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News-driven return reversals: Liquidity provision ahead of earnings announcements ☆

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A B S T R A C T

This study documents a six-fold increase in short-term return reversals during earnings announcements relative to non-announcement periods. Following prior research, we use reversals as a proxy for expected returns market makers demand for providing liquidity. Our findings highlight significant time-series variation in the magnitude of short-term return reversals and suggest that market makers demand higher expected returns prior to earnings announcements because of increased inventory risks that stem from holding net positions through the release of anticipated earnings news. Collectively, our findings suggest that uncertainty regarding anticipated information events elicits predictable increases in the compensation demanded for providing liquidity and that these increases significantly affect the dynamics and information content of market prices.

1. Introduction

Several market frictions have the potential to significantly impact the efficiency and information content of market prices. This study focuses on the friction that arises from the need to locate a counterparty in order to complete a trade. Market makers typically mitigate this friction by matching would-be sellers with would-be buyers. When there is an imbalance between the quantities sought by buyers and sellers at a given price, market makers may absorb the order imbalance into their own account by serving as the trade counterparty.[1] This practice is commonly known as liquidity provision.

This article's contribution is to study how the expected returns to liquidity provision change prior to anticipated information events. The theoretical motivation for this

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[1] Following Hendershott, Jones, and Menkveld (2011), we use the term market makers to refer to the broad category of liquidity providers that includes, but is not limited to, officially designated market makers, quantitative funds, and algorithmic and institutional traders. Related research underscores that the traditional role of market makers has shifted toward high frequency and algorithmic traders (e.g., Brogaard, 2010; Menkveld, 2013).

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paper stems from a setting that includes both informed and uninformed traders, as in Kyle (1985), and where risk-averse market makers demand compensation for providing liquidity, as in Grossman and Miller (1988). A common result in models of liquidity provision is that market makers are compensated via price concessions by setting prices below (above) fundamental value in response to sell (buy) order imbalances. As market makers unwind their net positions, the excess of price concessions when entering versus exiting the positions results in a positive expected return, which manifests as a negative autocorrelation in returns.

In this paper, we use the extent of negative return autocorrelation (i.e., return reversals) as a proxy for the expected returns that market makers demand for providing liquidity and earnings announcements as an example of anticipated information events. Our goal is to examine whether these events elicit predictable changes in return reversals. ex ante, it is unclear whether reversals should increase or decrease during anticipated information events. On one hand, models of liquidity provision such as Nagel (2012) indicate that market makers demand compensation for incurring inventory risks (i.e., risks of adverse changes in the prices of their net positions) and adverse selection. These models suggest that greater anticipated volatility and/or adverse selection risks associated with information events should lead to increased reversals. On the other hand, models such as those in Campbell, Grossman, and Wang (1993) and Llorente, Michaely, Saar, and Wang (2002) indicate that the arrival of fundamental news, via public announcements or privately informed trade, increases the martingale component of returns and thus should lead to decreased reversals during information events (see Appendix A for more details). This paper assesses the balance of these competing forces and establishes several robust patterns in the dynamics of reversals surrounding earnings announcements. Our central empirical result is that return reversals increase enormously during earnings announcements relative to non-announcement periods, indicating that market makers demand greater compensation for providing liquidity ahead of anticipated information events.

We quantify the impact of anticipated information events on liquidity provision by contrasting reversal magnitudes during earnings announcements and non-announcement periods. Specifically, we show that a long (short) position in firms whose returns strongly underperform (outperform) the market in the three days prior to earnings announcements yields an average return of 145 basis points (bps) during the announcement window. By comparison, the average return to a comparable portfolio during non-announcement periods is 22 bps, indicating that return reversals increase more than six-fold during earnings announcements. We also plot reversal magnitudes in event-time and show that they gradually rise ahead of announcements and fall sharply immediately afterwards. These findings are consistent with a sizable decrease in liquidity as defined by Pastor and Stambaugh (2003) in the sense that order flow induces increasingly large price fluctuations prior to earnings announcements. Additional tests confirm that the concentration of reversals during earnings announcements is robust to the use of midpoint and open-to-close returns, and skipping a day between return windows, which mitigate the influence of bid–ask bounce.

Several decades of research document robust empirical evidence of return reversals in daily, weekly, and monthly calendar-time portfolios [see Madhavan (2000) for a review of this literature]. Our study differs from these prior studies by examining changes in liquidity provision ahead of anticipated information events and is thus closely related to Tetlock (2010). Tetlock (2010) models how risk-averse market makers accommodate liquidity demands but differs from standard models of liquidity provision in its explicit assumptions regarding the role and timing of public news. In Tetlock (2010), traders receive a private signal and incur a persistent liquidity shock prior to a public announcement. Consistent with our central empirical prediction, market makers in his model are particularly averse to providing liquidity prior to the announcement. However, the announcement reduces asymmetric information, which makes market makers less reluctant to accommodate the persistent liquidity shock and contributes to positive return momentum following the announcement. Empirically, Tetlock (2010) provides evidence that public information can attenuate return reversals. Thus, whereas Tetlock (2010) focuses on changes in return dynamics after announcements, our contribution is to examine how liquidity provision changes prior to announcements.

We also explore adverse selection and inventory risks as non-mutually exclusive explanations for increased return reversals during earnings announcements. Greater adverse selection can increase reversals by eliciting larger net order imbalances but can also decrease reversals by raising the martingale component of returns driven by the arrival of fundamental news. Our empirical tests show that return reversal magnitudes do not vary significantly with proxies for asymmetric information, which suggests that increased reversals during earnings announcements are less likely to be driven by adverse selection because asymmetric information is a necessary condition for, and contributing factor to, informed trade. Our inferences are also unchanged when implementing reversal strategies using portfolio weights designed to mitigate the influence of price impact due to adverse selection. These findings corroborate predictions common to models of liquidity provision with bid–ask spreads that adverse selection results in wider spreads but does not induce negative autocorrelation in returns (Glosten and Milgrom, 1985).[2]

To explore the role of inventory risks, we predict that market makers demand higher expected returns for providing liquidity ahead of announcements with greater anticipated return volatility.[3] The intuition for this

[2] The model in Nagel (2012) does not include a bid–ask spread. The addition of a spread allows market makers to widen spreads as compensation for exposure to adverse selection risks.

[3] Prior research shows that market makers manage small baskets of securities, rather than diversified portfolios, which makes them averse to idiosyncratic risks, and also have limited risk-bearing capacity because losses on positions may trigger margin requirements and/or internal risk

prediction is that market makers often take multiple days to unwind net positions and, thus, providing liquidity immediately prior to high volatility events increases their exposure to inventory risks (Madhavan and Smidt, 1993). Following Patell and Wolfson (1981), we use implied volatilities from pre-announcement option prices to measure anticipated volatility specific to the earnings announcement window. We show that return reversals are larger when there is greater volatility expected during the announcement, suggesting that market makers anticipate the level of uncertainty associated with information events and adjust expected returns to compensate themselves for varying levels of inventory risks.[4] Similarly, we predict and find that unanticipated earnings announcements do not give rise to increased return reversals, suggesting that market makers do not raise expected returns to liquidity provision when they are not anticipating an increase in volatility. Together, these findings suggest that increases in return reversals during earnings announcements are more likely driven by market makers' aversion to greater inventory risks associated with holding net positions through the release of earnings news.

The results of this paper show that a substantial portion of short-term reversals are concentrated around anticipated information events, which provides evidence that return reversals are highly time-varying and depend on investors' expectations of impending news. These findings highlight significant variation in the time-series properties of return reversals and provide evidence that liquidity providers' short-term demand curves are increasingly downward sloping prior to anticipated information events. These findings contribute to the literature by documenting the time-series properties of short-term reversal magnitudes and by providing evidence that anticipated information events elicit rapid shifts in the expected returns to liquidity provision.

Our findings also indicate that market makers anticipate the level of uncertainty associated with information events and adjust expected returns to compensate themselves for variation in the level and timing of risks. Because the uncertainty associated with an earnings announcement is likely a function of the reporting firm's disclosures, our findings relate to prior research on the link between disclosure and liquidity (e.g., Amihud and Mendelson, 1986; Diamond and Verrecchia, 1991). Whereas most empirical tests of these theories focus on the impact of disclosure on liquidity through the lens of adverse selection [see Healy and Palepu (2001) and Beyer, Cohen, Lys, and Walther (2010) for reviews of this literature], our findings emphasize inventory risks as an alternative and complementary channel through which firms' disclosures elicit significant variation in liquidity around earnings announcements by mitigating uncertainty regarding the timing and content of news releases. Our findings suggest that overnight inventory risks significantly increase prior to earnings announcements and reduce liquidity by making prices more sensitive to net order flows.

The remainder of the paper is organized as follows. Section 2 discusses our methodology and main findings. Section 3 discusses additional analyses and Section 4 concludes.

2. Empirical tests

This section contains details of our sample selection and the results of our main tests.

2.1. Sample selection

We construct the main dataset used in our analyses from three sources. We obtain price and return data from the Center for Research in Security Prices (CRSP), firm fundamentals from Compustat, and option-implied volatilities from OptionMetrics to calculate pre-announcement implied volatilities associated with the earnings announcement window.[5] We begin our analysis by examining quarterly earnings announcement dates reported in Compustat, though we also consider expected announcement dates in subsequent tests. To mitigate the influence of bid–ask bounce on our calculation of return reversals as noted in Roll (1984), we next eliminate firms with prices below \$5 and employ alternative means of calculating returns. Our final sample consists of 107,039 earnings announcements spanning from 1996 to 2011.

Panel A of Table 1 contains descriptive statistics on the sample used throughout our main analyses. Because our main analyses examine return reversals during earnings announcements, our primary predictive variable is the pre-announcement return, PAR, defined as the cumulative market-adjusted return from $t-4$ to $t-2$ where t is the firm's quarterly earnings announcement date.[6] For our primary analyses, we measure pre-announcement returns over the three-day window from $t-4$ to $t-2$ for ease of comparison with the three-day earnings announcement window from $t-1$ to $t+1$, though we examine the robustness of our findings to alternative return specifications in subsequent tests. RET$(-1,+1)$ reflects the market-adjusted announcement return from $t-1$ to $t+1$. SUE equals a firm's standardized unexpected earnings, calculated as realized earnings-per-share (EPS) minus EPS from four-quarters ago, divided by its standard deviation over

(*footnote continued*)
controls that force market makers to lock in trading losses by closing losing positions (e.g., Comerton-Forde, Hendershott, Jones, Moulton, and Seasholes, 2010).

[4] Market makers distort prices to prevent excess inventories in a way that may impose costs on the market maker. The model in Hendershott and Menkveld (2014) captures the idea that by charging a transitory price impact, the market maker induces offsetting buy or sell orders by effectively paying other traders to take the position for him. However, when inducing other traders to take the position, the market maker incurs a revenue loss that reduces expected consumption.

[5] In untabulated results, we find qualitatively identical return reversals when removing the requirement that observations have option-implied volatilities in the OptionMetrics database.

[6] Our main analyses focus on the returns during actual announcement dates, instead of expected announcement dates, because we are interested in understanding the source of predictable patterns in announcement returns, which are commonly the focus in studies of the market's reaction to earnings news. See Section 3.2 for discussion of expected announcement dates.

Table 1
Descriptive statistics.

Panel A presents descriptive statistics of the main variables used throughout the paper. PAR is the pre-earnings-announcement return calculated as the cumulative market-adjusted return from $t-4$ to $t-2$, where day t denotes the earnings announcement date. SUE is the standardized unexpected earnings, calculated as realized EPS minus EPS from four-quarters ago, divided by its standard deviation over the prior eight quarters. RET($-1,+1$) is the market-adjusted earnings announcement return from $t-1$ to $t+1$. SIZE and LBM are the log of market capitalization and log of one plus the book-to-market ratio, respectively. VLTY is the standard deviation of daily returns over the six months ending on $t-10$. SP equals the relative spread calculated from $t-4$ to $t-2$. PRICE is the beginning-of-quarter equity share price. Panel B contains descriptive statistics across PAR quintiles. Observations are assigned to quintiles each calendar quarter where the highest (lowest) values are assigned to quintile Q5 (Q1) using distributional breakpoints from the prior calendar quarter. The sample consists of 107,039 earnings announcements spanning 1996 through 2011.

Panel A: Sample characteristics

	Mean	STD	P25	Median	P75
PAR	0.153	4.893	−2.040	−0.018	2.099
SUE	0.003	1.869	−0.539	0.081	0.690
RET(−1,+1)	0.176	8.774	−3.771	0.092	4.205
SIZE	14.265	1.527	13.156	14.094	15.178
LBM	0.387	0.256	0.219	0.345	0.501
VLTY	0.026	0.015	0.016	0.023	0.033
SP	0.610	0.835	0.109	0.224	0.830

Panel B: Characteristics by pre-announcement return quintiles

	SIZE	LBM	VLTY	SP	PRICE
Q1 (Low PAR)	13.913	0.383	0.031	0.696	26.319
Q2	14.380	0.388	0.025	0.664	41.734
Q3	14.529	0.386	0.023	0.656	41.829
Q4	14.428	0.387	0.025	0.660	49.017
Q5 (High PAR)	13.962	0.377	0.031	0.680	38.111
High–Low	0.049	−0.006	0.000	−0.016	11.792
p-Value	(0.05)	(0.14)	(0.70)	(0.11)	(0.14)

the prior eight quarters. SIZE and LBM are the log of market capitalization and log of one plus the book-to-market ratio, respectively, where both are measured five days prior to the announcement. PRICE is the beginning-of-quarter share price. VLTY is the standard deviation of daily returns, and SP equals the bid–ask spread scaled by the midpoint quote calculated using the methodology in Corwin and Schultz (2012), where both variables are measured over the six months ending on $t-10$.

Panel B of Table 1 presents descriptive statistics across quintiles of PAR. Quintiles are formed each quarter using the distributional breakpoints from the prior calendar quarter, where higher (lower) values are assigned to quintile Q5 (Q1). Panel B demonstrates that the extreme quintiles of PAR (i.e., quintiles Q5 and Q1) consist of firms that are generally smaller, possess lower book-to-market ratios and share prices, and have higher volatility and relative spreads. These results suggest that pre-announcement price movements are concentrated among firms with poor information environments and larger trading frictions.

2.2. Announcement-window return reversals

In this section, we test our central hypothesis that expected returns to liquidity provision rise prior to information events due to increases in anticipated volatility and/or adverse selection. Market makers demand compensation because they are averse to inventory imbalances and liquidity provision requires absorbing net order flows in their own account. We are unable to directly observe market makers' inventory imbalances and thus, similar to studies of asymmetric information, we are unable to directly observe the underlying factor driving variation in liquidity and must instead make inferences based on observable market outcomes. Following Nagel (2012), we use market-adjusted returns in the pre-announcement period to proxy for market makers' inventory imbalances.

Panel A of Table 2 contains time-series averages of various return metrics across quintiles of pre-announcement returns (PAR). Positive (negative) pre-announcement returns are consistent with market makers raising (lowering) prices in response to buy (sell) order imbalances and thus, we expect to observe negative (positive) returns during the announcement that reflect the reversal of pre-announcement price concessions. Bolded values in Table 2 indicate that the reported value is significantly different from zero at the 5% level, which we calculate using the quarterly time-series spanning our 1996–2011 sample window.

The first column of Panel A shows that the pre-announcement return is fairly symmetric across the extreme quintiles of PAR and that they are reliably different than zero for all but the middle quintile. The second column shows that returns in the pre-announcement period reverse during the earnings announcement and that average announcement returns are monotonically decreasing across quintiles of PAR. Low PAR firms tend to earn 81 basis points during the announcement window and high PAR firms tend to lose 64 basis points.[7] The bottom row shows that the combined return earned over the three-day announcement window is 145 basis points and significant at the 1% level. These findings indicate that reversals significantly impact realized returns during earnings announcements and are thus related to a substantial literature that uses the magnitude of earnings announcement returns to study the information content of earnings (e.g., Ball and Brown, 1968), shocks to investor expectations (e.g., Hirshleifer, Lim, and Teoh, 2009; Della Vigna and Pollet, 2009), and whether investors misprice predictable variation in earnings (e.g., Sloan, 1996; La Porta, Lakonishok, Shleifer, and Vishny, 1997; Piotroski and So, 2012). Specifically, our findings show that changes in the

[7] Larger reversals among low PAR firms are consistent with Comerton-Forde, Hendershott, Jones, Moulton, and Seasholes (2010) who find that NYSE specialists have positive net positions 94% of the time (not specific to announcements) and suggests that market makers prefer to sell existing positions over increasing long positions ahead of announcements.

Table 2
Announcement-window returns across pre-announcement return portfolios.

Panel A presents the time-series average returns by quintiles of PAR. PAR is the pre-earnings-announcement return calculated as the cumulative market-adjusted return from $t-4$ to $t-2$, where t denotes the earnings announcement date. Observations are assigned to quintiles each calendar quarter where the highest (lowest) values are assigned to quintile Q5 (Q1) using distributional breakpoints from the prior calendar quarter. RET(X,Y) equals the cumulative market-adjusted return from X days relative to the announcement until Y days relative to the announcement date. The average return to each PAR quintile is calculated each calendar quarter and subsequently averaged across all quarters in the 1996–2011 sample window. Panel B presents analogous average returns using pseudo-earnings-announcements. Pseudo-announcement dates are calculated by subtracting a randomly selected number of trading days from the actual announcement date. The randomly selected numbers are drawn from a uniform distribution spanning 10–40 days. Panel C compares the returns from reversal strategies at actual and pseudo-announcement dates. The p-values corresponding to the high-low difference are based on the time-series of quarterly returns. Bolded values indicate that the return is significant at the 5% confidence level. The sample consists of 107,039 earnings announcements spanning 1996 through 2011.

Panel A: Averages across pre-announcement return quintiles

	PAR	RET(−1,+1)	RET(+2,+5)	RET(+6,+8)
Q1 (Low PAR)	**−5.780**	**0.813**	0.072	0.038
Q2	**−1.763**	**0.529**	0.099	0.074
Q3	−0.018	**0.250**	0.032	**0.086**
Q4	**1.823**	0.059	0.042	0.045
Q5 (High PAR)	**6.621**	**−0.635**	**−0.191**	0.011
Low–High	−12.401	1.448	0.263	0.028
p-Value	(0.00)	(0.00)	(0.01)	(0.75)

Panel B: Averages across pre-announcement return quintiles

	PAR	RET(−1,+1)	RET(+2,+5)	RET(+6,+8)
Q1 (Low PAR)	**−5.734**	**0.214**	**0.196**	0.106
Q2	**−1.771**	0.032	**0.142**	−0.012
Q3	**−0.101**	0.029	−0.007	−0.012
Q4	**1.616**	−0.029	−0.039	0.025
Q5 (High PAR)	**6.323**	−0.004	−0.085	0.044
Low–High	−12.058	0.218	0.281	0.062
p-Value	(0.00)	(0.00)	(0.00)	(0.47)

Panel C: Average differences between actual and pseudo dates

	PAR	RET(−1,+1)	RET(+2,+5)	RET(+6,+8)
Mean	−0.343	1.230	−0.018	−0.035
p-Value	(0.04)	(0.00)	(0.88)	(0.80)

expected returns to liquidity provision have an economically large impact on announcement returns. Thus, these findings highlight the need to control for the component of announcement returns driven by the expected returns to liquidity provision to avoid misattributing this component to other phenomena such as the information content of the announcement.

The bolded values of RET(−1,+1) in Panel A of Table 2 also show that announcement returns are significantly positive only for the bottom three PAR quintiles, for which the pre-announcement return is negative.[8] The third and final columns of Panel A demonstrate that although there is some continuation of the reversal during the $t+2$ to $t+5$ window, the magnitudes drop significantly and become insignificant in the $t+6$ to $t+8$ window indicating that the reversal is short-lived. The continuation of reversals past the announcement window is consistent with Madhavan and Smidt (1993) and Jegadeesh and Titman (1995), which find that market makers take multiple days to revert inventory imbalances toward targeted levels.

To compare the magnitude of announcement-window return reversals to those in non-announcement periods, we repeat the analysis from Panel A using a randomly selected ‘pseudo-announcement’ date in place of the actual announcement date, as depicted in the timeline in Fig. 1. The timeline uses firms with a December 2nd earnings announcement date as an example, and ignores weekends and trading holidays, to illustrate the separation between actual and pseudo-announcement dates. Similar to Lee, Ready, and Seguin (1994) and Christie, Corwin, and Harris (2002), we calculate pseudo-announcement dates as a baseline period relative to actual announcement dates by subtracting a randomly selected number of trading days. We draw from a uniform distribution spanning 10–40 days to reduce the likelihood that returns surrounding pseudo-announcement dates are influenced by the proximity to actual earnings announcement dates. Panel B contains time-series average returns, where all returns are measured relative to pseudo-announcement dates.[9]

The first column of Panel B contains returns in the three days prior to pseudo-announcements, which are similar to the magnitudes of pre-announcement returns shown in Panel A. The second column shows that the average reversal strategy return during pseudo-announcement dates is 21.8 basis points, which is statistically significant but less than one-sixth of the average from actual announcement dates. The analyses underlying Panel B are akin to a placebo test because the pseudo-announcement matches the duration of the actual earnings announcement but corresponds to a time when we would not expect an increase in return reversals due to anticipated news. Panel C of Table 2 shows the difference in returns across actual and pseudo-announcement dates. Although the difference in pre-announcement returns for

[8] In studying predictable return reversals, our findings also relate to the literature on predictable returns around earnings announcements. Several papers including Ball and Kothari (1991), Barber, De George, Lehavy, and Trueman (2013), and Johnson and So (2014) document that equity returns are generally positive around earnings announcements and that they are concentrated among smaller, more volatile firms where market makers' inventory holding costs are likely to be high. Whereas these prior studies focus on the difference in average returns across announcing and non-announcing firms, our findings examine changes in reversal strategy returns in the period prior to firms' earnings announcements.

[9] For example, if k denotes the pseudo-announcement date, PAR measures the market-adjusted return from $k-4$ to $k-2$. Additionally, for pseudo-announcements, we use the notation RET(X,Y) to indicate market-adjusted return from $k+X$ to $k+Y$.

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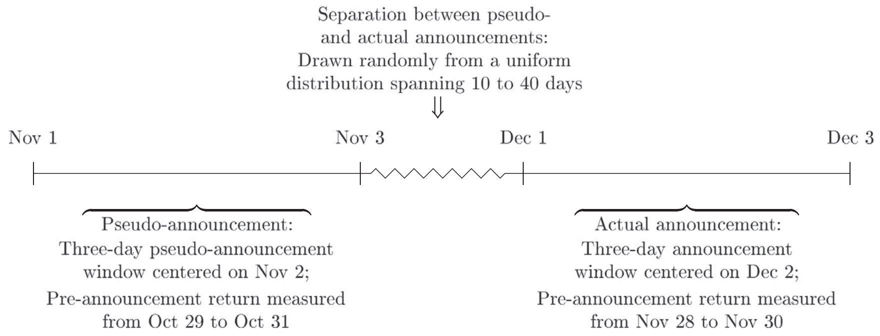

Fig. 1. Timeline of analysis. The figure contains a timeline of actual and pseudo-announcement dates used in the main analyses. The timeline uses firms with a December 2nd earnings announcement date as an example, and ignores weekends and trading holidays, to illustrate the separation between actual and pseudo-announcement dates. Actual announcement dates reflect the quarterly earnings announcement as reported in Compustat. Pre-announcement returns are calculated from $t-4$ to $t-2$ as the cumulative market-adjusted return, where day t is the earnings announcement. Pseudo-announcement dates are calculated by subtracting a randomly selected number of trading days from the actual announcement date. The randomly selected numbers are drawn from a uniform distribution spanning 10–40 days. The sample consists of 107,039 earnings announcements spanning 1996 through 2011.

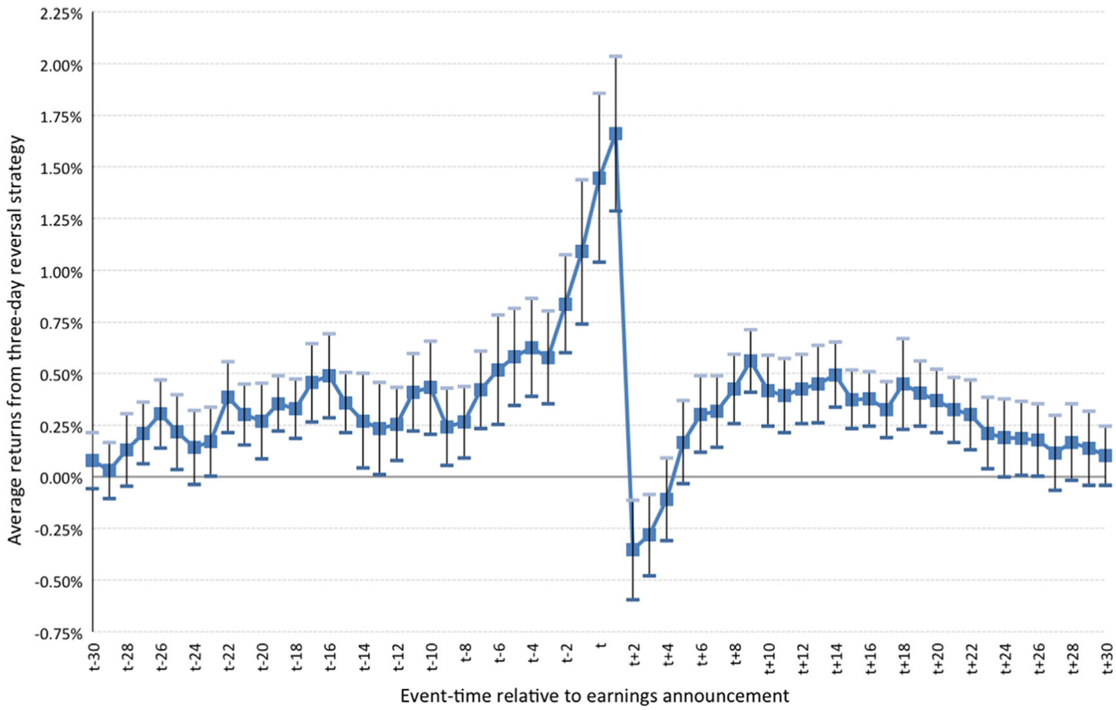

Fig. 2. Event-time return reversals relative to announcement. The figure plots the average three-day return reversal and 95% confidence interval from a strategy that takes a short position in firms within the highest quintile of returns over the prior three-day window and a long position in firms within the lowest quintile. Quintiles are formed each calendar quarter using breakpoints from the prior calendar quarter. The figure is shown in event-time, where day t corresponds to the earnings announcement date. The reported strategy return is centered on the date shown on the X-axis such that the reported quantity corresponding to day t reflects the three-day cumulative strategy return from $t-1$ to $t+1$ from a long position in the lowest quintile of returns from $t-4$ to $t-2$ and a short position in the highest quintile of returns from $t-4$ to $t-2$. The 95% confidence interval is constructed using the time-series of quarterly average returns. The sample consists of 107,039 earnings announcements spanning 1996 through 2011.

actual and pseudo-announcements is 34 basis points, the return reversal for actual announcements is over 120 basis points larger than for pseudo-announcements. The six-fold increase in reversals during actual announcements compared to pseudo-announcements is significant at the 1% level, suggesting that impending information events significantly shift market makers' willingness to provide liquidity and thus increase the expected returns that market makers demand ahead of anticipated information events.

Fig. 2 captures one of the main results of the paper. The figure contains the time-series average three-day return reversal and 95% confidence interval from an event-time strategy that takes a short (long) position in firms with the highest (lowest) returns over the prior three-day window. The reported strategy return is centered on the date

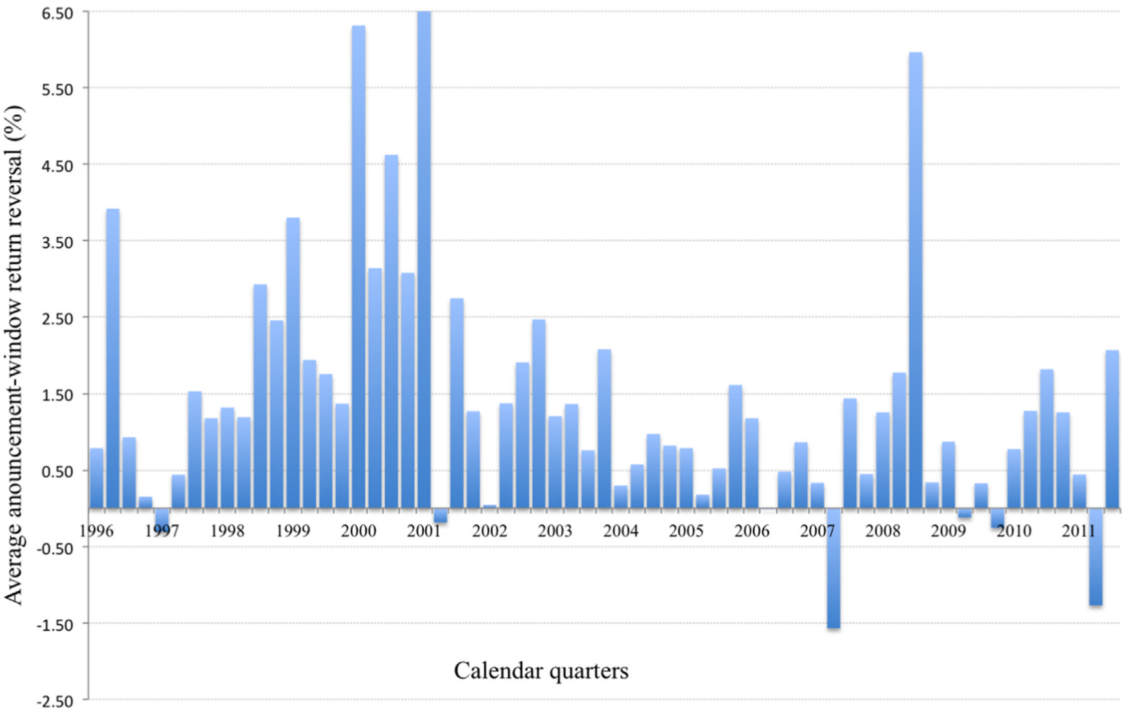

Fig. 3. Average reversal returns by calendar quarter. The figure plots the average reversal strategy return for each calendar quarter in the sample. The strategy involves buying (selling) firms in the lowest (highest) pre-announcement returns (PAR) during the firm's three-day earnings announcement window, denoted by $t-1$ to $t+1$, where day t is the earnings announcement. PAR is calculated from $t-4$ to $t-2$ as the cumulative market-adjusted return. Quintiles are formed each calendar quarter using breakpoints from the prior calendar quarter. The sample consists of 107,039 earnings announcements spanning 1996 through 2011.

shown on the X-axis such that the reported quantity corresponding to day t reflects the three-day cumulative strategy return from $t-1$ to $t+1$ from a long position in the lowest quintile of returns from $t-4$ to $t-2$ and a short position in the highest quintile of returns from $t-4$ to $t-2$.[10] Consistent with the findings in Table 2, Fig. 2 highlights a stark contrast in reversal magnitudes during earnings announcement dates relative to non-announcement periods.

Fig. 2 also highlights a pattern of gradually increasing reversals leading up to the announcement suggesting that market makers increase expected returns in anticipation of information leakage, and thus potential volatility, ahead of the announcement date. Reversals peak on day $t+1$ rather than t, which demonstrates that the peak reversal occurs when the pre-announcement return is measured from $t-3$ to $t-1$ and the reversal is measured from t to $t+2$, consistent with the expected returns to liquidity provision increasing in the proximity to information events. The figure also demonstrates that reversals fall precipitously following the announcement suggesting that market makers drastically reduce the premium for liquidity provision immediately following the resolution of uncertainty associated with the announcement. The fact that the sign of the reversal strategy return changes immediately after the announcement is also consistent with the evidence in Tetlock (2010) that returns on non-news days tend to reverse whereas returns on news days tend to continue.

Together, the evidence in Fig. 2 illustrates a sharp contrast between the pre-announcement ascent and post-announcement descent of return reversals and thus provides compelling evidence of the influence of anticipated information events on the expected returns to liquidity provision. Whereas Nagel (2012) provides evidence of longer lasting variation in return reversals driven by market-wide funding constraints, our findings contribute to the literature by documenting the time-series properties of return reversals over short horizons. Thus, studies weighing behavioral explanations for reversal patterns should consider how their explanations reconcile with predictable spikes and declines in reversal magnitudes around earnings announcements (e.g., Subrahmanyam, 2005; Da, Liu, and Schaumburg, 2014). Additionally, our results suggest that prices become increasingly sensitive to order flow ahead of announcements and thus highlight a sizable shift in common metrics for liquidity (Pastor and Stambaugh, 2003). Hence, these results strongly caution against the use of non-event-based measures of liquidity when examining the profitability of trades placed ahead of anticipated information events.

[10] We also examine the rolling three-day average returns to the long- and short-legs of the reversal strategy (i.e., portfolios of 'winners' and 'losers' sorted by their returns over the prior three days) in event-time. We find that change in reversals is symmetric across the long- and short-legs such that both portfolios earn more extreme returns during announcements relative to non-announcement periods. These findings are available in an online appendix.

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Fig. 3 provides the average reversal strategy return during earnings announcements for each calendar quarter in the sample. The average return is positive for 58 out of the 64 calendar quarters and positively skewed. Reversal strategy returns appear more pronounced in the first half of the sample, which may reflect the evolution of market microstructure, shifts in the types of traded firms, and/or changes to the composition of liquidity providers such as increased involvement from high-frequency traders that attempt to avoid holding inventories overnight (Brogaard, Hendershott, and Riordan, 2013).[11] While disentangling these potential explanations is beyond the scope of this paper, the figure demonstrates that the average return remains economically significant throughout the 1996–2011 sample window. Additionally, consistent with Nagel (2012), Fig. 3 shows that reversal returns are largest during the collapse of the tech bubble and during the financial crisis, suggesting that market makers demand higher expected returns for providing liquidity in periods of market turmoil when they have limited access to capital to fund net positions.

Table 3 examines the robustness of the return reversals documented in Table 2 when using three alternative definitions of returns. One alternative explanation for the evidence of predictable announcement returns is that they are inflated by bid–ask bounce (Kaul and Nimalendran, 1990). To mitigate this concern, we repeat our analyses using open-to-close returns, midpoint-to-midpoint returns, and close-to-close returns after skipping one trading day between the pre-announcement and announcement windows. Open-to-close indicates that returns are measured from the opening price on the first day of the window to the closing price on the last day of the window. Specifically, OPAR measures open-to-close returns from $t-4$ to $t-2$ and ORET measures open-to-close returns from $t-1$ to $t+1$. Midpoint-to-midpoint returns are defined analogously using the midpoint of the closing bid and ask quotes in CRSP following Nagel (2012). MPAR measures midpoint-to-midpoint returns from $t-4$ to $t-2$ and MRET measures midpoint-to-midpoint returns from $t-1$ to $t+1$. Additionally, Close-to-close, 1-Day skip indicates the use of standard returns reported in CRSP while measuring pre-announcement returns from $t-5$ to $t-3$ and announcement-window returns from $t-1$ to $t+1$. We implement the three alternative measures of returns for both actual and pseudo-announcements. The average reversal strategy return exceeds one hundred basis points for each of the three implementations. More importantly, across each implementation, reversal strategy returns during actual announcements are at least five-fold of those corresponding to pseudo-announcements. These results indicate that the level and increase of return reversals during announcements are not sensitive to a particular specification or window of returns. In the remaining analyses, we use close-to-close returns to link our findings to the extant literature that examines the market's reaction to news during earnings announcements.

In the last two columns in Table 3, we report reversal magnitudes after weighting observations by share turnover, where turnover is measured as total volume in the pre-announcement period scaled by total shares outstanding. Several studies show that reversal magnitudes increase when conditioning upon share turnover because higher turnover tends to indicate greater uninformed trade (e.g., Campbell, Grossman, and Wang, 1993; Llorente, Michaely, Saar, and Wang, 2002). Consistent with these prior studies, we find that conditioning upon share turnover increases the magnitudes of return reversals. Interestingly, we find no evidence that the magnitudes of pseudo-announcement reversals increase when weighting observations by the level of share turnover prior to pseudo-announcements, indicating that conditioning upon share turnover only strengthens the disparity in reversal magnitudes across announcement and non-announcement periods.

Table 4 contains results from regressing announcement returns on quintiles of PAR and additional variables that allow us to control for risk proxies and the content of the earnings news. We use quintiles in our regressions to mitigate the influence of intertemporal shifts in the distributions of our variables across quarters. Additionally, we scale the quintile values to range from zero to one and interpret the regression coefficient as the average difference in returns across the highest and lowest quintile of a given variable.[12] We report t-statistics, shown in parentheses, based on standard errors that are two-way clustered by firm and quarter to mitigate cross-sectional and time-series correlations in the residuals. The PAR coefficient in column 1 is significantly negative (t-statistic$=-6.35$) indicating a negative autocorrelation in returns at earnings announcements. The PAR coefficient in column 1 also indicates that the average difference in announcement returns across highest and lowest PAR quintiles is approximately 116 basis points, which is consistent with the magnitude of reversal strategy returns shown in Tables 2 and 3. Columns (2) through (4) demonstrate that the relation between PAR and announcement-window returns is distinct from return momentum and robust to standard risk controls including size, book-to-market ratios, and capital asset pricing model (CAPM) betas estimated using daily data from the past year.

Column 5 of Table 4 demonstrates that PAR remains significant after controlling for earnings surprises measured contemporaneously with the announcement, indicating that pre-announcement demand for liquidity gives rise to predictable announcement returns that are distinct from the market's reaction to the announced earnings

[11] Related studies provide evidence that this shift in market making roles and concurrent advances in trade execution technologies has significantly improved liquidity and price efficiency (e.g., Hendershott, Jones, and Menkveld, 2011; Menkveld, 2013).

[12] To the extent that the reversal effect is greater among observations in the extreme PAR quintiles, the magnitude of the regression coefficient could understate the average difference between the highest and lowest PAR quintile. Additionally, interpreting the regression coefficient as the average difference in returns assumes that the difference is constant over time. Changes in the return distribution could induce differences between the magnitude of the regression coefficient and the time-series average reversal strategy returns reported in Table 2.

Table 3
Alternative strategy returns.

Panel A presents the time-series average returns across quintiles of pre-announcement returns, using four implementations of the reversal strategy. Open-to-close indicates returns in a given window from the opening price on the first day of the window to the closing price on the last day of the window. OPAR measures open-to-close returns from $t-4$ to $t-2$ and ORET measures open-to-close returns from $t-1$ to $t+1$, where t is the announcement date. Midpoint-to-midpoint indicates returns in a given window from the midpoint quote at the close of the day prior to the first day of the window to the midpoint quote on the last day of the window. MPAR measures midpoint-to-midpoint returns from $t-4$ to $t-2$ and MRET measures midpoint-to-midpoint returns from $t-1$ to $t+1$. Close-to-close, 1-Day skip indicates the use of standard returns reported in CRSP while measuring pre-announcement returns from $t-5$ to $t-3$ and announcement-window returns from $t-1$ to $t+1$. The Turnover-weighted column contains results analogous to the main tests in Table 2 when weighting observations by the amount of share turnover during the pre-announcement window, where share turnover is defined as total volume scaled by total shares outstanding. RET(X,Y) equals the cumulative market-adjusted return from X days relative to the announcement until Y days relative to the announcement date. Observations are assigned to quintiles each calendar quarter where the highest (lowest) values are assigned to quintile Q5 (Q1) using distributional breakpoints from the prior calendar quarter. Panel B presents analogous average returns using pseudo-earnings-announcements. Pseudo-announcement dates are calculated by subtracting a randomly selected number of trading days from the actual announcement date. The randomly selected numbers are drawn from a uniform distribution spanning 10–40 days. Panel C compares the returns from reversal strategies at actual and pseudo-announcement dates. The p-values corresponding to the high-low difference are based on the time-series of quarterly returns. Bolded values indicate that the return is significant at the 5% confidence level. The sample consists of 107,039 earnings announcements spanning 1996 through 2011.

Panel A: Alternative returns on actual announcements

	Open-to-close		Midpoint-to-midpoint		Close-to-close, 1-day skip		Turnover-weighted	
	OPAR	ORET(−1,+1)	MPAR	MRET(−1,+1)	PAR(−5,−3)	RET(−1,+1)	PAR	RET(−1,+1)
Q1 (Low PAR)	**−5.787**	**0.503**	**−5.483**	**0.678**	**−5.835**	**0.634**	**−7.831**	**0.960**
Q2	**−1.801**	**0.429**	**−1.634**	**0.330**	**−1.801**	**0.383**	**−1.793**	**0.430**
Q3	−0.049	**0.199**	−0.020	0.207	−0.049	**0.285**	−0.015	**0.182**
Q4	**1.792**	0.007	**1.668**	−0.143	**1.777**	0.057	**1.868**	0.072
Q5 (High PAR)	**6.479**	**−0.694**	**6.092**	**−0.492**	**6.643**	**−0.374**	**9.149**	**−1.025**
Low–High	−12.266	1.197	−11.575	1.169	−12.479	1.007	−16.979	1.985
p-Value	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Panel B: Alternative returns on pseudo-announcements

	Open-to-close		Midpoint-to-midpoint		Close-to-close, 1-day skip		Turnover-weighted	
	OPAR	ORET(−1,+1)	MPAR	MRET(−1,+1)	PAR(−5,−3)	RET(−1,+1)	PAR	RET(−1,+1)
Q1 (Low PAR)	**−5.735**	0.116	**−5.478**	**0.223**	**−5.799**	0.140	**−7.815**	0.279
Q2	**−1.811**	0.006	**−1.607**	0.043	**−1.773**	0.061	**−1.800**	−0.108
Q3	**−0.117**	−0.041	**−0.060**	−0.013	**−0.087**	0.026	**−0.100**	0.107
Q4	**1.610**	0.007	**1.520**	−0.053	**1.631**	0.061	**1.666**	0.131
Q5 (High PAR)	**6.206**	−0.057	**5.850**	0.001	**6.395**	−0.036	**9.025**	0.126
Low–High	−11.940	0.174	−11.328	0.222	−12.194	0.176	−16.840	0.153
p-Value	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.34)

Panel C: Differences between actual and pseudo dates

	Open-to-close		Midpoint-to-midpoint		Close-to-close, 1-day skip		Turnover-weighted	
	OPAR	ORET(−1,+1)	MPAR	MRET(−1,+1)	PAR(−5,−3)	RET(−1,+1)	PAR	RET(−1,+1)
Mean	−0.326	1.023	−0.247	0.947	−0.285	0.831	−0.139	1.833
p-Value	(0.07)	(0.00)	(0.20)	(0.00)	(0.06)	(0.00)	(0.78)	(0.00)

news. The magnitude of the PAR coefficient is roughly 44% (=1.24/2.82) of the size of the SUE coefficient, which not only attests to the economic significance of the reversal but also underscores the need to control for the influence of reversals in studies examining the market's reaction to earnings news. Moreover, these findings provide evidence of predictable return reversals after controlling for proxies for earnings news and are thus related to prior research showing increases in the prices of securities added to major stock indexes, where the increases are driven by shifts in demand for shares by index funds that are likely orthogonal to news about the added firms' cash flows (e.g., Shleifer, 1986; Kaul, Mehrotra, and Morck, 2000). Our results corroborate the findings of these studies that liquidity providers' short-term demand curves are downward sloping and extends these findings by showing that prices are particularly sensitive to changes in the demand for liquidity prior to anticipated information events.

Table 4
Announcement-window return regressions.

This table presents the results from regressions where the dependent variable equals the three-day market-adjusted announcement-window return from $t-1$ to $t+1$, where t is the earnings announcement date. PAR is the pre-earnings-announcement return calculated as the cumulative market-adjusted return from $t-4$ to $t-2$. LBM and SIZE are the log of one plus the book-to-market ratio and log of market capitalization, respectively. MOMEN equals the firm's market-adjusted return over the six months ending on $t-10$. CAPM is the firm's market-beta, estimated over the year ending 10 days prior to the announcement. SUE is the standardized unexpected earnings, calculated as realized EPS minus EPS from four-quarters ago, divided by its standard deviation over the prior eight quarters. Pre-decimal is an indicatory variable that equals one for earnings announcements that took place prior to quote decimalization, which took place on April 9, 2001. All continuous control variables are assigned to quintiles each calendar quarter using distributional breakpoints from the prior calendar quarter. Observations in the highest (lowest) quintile are assigned a value 1 (0). The sample consists of 107,039 earnings announcements spanning 1996 through 2011. t-Statistics, shown in parentheses, are based on two-way cluster robust standard errors, clustered by firm and quarter. The notation ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Q(PAR)	−1.161***	−1.166***	−1.167***	−1.166***	−1.248***	−1.004***
	(−6.35)	(−6.40)	(−6.40)	(−6.41)	(−6.91)	(−4.74)
Q(SIZE)	–	0.429***	0.429***	0.421***	0.319**	0.315**
	–	(2.93)	(3.03)	(3.04)	(2.33)	(2.30)
Q(LBM)	–	0.244*	0.245*	0.243*	0.516***	0.515***
	–	(1.65)	(1.70)	(1.69)	(3.72)	(3.71)
Q(MOMEN)	–	–	0.002	0.001	−0.387**	−0.388**
	–	–	(0.01)	(0.01)	(−2.43)	(−2.45)
Q(CAPM)	–	–	–	−0.092	−0.122	−0.121
	–	–	–	(−0.73)	(−0.97)	(−0.96)
Q(SUE)	–	–	–	–	2.824***	2.821***
	–	–	–	–	(15.88)	(15.85)
Pre-decimal	–	–	–	–	–	0.496*
	–	–	–	–	–	(1.76)
Q(PAR)*Pre-decimal	–	–	–	–	–	−0.848**
	–	–	–	–	–	(−2.33)
Intercept	0.756***	0.422**	0.420*	0.472**	−0.786***	−0.924***
	(5.85)	(2.22)	(1.82)	(2.16)	(−3.75)	(−4.07)
Adj-R^2	0.002	0.003	0.003	0.003	0.015	0.015

Finally, the interaction effect in column 6 of Table 4 shows that reversals were larger prior to quote decimalizations, enacted on April 9th of 2001, which is consistent with prior studies documenting increased liquidity following the change toward a continuous range of permitted price quotes (e.g., Nagel, 2012). More importantly, column 6 demonstrates that reversals remain economically and statistically significant following decimalization.

To summarize the results up to this point, we provide evidence suggesting that anticipated information events elicit predictable increases in the expected returns to liquidity provision that have an economically significant impact on both liquidity and returns. Specifically, we show that reversals increase more than six-fold during announcements relative to non-announcement periods and that reversal magnitudes gradually rise ahead of announcements and fall sharply immediately after announcements.

3. Additional analyses

The preceding sections provide empirical evidence that the returns to reversal strategies significantly increase during earnings announcements relative to non-announcement periods. In this section, we investigate the source of this increase. The model in Nagel (2012) predicts that the compensation that market makers demand for providing liquidity is increasing in next-period volatility and the amount of price impact due to adverse selection. Guided by these predictions, we explore inventory risks and adverse selection as potential explanations for the increase in return reversals during earnings announcements.

3.1. Adverse selection risk

Prior research documenting changes in liquidity around earnings announcements commonly attributes the decrease in liquidity to increases in adverse selection risks (e.g., Krinsky and Lee, 1996; Affleck-Graves, Callahan, and Chipalkatti, 2002). Thus, it is natural to question whether increases in return reversals during earnings announcements result from greater adverse selection risks. To address this question empirically, Panel A of Table 5 examines return reversals during earnings announcements after partitioning the sample by firm size, which is a commonly used proxy for asymmetric information. We condition the analysis on firm size because asymmetric information is a necessary condition for, and contributing factor to, adverse selection. Thus, if return reversals at earnings announcements are driven by adverse selection risk, we would expect to see larger reversals among small firms (i.e., the subsamples where asymmetric information is likely to be highest). Partitioning the sample based on firm size, we find no evidence that reversal magnitudes are significantly larger for firms with high levels of asymmetric information, which casts significant doubt on the idea that our findings are driven by adverse selection risks.

As an alternative approach to exploring the role of adverse selection, Nagel (2012) suggests gauging the

Table 5
Testing the impact of adverse selection on reversals.

Panel A presents time-series average three-day market-adjusted announcement-window returns from independently sorting firm-quarters into quintiles of PAR and firm size. PAR is the pre-earnings-announcement return calculated as the cumulative market-adjusted return from $t-4$ to $t-2$, where day t denotes the earnings announcement date. SIZE is the log of market capitalization in the quarter prior to the earnings announcement. Observations are assigned to quintiles each calendar quarter where the highest (lowest) values are assigned to quintile Q5 (Q1) using distributional breakpoints from the prior calendar quarter. Reported t-statistics are estimated using the quarterly time-series over the 1996–2011 sample window. The sample used to construct Panel A consists of 107,039 earnings announcements spanning 1996 through 2011. Panel B presents the time-series average announcement-window returns to reversal strategies using alternative portfolio weights as designed in Nagel (2012). The strategy weights firms' pre-announcement returns as follows:

$w_{i,t,}=-\left(\sum_{i=1}^{N}(R_{i,t-1}-R_{m,t-1})^2\right)^{-1}(R_{i,t-1}-R_{m,t-1}),$

which is designed to mitigate the reversal portfolio's sensitivity to changes in price impact due to adverse selection. Panel B also presents analogous average returns using pseudo-earnings-announcements. Pseudo-announcement dates are calculated by subtracting a randomly selected number of trading days from the actual announcement date. The 'All observations' column corresponds to the main sample consisting of 107,039 earnings announcements spanning 1996 through 2011. The '25+ Announcements' column contains analogous results when limiting the sample to calendar dates with at least 25 earnings announcements, which consists of 84,569 earnings announcements spanning 1,202 calendar days.

Panel A: Announcement returns conditioned on firm size

	SIZE quintiles					
	Q1 (Low SIZE)	Q2	Q3	Q4	Q5 (High SIZE)	High–Low SIZE
Q1 (Low PAR)	0.414	0.767	1.018	1.272	0.988	0.574
Q2	0.314	0.596	0.659	0.413	0.623	0.310
Q3	−0.188	0.431	0.466	0.257	0.179	0.367
Q4	−0.096	0.189	0.037	0.227	−0.117	−0.021
Q5 (High PAR)	−1.249	−0.531	−0.264	−0.398	−0.600	0.649
Low–High PAR	1.663	1.298	1.282	1.670	1.588	−0.075
t-Statistic	(5.57)	(4.34)	(4.60)	(6.00)	(6.54)	−(0.25)

Panel B: Portfolio weights to mitigate adverse selection

	All observations		25+ Announcements	
	Actual	Pseudo	Actual	Pseudo
Strategy return	0.969	0.176	0.941	0.118
p-Value	(0.00)	(0.00)	(0.00)	(0.08)

sensitivity of reversal strategy returns to the use of the following weights:

$$w_{i,t}=-\left(\sum_{i=1}^{N}(R_{i,t-1}-R_{m,t-1})^2\right)^{-1}(R_{i,t-1}-R_{m,t-1}), \qquad (1)$$

where N is the number of stocks in the cross-section, $R_{i,t-1}$ is the return to stock i on day $t-1$, and $R_{m,t-1}$ is the return to the market portfolio. Nagel (2012) shows that the returns to a reversal portfolio using these weights should be relatively insensitive or even inversely related to changes in the amount of price impact due to adverse selection.

To further gauge the impact of adverse selection on our findings, Panel B of Table 5 contains average reversal portfolio returns during actual and pseudo-announcements when applying weights $w_{i,t}$ as defined above to the main sample used in our primary tests.[13] The first two columns of Panel B show that reversal magnitudes remain economically large during earnings announcements and are at least five times as large as those corresponding to pseudo-announcements. A potential concern with this finding is that announcements are non-synchronized and, thus, weighting observations in the pooled sample by $w_{i,t}$ may not account for temporary changes in adverse selection that differ across earnings announcement dates. To mitigate this concern, Panel B also reports results from analogous tests when limiting the sample to calendar days when at least 25 firms announce earnings. The resulting sample consists of 84,569 announcements spanning 1,202 days between 1996 and 2011. Announcement-window reversals remain economically significant and several times larger than those corresponding to pseudo-announcements, which is consistent with the idea that price impact due to adverse selection does not induce negative autocorrelation in returns (Glosten and Milgrom, 1985). Taken together, the results in Table 5 suggest that although the extent of informed trade may change ahead of earnings announcements, our evidence of increased reversal magnitudes is unlikely to be driven by changes in adverse selection risks.

3.2. Inventory risks

In this section, we explore inventory risks as an alternative explanation for increases in return reversals during earnings announcements. To the extent that market

[13] We also find that our results are largely insensitive to the use of portfolio weights designed to mitigate changes in the variance of public information shocks. These findings are available in our online appendix.

makers have limited risk-bearing capacity and are driven to limit net exposure to inventory risks, we expect that market makers demand higher expected returns for providing liquidity ahead of earnings announcements when there is greater uncertainty regarding the market's reaction to earnings news. To examine the role of inventory risks, we use an ex ante measure of uncertainty associated with earnings announcements as implied by pre-announcement option prices. Following Patell and Wolfson (1981), we calculate implied announcement volatility, IAV, as the total announcement-specific volatility implied by option prices. Specifically, we use the implied volatilities of two at-the-money standardized options measured five trading days apart to separate the components of volatility attributable to the announcement versus non-announcement periods, where option prices are measured in the $t-4$ to $t-2$ window (see Appendix B for more details on the calculation of IAV).

There are two primary factors that motivate the Patell and Wolfson (1981) approach. The first is that it relies on market-based measures of expected volatility as reflected in traded option prices and thus approximates investors' expectations during the pre-announcement window. Second, it uses the change in implied volatility to isolate the component of anticipated volatility directly associated with the impending announcement, which helps to identify near-term risks that are likely to influence market makers' willingness to provide liquidity ahead of the announcement.

To test the relation between anticipated announcement volatility and expected returns to liquidity provision, we examine the magnitude of return reversals after conditioning on IAV. Panel A of Table 6 presents time-series average announcement-window returns after independently double-sorting observations into quintiles of PAR and IAV. The bottom row of Table 6 shows that the average reversal strategy return is 96 basis points (t-statistic$=$4.37) among the lowest IAV quintile, whereas the average reversal strategy return is 217 basis points (t-statistic$=$5.49) among high IAV firms. The time-series average difference between high and low IAV quintiles is 121 basis points (t-statistic$=$3.20), which is consistent with market makers demanding higher expected returns for providing liquidity ahead of announcements that pose greater inventory risks.

To examine the robustness of the link between inventory risks and reversal magnitudes, Panels B and C of Table 6 present the magnitudes of return reversals when conditioning on alternative proxies for inventory risks. Specifically, Panel B uses the level of implied volatility (IV) from a 30-day standardized option during the pre-announcement period and Panel C uses the firm's historical absolute market-adjusted return (HR) during its most recent quarterly earnings announcement. Higher levels of IV and HR signal a higher likelihood of extreme price movements during the impending announcement and thus correspond to greater inventory risks. The bottom row of Panels B and C show that reversal magnitudes during announcements are monotonically increasing across portfolios of both IV and HR, indicating that the positive link between reversal magnitudes and inventory risk is robust to alternative proxies.

The findings in Table 6 suggest that inventory risks significantly decrease liquidity prior to earnings announcements, which may be surprising in light of prior research that concludes the opposite. Krinsky and Lee (1996) empirically decomposes the components of the bid–ask spread using intraday data and find a decline in inventory risks as measured by the extent to which intraday price movements reverse within 30-minute windows in the days prior to earnings announcements. One potential explanation for these differing conclusions is that Krinsky and Lee (1996) examine intraday inventory risks, whereas we measure return reversals accumulated over multiple days to highlight the influence of overnight inventory risks associated with holding net positions through the release of earnings news. Our finding suggests that overnight inventory risks not only increase prior to earnings announcements but also give rise to the concentration of return reversals during the announcements.

To mitigate concerns that the results in Panels A through C of Table 6 are driven by the fact that our inventory risk proxies measure time-invariant characteristics corresponding to the cost of providing liquidity in a given firm (i.e., that are not associated with the announcement), we conducted analogous tests of return reversals around pseudo-announcements, where IAV and IV are measured prior to pseudo-announcements. In untabulated results, we find no significant relation between our inventory risk proxies and reversal magnitudes around pseudo-announcements, indicating that the pricing of inventory risks is more pronounced ahead of anticipated information events.

To further shed light on the influence of inventory risks on return reversals during announcements, we exploit variation in the extent to which market participants anticipate the timing of the announcement. To the extent that increased reversals are driven by greater inventory risks, we predict that unanticipated announcements do not give rise to increased return reversals because market makers are not anticipating an increase in volatility.

Our primary analyses use Compustat announcement dates to help explain predictable variation in liquidity and returns that are commonly the focus of research on earnings announcements. However, a potential benefit of examining reversal returns around expected, rather than actual, announcement dates is that they allow us to gauge how reversals are affected by the market's ability to anticipate the information event. An important caveat, however, is that the market's expectations are difficult to measure and thus, measures of expected announcement dates potentially introduce measurement errors into our analyses. With that caveat in mind, Table 7 examines returns to reversal strategies around expected announcement dates.

To construct Table 7, we calculate expected earnings announcement dates for each firm/fiscal quarter by calculating the historical median number of trading days between a firm's actual announcement date and the date of the most recent fiscal quarter-end, where the median is calculated for the same fiscal quarter over the prior 10 years. For each firm/fiscal quarter, we then add the historically estimated median number of trading days to

Table 6
Return reversals conditioned on inventory risk proxies.

This table presents time-series average three-day market-adjusted announcement-window returns during actual announcements from independently sorting firm-quarters into quintiles of PAR and proxies for inventory risks. PAR is the pre-earnings-announcement return calculated as the cumulative market-adjusted return from $t-4$ to $t-2$, where day t denotes the earnings announcement date. IAV is the total announcement-specific volatility implied by option prices in the $t-4$ to $t-2$ window and is calculated using the procedure developed by Patell and Wolfson (1981). See Appendix B for more details on the calculation of IAV. IV is the implied volatility from a 30-day standardized, at-the-money option and HR is the firm's historical absolute market-adjusted return during its most recent quarterly earnings announcement. Observations are assigned to quintiles each calendar quarter where the highest (lowest) values are assigned to quintile Q5 (Q1) using distributional breakpoints from the prior calendar quarter. Reported t-statistics are estimated using the quarterly time-series over the 1996–2011 sample window.

Panel A: Announcement returns conditioned on implied announcement volatility

	Implied announcement volatility (IAV) quintiles					
	Q1 (Low IAV)	Q2	Q3	Q4	Q5 (High IAV)	High–Low IAV
Q1 (Low PAR)	0.763	0.642	0.292	0.870	1.305	0.542
Q2	0.471	0.449	0.631	0.618	0.530	0.059
Q3	0.242	0.233	0.248	0.229	0.557	0.315
Q4	−0.079	−0.149	−0.016	0.310	0.116	0.195
Q5 (High PAR)	−0.193	−0.672	−0.646	−0.465	−0.866	−0.674
Low–High PAR	0.955	1.314	0.938	1.335	2.171	1.216
t-Statistic	(4.37)	(4.40)	(3.20)	(5.42)	(5.49)	(3.20)

Panel B: Announcement returns conditioned on the level of implied volatility

	Implied volatility (IV) quintiles					
	Q1 (Low IV)	Q2	Q3	Q4	Q5 (High IV)	High–Low IV
Q1 (Low PAR)	0.374	1.039	0.997	1.072	0.534	0.160
Q2	0.387	0.604	0.687	1.015	−0.255	−0.641
Q3	0.071	0.432	0.644	0.319	−0.210	−0.282
Q4	−0.095	0.140	0.072	0.065	−0.075	0.020
Q5 (High PAR)	−0.394	−0.110	−0.307	−0.380	−1.382	−0.988
Low–High PAR	0.768	1.149	1.304	1.451	1.916	1.148
t-Statistic	(3.39)	(6.37)	(5.48)	(5.59)	(5.41)	(3.37)

Panel C: Announcement returns conditioned on historical announcement return

	Historical announcement return (HR) quintiles					
	Q1 (Low HR)	Q2	Q3	Q4	Q5 (High HR)	High–Low HR
Q1 (Low PAR)	0.621	0.550	0.669	1.011	1.156	0.534
Q2	0.469	0.425	0.482	0.699	0.664	0.195
Q3	0.292	−0.009	0.326	0.224	0.540	0.249
Q4	0.062	−0.001	−0.014	0.193	0.255	0.193
Q5 (High PAR)	−0.418	−0.423	−0.355	−0.528	−0.971	−0.554
Low–High PAR	1.039	0.973	1.024	1.540	2.127	1.088
t-Statistic	(4.08)	(3.34)	(3.92)	(6.26)	(6.46)	(3.37)

the most recent fiscal quarter-end to arrive at the expected announcement date.

Table 7 reports announcement return averages across early, on-time, and late announcements, where on-time announcements are those whose actual announcement occurs within one day of the expected date. Similarly, early (late) announcements are those that occur more than one day before (after) the actual announcement date. The pooled sample average reversal corresponding to expected announcement dates remains statistically and economically significant at 65 basis points but is considerably lower than the 145 basis point reversal corresponding to actual announcement dates in Table 2. The second column of Table 7 indicates that the lower pooled mean is driven by the absence of reversals during early announcement dates indicating that market makers do not raise expected returns for liquidity provision ahead of information events when the event is unanticipated. The table also shows that reversals are largest for on-time announcements when the actual and expected date coincide, which reinforces the importance of information events being anticipated. Finally, the final column of Table 7 shows that reversals are

Table 7
Expected earnings announcement dates.

This presents the time-series average expected earnings announcement-window returns by quintiles of PAR. We calculate the expected earnings announcement date for each firm/fiscal quarter by calculating the median number of trading days between the end of a calendar quarter and the firm's actual announcement date, where the median is calculated for the same fiscal quarter over the prior 10 years. For each firm/fiscal quarter, we then add the historically estimated median to the most recent calendar quarter end to arrive at the expected announcement date. We report announcement return averages across early, on-time, and late announcements, where on-time announcements are those whose actual announcement occurs within one day of the expected date. PAR is the pre-earnings-announcement return calculated as the cumulative market-adjusted return from $t-4$ to $t-2$, where t denotes the earnings announcement date. Observations are assigned to quintiles each calendar quarter where the highest (lowest) values are assigned to quintile Q5 (Q1) using distributional breakpoints from the prior calendar quarter. RET(X,Y) equals the cumulative market-adjusted return from X days relative to the announcement until Y days relative to the announcement date. The average return to each PAR quintile is calculated each calendar quarter and subsequently averaged across all quarters in the 1996–2011 sample window. The p-values corresponding to the high-low difference are based on the time-series of quarterly returns. Bolded values indicate that the return is significant at the 5% confidence level. The sample consists of 102,895 expected earnings announcement dates spanning 1996 through 2011.

	Expected (all)	Early	On-time	Late
Q1 (Low PAR)	**0.408**	−0.046	**0.971**	**0.458**
Q2	**0.306**	−0.038	**0.652**	**0.233**
Q3	0.094	−0.014	**0.273**	−0.001
Q4	0.005	0.023	−0.096	0.036
Q5 (High PAR)	−**0.245**	0.101	−**0.695**	−**0.231**
Low–High	0.652	−0.147	1.666	0.689
p-Value	(0.00)	(0.28)	(0.00)	(0.00)
Observations	102,895	29,778	34,837	38,280

smaller for late announcements, which suggests that the delayed release of earnings news may signal the content of the announcement and thus reduce uncertainty and inventory risks.

Together, the findings in Tables 6 and 7 relate to a vast literature examining the effect of firms' disclosures on liquidity. Whereas most of this literature focuses on the impact of disclosure on liquidity through the lens of adverse selection, our findings highlight inventory risks as an alternative channel through which firms' disclosures elicit intertemporal variation in liquidity by mitigating uncertainty regarding the timing and content of value-relevant news.

3.3. Additional tests

A few additional robustness checks are worth mentioning. First, to mitigate the influence of differences in volume prior to actual and pseudo-announcements, we partitioned our sample based on whether volume prior to actual announcements was higher, equal to, or lower than the volume prior to pseudo-announcements. Reversal magnitudes during actual announcements remain significantly larger (three- to seven-fold) compared to those during pseudo-announcements among all of these sample partitions. Second, we separate the sample by the firm's primary exchange listing and find that the average announcement reversal is 130 bps among NYSE-listed firms and 171 bps among Nasdaq-listed firms. These findings suggest that inventory risks are larger among Nasdaq firms but does not identify whether the disparity is attributable to differences in the composition of firms across exchanges and/or differences in exchange structures that were more pronounced earlier in the sample. Finally, we find that reversal magnitudes increase when a large number of firms in the same two-digit standardized industrial classification (SIC) industry announce earnings on the same day. To the extent that market makers tend to provide liquidity in peer firms, these results complement findings in Corwin and Coughenour (2008) that specialists focus their attention and resources on stocks with information events by shifting liquidity away from remaining assigned stocks. The results of these analyses are not tabulated in the paper but are available in an online appendix.

4. Conclusion

This study documents a dramatic increase in short-term return reversals during earnings announcements relative to non-announcement periods. Our findings suggest that liquidity providers' short-term demand curves are increasingly downward sloping prior to anticipated information events due to increases in inventory risks associated with the announcement.

We show that a long (short) position in firms whose returns strongly underperform (outperform) the market in the three days prior to earnings announcements produces an average return of 145 basis points during the announcement window. By comparison, the average return to a comparable portfolio during non-announcement periods is 22 basis points, indicating that return reversals increase more than six-fold during earnings announcements. These findings are consistent with a sizable shift in liquidity as defined by Pastor and Stambaugh (2003) in the sense that order flow induces increasingly large price fluctuations prior to earnings news. Contrary to prior studies that measure intraday inventory risks, our findings suggest that earnings announcements elicit predictable increases in overnight inventory risks associated with holding net positions through the announcement and that these increases have an economically large impact on both liquidity and returns.

Our findings contribute to the literature by documenting significant time-series variation in the magnitudes of short-term return reversals and by providing evidence that anticipated information events elicit rapid shifts in the expected returns to liquidity provision. Taken together, our findings show that anticipated information events give rise to increased inventory risks that have a striking influence on the autocorrelation of returns and the information content of market prices.

Appendix A. Illustration of autocorrelation in returns

This appendix illustrates sources of negative autocorrelation in returns within a simplified setting that incorporates features from the models in Campbell, Grossman, and Wang (1993), Llorente, Michaely, Saar, and Wang (2002), and Nagel (2012), among others. As in Kyle (1985), the public trades for informational and liquidity reasons and, as in Grossman and Miller (1988), market makers are averse to net inventory positions and receive compensation for providing liquidity.

In this simplified setting, assume that there are two sources of price changes. The first is fundamental news, n_t, that reflects information about a firm's value that is incorporated into prices via public announcements and/or through privately informed trade. The second source of price changes, l_t, is the compensation that market makers receive for accommodating period t liquidity demands. As in Nagel (2012), the compensation that market makers receive increases with inventory risks and price impact due to adverse selection, and is assumed to be uncorrelated over time. Price changes in period t can be expressed as

$$P_t - P_{t-1} = c + n_t + l_t - l_{t-1}, \tag{2}$$

where P_t is the price in period t, c is a constant, and the inclusion of l_{t-1} reflects the fact that a portion of the price change in period $=t$ is driven by the reversal of price concessions that market makers received for accommodating period $t-1$ liquidity demands. Additionally, we make the simplifying assumption that l_t and n_t are independent, which allows us to more clearly illustrate tensions underlying the determination of return autocorrelations.[14] Within this setting, the autocorrelation of price changes can be expressed as follows:

$$\begin{aligned}\frac{\text{cov}(P_{t+1}-P_t, P_t-P_{t-1})}{\text{var}(P_t-P_{t-1})} &= -\frac{\text{cov}(c+n_{t+1}+l_{t+1}-l_t, c+n_t+l_t-l_{t-1})}{\text{var}(n_t)+\text{var}(l_t)+\text{var}(l_{t-1})} \\ &= -\frac{\text{var}(l_t)}{\text{var}(n_t)+\text{var}(l_t)+\text{var}(l_{t-1})}.\end{aligned} \tag{3}$$

Eq. (3) highlights a potential source of tension in return autocorrelations during earnings announcements. Specifically, greater inventory risks and price impact due to adverse selection increase the extent of negative autocorrelation by increasing var(l_t).[15] However, extra fundamental news revealed through announcements or informed trade decreases the extent of negative autocorrelation by increasing var(n_t). To the extent that var(l_t) and var(n_t) both increase prior to announcements, the predicted change in return autocorrelation during earnings announcements is ambiguous. In our empirical tests, we explore the balance of these factors by examining the change in return reversals during earnings announcements.

Appendix B. Estimation of implied announcement volatility

This appendix provides an overview of the calculation of the total volatility associated with the earnings announcement date as implied by option prices. The calculation follows Patell and Wolfson (1981), which posits that instantaneous volatility remains at the level γ, except at the earnings announcement. During an announcement with length τ, the instantaneous volatility increases to $\gamma+\tau\delta$. Letting t_e denote the announcement date, the implied volatility of an option on day $t_a < t_e$ satisfies

$$\sigma(t_a) = \gamma + \frac{\tau\delta}{(t_e - t_a)}. \tag{4}$$

Using the implied volatility of an at-the-money option with the expiration date t_e on days t_a and t_b, where $t_a < t_b < t_e$, we solve for $\tau\delta$ as follows:

$$\tau\delta = \frac{(\sigma(t_b)-\sigma(t_a))(t_e-t_a)(t_e-t_b)}{(t_b-t_a)} \tag{5}$$

We calculate the implied increase in volatility at announcements, $\tau\delta$, for three different pairs of dates separated by five trading days: $[t_a, t_b] = [(t-7, t-2), (t-8, t-3), (t-9, t-4)]$. To reduce measurement error associated with a particular date, we calculate $\tau\delta$ for each pair and use the average. Plugging $\tau\delta$ back into Eq. (4) allows us to solve for γ. Next, we solve for the total implied announcement volatility (IAV) as follows:

$$\text{IAV} = \gamma + \tau\delta, \tag{6}$$

where IAV reflects the total implied volatility specific to the earnings announcement and is expressed as an instantaneous variance.

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[14] Our main result is likely to still hold when relaxing this assumption. In this case, the numerator (denominator) of Eq. (3) decreases (increases) by cov(n_t, l_t). So long as the covariance between n_t and l_t does not *decrease* when their respective variances increase, the central tension we highlight remains.

[15] Another popular measure of reversals is the extent of autocovariance in returns (e.g., Nagel, 2012). In this setting, $\text{cov}(P_{t+1}-P_t, P_t-P_{t-1}) = -\text{var}(l_t)$, indicating that the autocovariance in returns is driven entirely by the variance of the liquidity provision component of returns.

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