our data and sample. Section 4 presents our results on liquidity, earnings announcements, inventory, and attention constraints. Section 5 studies the link between market-maker trading on earnings-announcement days and attention constraints. Section 6 summarizes a number of robustness checks, and Section 7 concludes.

2. Background and Hypotheses

In this section we review the related literature on the links between (i) attention constraints and earnings announcements and (ii) market maker inventory risk management and earnings announcements. We then formulate the hypotheses tested in this study.

2.1 Attention Constraints and Earnings Announcements

The difficulty humans have in processing multiple sources of information or performing multiple tasks at the same time, first documented in the psychology literature, is widely recognized as a potentially important factor in financial markets. Research on attention constraints in financial markets largely focuses on investor behavior. Peng (2005) posits that investors who have limited time and attention allocate their information capacity across multiple sources of uncertainty to minimize their total portfolio uncertainty, leading to faster information incorporation in large than small stocks. In Peng's model, agents allocate their time and attention (capacity) across the stocks in their portfolio: Stocks that have a greater contribution to the uncertainty in a portfolio attract a higher capacity allocation. Peng also predicts that when total capacity increases, the allocation of capacity becomes less sensitive to the relative uncertainty of assets in the portfolio. Hirshleifer and Teoh (2003) and DellaVigna and Pollet (2009)

predict that investors' failure to pay attention to public information can lead to mispricing, and Hirshleifer, Hou, Teoh, and Zhang (2004) find that investors neglect information regarding cash profitability, leading to predictability in long-run stock returns. Similarly, Sims (2003) argues that the inability of economic agents to process all available information leads them to under-react to new information. Evidence of the effects of investors' limited attention is provided by numerous empirical studies, including Huberman (2001), Huberman and Regev (2001), Peng and Xiong (2006), and Barber and Odean (2008). Hirshleifer, Lim, and Teoh (2009) examine days with many corporate earnings announcements as a proxy for when investors are likely to face a heavy information load and thus be most affected by their attention constraints. They find that the market reaction to a corporate earnings surprise is weaker on days with many other announcements.

Examinations of attention constraints' effects on investor behavior are largely indirect tests, as it is difficult to observe how investors allocate their attention across securities or even which securities are in their opportunity set. In contrast, designated market makers such as NYSE specialists are responsible for well-defined lists of securities. On the NYSE each stock is assigned to only one specialist, but a single NYSE specialist may be assigned one or more stocks, referred to as the specialist's panel, for which he bears market-making responsibilities. Time and cognitive constraints force the specialist to divide his attention among the stocks on his panel. The NYSE's structure offers researchers the advantage of knowing the set of securities across which each specialist is allocating his attention. Corwin and Coughenour (2008) find that liquidity for individual NYSE stocks is worse over 30-minute periods in which other stocks handled by the same specialist are unusually active (measured by high volume and returns), but they do not control for specialist inventories (see Section 2.2). They also find evidence suggesting that the specialist provides less price improvement (compared to advertised quotes) for individual stocks during intraday periods in which other stocks he handles are unusually active.

We are particularly interested in how earnings announcements affect the liquidity of non-announcement stocks through the specialist's attention constraint. A key assumption is that on earnings-announcement days the specialist's attention is focused on a subset of his panel stocks, those with

earnings announcements. One advantage of earnings announcements over trade-based measures of attention is that while a stock's high trading volume may either cause or be caused by more specialist attention (e.g., the specialist may induce more trading by providing aggressive quotes), the timing of earnings announcements is determined by the listed company and thus clearly exogenous to the specialist.[6] Furthermore, studies suggest that more information arrives in the market on earnings-announcement days than at any other time (Beaver, 1968), information asymmetry is highest before earnings announcements (Levi and Zhang, 2011), and the probability of informed trading rises before earnings announcements and falls after them (Easley, Engle, O'Hara, and Wu, 2008). We thus expect that stocks with earnings announcements on a particular day demand more attention from the specialist than non-announcement stocks do.

While all earnings announcements are likely to attract the specialist's attention toward announcing stocks and therefore away from his other assigned stocks, the effect is likely to be stronger for some earnings announcements than for others. For example, several studies find that earnings surprises lead to greater stock price movements (e.g., Fried and Givoly, 1982). More generally, earnings announcements that induce larger investor reactions are likely to attract more of the specialist's attention to announcing stocks. The reaction of stock prices to information events is analyzed in the accounting literature in various contexts. In an efficient market setting, Ball and Brown (1968) pioneer the use of observed price response to study the effect of news, in their case expected and unexpected income changes. They find that prices rise after good news and fall after bad news, which they interpret as validation of the efficient market hypothesis – previously unknown information (good or bad news) being impounded into stock price creates the observed changes. Bloomfield (2002) offers an extended version of this argument, which he calls the Incomplete Revelation Hypothesis. Bloomfield posits that the price reaction will depend on both the news itself and the degree of difficulty investors face in processing this new information. The

[6] Although exogenous, earnings announcement dates are generally known in advance, giving rise to the possibility that specialist firms strategically reassign stocks prior to earnings announcements to alleviate specialists' attention constraints. Such reassignments would work against our finding evidence of attention constraints binding, though we find no evidence of such strategic reassignments in the data.

easier it is to analyze or interpret the content of news, the more quickly the information will be impounded into prices through trading activity. Empirical studies of investor responsiveness to earnings (measured by a firm's earnings response coefficient) suggest that some firms' earnings announcements contain more information that is useful in equity valuation (e.g., Ball and Brown, 1967, 1968; Liu and Thomas, 2000; see Dechow, Ge, and Schrand, 2010, for a survey).[7] The earnings announcements of firms with high earnings response coefficients are therefore likely to attract more of the specialist's attention, to the potential detriment of the other stocks on the panel.

2.2 Inventory Risk Management and Earnings Announcements

The amount of liquidity a specialist provides for stocks on his panel is likely to be affected by his inventory position in addition to any potentially binding attention constraints. Several models of market-maker behavior predict that when a market maker has or acquires a large (long or short) inventory position, he provides less liquidity in his assigned stocks as he attempts to manage his inventory risk. Spreads vary positively with the amount of inventory exposure in the linear demand and supply case of Amihud and Mendelson (1980) and in Shen and Starr (2002) when a market maker faces quadratic costs. O'Hara and Oldfield (1986) show that spreads depend positively on inventories if market makers are risk-averse. Brunnermeier and Pedersen (2009) link market makers' funding and market liquidity, predicting that market makers provide less liquidity when they are capital-constrained in the short run, such as when they have large inventory positions. Regarding the specific situation of a market maker who is responsible for trading multiple stocks, Naik and Yadav (2003) predict and find empirically that an individual market maker's trading and pricing decisions are governed by his inventory in all the stocks he trades. Empirically, Comerton-Forde et al. (2010) find that when a specialist's closing inventory is large, his assigned stocks' liquidity is lower (spreads are wider) the following day.

Our interest in how earnings announcements affect the liquidity of non-announcement stocks requires that we consider how earnings announcements may affect a specialist's inventory. The specialist has a

[7] Dechow, Ge, and Schrand (2010) identify investor responsiveness to earnings as one of three broad categories of earnings quality, because a stronger response of stock prices to earnings announcements signals that investors view the earnings as providing more useful information about the features of a firm's financial performance.

positive obligation to provide liquidity in a stock when there is an order imbalance: more public sell orders than buy orders, or vice versa. If such a situation arises in any of his assigned stocks, the specialist is likely to accumulate a long or short inventory position. The combination of increased trading volume (Kim and Verrecchia, 1994; Lee, Mucklow, and Ready, 1993), higher information asymmetry (Levi and Zhang, 2011), and higher probability of informed trading (Easley et al., 2008) around earnings announcements is likely to lead to higher public order imbalances and thus a greater demand for the specialist to provide liquidity, acquiring inventory in the process. This inventory position in turn may cause the specialist to optimally provide less liquidity (widen spreads) in his other, non-announcement stocks in order to manage his panel-wide inventory risk (Naik and Yadav, 2003): When the specialist acquires a large inventory position in one stock, he provides less liquidity in all of the stocks on his panel. The liquidity of non-announcement stocks should be affected by (i) the specialist's panel-wide inventory as of the previous day's close (Comerton-Forde et al., 2010), which would capture the specialist's response to order imbalances prior to the earnings announcement as well as other inventory positions panel-wide, and (ii) changes in his announcement-stock inventory on the earnings announcement day, when volume, information asymmetry, and order imbalances should peak for announcement stocks.

2.3 Hypotheses

The main questions we address in this paper are whether the specialist's attention constraint affects stock liquidity on earnings-announcement days beyond the effects of inventory risk management, and, if so, whether an increase in automation reduces the effects of the specialist's attention constraint. At the end of 2006 the NYSE introduces its Hybrid market, speeding up execution, expanding automated electronic trading, and providing specialists with new tools to participate in trading electronically.[8] One of the NYSE's reasons for introducing the Hybrid market is that "higher volume can be handled more efficiently in a more automated system" (NYSE, 2006b), a statement that may encompass a recognition of human attention constraints as well as manual processing capabilities. The Hybrid market introduction

[8] Discussions with specialists indicate that they constantly monitor and adjust the parameters of their trading algorithms intraday, suggesting that they continue to allocate their attention across stocks on their panel even after the introduction of electronic tools under Hybrid.

also leads to changes in public order submission strategies, for which we control in our analysis since the prevalence of market versus limit orders affects specialist participation (see, e.g., Harris and Hasbrouck, 1996; Chung, Van Ness, and Van Ness, 1999).

Null hypothesis. Our null hypothesis is that the structural features of the specialist system are sufficient to ensure that the liquidity of the stocks handled by a particular specialist is not affected by his attention constraint when other stocks on his panel have earnings announcements. Specialist firms generally organize panels in order to balance the demands on a specialist's attention, putting the most active stocks on panels with few other stocks and diversifying across industries on a panel.[9] Since a specialist's performance in his current panel of stocks influences future stock allocations, he has ample incentive to provide liquidity for all of his assigned stocks. When trading volume rises significantly above its normal level, a specialist may call in a relief specialist to help trade the stocks on the panel.[10] Stocks may also be reassigned to other panels. Both the variable panel size and the availability of relief specialists should work against our finding evidence of attention constraints affecting stock liquidity. Finally, although Hybrid's introduction of electronic tools for specialists may be expected to alleviate their attention constraints *ceteris paribus*, specialist firms simultaneously reduce the number of specialists they employ and increase the average number of stocks per specialist panel by combining panels, potentially offsetting the effects of increased automation at the specialist level.

Alternative hypotheses. Our main hypothesis is motivated by the prediction of Peng (2005) that stocks that contribute more to portfolio uncertainty attract more attention, while those that contribute less uncertainty attract less attention. In our setting, stocks with earnings announcements involve greater uncertainty for the specialist (Kim and Verrecchia, 1994). If the structural features of the specialist system are not sufficient to offset the effects of a specialist's attention constraint, we expect to see liquidity

[9] Because the choice of how many stocks are assigned to each specialist is endogenous, we do not expect attention constraints to be more binding on panels with more stocks than those with fewer stocks. Boulatov, Hatch, Johnson, and Lei (2009) find evidence that specialist firms consider relative trading activity in assigning stocks to individual specialist panels, in order to manage the specialist's attention constraint.

[10] Unfortunately the data we have do not indicate when a relief specialist is called in, so we are unable to isolate those events in our analysis.

worsen more than inventory risk management alone would suggest for non-announcement stocks on a panel when other stocks on the panel have earnings announcements, as the specialist allocates more of his attention to announcement stocks. Similarly, we expect to see the specialist participating less in the trading of non-announcement stocks on a panel when other stocks on his panel have earnings announcements. The effect should be stronger when earnings announcements contain surprises and for firms with higher earnings response coefficients, as those announcements demand more of the specialist's attention.

Our second hypothesis is related to the prediction of Peng (2005) that when total capacity increases, the allocation of capacity becomes less sensitive to the relative uncertainty of assets in the portfolio. In our setting, we expect that the increased automation introduced by the Hybrid market should alleviate the effects of the specialist's attention constraint, reducing the liquidity deterioration for non-announcement stocks post-Hybrid. There are two possible ways that Hybrid may alleviate the effects of the specialist's attention constraint. First, the specialist's ability to manage his stocks algorithmically (using his new electronic tools) may increase his own capacity and allow him to participate more actively in non-announcement stocks when some of his stocks have earnings announcements.[11] This effect may be at least partially offset by specialist firms' increasing the number of stocks assigned to each specialist after Hybrid. Second, the potentially greater involvement of off-floor market makers encouraged by the faster execution systems of the Hybrid market may offset the specialist's attention constraint.[12] Such off-floor market makers (including market makers on other exchanges and other traders pursuing a market-making strategy) are not constrained to trading any particular set of stocks; they can trade opportunistically and may see the greatest opportunities in some stocks when a specialist is occupied by other stocks on his panel (as in Pasquariello and Vega, 2011).

[11] In a speech before the Hybrid market introduction, NYSE CEO John Thain said, "Right now, if you were on the floor of the Exchange, particularly at the point of sale and watching what the specialist clerks were doing, you would see that they are doing too many keystrokes – as many as 40 million keystrokes a day. They can barely keep up, particularly on really busy days." (http://exchanges.nyse.com/archives/ 2006/03/debunking_lump.php)

[12] Foucault, Kadan, and Kandel (2011) predict that when market makers' monitoring costs are reduced, market makers supply liquidity more quickly, leading to lower bid-ask spreads. In our setting, Hybrid's faster systems likely reduce monitoring costs for off-floor market makers.

3. Data and Sample Selection

Our analysis uses data from the NYSE's Trade and Quote (TAQ) database, the Center for Research in Security Prices (CRSP), the Chicago Board of Options Exchange (CBOE), the NYSE Specialist Equity Trade Summary (SPETS) file, the NYSE Symbol Trading Location file, the NYSE Consolidated Audit Trail (CAUD) file, the NYSE System Order Data (SOD) file, IBES, Bloomberg, and the Wall Street Journal. We collect data from June 1, 2006 through May 31, 2007.[13] This period covers roughly from four months before to four months after the Hybrid rollout period, which begins on October 6, 2006 and concludes on January 24, 2007.

3.1 Sample Construction

We construct our sample of NYSE-listed stocks as follows. We begin by collecting from TAQ all NYSE-listed securities during our sample period, then use the TAQ Master History file to determine CUSIP numbers that correspond to the symbols in TAQ, to match securities in CRSP and TAQ. A total of 2,681 NYSE-listed securities can be matched between TAQ and CRSP, of which 1,425 are common stocks. We deliberately retain small and low-priced stocks in our sample because specialist panels often comprise a mix of high- and low-activity stocks, which may be an attempt by specialist firms to manage the specialist's attention constraint. Eliminating inactive stocks from our study would thus risk misconstruing the true activity and attention allocation on a specialist's panel. Our main analysis focuses on how the liquidity of the 1,425 common stocks is affected by earnings announcements of stocks on the same specialist panel; we also test the full sample of all NYSE-listed securities in our robustness checks.

3.2 Data and Measures

Summary descriptive statistics about the 1,425 of common stocks are included in Panel A of Table 1. Because the Hybrid market changes are rolled out stock-by-stock between October 2006 and January

[13] We exclude data from February 27, 2007, when the Shanghai stock market crashed, former Federal Reserve Chairman Greenspan warned of a recession, and Dow Jones reported erroneous values for the Dow Jones Industrial Average: a perfect storm of record volume and market dislocation that led to irregular reporting on all U.S. stock markets.

2007, the pre-Hybrid and post-Hybrid periods vary by stock and the full-year statistics in Panel A (first four columns) are not a simple average of the pre-Hybrid and post-Hybrid averages (next eight columns).

[Table 1 Here]

To examine the activity and attention constraints of individual specialists, we calculate several measures at the specialist panel level. Each day we update the set of stocks traded on each specialist panel, using the information provided in the NYSE Symbol Trading Location file. Panel B of Table 1 summarizes the sample characteristics at the specialist panel level for the full year and for the pre-Hybrid and post-Hybrid sub-periods. In Table 1 we present information for all of the stocks and panels to provide a complete picture of how stocks are allocated; our subsequent analysis excludes panels containing only one stock because they cannot not be used to test our hypotheses. Over the full year, the average panel contains 5.06 common stocks (Panel B of Table 1). We measure the industry diversification on a panel as the ratio of the number of distinct two-digit SIC codes on the panel minus one to the number of stocks on the panel minus one. Thus a panel on which all stocks have different industry codes has 100 percent diversification, and a panel on which all stocks are from the same industry has zero percent diversification. Panels appear to be arranged to have significant industry diversification, suggesting that specialist firms attempt to manage the individual specialist's attention constraint. Furthermore, panels with the largest number of stocks tend to contain the least active stocks.[14] The average industry diversification is 84.06% (Panel B, Full Year), which translates into stocks from roughly 4.4 different industries for the average panel size of 5.06 stocks.[15] The average number of stocks per panel increases (from 4.56 to 5.82 stocks) and the average industry diversification decreases (from 88.67% to 78.57%) from pre- to post-Hybrid as specialist firms reallocate stocks in the wake of the increase in automation.[16] These shifts should generally work against our finding an easing of the effects of attention constraints

[14] Descriptive statistics by panel-size quartile are available from the authors on request.

[15] As a robustness check, we exclude from our analyses stocks from the same industry as the earnings-announcement stock on the panel.

[16] Analyses over periods of one, five, and ten days prior to and following earnings announcements reveal no significant change in the number of stocks assigned to a panel in the days surrounding earnings announcements.

after Hybrid is introduced, as more stocks and higher industry concentration may strain specialists' attention further.

Figure 1 shows that the greatest decrease in the number of specialist panels (and commensurate increase in the average number of stocks per panel) occurs between October 2006 and January 2007, during the rollout of the NYSE's Hybrid market structure.[17]

[Figure 1 Here]

Liquidity. The liquidity measures in Table 1 and throughout the paper are calculated from NYSE trades and quotes data from TAQ.[18] Note that spreads are really an illiquidity measure: the wider the spread, the less liquid the stock. We equal-weight spread measures across trades within the day to calculate measures for each stock each day; we also conduct robustness checks using volume-weighted spreads.

The quoted spread is the difference between the best ask price and the best bid price; the percentage quoted spread is the quoted spread divided by the prevailing quote midpoint. The effective spread for each trade captures the difference between an estimate of the true value of the security (the quote midpoint) and the actual transaction price. The effective spread for stock j at time k on day t is calculated as $Effective\ Spread_{j,k,t} = 2\, q_{j,k,t}\, (p_{j,k,t} - m_{j,k,t})$, where $q_{j,k,t}$ is an indicator variable that equals one for buyer-initiated trades and negative one for seller-initiated trades, $p_{j,k,t}$ is the trade price, and $m_{j,k,t}$ is the prevailing quote midpoint. We follow the standard trade-signing approach of Lee and Ready (1991) and use contemporaneous quotes to sign trades (see Chakrabarty, Moulton, and Shkilko, 2011). The percentage

[17] The number of specialist firms is constant at seven over the sample period, but the number of individual specialists employed by the firms declines over the year as stocks are reassigned to create larger panels; see Lucchetti (2007).

[18] We apply the following filters to clean the trade and quote data. We use trades and quotes from regular-hours trading only. We use only trades for which TAQ's CORR field is equal to zero, one, or two and for which the COND field is either blank or equal to @, E, F, I, J, or K. Trades with non-positive prices or quantities are eliminated, as are trades with prices more than (less than) 150% (50%) of the previous trade price. We use only quotes for which TAQ's MODE field is equal to 1, 2, 6, 10, 12, 21, 22, 23, 24, 25, or 26. We eliminate quotes with non-positive price or size, with bid price greater than ask price, when the quoted spread is greater than 25% of the quote midpoint, or when the ask price is more than 150% of the bid price. We calculate all spreads two ways: (i) using trades and quotes from the NYSE only; and (ii) using trades and quotes from NYSE, ARCA, and Nasdaq (we exclude other exchanges, which account for less than two percent of off-NYSE trading volume during our sample period, to avoid stale quotes). Results based on both spread calculations are qualitatively similar; for brevity we present only the NYSE spread results.

effective spread is the effective spread divided by the prevailing quote midpoint. We focus on effective spreads because transactions can take place at prices within the quoted bid and ask prices when floor traders participate in trades.

Table 1 shows a general downward trend in spreads from pre- to post-Hybrid, which we control for by including a time trend in our empirical analysis.

Market maker participation. Our proxy for specialist attention is the daily specialist participation rate from the SPETS file. The participation rate equals the number of shares traded by the specialist divided by twice total volume in the stock that day. This measure has the advantage of capturing the specialist's actual level of trading in each stock. We do not use attention measures based on price improvement (trades that execute inside the quote), as in Corwin and Coughenour (2008), because price improvement has declined sharply over the past eight years and virtually disappears with the introduction of the Hybrid market during our sample period (see Boni and Rosen, 2006).

Panel B of Table 1 shows that specialist participation rates vary widely across panels over the full year, from less than one percent in some panels to nearly 22 percent in others. There is a pronounced decline in specialist participation rates over our sample period, with average specialist participation per panel falling from 7.54 percent pre-Hybrid to 4.36 percent post-Hybrid (see Hendershott and Moulton, 2011, for an analysis of the change in specialist trading around the Hybrid introduction). We control for this decline by including a time trend and a Hybrid indicator in our empirical analysis.

We calculate the participation rate for off-floor market makers from the CAUD file as the number of shares traded on the NYSE by off-floor market makers divided by twice total NYSE volume in the stock that day.

Earnings announcements. We determine the earnings announcement dates for each stock from the IBES database.[19] In aggregate the stocks have 5,282 earnings announcements, and these announcements

[19] IBES is missing earnings announcement dates for about two percent of our sample stocks. From Bloomberg we identify earnings announcement dates for almost half of the stocks missing in IBES, and we do not exclude from our analysis securities that lack earnings announcement data.

occur on 237 different days (out of 250 trading days in our sample period).[20] From the Wall Street Journal we collect information about what time of day each earnings announcement is made. The prevalence of after-hours earnings announcements in recent years has shifted much of the earnings-related trading activity to the following trading day.[21] We use the time-of-day information to refine our earnings announcement data, designating the day following the actual announcement date as the earnings announcement date for stocks with after-hours earnings announcements. We use full-day windows because trading volume on earnings announcement days is more than double average non-announcement-day volume in all half-hour intraday periods, suggesting that the specialist's attention is demanded well beyond the few minutes in which the earnings announcement occurs.[22] For stocks with no time-of-day information available (13 percent of the earnings announcements in our sample), we designate both the day reported in IBES and the following trading day as earnings announcement dates. We also examine the robustness of our results to other earnings announcement windows.

We calculate the earnings announcement percentage for each panel each day as the percentage of stocks on the panel having earnings announcements that day, with the stocks weighted by their average trading volume over the full year excluding their earnings announcement days. Weighting by average trading volume recognizes that non-announcement stocks are likely to be affected more by an earnings announcement for the most active panel stock than for the least active panel stock. For robustness we also test unweighted earnings announcement percentages (number of announcement stocks divided by number of stocks on the panel). Figure 2 shows that the weighted percentage of stocks on a specialist panel having earnings announcements exhibits considerable variation across panels and over time, with earnings

[20] Fewer than two percent of the panel/day observations in our sample have more than one earnings announcement on a panel on the same day, and we exclude the multiple-announcement events in a robustness check in Section 6.

[21] Berkman and Truong (2008) find that from the early 1980s to 2004 the incidence of after-hours earnings announcements rises from 10-15 percent to over 50 percent.

[22] Kim and Verrecchia (1994) predict that volume and spreads remain elevated beyond the immediate announcement time, and Lee, Mucklow, and Ready (1993) find that volume is higher for earnings-announcement stocks throughout the entire announcement day. Examining intraday windows might also be interesting but is not feasible because our data do not identify the precise time of intraday earnings announcements; excluding panels containing stocks with intraday releases would reduce our sample by 73%, from 470 to 125 panels. More importantly, theory suggests that inventories are an important determinant of specialist behavior and liquidity, and inventory data are available only at the daily frequency.

announcements peaking in July, October, January, and April. Because earnings announcements tend to cluster in time, we use standard errors that are robust to time-series as well as cross-sectional correlation throughout our empirical analysis.

[Figure 2 Here]

In the Appendix we examine the correlation between earnings announcements and the three trade-based attention measures in Corwin and Coughenour (2008). Corwin and Coughenour construct measures of attention based on stock volume and return over 30-minute periods; we calculate their full-day analogs and find that earnings announcements are as highly correlated with the volume- and return-based measures as the volume- and return-based measures are with each other. We use only the earnings announcements in our analysis to avoid possible endogeneity if trading is driven by the specialist's attention rather than the other way around.

Earnings surprises. We define the earnings surprise for a stock as the absolute difference between the announced earnings and the mean of recent analyst forecasts preceding the announcement, normalized by the stock price.[23] We use the mean of recent forecasts because combination forecasts are generally less noisy than a single forecast (e.g., Brown and Caylor, 2005) and better represent the definition of earnings surprise, as traders' expectations are likely to reflect recent analyst forecasts. We create separate variables for positive and negative earnings surprises because numerous studies have shown asymmetric market reactions to earnings surprises (e.g., Bartov, Givoly, and Hayn, 2002; Brown, Hillegeist, and Lo, 2009; and Kasznik and McNichols, 2002). We calculate the positive (negative) earnings surprise for each panel each day as the absolute value of the average earnings surprise for all stocks on the panel announcing positive (negative) earnings surprises that day, and then designate the top quartile of positive (negative) earnings surprises as large positive (negative) earnings surprise panel/days.

Earnings response coefficient. We calculate each firm's earnings response coefficient (ERC) as the coefficient estimate from a regression of stock returns on earnings, using short-run cumulative abnormal

[23] Using the single most timely forecast, as in O'Brien (1988), yields identical inference; results available from the authors on request.

returns and the firm-specific coefficient methodology of Teets and Wasley (1996). After calculating each stock's ERC, we designate stocks with coefficients in the top quartile of ERCs as high ERC firms. Panel/days containing one or more high ERC stock(s) are designated high ERC panel/days.[24]

Inventory. We obtain the specialist closing dollar inventory for each stock each day from the SPETS file, from which we calculate two inventory measures at the panel level. We aggregate inventory at the panel level because the specialist's trading decisions are likely to be most strongly influenced by his inventory in his own panel of stocks (Naik and Yadav, 2003). To measure panel-level inventory, we aggregate (signed) dollar inventory for all stocks handled by each specialist and then take the absolute value to get the magnitude of the overall position at the end of day *t*-1 (as in Comerton-Forde et al., 2010).[25] We also calculate the change in the absolute value of dollar inventory for announcement stocks on each panel on day *t*, to examine the extent to which the specialist's inventory accumulation in announcement stocks affects his contemporaneous trading of the other stocks on his panel.

Public orders. To measure liquidity offered by public limit orders, we calculate non-marketable limit orders from the SOD and TAQ files as the number of shares submitted by limit orders that are priced below the best offer (for buy limit orders) or above the best bid (for sell limit orders) at the time the order is entered. All other limit orders are marketable limit orders, which are liquidity-demanding. We focus on the number of shares submitted rather than the number of orders because average trade size falls significantly over our sample period, from 417 shares pre-Hybrid to 304 shares post-Hybrid (Table 1, Panel A), so the number of shares better reflects liquidity demand and supply. Non-marketable shares increase from pre- to post-Hybrid, while share volume (which reflects trades initiated by market orders and marketable limit orders) is fairly constant over the period (Table 1, Panel A).

Control variables. To measure market-wide volatility we use the daily opening CBOE volatility index (VIX), which is derived from S&P 500 stock index options. We collect each stock's closing price,

[24] Using the number of high ERC stocks on the panel/day, instead of a zero/one indicator, yields similar inference; results available from the authors on request.

[25] Comerton-Forde et al. (2010) examine the effect of inventory on following-day liquidity because market makers are more exposed to the possibility of losses on inventories held overnight or longer.

number of trades, and average trade size from NYSE trades in TAQ, and we collect daily stock returns from CRSP. We determine the date on which each stock went Hybrid from the rollout list posted on the NYSE website.

Table 2 shows pooled correlations between our main variables of interest and key control variables. Most variables are aggregated at the stock level; the exceptions are earnings announcement percentage, positive and negative earnings surprises, high earnings response coefficient, and specialist inventory, which are aggregated at the panel level, and market-wide volatility. Variables with the superscript "non-EA" exclude each stock's own earnings announcement days. The correlations show that the specialist participation rate tends to be higher for stocks with higher effective spreads (coefficient of 0.42, significant at the 1% level), reflecting specialists' tendency to participate more in the least liquid stocks because of the public precedence rule and the specialists' affirmative obligations (Madhavan and Sofianos, 1998). Spreads tend to be wider for non-announcement stocks on days when more stocks on their panel have earnings announcements (correlation of 0.02, significant at the 1% level). Likewise specialist participation tends to be lower for non-announcement stocks on days when more stocks on their panel have earnings announcements (correlation of -0.02, significant at the 1% level). Spreads and specialist participation are both lower for stocks that have gone Hybrid (coefficients of -0.10 and -0.32, both significant at the 1% level). Inventories tend to be higher when there are earnings announcements on the panel (correlation of 0.41, significant at the 1% level) and lower after Hybrid (-0.04, significant at the 1% level). Nonmarketable (liquidity-supplying) limit orders are lower for stocks with higher effective spreads (correlation of -0.13, significant at the 1% level). Nonmarketable limit orders are also inversely related to specialist participation (correlation of -0.12, significant at the 1% level), reflecting the specialist's negative obligation to yield to public limit orders as well as his role as liquidity provider of last resort. Nonmarketable limit orders are higher after Hybrid (correlation of 0.20, significant at the 1% level), as limit order providers find it easier to compete with the specialist in the more automated Hybrid market.

[Table 2 Here]

4. Liquidity, Earnings Announcements, Inventory, and Attention Constraints

This section first presents our main analysis of the link between stock liquidity and earnings announcements for stocks traded on the same specialist panel. We then add inventory to our analysis, to examine how much of the effect of earnings announcements on liquidity can be attributed to traditional inventory risk management explanations. Finally, we explore the effects of possible information spillovers from industry and market-wide earnings announcements. Robustness checks are discussed in Section 6.

4.1 Stock Liquidity and Panel Earnings Announcements

Our main empirical goals are to test whether the liquidity of some stocks suffers when other stocks handled by the same specialist have earnings announcements and, if so, whether this effect is reduced with the introduction of the Hybrid market. We test whether the spreads of non-announcement stocks on a specialist's panel widen on days when other stocks on the same panel have earnings announcements, and whether announcements that contain earnings surprises or pertain to stocks with high earnings response coefficients have a bigger impact. To control for the changes in public order submission strategies evidenced in Table 1, we include the ratio of liquidity-supplying limit orders to all orders. Control variables account for other possible factors influencing spreads, such as market-wide volatility, trade size, and absolute stock returns. Our basic regression equation is:

$$
\begin{aligned}
ESpread_{i,t}^{non-EA} = {} & \alpha + \beta_1 EA\%_{p,t} + \beta_2 EA\%_{p,t} \times Hybrid_{i,t} \\
& + \beta_3 LargePosSurprise_{p,t} \times EA\%_{p,t} + \beta_4 LargePosSurprise_{p,t} \times EA\%_{p,t} \times Hybrid \\
& + \beta_5 LargeNegSurprise_{p,t} \times EA\%_{p,t} + \beta_6 LargeNegSurprise_{p,t} \times EA\%_{p,t} \times Hybrid \\
& + \beta_7 HighERC_{p,t} \times EA\%_{p,t} + \beta_8 HighERC_{p,t} \times EA\%_{p,t} \times Hybrid \\
& + \chi_1 LimitOrderRatio_{i,t} + \chi_2 LimitOrderRatio_{i,t} \times Hybrid_{i,t} \\
& + \delta_1 Volatility_t + \delta_2 Volatility_t \times Hybrid_{i,t} \\
& + \sum_{m=1}^{4} \gamma_{1,m} ControlVar_{m,i,t} + \sum_{m=1}^{4} \gamma_{2,m} ControlVar_{m,i,t} \times Hybrid_{i.t} \\
& + \sum_{n=1}^{1424} \theta_n StockDummy_{n,i} + \sum_{n=1}^{1424} \theta_n StockDummy_{n,i} \times Hybrid_{i,t} \\
& + \sum_{k=2}^{6} \phi_k ESpread_{i,t-k}^{non-EA} + \varepsilon_{i,t}
\end{aligned}
\tag{1}
$$

where $ESpread_{i,t}^{non\text{-}EA}$ is the average percentage effective spread for stock *i* on specialist panel *p* on day *t*, which is not an earnings announcement day for stock *i*. $EA\%_{p,t}$ is the average-volume-weighted percentage of stocks on panel *p* that have earnings announcements on day *t*. $Hybrid_{i,t}$ is an indicator variable equal to one if stock *i* has gone Hybrid by day *t*, else zero. $LargePosSurprise_{p,t}$ ($LargeNegSurprise_{p,t}$) is an indicator variable equal to one for panel-days *p,t* with positive (negative) earnings surprises in the top quartile of positive (negative) earnings surprises; $HighERC_{p,t}$ is an indicator variable equal to one if the earnings response coefficient for announcing stocks on panel *p* is in the top quartile of earnings response coefficients, else zero. $LimitOrderRatio_{i,t}$ is the ratio of non-marketable limit order volume to total order volume for stock *i* on day *t*. $Volatility_t$ is market-wide volatility measured by the opening value of the VIX index on day *t*. $ControlVar_{i,t}$ are four control variables: the log of the number of trades for stock *i* on day *t*, log of the average trade size for stock *i* on day *t*, absolute return for stock *i* on day *t*, and a time trend. The time trend is included because spreads are generally downward trending over the sample period.[26] $StockDummy_{n,i}$ is an indicator variable equal to one if observation $ESpread_{i,t}^{non\text{-}EA}$ is for stock *n*, else zero, to incorporate stock fixed effects. Because we control for stock

[26] A similar methodology is used in Hendershott and Moulton (2011) for analyses including order-level data, where a matched sample is not feasible. Interacting the time trend with all other explanatory variables does not change the coefficients on the variables of interest; see Section 6 for all robustness checks.

fixed effects, the identification is driven by the variation in the time series of liquidity and not by the cross-sectional variation in liquidity. For estimation purposes, we suppress one stock fixed effect because the model contains an intercept. We include five lags of our dependent variable to control for autocorrelation in liquidity.[27] We conduct inference in this and all subsequent regressions using standard errors that are robust to both cross-sectional correlation and idiosyncratic time-series persistence (Thompson, 2011).

Our main hypotheses are that the coefficient β_1 in Equation (1) is positive, showing that the spreads of non-announcement stocks are higher when other stocks on the same panel have earnings announcements, and that the coefficient β_2 in Equation (1) is negative, showing that the Hybrid market structure reduces the effect of earnings announcements on non-announcement stock liquidity. We also expect that if stocks with greater earnings surprises and higher earnings response coefficients attract more attention, the coefficients β_3, β_5, and β_7 will be positive, and β_4, β_6, and β_8 will be negative if the Hybrid changes reduce the effect of the most attention-worthy announcements. Table 3 presents the results of the panel regression described in Equation (1) and variations including subsets of the explanatory variables.

[Table 3 Here]

In all four specifications there is a strong positive relation between the non-announcement stock's spread and the ratio of limit orders to total orders, consistent with Biais, Hillion, and Spatt's (1995) finding that traders use more limit orders relative to market orders when spreads are wide. The introduction of Hybrid reduces this effect, consistent with Chung, Van Ness, and Van Ness (1999) and Harris and Hasbrouck (1996), who find that when public limit orders can compete effectively with the specialist, spreads narrow. We include the limit order ratio in all specifications to control for changes in

[27] Spreads are significantly autocorrelated (average coefficient 0.80) while the changes in spreads are significantly negatively autocorrelated (-0.45 coefficient), so differencing the spread may lead to over-differencing and induce autocorrelation in the computed residuals (as discussed by Hasbrouck and Seppi, 2001). Throughout our analysis, we focus on liquidity levels rather than changes to avoid concerns about over-differencing. We use lags two through six to avoid overlapping with two-day earnings announcement periods for stocks lacking time-of-day announcement information.

order submission strategies brought on by Hybrid, so that we can focus on the effects of the specialist's attention constraint.

Specification (1) in Table 3 shows that spreads are wider (liquidity is lower) for non-announcement stocks when more of the stocks on the same panel have earnings announcements, and that this effect is significantly lessened after Hybrid. The coefficient of 4.08 on *Earnings Announcement %* in the first regression indicates that when half the stocks on a panel have earnings announcements, the effective spread of the non-announcement stocks on the panel is 2.04 basis points higher (4.08 coefficient times 0.5 earnings announcement percentage). In terms of economic significance, 2.04 basis points represents 18 percent of the full-period average effective spread (11.07 basis points, from Panel A of Table 1). The effect drops to 0.8 basis points with the Hybrid market change (4.08 coefficient minus 2.43 coefficient on Hybrid interaction, times 0.5 earnings announcement percentage).

We next look at whether non-announcement stock spreads are more sensitive to earnings announcements on the panel when the earnings announcements contain surprises, motivated by Sims' (2006) suggestion that attention constraints may be nonlinear. Specification (2) reveals that large positive earnings surprises are particularly associated with higher spreads, while negative earnings surprises have no significant effect. The asymmetry in the coefficients for earnings surprises is consistent with numerous studies that have found a larger market response to positive than negative earnings surprises (see Hotchkiss and Strickland, 2003, for a survey). The effect of positive earnings surprises appears lower under Hybrid, with a significant negative coefficient on the Hybrid interaction term.

Finally, we examine whether stocks with high earnings response coefficients demand more of the specialist' attention, motivated by the extensive literature documenting that some firms' earnings announcements contain more stock-value-relevant information than others (e.g., Liu and Thomas, 2000). Specification (3) reveals that stocks with high earnings response coefficients have a larger impact on the liquidity of non-announcing stocks on the same panel (increasing the non-announcing stock's spreads by a significant 2.07 basis points). Hybrid appears to diminish the effect somewhat, although the coefficient on the Hybrid interaction term is only weakly significant.

Specification (4) combines all of the explanatory variables relating to earnings announcements into one analysis. This specification asks a lot of the data given the correlations between many of the right-hand side variables, and not all coefficient estimates remain significant. Nonetheless, the picture that emerges is consistent with our hypothesis that liquidity worsens for stocks when other stocks on the same panel have earnings announcements, that the effect is more severe when the announcements contain surprises (especially positive surprises) or pertain to stocks with high earnings response coefficients, and that Hybrid generally alleviates the effect of earnings announcements on non-announcement stocks.

4.2 Stock Liquidity and Panel Inventory Risk Management

In this section we examine how much of the spread widening for non-announcement stocks on a specialist's panel can be explained by the specialist's inventory risk management. For example, models such as Naik and Yadav (2003) suggest that each specialist manages his risk based on the combined inventory of all the stocks on his panel, and Comerton-Forde et al. (2010) find that specialists' closing inventory predicts spreads the following day. In addition, on an earnings announcement day a specialist is likely to acquire a larger inventory position in the announcing stock, as his positive obligation requires him to supply liquidity when there is a public order imbalance. We thus expect that the specialist's ability and willingness to provide liquidity in non-announcement stocks on his panel will be affected by the prior day's panel-wide closing inventory and changes in the announcing stocks' inventory during the announcement day. Our basic regression equation is:

$$
\begin{aligned}
ESpread_{i,t}^{non-EA} = {} & \alpha + \lambda_1 Inv_{p,t-1} + \lambda_2 Inv_{p,t-1} \times Hybrid_{i,t} \\
& + \theta_1 InvChg_{p,t}^{EA} + \theta_2 InvChg_{p,t}^{EA} \times Hybrid_{i,t} \\
& + \beta_1 EA\%_{p,t} + \beta_2 EA\%_{p,t} \times Hybrid_{i,t} \\
& + \beta_3 LargePosSurprise_{p,t} \times EA\%_{p,t} + \beta_4 LargePosSurprise_{p,t} \times EA\%_{p,t} \times Hybrid \\
& + \beta_5 LargeNegSurprise_{p,t} \times EA\%_{p,t} + \beta_6 LargeNegSurprise_{p,t} \times EA\%_{p,t} \times Hybrid \\
& + \beta_7 HighERC_{p,t} \times EA\%_{p,t} + \beta_8 HighERC_{p,t} \times EA\%_{p,t} \times Hybrid \\
& + \chi_1 LimitOrderRatio_{i,t} + \chi_2 LimitOrderRatio_{i,t} \times Hybrid_{i,t} \\
& + \delta_1 Volatility_t + \delta_2 Volatility_t \times Hybrid_{i,t} \\
& + \sum_{m=1}^{4} \gamma_{1,m} ControlVar_{m,i,t} + \sum_{m=1}^{4} \gamma_{2,m} ControlVar_{m,i,t} \times Hybrid_{i.t} \\
& + \sum_{n=1}^{1424} \theta_n StockDummy_{n,i} + \sum_{n=1}^{1424} \theta_n StockDummy_{n,i} \times Hybrid_{i,t} \\
& + \sum_{k=2}^{6} \phi_k ESpread_{i,t-k}^{non-EA} + \varepsilon_{i,t}
\end{aligned}
\qquad (2)
$$

where $Inv_{p,t-1}$ is the absolute value of the aggregate closing dollar inventory for all stocks on panel *p* on day *t-1*, $InvChg^{EA}_{p,t}$ is the change in absolute value of the aggregate dollar inventory for all announcement stocks on panel *p* on day *t*, and the remaining variables are as defined in equation (1).

We expect the coefficients λ_1 and θ_1 in Equation (2) to be positive, showing that the spreads of non-announcement stocks are higher when the specialist has or acquires more inventory, and λ_2 and θ_2 in Equation (2) to be negative, showing that the Hybrid market structure reduces the effect of specialist inventory risk management on stock liquidity. Table 4 presents the results of the panel regression described in Equation (2) and variations including subsets of the explanatory variables.

[Table 4 Here]

Specification (1) shows that spreads for non-announcement stocks are wider when the specialist's previous-day closing inventory for his panel is higher (coefficient estimate of 0.82 with a t-statistic of 2.7) and when he increases his inventory position in announcement stocks on his panel (coefficient estimate of 0.22 with a t-statistic of 5.1), consistent with the predictions of inventory risk-management models. Both effects are reduced with the Hybrid introduction, perhaps because increased participation of off-floor

market makers after Hybrid reduces the effect of specialists' inventory risk management on stock liquidity. Specification (2) of Table 4 includes earnings announcements and specialist inventories. As noted in Table 2, there is some collinearity between the explanatory variables, so not all of the right-hand side variables remain significant. The coefficients on *Earnings announcement %* and *Earnings announcement % x Hybrid* remain significant, with positive and negative coefficients respectively. When there are earnings announcements on a panel, non-announcement stock spreads widen even if the specialist does not have a large inventory position going into the day and does not acquire a large inventory position in the announcement stocks. The Hybrid introduction reduces the effect of earnings announcements substantially, from a coefficient estimate of 2.11 on *Earnings announcement %* alone to 0.64 after Hybrid (2.11 plus the coefficient estimate of -1.47 on *Earnings announcement % x Hybrid*). In specifications (3) and (4) we include the nonlinear effects for earnings announcements containing large earnings surprises and for stocks with high earnings response coefficients; the surprise and earnings response coefficient interactions retain nearly the same coefficients as Table 3, the analysis without inventory as an explanatory variable.

Overall, we find that about half of the effect of earnings announcements on non-announcement stocks is due to specialist inventory risk management, but after controlling for inventories, there still appears to be a significant effect attributable to specialist attention constraints.

4.3 Stock Liquidity and Market-wide Earnings Announcements

The regression results reported above control for specialist inventory risk management, order submission strategies, stock characteristics, and market-wide volatility, but the results may still reflect other market-wide factors. For example, Figure 2 shows that earnings announcements tend to cluster in time. Perhaps our results reflect market-wide earnings announcements as well as earnings announcements on the same panel, either because of information spillovers (as summarized in Kothari, Lewellen, and Warner, 2006) or because of the attention constraints of investors (as in Hirshleifer, Lim, and Teoh, 2009), who are not restricted to trading stocks on only one specialist's panel. Furthermore, earnings announcements for off-panel stocks may have a larger effect on a non-announcement stock if they are in

the same industry; Han and Wild (1990) find that firms' returns are affected by competitors' earnings announcements, and Ayers and Freeman (1997) find that industry-wide earnings affect stock returns. To control for these possibilities as well as commonality in liquidity (Chordia, Roll, and Subrahmanyam, 2000), we incorporate controls for market-wide earnings announcements, industry-wide earnings announcements, and market-wide liquidity (which should encompass the effects of market-wide inventory – see Comerton-Forde et al., 2010).

We calculate *Off-panel Earnings announcement %* as the earnings announcement percentage across all stocks not traded on the panel, and off-panel liquidity as the equal-weighted percentage effective spread across all stocks not traded on the panel. We calculate *Off-panel Industry Earnings announcement %* as the earnings announcement percentages for stocks in the same industry, across all stocks not traded on the panel. We then employ a two-step methodology to control for market liquidity and market earnings announcements simultaneously. First we regress the liquidity of non-announcement stocks on market-wide liquidity (excluding same-panel stocks). The residual from this regression is the variation in the non-announcement effective spread that is not explained by variations in market-wide liquidity. We use this residual as the dependent variable in regressions similar to Equation (1), with the addition of the explanatory variables *Off-panel Earnings announcement %* and *Off-panel Industry Earnings announcement %* to control for market-wide earnings announcements in general and within the same industry.

[Table 5 Here]

Table 5 presents the results of the analysis controlling for market-wide liquidity and earnings announcements. Specification (1) includes only the general measure of off-panel earnings announcements, *Off-panel Earnings announcement %*; specification (2) includes only the measure of same-industry off-panel earnings announcements, *Off-panel Industry Earnings announcement %*; and specification (3) includes both off-panel earnings announcement measures together. In all three specifications, the coefficient on *Earnings announcement %* (which reflects the percentage of stocks on the same panel having earnings announcements on that day) is positive and of similar magnitude to the

results in Table 4 (3.02 and 3.03 compared to 2.11 in Table 4, specification (2)), as is the coefficient on earnings announcement percentage interacted with the Hybrid indicator (-1.59 and -1.45 compared to -1.47 in Table 4, specification (2)), while the coefficients on the off-panel earnings announcement measures and their interactions with Hybrid are not significant. Table 5 suggests that the decline in non-announcement stock liquidity is not explained by information spillovers or market-wide liquidity commonality. These results provide further evidence in support of our hypotheses that the specialist's attention constraints lead to wider spreads for non-announcement stocks when other stocks on his panel have earnings announcements and that this effect declines after Hybrid.

5. Market Maker Activity, Earnings Announcements, and Attention Constraints

This section first presents our main analysis of the link between specialist trading and earnings announcements before and after the Hybrid changes are introduced. We then examine how off-floor market maker participation in non-announcement stocks changes with Hybrid. Robustness checks are discussed in Section 6.

5.1 Specialist Activity on Earnings Announcement Days

We begin by testing whether the specialist devotes less attention to some stocks when other stocks he handles have earnings announcements, suggesting a binding attention constraint. We examine whether the specialist's participation rate in non-announcement stocks falls on days when other stocks on his panel have earnings announcements and how his participation in non-announcement and announcement stocks changes with the Hybrid market introduction.

To study how earnings announcements affect the specialist's participation in non-announcement stocks on his panel, we run regressions of the following form:

$$
\begin{aligned}
PRate_{i,t}^{non-EA} = {} & \alpha_{1,i} + \alpha_{2,i} \times Hybrid_{i,t} + \beta_1 EA\%_{p,t} + \beta_2 EA\%_{p,t} \times Hybrid_{i,t} \\
& + \beta_3 LargePosSurprise_{p,t} \times EA\%_{p,t} + \beta_4 LargePosSurprise_{p,t} \times EA\%_{p,t} \times Hybrid \\
& + \beta_5 LargeNegSurprise_{p,t} \times EA\%_{p,t} + \beta_6 LargeNegSurprise_{p,t} \times EA\%_{p,t} \times Hybrid \\
& + \beta_7 HighERC_{p,t} \times EA\%_{p,t} + \beta_8 HighERC_{p,t} \times EA\%_{p,t} \times Hybrid \\
& + \chi_1 LimitOrderRatio_{i,t} + \chi_2 LimitOrderRatio_{i,t} \times Hybrid_{i,t} \\
& + \delta_1 Volatility_t + \delta_2 Volatility_t \times Hybrid_{i,t} \\
& + \sum_{m=1}^{5} \gamma_{1,m} ControlVar_{m,i,t} + \sum_{m=1}^{5} \gamma_{2,m} ControlVar_{m,i,t} \times Hybrid_{i,t} \\
& + \sum_{j=2}^{6} \phi_j PRate_{i,t-j}^{non-EA} + \varepsilon_{i,t},
\end{aligned}
\tag{3}
$$

where $PRate_{i,t}^{non\text{-}EA}$ is the log of the odds ratio (*prate*/(1-*prate*)), with *prate* equal to specialist's participation rate for stock *i* on specialist panel *p* on day *t*, which is not an earnings announcement day for stock *i*.[28] The right-hand side variables are as described for the effective spread regressions in Equation (1) with one additional control variable, the inverse of the price of stock *i* on day *t*.[29] The time trend is included because specialist participation rates are generally downward trending over the sample period (Table 1).

If the specialist trades less in non-announcement stocks when other stocks on his panel have earnings announcements, the coefficient β_1 in Equation (3) should be negative. If the specialist's participation in non-announcement stocks rises after Hybrid, the coefficient β_2 in Equation (3) should be positive. Table 6 presents the results from regression Equation (3) and variations including subsets of the explanatory variables.

[Table 6 Here]

Specifications (1) and (2) in Table 6 show that specialist participation is lower for non-announcement stocks when other stocks on his panel have earnings announcements, consistent with the attention

[28] We transform the participation rate using the log odds ratio because it is a limited dependent variable. Regressions using the simple participation rate as the dependent variable yield identical inference and are available from the authors on request.

[29] Stock price is not included as a control variable in regressions with percentage effective spread as the dependent variable, since stock price has a mechanical relation to percentage effective spread when spreads are limited by a discrete price grid.

constraint binding. The effect is greater when the announcing stocks have high ERCs, and there is weak evidence of positive earnings surprises having a greater effect. Notably, the earnings-announcement effect is greater in the post-Hybrid period than in the pre-Hybrid period: The coefficient on *Earnings announcement % x Hybrid* is negative in both specifications. One possible explanation is that the increase in non-marketable limit orders after Hybrid (Table 1) crowds out the specialist, whose negative obligation requires that he yield priority to public limit orders. The increase in non-marketable limit orders could reduce the specialist's participation rate even without a binding attention constraint. Specifications (3) and (4) show that even after controlling for non-marketable limit orders, specialist participation still declines in non-announcement stocks after the Hybrid introduction.

Another potential explanation for the drop in specialist participation in non-announcement stocks is that the increase in panel size following Hybrid makes the specialist's attention constraint more binding despite the increase in automation, leading him to reduce his participation in all of his assigned stocks (those with earnings announcements as well as those without earnings announcements). Alternatively, after Hybrid the specialist may shift even more of his attention to earnings-announcement stocks, away from non-announcement stocks. To investigate these two possibilities, we examine whether specialists increase or decrease their trading of earnings-announcement stocks after Hybrid with the following regression:

$$\begin{aligned} PRate_{i,t} = {} & \alpha_{1,i} + \alpha_{2,i} \times Hybrid_{i,t} + \beta_1 EA_{i,t} + \beta_2 EA_{i,t} \times Hybrid_{i,t} \\ & + \chi_1 MarketOrderRatio_{i,t} + \chi_2 MarketOrderRatio_{i,t} \times Hybrid_{i,t} \\ & + \delta_1 Volatility_t + \delta_2 Volatility_t \times Hybrid_{i,t} + \sum_{j=1}^{5} \gamma_{1,j} ControlVar_{j,i,t} \\ & + \sum_{j=1}^{5} \gamma_{2,j} ControlVar_{j,i,t} \times Hybrid_{i,t} + \sum_{k=2}^{6} \phi_k PRate_{i,t-k} + \varepsilon_{i,t}, \end{aligned} \tag{4}$$

where $PRate_{i,t}$ is the log of the odds ratio (*prate*/(1-*prate*)), with *prate* equal to specialist's participation rate for stock *i* on day *t*; $EA_{i,t}$ is an indicator variable equal to one if stock *i* has an earnings announcement on day *t*, else zero; $MarketOrderRatio_{i,t}$ is the ratio of market and marketable limit order volume to total order volume for stock *i* on day *t*; $Hybrid_{i,t}$ is an indicator variable equal to one if stock *i* has gone Hybrid

by day *t*, else zero; $Volatility_t$ is market-wide volatility measured by the opening value of the VIX index; and $ControlVar_{j,i,t}$ are five stock-level control variables: the inverse price, log of the number of trades, log of the average trade size, absolute return, and a time trend.

If the decline in specialist participation for non-announcement stocks under Hybrid is driven by the increase in panel size, we would expect the coefficient β_2 in Equation (4) to be negative, indicating that the specialist trades less in announcement as well as non-announcement stocks. If the decline in specialist participation for non-announcement stocks under Hybrid is driven by his allocating more attention to announcement stocks, we would expect the coefficient β_2 in Equation (4) to be positive.

[Table 7 Here]

Specification (1) in Table 7 shows that specialist participation increases in stocks on their earnings announcement days (positive coefficient on *Earnings announcement*) and even more so after the Hybrid market introduction (positive coefficient on *Earnings announcement x Hybrid*). This evidence is inconsistent with the increased panel size explanation, but it is consistent with the specialist shifting more of his attention from non-announcement to announcement stocks after Hybrid. A related explanation is that in Hybrid more marketable orders (market orders and marketable limit orders) are submitted relative to non-marketable orders for stocks on their earnings announcement days, forcing the specialist to participate more because of his positive obligation to provide liquidity when it is demanded. In specification (2) we include the ratio of marketable order volume to total order volume, to control for changes in order submission strategies. The specialist's participation rate is positively related to the ratio of marketable orders submitted, but their inclusion does not significantly diminish the coefficients on the earnings announcement indicators. These findings suggest that while the increase in marketable orders on earnings-announcement days is part of the story, it does not fully explain the specialist's attention shift toward stocks having earnings announcements.

5.2 Off-Floor Market Maker Activity on Earnings Announcement Days

The reduction in liquidity effect for non-announcement stocks following Hybrid (Tables 3 and 4) suggests that the specialist's reduced attention is not detrimental to the liquidity of non-announcement stocks. We next examine whether off-floor market makers (such as registered market makers on other exchanges and other traders following a market-making strategy) participate more in the NYSE trading of non-announcement stocks when other stocks on the specialist's panel have earnings announcements, and whether their participation changes after Hybrid. Table 8 presents results from regressions analogous to Equation (3), but with off-floor market maker participation rate in non-announcement stocks as the dependent variable.

[Table 8 Here]

The results in Table 8 show that off-floor market makers trade more in non-announcement stocks when other stocks on the same panel have earnings announcements, as the specialist focuses his attention on the announcement stocks. Furthermore, off-floor market makers' participation in non-announcement stocks increases even more after the Hybrid introduction as they are able to compete more efficiently with the specialist. This increased participation by off-floor market makers, who are not limited to trading the set of stocks on a single specialist's panel, offers an explanation for why the specialist's attention constraint is less consequential for the liquidity of the non-announcement stocks in his panel after Hybrid.

6. Robustness Checks

We conduct numerous additional tests to confirm the robustness of our results; all results are available from the authors on request. Conducting our analyses by market-capitalization quartiles shows that our results are not driven by the smallest or largest stocks; results are qualitatively similar across all stock quartiles and exhibit no monotonicity by stock size. Including all stocks, rather than only common stocks, in our sample leads to identical inference. Results are qualitatively similar when we use alternative earnings announcement windows: designating both the day of and the day following the earnings

announcement date in IBES for all stocks, or designating only the IBES date for stocks lacking time-of-day information in the Wall Street Journal.

Calculating the panel earnings announcement percentage as a simple ratio (the number of panel stocks with earnings announcements divided by the number of stocks on panel), rather than weighted by average volume, yields identical inference. Excluding observations in which the non-announcement stock and the earnings-announcement stock are from the same industry does not change the reported results. We test an alternative indicator of earnings announcement surprises, by interacting earnings announcements with an indicator variable equal to one for stock/days with the most extreme abnormal returns. Results using the return-based indicator are weaker than results using analyst forecasts to identify surprises, reflecting the fact that stock prices can move for many reasons other than an earnings surprise even on an earnings-announcement day and such price moves may not induce the same reallocation of specialist attention across his panel stocks.[30] Including the number of stocks on a panel as a control variable does not change the coefficient estimates on our variables of interest, nor does running the analyses by panel-size quartiles. Our findings are nearly identical when we restrict our sample to panels containing more than two stocks and when we exclude panel/days with more than one earnings announcement. Including indicator variables for each specialist firm does not change the coefficient estimates on our variables of interest and yields insignificant coefficients on the specialist-firm indicators. Interacting the time trend variable with all of the explanatory variables does not affect inference for the variables of interest.

In the liquidity regressions, omitting the limit order ratio does not change the magnitude or significance of the coefficient estimates for the variables of interest. Our results are robust to alternative liquidity measures, including dollar effective spreads, percentage and dollar quoted spreads, spreads that are volume-weighted rather than equal-weighted within the day, and value-weighted market-wide spreads.

[30] For example, on January 21, 2010, Goldman Sachs announced earnings in line with expectations, but its stock price dropped seven percent because on the same day the government announced a proposal to ban banks' proprietary trading.

In addition to the declining specialist participation rate in trading on the NYSE, the percentage of consolidated share volume that trades on the NYSE (NYSE market share) in the sample stocks declines an average of 9.4 percent from the pre-Hybrid to the post-Hybrid period. As a robustness check that the change in NYSE market share does not explain our results, we include indicator variables for the stocks with the largest and smallest (top and bottom quartile) changes in NYSE market share; the coefficients on the variables of interest are unchanged. We also conduct our entire analysis by quartiles defined by the NYSE market share and, alternately, the change in NYSE market share; all results are qualitatively similar.

7. Conclusion

In this paper we examine a new channel – the attention constraints of a market maker – through which one firm's earnings announcement can affect the liquidity of other firms' stocks, even stocks without any industry link to the announcing firm. Earnings announcements are exogenous to designated market makers (NYSE specialists), each of whom has a specific panel of securities for which he is uniquely responsible. This structure allows us to directly examine how increased attention demands from earnings-announcement stocks on a specialist's panel affect the liquidity of other stocks on his panel. We find that the liquidity of non-announcement stocks is worse on days when other stocks on the specialist's panel have earnings announcements. This effect is significant even after controlling for the specialist's inventory risk management, and it is stronger when earnings announcements contain surprises or are associated with stocks that have high earnings response coefficients. We further find that the effect of this attention constraint is lower after the NYSE introduces the Hybrid market, which gives the specialist additional electronic tools for managing his stocks and increases the automation and speed of trading, making it easier for off-floor market makers to compete with the specialist. Although we cannot say that the introduction of the NYSE's Hybrid market directly reduces the specialist's attention constraint, it appears to alleviate the effect of the attention constraint on stock liquidity by facilitating greater competition from off-floor market makers who are not obligated to trade the same set of stocks.

While we use the NYSE's Hybrid market change to examine how increased automation can ease the effects of attention constraints on earnings announcement days, our results should generalize to other markets with designated market makers. Our findings suggest that exchanges can alleviate the effects of designated market maker attention constraints by facilitating the participation of other (non-designated) market makers. Attention constraints are an enduring human attribute, and the reintroduction of designated market makers on many financial exchanges makes it important to find ways to alleviate attention constraints. After converting from human-intermediated to purely electronic markets over the past two decades, in recent years many electronic markets have been reintroducing designated market makers to enhance the liquidity of their listed stocks.[31] In testimony before the U.S. Congress in 2010, the Chairman of the U.S. Securities and Exchange Commission pointed out the potential advantages of human intervention over purely electronic trading systems, stating that "unlike pre-coded algorithms, people have the capacity, flexibility, and creativity to assess and respond to highly unusual events."[32] Bessembinder, Hao, and Lemmon (2008) show that designated market makers can enhance efficiency particularly when information asymmetries are important; in the time series, this is also likely to be when attention constraints bind most. Easley and O'Hara (2010) further suggest that designated market makers reduce the ambiguity attached to worst-case scenarios and thus induce uninformed investors to participate in the market.

Finally, this work relates to the wide-ranging literature on the effect of automation on human performance. In aviation science, where safety is the primary concern, the effect of greater automation on air traffic controllers' and pilots' attention is a topic of extensive research. Studies in ergonomics that examine human-machine interaction show that designing systems to optimize attention allocation leads to better matches between task and human capacity in automated processes (Neerincx & Griffioen, 1996).

[31] Jain (2005) documents the rise of purely electronic market structures beginning in the 1980s. Markets that have since introduced or reintroduced designated market makers include the Paris Bourse, Euronext Amsterdam, the Chicago Board of Options Exchange, the Stockholm Stock Exchange, the Italian Stock Exchange, the Singapore Exchange, Euronext Derivatives, Eurex, and NYSE ARCA.

[32] Full text of Chairman Shapiro's testimony concerning the severe market disruption on May 6, 2010 is available at http://sec.gov/news/testimony/2010/ts051110mls.htm.

But automated systems can also reduce human performance if automation leads to suboptimal mental workloads (Young and Stanton, 2002). The question of how much automation is optimal in financial markets remains an area for future research.

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Table 1: Sample Descriptive Statistics

Descriptive statistics are presented for the sample of 1425 common stocks (in Panel A) and the 409 specialist panels on which they are traded (in Panel B) over the period June 1, 2006 through May 31, 2007. For each stock (panel of stocks assigned to a single specialist), variables are averaged across all days in the period, and we report the cross-sectional statistics of these individual stock (panel) means. *Price* is the closing stock price; *Dollar volume* is the daily dollar volume traded; *Share volume* is the daily share volume traded; *Number of trades* is the daily number of trades; *Trade size* is the daily average trade size; *Absolute return* is the absolute daily return; *Specialist participation rate* is the daily number of shares bought or sold by the specialist divided by twice total daily volume; *Specialist inventory* is the daily average absolute dollar inventory; *Non-marketable shares* is the number of shares offered by non-marketable limit orders; *Quoted spreads* and *Effective spreads* are as defined in the text; *Stocks per panel* is the number of stocks traded on a panel. In Panel B, Industry diversification is the ratio of the number of distinct two-digit SIC codes minus one to the number of stocks minus one on the panel. *Mean diff* is the Post-Hybrid mean minus Pre-Hybrid mean; *p-value* in Panel A (Panel B) is from t-tests based on the subset of stocks (panels) that are present in both the Pre-Hybrid and Post-Hybrid period. Measures are calculated from TAQ, CRSP, SPETS, SOD, and the NYSE Symbol Trading Location file.

Panel A: Stock Level (N = 1425)

	Full Year				Pre-Hybrid				Post-Hybrid				Post-Pre Hybrid	
	Mean	StdDev	Min	Max	Mean	StdDev	Min	Max	Mean	StdDev	Min	Max	Mean Diff	p-value
Price ($)	36.98	34.78	0.80	755.86	35.44	33.30	0.80	752.29	39.53	37.70	1.08	759.86	4.09	<.0001
Dollar volume ($millions)	32.68	62.67	0.01	896.36	31.99	60.22	0.01	845.93	34.40	67.92	0.01	936.33	2.40	<.0001
Share volume (thousands)	841.01	1524.40	0.71	18155.67	848.76	1491.67	0.69	15527.14	847.32	1699.71	0.74	28926.70	-1.44	0.8602
Number of trades	1792.97	1853.99	0.00	17905.44	1528.40	1403.85	0.00	11001.65	2175.90	2448.94	2.28	23377.33	647.50	<.0001
Trade size	372.33	336.62	128.86	8114.98	416.79	360.86	130.46	7057.05	304.07	360.01	126.69	11742.18	-112.72	<.0001
Absolute return (bps)	123.51	59.50	3.30	1352.28	132.61	63.81	3.30	1352.28	110.41	47.79	5.04	559.42	-22.20	<.0001
Specialist participation rate (%)	5.85	3.28	0.00	33.82	7.31	3.98	0.00	32.59	3.84	2.74	0.76	37.75	-3.46	<.0001
Specialist inventory ($millions)	14.84	146.81	0.00	5421.55	27.24	635.52	0.01	23796.30	14.26	83.04	0.00	2748.86	-12.98	0.3895
Non-marketable shares (millions)	4.97	8.57	0.00	253.38	3.30	7.42	0.00	223.62	7.32	11.90	0.14	350.57	4.02	<.0001
Quoted spread (cents)	4.85	10.78	1.02	238.49	5.10	11.73	1.01	277.44	4.47	9.80	1.02	194.75	-0.63	<.0001
% Quoted spread (bps)	18.91	32.22	2.06	463.88	20.57	34.68	2.27	463.88	15.39	24.51	1.89	429.09	-5.19	<.0001
Effective spread (cents)	2.86	5.99	0.88	137.13	3.07	6.60	0.88	163.11	2.53	5.36	0.90	112.60	-0.54	<.0001
% Effective spread (bps)	11.07	16.85	1.54	285.71	12.16	18.14	1.60	285.71	8.93	12.86	1.41	218.63	-3.23	<.0001

Panel B: Specialist Panel Level (N = 409)

	Full Year				Pre-Hybrid				Post-Hybrid				Post-Pre Hybrid	
	Mean	StdDev	Min	Max	Mean	StdDev	Min	Max	Mean	StdDev	Min	Max	Mean Diff	p-value
Stocks per panel	5.06	2.50	1.00	13.46	4.56	2.34	1.00	12.67	5.82	2.94	1.00	14.66	1.25	0.0447
Industry diversification (%)	84.06	0.00	74.88	89.27	88.67	0.00	84.81	91.37	78.57	0.00	62.50	87.56	-10.09	0.0834
Price ($)	38.77	31.88	6.81	541.37	37.25	32.38	5.87	521.74	40.95	34.37	8.89	563.36	3.71	0.0307
Dollar volume ($millions)	40.96	56.08	0.13	428.60	44.61	68.15	0.01	504.74	41.17	53.06	0.16	417.42	-3.44	0.1033
Share volume (thousands)	1034.38	1425.97	10.33	11081.12	1167.63	1813.62	0.40	17218.60	978.17	1195.64	10.29	10632.10	-189.46	0.0398
Number of trades	1979.95	1415.14	14.34	11842.00	1722.60	1180.53	4.00	8418.95	2378.60	1795.34	18.06	11842.00	656.00	<.0001
Trade size	389.01	236.06	150.45	2476.69	468.20	349.64	100.00	3654.98	310.66	127.53	134.85	1483.22	-157.54	<.0001
Absolute return (bps)	129.90	55.68	31.25	728.60	145.55	132.43	35.81	2256.59	110.48	26.74	31.25	229.09	-35.07	<.0001
Specialist participation rate (%)	5.98	2.75	0.76	21.92	7.54	3.06	2.45	25.00	4.36	2.40	0.76	19.46	-3.18	<.0001
Specialist inventory ($millions)	18.19	69.48	0.14	1166.38	33.03	354.86	0.08	6520.26	21.02	103.06	0.02	1913.12	-12.01	0.3101
Non-marketable shares (millions)	5.22	5.09	0.00	44.10	3.71	4.79	0.00	55.58	6.87	5.47	0.00	44.10	3.16	<.0001
Quoted spread (cents)	5.02	10.04	1.17	195.32	5.23	11.18	1.16	196.68	4.87	10.36	1.17	193.80	-0.37	0.2210
% Quoted spread (bps)	18.33	17.26	2.56	151.53	20.50	23.45	2.71	221.98	15.72	13.18	2.11	118.44	-4.77	0.0112
Effective spread (cents)	2.95	5.88	0.96	115.14	3.19	6.75	0.89	119.10	2.78	5.86	0.89	110.71	-0.40	0.0040
% Effective spread (bps)	10.64	8.75	1.87	74.86	12.04	11.91	1.99	113.51	9.12	7.23	1.51	72.25	-2.92	0.0035

Table 2: Variable Correlations

Pooled correlations are presented for the sample of 1425 common stocks from June 1, 2006 to May 31, 2007. *Effective spread*$^{non\text{-}EA}$ is the effective spread of the stock on its non-announcement days; *Participation rate*$^{non\text{-}EA}$ is the specialist participation rate for the stock on its non-announcement days; *Earnings ann'ment %*^{panel} is the percentage of stocks on the panel having earnings announcements; *Positive (negative) earnings surprise*^{panel} is the absolute value of the average positive (negative) earnings surprise for stocks on the panel; *High earnings response coefficient*^{panel} is an indicator variable equal to one if the earnings response coefficient for the announcing stock is in the top quartile of earnings response coefficients, else zero. *Hybrid* is an indicator variable equal to one if the stock has gone Hybrid, else zero; *Inventory*^{panel} is the absolute value of aggregate dollar inventory for stocks on the panel; *Non-marketable shares*$^{non\text{-}EA}$ is the number of shares offered by non-marketable limit orders; *Volatility* is market-wide volatility measured by the opening level of the VIX index; *Price*$^{non\text{-}EA}$ is the price of of the stock on its non-announcement days; *Trades*$^{non\text{-}EA}$ is the number of trades for the stock on its non-announcement days; *Trade size*$^{non\text{-}EA}$ is the average trade size for the stock on its non-announcement days; and *Absolute return*$^{non\text{-}EA}$ is the absolute return for the stock on its non-announcement days.

Data are from TAQ, CRSP, SPETS, SOD, IBES, and the NYSE Symbol Trading Location file. Correlations in bold are significant at the 1% level; correlations in italics are significant at the 5% level.

	Effective spread$^{non\text{-}EA}$	Participation rate$^{non\text{-}EA}$	EA %^{panel}	Positive ESur^{panel}	Negative ESur^{panel}	High ERC^{panel}	Hybrid	Inventory^{panel}	Non-marketable shares$^{non\text{-}EA}$	Volatility	Price$^{non\text{-}EA}$	Trades$^{non\text{-}EA}$	Trade size$^{non\text{-}EA}$	Absolute return$^{non\text{-}EA}$
Effective spread$^{non\text{-}EA}$	1.00													
Participation rate$^{non\text{-}EA}$	**0.42**	1.00												
Earnings ann'ment %^{panel}	**0.02**	**-0.02**	1.00											
Positive earnings surprise^{panel}	**0.01**	**-0.01**	**0.17**	1.00										
Negative earnings surprise^{panel}	**0.01**	**-0.01**	**0.11**	**0.03**	1.00									
High earnings resp coeff^{panel}	**0.02**	**-0.06**	**0.01**	0.00	**0.01**	1.00								
Hybrid	**-0.10**	**-0.32**	0.00	**0.03**	0.00	**0.07**	1.00							
Inventory^{panel}	**0.01**	0.00	**0.41**	**0.08**	**0.04**	**0.01**	**-0.04**	1.00						
Nonmarketable shares$^{non\text{-}EA}$	**-0.13**	**-0.12**	0.00	0.00	0.00	**-0.01**	**0.20**	0.00	1.00					
Volatility	**0.05**	**0.05**	**-0.03**	0.00	0.00	**-0.02**	**-0.12**	**0.01**	0.00	1.00				
Price$^{non\text{-}EA}$	**-0.19**	**0.01**	*-0.01*	**-0.01**	**-0.01**	**-0.08**	**0.06**	**0.01**	**0.13**	**-0.02**	1.00			
Trades$^{non\text{-}EA}$	**-0.28**	**-0.15**	**-0.02**	**-0.01**	**-0.01**	**-0.07**	**0.17**	**0.03**	**0.46**	**0.04**	**0.19**	1.00		
Trade size$^{non\text{-}EA}$	**0.03**	**-0.01**	**-0.01**	**-0.01**	**-0.01**	**-0.02**	**-0.13**	**0.01**	**0.32**	**0.02**	**-0.11**	**0.21**	1.00	
Absolute return$^{non\text{-}EA}$	**0.15**	**0.08**	0.00	0.00	0.01	**0.01**	**-0.07**	0.00	**-0.03**	**0.11**	**-0.09**	**0.07**	**0.07**	1.00

Table 3: Regressions of Non-EA Liquidity on Panel Earnings Announcements

Analysis period is June 1, 2006 through May 31, 2007. The dependent variable is *Effective spread* (in basis points) for common stocks on non-announcement days, which is regressed on earnings announcement measures and each measure interacted with *Hybrid* , an indicator variable equal to one if the stock has gone Hybrid on or before day t, else zero. *Earnings announcement %* is the percentage of stocks on the panel having earnings announcements on day t; *Large positive (negative) earnings surprise x Earnings announcement %* is the interaction of Earnings announcement % with an indicator variable equal to to one for panel-days with positive (negative) earnings surprise in the top quartile of positive (negative) earnings surprises, else zero. *High earnings response coefficient x Earnings announcement %* is the interaction of Earnings announcement % with an indicator variable equal to one if the earnings response coefficient for the announcing stock is in the top quartile of earnings response coefficients, else zero. *Limit order ratio* is the ratio of non-marketable limit order volume to total order volume.

Regressions also include stock fixed effects and the following control variables: the Hybrid indicator; market-wide volatility measured by the opening level of the VIX index; the log of the number of trades; the log of the average trade size; the stock's absolute return; a time trend; the Hybrid indicator interacted with all other control variables; and five lags of the dependent variable. Coefficients for the control variables other than Limit order ratio and for the constant are not reported. T-statistics, reported in parentheses below coefficient estimates, are robust to time-series and cross-sectional correlation.

	(1)	(2)	(3)	(4)
Earnings announcement %	4.08	2.40	2.45	1.96
	(7.7)	*(11.1)*	*(2.3)*	*(1.9)*
Earnings announcement % x Hybrid	-2.43	-1.00	-1.57	-1.00
	(-4.1)	*(-2.8)*	*(-1.3)*	*(-0.8)*
Large positive earnings surprise x Earnings announcement %		4.47		4.45
		(2.1)		*(1.5)*
Large positive earnings surprise x Earnings announcement % x Hybrid		-4.22		-4.59
		(-2.0)		*(-1.5)*
Large negative earnings surprise x Earnings announcement %		1.36		-1.05
		(1.2)		*(-0.9)*
Large negative earnings surprise x Earnings announcement % x Hybrid		-0.90		0.64
		(-0.7)		*(0.5)*
High earnings response coefficient x Earnings announcement %			2.07	2.00
			(2.4)	*(2.4)*
High earnings response coefficient x Earnings announcement % x Hybrid			-1.78	-1.75
			(-1.7)	*(-1.7)*
Limit order ratio	0.99	0.99	0.99	0.99
	(4.6)	*(4.6)*	*(4.6)*	*(4.6)*
Limit order ratio x Hybrid	-0.67	-0.67	-0.67	-0.67
	(-2.2)	*(-2.2)*	*(-2.2)*	*(-2.2)*
Observations	321,435	321,435	321,435	321,435
R^2	82%	82%	80%	83%

Table 4: Regressions of Non-EA Liquidity on Panel Inventories without and with Earnings Announcements

Analysis period is June 1, 2006 through May 31, 2007. The dependent variable is *Effective spread* (in basis points) for common stocks on non-announcement days, which is regressed on inventory and earnings announcement measures and each measure interacted with *Hybrid* , an indicator variable equal to one if the stock has gone Hybrid on or before day t, else zero. $Inventory_{t-1}$ is the absolute inventory (in $100 millions) for all stocks on the panel on day t-1. $Inventory\ change^{EA}$ is the change in absolute inventory (in $1 millions) from day t-1 to day t for stocks on the panel having earnings announcements on day t. *Earnings announcement %* is the percentage of stocks on the panel having earnings announcements on day t; *Large positive (negative) earnings surprise x Earnings announcement %* is the interaction of Earnings announcement % with an indicator variable equal to toone for panel-days with positive (negative) earnings surprise in the top quartile of positive (negative) earnings surprises, else zero. *High earnings response coefficient x Earnings announcement %* is the interaction of Earnings announcement % with an indicator variable equal to to one if the absolute value of the earnings response coefficient for the announcing stock is in the top quartile of the absolute value of earnings response coefficients, else zero. *Limit order ratio* is the ratio of non-marketable limit order volume to total order volume.
Regressions also include stock fixed effects and the following control variables: the Hybrid indicator; the ratio of non-marketable limit order volume to total order volume; market-wide volatility measured by the opening level of the VIX index; the log of the number of trades; the log of the average trade size; the stock's absolute return; a time trend; the Hybrid indicator interacted with all other control variables; and five lags of the dependent variable. Coefficients for the control variables other than Limit order ratio and for the constant are not reported. T-statistics, reported in parentheses below coefficient estimates, are robust to time-series and cross-sectional correlation.

	(1)	(2)	(3)	(4)
$Inventory_{t-1}$	0.82	0.44	0.44	0.44
	(2.7)	*(2.2)*	*(2.2)*	*(2.1)*
$Inventory_{t-1}$ x Hybrid	-0.53	-0.14	-0.15	-0.15
	(-1.9)	*(-0.5)*	*(-0.6)*	*(-0.6)*
$Inventory\ change^{EA}$	0.22	0.07	0.07	0.06
	(5.1)	*(1.5)*	*(1.4)*	*(1.2)*
$Inventory\ change^{EA}$ x Hybrid	-0.18	-0.06	-0.07	-0.06
	(-3.9)	*(-1.3)*	*(-1.2)*	*(-1.1)*
Earnings announcement %		2.11	1.44	1.08
		(3.1)	*(2.4)*	*(1.0)*
Earnings announcement % x Hybrid		-1.47	-0.74	-0.11
		(-2.0)	*(-1.1)*	*(-0.1)*
Large positive earnings surprise x Earnings announcement %			4.47	4.45
			(2.1)	*(1.5)*
Large positive earnings surprise x Earnings announcement % x Hybrid			-4.22	-4.59
			(-2.0)	*(-1.5)*
Large negative earnings surprise x Earnings announcement %			1.36	-1.04
			(1.2)	*(-0.9)*
Large negative earnings surprise x Earnings announcement % x Hybrid			-0.89	0.64
			(-0.7)	*(0.5)*
High earnings response coefficient x Earnings announcement %				1.99
				(2.4)
High earnings response coefficient x Earnings announcement % x Hybrid				-1.74
				(-1.7)
Limit order ratio	0.99	0.99	0.99	0.99
	(4.6)	*(4.6)*	*(4.6)*	*(4.6)*
Limit order ratio x Hybrid	-0.67	-0.67	-0.67	-0.67
	(-2.2)	*(-2.2)*	*(-2.2)*	*(-2.2)*
Observations	321,435	321,435	321,435	321,435
R^2	81%	82%	83%	83%

Table 5: Regressions of Non-EA Liquidity on Panel Earnings Announcements and Inventories, Controlling for Market-Wide Effects

Analysis period is June 1, 2006 through May 31, 2007. The dependent variable is *Residual effective spread* (in basis points) for common stocks on non-announcement days, calculated as the residual from a regression of the stock's effective spread on the average off-panel (market-wide) effective spread. *Residual effective spread* is regressed on earnings announcement and inventory measures and each measure interacted with *Hybrid*, an indicator variable equal to one if the stock has gone Hybrid on or before day t, else zero. *Earnings announcement %* is the percentage of stocks on the panel having earnings announcements on day t; *Off-panel Earnings announcement %* is the percentage of stocks off the panel (market-wide) having earnings announcements on day t; *Off-panel Industry Earnings announcement %* is the percentage of stocks off the panel (market-wide) in the same industry having earnings announcements on day t. *Inventory* $_{t-1}$ is the absolute inventory (in $100 millions) for all stocks on the panel on day t-1. *Inventory change* ^{EA} is the change in absolute inventory (in $1 millions) from day t-1 to day t for stocks on the panel having earnings announcements on day t. *Limit order ratio* is the ratio of non-marketable limit order volume to total order volume. Regressions also include stock fixed effects and the following control variables: the Hybrid indicator; market-wide volatility measured by the opening level of the VIX index; the log of the number of trades; the log of the average trade size; the stock's absolute return; a time trend; the Hybrid indicator interacted with all other control variables; and five lags of the dependent variable. Coefficients for the control variables other than Limit order ratio and for the constant are not reported. T-statistics, reported in parentheses below coefficient estimates, are robust to time-series and cross-sectional correlation.

	(1)	(2)	(3)
Earnings announcement %	3.02	3.03	3.02
	(3.4)	*(3.4)*	*(3.4)*
Earnings announcement % x Hybrid	-1.59	-1.45	-1.59
	(-1.7)	*(-1.6)*	*(-1.7)*
Off-panel Earnings announcement %	0.28		0.28
	(0.2)		*(0.2)*
Off-panel Earnings announcement % x Hybrid	-0.77		-0.78
	(-0.5)		*(-0.5)*
Off-panel Industry Earnings announcement %		-0.04	-0.04
		(-0.2)	*(-0.2)*
Off-panel Industry Earnings announcement % x Hybrid		0.19	0.20
		(0.9)	*(1.0)*
$Inventory_{t-1}$	0.45	0.45	0.45
	(2.3)	*(2.2)*	*(2.3)*
$Inventory_{t-1}$ x Hybrid	-0.25	-0.24	-0.25
	(-1.0)	*(-0.9)*	*(-1.0)*
Inventory change^{EA}	0.08	0.08	0.08
	(1.6)	*(1.6)*	*(1.6)*
Inventory change^{EA} x Hybrid	-0.07	-0.06	-0.07
	(-1.3)	*(-1.3)*	*(-1.3)*
Limit order ratio	1.00	1.00	1.00
	(4.6)	*(4.6)*	*(4.6)*
Limit order ratio x Hybrid	-0.65	-0.65	-0.65
	(-2.1)	*(-2.1)*	*(-2.1)*
Observations	321,435	321,435	321,435
R^2	82%	82%	84%

Table 6: Regressions of Non-EA Specialist Participation on Panel Earnings Announcements

Analysis period is June 1, 2006 through May 31, 2007. *Specialist participation rate* (expressed as a log odds ratio) for common stocks on non-announcement days is regressed on earnings announcement measures and each measure interacted with *Hybrid*, an indicator variable equal to one if the stock has gone Hybrid on or before day t, else zero. *Earnings announcement %* is the percentage of stocks on the panel having earnings announcements on day t; *Large positive (negative) earnings surprise x Earnings announcement %* is the interaction of Earnings announcement % with an indicator variable equal to to one for panel-days with positive (negative) earnings surprise in the top quartile of positive (negative) earnings surprises, else zero. *High earnings response coefficient x Earnings announcement %* is the interaction of Earnings announcement % with an indicator variable equal to one if the earnings response coefficient for the announcing stock is in the top quartile of earnings response coefficients, else zero. *Limit order ratio* is the ratio of non-marketable limit order volume to total order volume.

Regressions also include stock fixed effects and the following control variables: the Hybrid indicator; market-wide volatility measured by the opening level of the VIX index; the inverse of the stock price; the log of the number of trades; the log of the average trade size; the stock's absolute return; a time trend; the Hybrid indicator interacted with all other control variables; and five lags of the dependent variable. Coefficients for the control variables other than Limit order ratio and for the constant are not reported. T-statistics, reported in parentheses below coefficient estimates, are robust to time-series and cross-sectional correlation.

	(1)	(2)	(3)	(4)
Earnings announcement %	-0.08	-0.07	-0.09	-0.07
	(-3.2)	*(-2.6)*	*(-3.3)*	*(-2.7)*
Earnings announcement % x Hybrid	-0.06	-0.08	-0.05	-0.09
	(-2.9)	*(-2.3)*	*(-2.3)*	*(-2.6)*
Large positive earnings surprise x Earnings announcement %		-0.05		-0.05
		(-1.9)		*(-2.0)*
Large positive earnings surprise x Earnings announcement % x Hybrid		0.09		0.10
		(0.7)		*(0.8)*
Large negative earnings surprise x Earnings announcement %		-0.06		-0.06
		(-0.8)		*(-0.8)*
Large negative earnings surprise x Earnings announcement % x Hybrid		0.20		0.20
		(1.1)		*(1.1)*
High earnings response coefficient x Earnings announcement %		-0.11		-0.11
		(-2.5)		*(-2.5)*
High earnings response coefficient x Earnings announcement % x Hybrid		0.10		0.11
		(1.0)		*(1.1)*
Limit order ratio			-0.02	-0.03
			(-3.4)	*(-3.4)*
Limit order ratio x Hybrid			-0.04	-0.04
			(-3.1)	*(-3.1)*
Observations	316,353	316,353	316,353	316,353
R^2	60%	60%	60%	61%

Table 7: Regressions of Specialist Participation on Same-Stock Earnings Announcements

Analysis period is June 1, 2006 through May 31, 2007. Specialist participation rate (expressed as a log odds ratio) for common stocks on all days is regressed on *Earnings announcement* , an indicator variable equal to one if the stock has an earnings announcement on day t, else zero, and Earnings announcement interacted with *Hybrid* , an indicator variable equal to one if the stock has gone Hybrid on or before day t, else zero. *Market order ratio* is the ratio of market and marketable limit order volume to total order volume.

Regressions also include stock fixed effects and the following control variables: the Hybrid indicator; market-wide volatility measured by the opening level of the VIX index; the inverse of the stock price; the log of the number of trades; the log of the average trade size; the stock's absolute return; a time trend; the Hybrid indicator interacted with all other control variables; and five lags of the dependent variable. Coefficients for the control variables other than Market order ratio and for the constant are not reported. T-statistics, reported in parentheses below coefficient estimates, are robust to time-series and cross-sectional correlation.

	(1)	(2)
Earnings announcement	0.15	0.15
	(6.9)	*(7.5)*
Earnings announcement x Hybrid	0.07	0.06
	(3.3)	*(3.1)*
Market order ratio		0.02
		(3.3)
Market order ratio x Hybrid		0.05
		(3.7)
Observations	322,521	322,521
R^2	58%	58%

Table 8: Regressions of Non-EA Off-Floor Market Maker Participation on Panel Earnings Announcements

Analysis period is June 1, 2006 through May 31, 2007. Off-floor market maker participation rate (expressed as a log odds ratio) for common stocks on non-announcement days is regressed on earnings announcement measures and each measure interacted with *Hybrid* , an indicator variable equal to one if the stock has gone Hybrid on or before day t, else zero. *Earnings announcement %* is the percentage of stocks on the panel having earnings announcements on day t; *Large positive (negative) earnings surprise x Earnings announcement %* is the interaction of Earnings announcement % with an indicator variable equal to to one for panel-days with positive (negative) earnings surprise in the top quartile of positive (negative) earnings surprises, else zero. *High earnings response coefficient x Earnings announcement %* is the interaction of Earnings announcement % with an indicator variable equal to one if the earnings response coefficient for the announcing stock is in the top quartile of earnings response coefficients, else zero.

Regressions also include stock fixed effects and the following control variables: the Hybrid indicator; market-wide volatility measured by the opening level of the VIX index; the inverse of the stock price; the log of the number of trades; the log of the average trade size; the stock's absolute return; a time trend; the Hybrid indicator interacted with all other control variables; and five lags of the dependent variable. Coefficients for the control variables and constant are not reported. T-statistics, reported in parentheses below coefficient estimates, are robust to time-series and cross-sectional correlation.

	(1)	(2)
Earnings announcement %	0.49	0.51
	(3.2)	*(3.3)*
Earnings announcement % x Hybrid	0.51	0.53
	(3.0)	*(3.1)*
Large positive earnings surprise x Earnings announcement %		-0.12
		(-0.7)
Large positive earnings surprise x Earnings announcement % x Hybrid		0.05
		(0.2)
Large negative earnings surprise x Earnings announcement %		-0.08
		(-0.2)
Large negative earnings surprise x Earnings announcement % x Hybrid		0.31
		(0.5)
High earnings response coefficient x Earnings announcement %		-0.24
		(-1.3)
High earnings response coefficient x Earnings announcement % x Hybrid		0.36
		(1.4)
Observations	316,353	316,353
R^2	49%	49%

Appendix: Correlations between Earnings Announcements and Trade-based Attention Measures

Pooled correlations are presented for all stock panels from June 1, 2006 to May 31, 2007. Trade-based attention measures are defined as follows:
Attention1 = number of trades/standard deviation of number of trades across all panel/days
Attention2 = absolute return in basis points/standard deviation of absolute return in basis points across all panel/days
Attention3 = Attention1 x Attention2
Earnings announcement % is the percentage of stocks on the panel having earnings announcements that day. Data are from TAQ, IBES, and the NYSE Symbol Trading Location file. All correlations are significant at the 1% level, indicated by bold type.

	Attention1	Attention2	Attention3	Earnings announcement
Attention1	1.00			
Attention2	**0.43**	1.00		
Attention3	**0.73**	**0.57**	1.00	
Earnings announcement %	**0.53**	**0.65**	**0.34**	1.00

Figure 1: Specialist Panels and Average Number of Stocks per Panel
This chart graphs the number of specialist panels and the average number of stocks per panel from June 1, 2006 to May 31, 2007. The shaded box indicates the Hybrid rollout period. Data are from the NYSE Symbol Trading Location file.

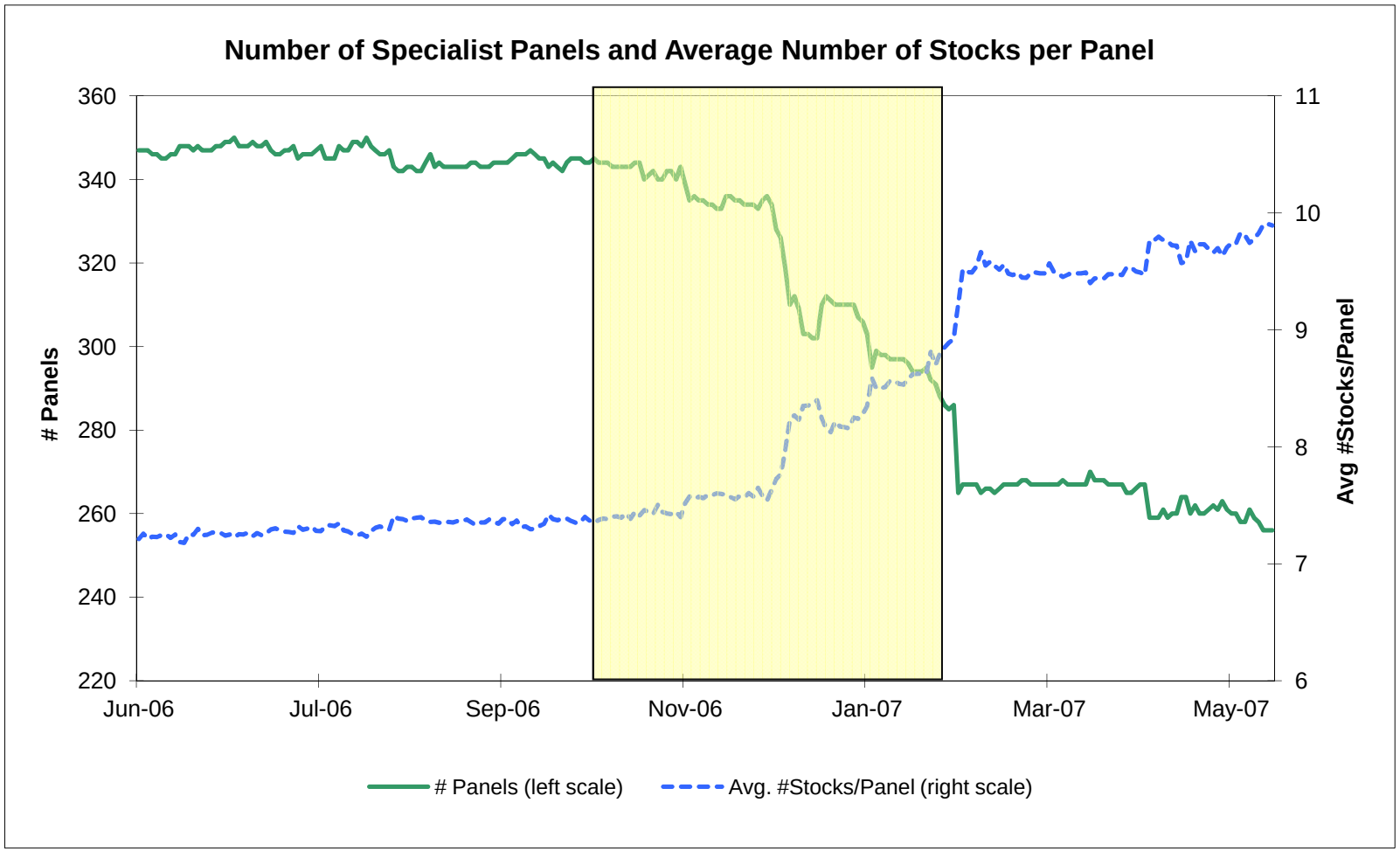

Figure 2: Earnings Announcement Percentages per Specialist Panel

This chart graphs the daily percentage of earnings announcements per specialist panel, excluding single-stock panels, from June 1, 2006 to May 31, 2007. Earnings announcement percentages are weighted by the average volume of stocks on the panel. Data are from IBES and the NYSE Symbol Trading Location file.