Dealers' Response to Industry-wide Information: Evidence from intraday short-sale data

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We investigate quote revisions of NYSE specialists in response to short selling in announcing firms and non-announcing, competing firms in the same industries around earnings announcements. We find evidence that quote revision and short selling of non-announcing, competing firms have information content for announcing firms. In addition, our results indicate that the presence of short-sale constraint has a significant impact on the direction of information flow. Our results suggest that short selling is a channel of intra-industry information flow and contributes to the process of price discovery.

1. Introduction

The SEC banned short selling of financial stocks in late 2008 to "protect the integrity and quality of the securities market and strength investor confidence." More recently, German authorities also banned short selling to promote market confidence in the midst of Europeans sovereign debt crisis. Blamed by the general public for every financial crisis in the last 400 years,[2] short sellers, however, are generally regarded by practitioners and academics as rational, informed agents who help increase information efficiency by correcting short-term deviation of stock prices from fundamental values (Miller (1977), Diamond and Verrecchia (1987)). In part due to increasing use of algorithmic trading and growth of the hedge-fund industry, short-selling activities have increased dramatically in recent years. An astonishing 23.89% of trading volume on the NYSE is based on short-sales volume (Diether, Werner, and Lee (2009)). How information stemming from short selling is incorporated into market prices is, thus, of critical importance to practicing investment professionals and the investing public. Professional practices (see e.g. Madhavan, 2002) and academic literature (see e.g. Hasbrouck, 2007) suggest that securities dealers such a NYSE specialist can infer information about a particular security from the direction, size, and timing of trades, adjust quotes accordingly, and communicate that information to the market by the process of quote revision.

In the study reported here, we directly document the intraday responses of NYSE specialists to information conveyed by short selling. Within the context of 127 earnings announcements in 63 industries over a 5 day period around announcement day, we investigate quote revisions (change in the mid-point between bid and ask quotes) in response to short selling in announcing firms and non-announcing, competing firms in the same industries. In particular, we focus on the interaction between NYSE specialists and short sellers by examining whether quote revision and short selling in competing firms have any predictive ability for subsequent quote revision and short selling in announcing firms. Besides examining the information role of short sales and dealer's responses thereof, we also investigate the impact of short-sale constraint on the flow of intra-industry

[2] "Short sellers have been the villain for 400 years," *Reuters* (2008-09-26).

information.

Our study generates several interesting results about the interaction between NYSE specialists and short sellers. First, we find that there is a strong link between quote revision and short selling in announcing firms and those in non-announcing firms and that the interaction between specialists and short sellers plays a facilitating role in intra-industry information flow. Both quote revision and short selling of competing firms have strong predictive ability for subsequent quote revision of announcing firm. Second, we find that quote revision of announcing firms have strong predictive ability for subsequent short selling in competing firms, suggesting that some short selling in competing firms may be initiated as a hedge to long positions in announcing firms. Third, we also find evidence that intra-industry information flow is influenced by short sale constraints. In the presence of significant short sale constraints on stocks of announcing firms, competing firms become the venue of choice for short sellers and information stemming from short selling flows one way from competing firms to announcing firms.

Our paper extends the current literature along several dimensions. First, we expand the intra-industry information flow literature (Foster 1981; Freeman and Tse, 1992; Tookes, 2008) by incorporating an information set that includes histories of quote revision and short selling. Previous studies suggest that short sellers in possession of material, non-public information face significant constraints. It is illegal for directors and officers to short stocks of their own firm (Allen and Gale, 1992). Many firms have explicit blackout periods around earning announcements (Bettis, Coles, Lemmon, 2000). In addition, short sellers may face impediments due to market friction such as unavailability of shares to be borrowed or excessively high fees charged by stock lenders (Jones and Lamont, 2002). By examining the dynamic relationship between short selling and quote revision in announcing firms and competing firms, we provide important evidence that short selling plays a facilitating role on information linkage in a multiple-stock setting.

Second, we build on prior research by studying short selling in an intraday framework. Most of the prior studies use monthly data (Asquith and Meulbrokk, 1995; Desai et al., 2002; Efendi et al., 2005, among others) and daily data (Diether et al., 2009). Aitken, Frino, McCorry and Swan (1998) analyze short sales in Australian Stock Exchange in an intraday setting and finds that market reacts to bad news conveyed by short sale almost instantaneously. Jones (2008) finds that "in-and-out shorting" where a short seller covers his short position before the end of the day represented 5% of the daily trading volume as far back as the early 1930s. By examining the price impact of information conveyed by short selling in an intra-day framework, we present a fuller picture on the information role of short selling.

Third, we expand the market microstructure literature that investigates the intraday trade-quote interaction (Chan et.al., 2002; Hasbrouck, 1991a; and Tookes, 2008) to short selling. While Hasbrouck (1991) and Tookes (2008) examine intraday trade-quote interaction on net trades (which should include short sales), these studies focus on data in the 1980's and 1990's. Christophe et al. (2004) shows that short sale volume in the last quarter of 2000 is about 3% of the total volume on the Nasdaq, while (Diether, Werner, and Lee (2009) shows that an astonishing 23.89% (30%) of total volume on the NYSE (Nasdaq) are short sales in 2005. There appears to be a tremendous increase in short sales in the first decade of the new millennium. Thus, short sales volume contained in Hasbrouck (1991) and Tookes (2008) are likely to be quite small. Our analysis of the informational role of short sellers contrasts and complements those studies. We document important evidences of information effect, inventory effect, and uptick rule effect in the order flow of short sellers.

The remainder of the paper is organized as follows. Section 2 describes the data and provides the summary statistics. Section 3 presents the empirical methodology and develops hypotheses within the context of the empirical model. Section 4 presents and discusses the results. Section 5 concludes.

2. Data

As part of the Regulation SHO (Reg SHO) mandate,[3] NYSE has made publicly available intraday short-sale data during the period between 2 January 2005 and 6 July 2007 at the end of which NYSE discontinued the Reg SHO database. Thus, this study covers the same period during which NYSE short-sale tick data are available. The dataset includes ticker, price, volume, date, time (hour, minute, second), and trader type (exempt vs. non-exempt from short-sale rules) for all NYSE short sales. Since our interest focuses on the how NYSE specialists respond to informationally motivated trades, we exclude short sales that are exempt, which are presumed to be from market-making activities.[4] We also exclude firms that are exempt from up-tick rules in the SEC pilot study.

Our process of sample selection follows previous literature closely (Freeman and Tse (1992), Tookes (2008)). The initial sample consists of all common stocks in *CRSP/Compustat* merged database (*CCM*) during the period 2005 to 2007. A valid announcement is defined as an earnings announcement by a NYSE firm that occurs within 90 days of quarter-end and that does not occur within two trading days of an earnings announcement by another firm in the same industry. Industries are defined as all firms with the same four-digit SIC codes. Financial institution and conglomerates are excluded (SIC codes 6000-6299, 6600-6999, and 9997). Following previous literature, we require announcers and competitors to have December fiscal year-end to synchronize quarters. We require that each industry has at least eight valid announcements over the sample period. Earnings announcements obtained from *CRSP/Compustat* merged database (*CCM*) are cross-checked with those in I/B/E/S for accuracy. In an intraday setting, the lack of liquidity could significantly impact the price-volume relation (Easley, O'Hara and Srinivas (1998)). Following prior literature (Chan et al. (2002), Easley et al. (1998), Tookes (2008)), we control for liquidity by imposing an active trade filter of 50 trades per day on the intraday short-sale data. In addition, the active filter also attenuates problems with nonsynchronous trading. After matching valid announcements from *CCM* with active firms from Regulation SHO, the sample consists of 127 earnings announcements associated with 127 unique announcing firms in 63 industries during the period 2 January 2005 -- 6 July 2007. In addition, we identify a group of active NYSE competing firms in the same industries. From this group of active competitors for a given valid announcement, one competing firm in the same industry is randomly selected for each announcing firm. Earnings announcement period is over a 5-day period from -2 to 2 relative to the announcement day. There are altogether 635 firm-days for both announcing and competing firms.

Motivated by a stream of literature related to short sale constraints (Boehme, Danielsen and Sorsecu, 2010; Danielsen and Sorsecu, 2001;   D'Avolio, 2002; Diether, Malloy, and Scherbina, 2002; Gebhart, Lee and Swaminathan, 2001), we obtain daily measures of market capitalization, price volatility, turnover, relative short interest, and short ratio for our sample. Market capitalization (in $M) is the daily market value of equity. Price volatility is the difference between the daily high price and daily low price divided by the daily high price (Diether et al., 2009). Turnover is the daily volume divided by shares outstanding. Relative short interest (RSI) is the daily short volume divided by shares outstanding. Short ratio is the daily short-sale volume divided by the trade volume. Data for market capitalization, price volatility, turnover, RSI, and short ratio were obtained from Regulation SHO and CRSP.

Table 1 provides a description of announcing firms and competing firms in the final sample. Consistent with existing literature, the active-trade filter has resulted in a sample of relatively large

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[3]We do not examine the effects of, and issues directly associated with, Reg SHO, rather we use the short-sale data made available by Reg SHO. For more information on Regulation SHO, see e.g. Diether et al. (2009).

[4]Wu (2007) points out that the exempt/nonexempt classification in Reg SHO is problematic--some exempt orders are not marked as such. Nonetheless, nonexempt short-sales as a group should contain more orders from informed investors than exempt short-sales.

firms. Both the mean and median of market capitalization of announcing firms are very close to those of competing firms. Trading-activities measures such as price volatility and turnover of announcing firms are higher on average than those of competing firms. The standard deviations of trading activities for competing firms are low compared with those of announcing firms. This is in part due to fact that there is a limited number of competing firm that could pass the active-trade filter and some competing firms were used multiple times. Interestingly, RSI and short ratio of announcing firms on average are very close to those of competing firms. Pearson correlations coefficients of price volatility, turnover, and RSI among announcing firms and competing firms in Panel B of Table 1 indicate that they are significantly correlated. This suggests that short selling activities of announcing firms and competing firms are sensitive to common, industry-wide information. This is consistent to similar findings in the literature on intra-industry information transfer (Bittlingmayer and Hazlett, 2000; Foster, 1981; Freeman and Tse, 1992; Lang and Stulz, 1992; Lauz, Starks, and Yoon, 1998; Tookes, 2008). Our analysis in this section documents these relationships for short selling activities among intra-industry firms.

Table 1
Summary Statistics

Panel A : Descriptive Statistics

	Announcing Firms			Competing Firms		
	Mean	median	St. Dev	mean	median	St. Dev
Price Volatility	0.0318	0.0261	0.0204	0.0241	0.0208	0.0051
Turnover	0.0131	0.0085	0.0197	0.0089	0.0063	0.0007
RSI	0.0021	0.0012	0.0029	0.0017	0.0009	0.0000
Short Ratio	0.1689	0.1450	0.1129	0.1835	0.1435	0.0158
Market Cap. (in $M	6,987	2,633	10,833	7,055	2,696	60,825

Panel B: Pearson Correlation Coefficients

Competing Firms	Market Cap.	Price Volatility	Turnover	RSI
Announcing Firms				
Market Cap.	0.09454**	-0.01065	-0.03691	0.05865
Price Volatility	0.01139	0.11526***	0.06184	0.03998
Turnover	-0.02292	0.06995*	0.07398*	0.05519
RSI	-0.03143	0.11539***	0.07237*	0.09347**

Notes: This table summarizes the sample of announcers and competitors. Market capitalization (in $M) is the daily market value of equity. Price volatility is the difference between the daily high price and daily low price divided by the daily high price. Turnover is the daily volume divided by shares outstanding. Relative short interest (RSI) is the daily short volume divided by shares outstanding. Short ratio is the daily short-sale volume divided by the trade volume. Data for market capitalization, price volatility, turnover, RSI, and short ratio were obtained from Regulation SHO and CRSP. *** denotes significance level at 1%;   ** denotes significance level at 5%; * denotes significance level at 10%.

To obtain prevailing quotes at the time of trade, we match bid and ask quotes from NYSE Trades and Quotes (TAQ) to short trades from Reg SHO by (1) firm, (2) market center (all NYSE), (3) date, (4) price (short-sale transaction price = bid quote) and (5) transaction time. We divide each trading day into 78 five-minute intervals from 9:30 am to 4:00 pm, Eastern Standard Time. Quote revision in interval t is defined as the log ratio of quote midpoint at the end of interval t over that at interval $t-1$. Short-sale volume is the signed volume provided by Regulation SHO. To control for

cross-sectional variations across different stocks, we standardized the quote-revision and short-sale volume variables by a process established by previous literature (Chan et al., 2002; Easley et al., 1998; Tookes, 2008). For each trading day, we first calculate the mean and standard deviation of a variable. The variable for the same day is then standardized by subtracting the mean and dividing by the standard deviation. The process allows us to pool all 635 firm-days and over 31,000 5-minute firm-intervals for the main analysis.

3. Methodology and Hypotheses

3.1. Dynamic interactions among announcing and competing firms

To examine the dynamic relationship of quote revision and short selling among announcing and competing firms, we take the basic econometric approach developed by Hasbrouck (1991) and later extended by Chan et al. (2002) and Tookes (2008). The interaction between quote revision and short selling is modeled with the following equations:

$$r_t^a = \sum_{i=1}^{k} \alpha^a{}_i r_{t-i}^a + \sum_{i=0}^{k} \beta^a{}_i v_{t-i}^a + \sum_{i=1}^{k} \alpha^c{}_i r_{t-i}^c + \sum_{i=0}^{k} \beta^c{}_i v_{t-i}^c + \varepsilon_{1,t}^a$$

$$r_t^c = \sum_{i=1}^{k} \alpha^a{}_i r_{t-i}^a + \sum_{i=0}^{k} \beta^a{}_i v_{t-i}^a + \sum_{i=1}^{k} \alpha^c{}_i r_{t-i}^c + \sum_{i=0}^{k} \beta^c{}_i v_{t-i}^c + \varepsilon_{1,t}^c \tag{1}$$

$$v_t^a = \sum_{i=1}^{k} \gamma^a{}_i r_{t-i}^a + \sum_{i=1}^{k} \phi^a{}_i v_{t-i}^a + \sum_{i=1}^{k} \gamma^c{}_i r_{t-i}^c + \sum_{i=1}^{k} \phi^c{}_i v_{t-i}^c + \varepsilon_{2,t}^a$$

$$v_t^c = \sum_{i=1}^{k} \gamma^a{}_i r_{t-i}^a + \sum_{i=1}^{k} \phi^a{}_i v_{t-i}^a + \sum_{i=1}^{k} \gamma^c{}_i r_{t-i}^c + \sum_{i=1}^{k} \phi^c{}_i v_{t-i}^c + \varepsilon_{2,t}^c \tag{2}$$

where r_t is the quote revision during a 5-minute interval t. Quote revision in interval t is defined as the log ratio of quote midpoint at the end of interval t over that at interval t-1. v_t is the short-sale volume during a 5-minute interval. Superscripts a and c denote announcers and competitors, respectively. The system of equations (1) and (2) is very similar to the standard vector autoregressive (VAR) specification except that the contemporaneous short-sale volume appears as one of the explanatory variables in equation (1), as in Hasbrouck (1991), Chan et al. (2002), and Tookes (2008). The assumption is that contemporaneous order flow causes quote revision, but not vice versa. The empirical model described by equations (1) and (2) is motivated by thoughtful theoretical considerations on the responses of market participants to trading activities in a setting of information asymmetry. Hasbrouck (1991) and Hasbrouck (2007) provide illuminating discussions on this approach.

3.2. Hypotheses Development

3.2.1. Impacts on quote revision

Previous studies on "intra-industry" information flow document that announcements of unexpected increases (decreases) in earnings and dividends of a firm tend to increase (decrease) the stock return of its industrial rivals (Baginski, 1987; Foster 1981; Firth, 1996). Tookes (2008) models informed trading in similar firms that are sensitive to common, industry-wide information and shows that there are incentives for insiders to trade in competing firms. The Securities Exchange Act

of 1934 stipulates that it is illegal for directors and officers to short stocks of their own firm (Allen and Gale, 1992). In addition, many firms have explicit blackout periods around earnings announcements (Bettis et al., 2000). Ayres and Bankman (2001) suggest that it is *not* illegal for an insider with material, non-public information about his own firm to trade on the stocks of his firm's rival. These studies suggest that there are compelling reasons and great incentives for insiders with material non-public information to trade in the stocks of rival firms. If an informed investor with unfavorable news of an announcing firm, for regulation-related (and/or other) reasons, cannot take a short position in that firm, she may short a competing firm in the same industry. If increasing short selling in the competing firm during the period near earnings announcement signals unfavorable news for the announcing firm, then it should be followed by a downward quote revision in the announcing firm. Similarly, quote revision in the competing firms should be positively related to subsequent quote revision of announcing firms.

Information effect discussed in a previous section provides a number of empirical predictions about the impacts of short selling on quote revision. If short selling in the competing firm suggests unfavorable news about the announcing firm, it should be followed by a downward quote revision in the announcing firm. If both announcing firms and competing firms are subject to industry-wide information, quote revision in the announcing firms (competing firms) should be positively correlated to subsequent competing firms (announcing firm). Within the context of equation (1), coefficients α_i^c and β_i^c (i = 1…k) in the announcing firm quote revision equation, r_t^a, should be significantly different from zero. Further, α_i^c should be positive and β_i^c should be negative.

Inventory models suggest that to control inventory, NYSE specialists lower both bid and ask quotes after public sells in order to induce public purchases and inhibit additional public sells (see e. g. Ho and Stoll, 1983). Similarly, both bid and ask quotes are raised after public buys in order to induce public sells and inhibit additional public buys. Information effect and inventory control effect suggest that short selling should be negatively related to the subsequent quote revision in a same-stock setting. Within the context of equation (1), coefficients α_i^a and β_i^a (i = 1…k) in the announcing-firm quote revision equation, r_t^a, should be negative and significantly different from zero.

To prevent short sales from being executed in a declining market, NYSE uses the uptick rule to determine if a short sale is permitted. A short sale is allowed if the most recent price change preceding the trade was a plus tick (NYSE Rule 440B; Diether et al., 2009; Jones, 2008). The same-stock contemporaneous relationship between quote revision and short selling is influenced by the uptick rule. Since short selling is only allowed on a plus tick, short selling should decrease as the market declines, all else being equal. A downward revision should be accompanied by a reduction in short selling, suggesting that β_i^a (i = 0) in the announcing-firm quote revision equation, r_t^a, should be positive and significantly different from zero.

3.2.2. Impact on short-sale volume

The relationship between quote revision and short selling may be influenced by hedging effect. If unfavorable news of a firm prompts investors to hedge their existing long positions by taking short positions in the same firm, then a downward revision in a firm should be followed by short selling of the same firm. Some investors cannot, for whatever reason, hedge their long positions in the announcing firms by taking short positions in response to bad news. If they take short positions in a competing in the same industry as a hedge, then downward revision in the announcing firms should followed by short selling in the competing firm. Hedging effect is related to information effect in that information contained in quote revisions are transmitted to order flow.

Empirical predictions about the cross-stock impact of quote revision on short selling stems from hedging effect. If investors hedge their existing long positions in announcing firms by taking short

positions in competing firms, a downward revision in announcing firms, which signals bad news, should be followed by increase in short-sale volume in competing firms. Within the context of equation (2), coefficients γ_i^a (i = 1…k) in the competing-firm short-sale volume equation, v_t^c, should be negative and significantly different from zero.

4. Empirical Results

We now estimate the multivariate model described in equations (1) and (2). Since quote revision and short-sale volume have been standardized and the lagged values of the dependent variables on the right-hand side of the equation that capture serial dependence effect have been included, the disturbances can be assumed to be homoscedastic and serially uncorrelated (Hasbrouck (2007)). Further, the disturbances in equation (1) are contemporaneously uncorrelated with the disturbances in equation (2) (Chan et al., 2002; Hasbrouck, 1991). Following Chan et al. (2002) and Tookes (2008), the four regression equations in equations (1) and (2) are estimated separately by OLS up to six lags.

4.1. Effect of cross-stock short selling on quote revision

Table 2 presents regression results where the dependent variable is the quote revision over 5-minute intervals during a 5-day period from -2 to 2 relative to the announcement day. Independent variables are lagged quote revisions and both contemporaneous and lagged short-sale volumes of announcing firms and competing firms.

Table 2
Quote revision and short-sale volume of announcing and competing firms around earnings announcements

	Announcing firms r_t^a	Competing firms r_t^c
	Coeff.	Coeff.
r_{t-1}^a	-0.04676***	0.02907***
r_{t-2}^a	-0.00981*	0.00965
v_t^a	0.12005 ***	0.00361
v_{t-1}^a	-0.00951*	-0.00820
v_{t-2}^a	-0.00867*	-0.01380**
r_{t-1}^c	0.02726***	-0.03636***
r_{t-2}^c	-0.00865	-0.01197**
v_t^c	-0.00271	0.01661***
v_{t-1}^c	-0.01522***	-0.01038
v_{t-2}^c	0.00444	-0.01661***
R^2	0.02220	0.02060
N	31,732	31,732

Notes: This table presents regression results of equation (1). Explanatory variables up to 6 lags are used in the regression. We report regression coefficients for the contemporaneous (when applicable) and first 2 lags (intercepts and Lags 3-6 are not reported for brevity). *** denotes significance level at 1%; ** denotes significance level at 5%; * denotes significance level at 10%.

We note that inventory control effect stemming the relationship between quote revisions and lagged short selling should *not* be presented in a cross-stock setting. The most striking feature of Table 2 is the significant cross-stock impact of short selling on quote revisions. Both short selling and quote revisions of competing firms are significantly related to the subsequent quote revision of announcing firms, even after controlling for both short selling and quote revisions of announcing firms up to six lags. For example, for the equation explaining quote revision of announcing firms, r_t^a, the coefficient for the first-lagged short-sale volume of competing firms is -0.01522 at 1% significance level; the coefficient for the first-lagged quote revision of competing firms in the same equation is 0.02726 at 1% significance level. These findings are consistent with information effect, indicating that informed investors with unfavorable information of announcing firms short competing firms in the same industries. Our results provide evidence that orders submitted by short-sellers on competing firms contain information for announcing firms and can predict the subsequent quote revisions of announcing firms. In addition, we also find a similar relationship between short selling of announcing firms and subsequent quote revision of competing firms. For the equation explaining quote revision of competing firms, r_t^c, the coefficient for the second-lagged short-sale volume of announcing firms is -0.01380 at 5 % significance level; the coefficient for the first-lagged quote revision of announcing firms is at 0.02907 at 1% significance level. Our result thus suggests that, during a 5 day period around earnings announcements, there is a "pooling equilibrium" (Easley et al., 1998) in which informed investors short both announcing firms and competing firms and that short-sale volume of announcing firms and competing firms have information contents for each other. In addition, the cross-stock correlation in quote revisions indicates that quote revision of competing (announcing) firms have predictive ability for the subsequent quote revisions of announcing (competing) firms, after controlling for short-sale volume up to six lags. Our results provide strong support for the hypotheses that quote revisions of an asset have future information content about a related asset.

4.2. Contemporaneous effects of short-sale volumes on quote revision

We observe from Table 2 that the contemporaneous relationship between short-sale volumes of announcing firms and their contemporaneous quote revisions are positive and significant. For the equation explaining quote revisions of announcing firms, the coefficient for the contemporaneous (zero-lagged) short-sale volume of announcing firms is 0.12005 at 1% significance level. As a firm is experiencing downward price pressure, its contemporaneous short-sale volume is reduced by the uptick rule. Since the uptick rule does not apply in a cross-stock setting, we observe from Table 2 that the short-sale volumes of competing firms (announcing firms) have no significant contemporaneous effect on quote revision of announcing firms (competing firms).

4.3. Effect of quote revision on short-sale volumes

Table 3 presents regression results where the dependent variable is short-sale volumes over the 5-minute interval *t* during a 5-day period from -2 to 2 relative to the announcement day. Independent variables are lagged quote revisions and lagged short-sale volumes of announcing firms and competing firms.

First, we observe that there is a strong cross-stock impact of quote revision on short-sale volume, consistent with hedging effect. Quote revisions of competing firms (announcing firms) are negatively related to the subsequent short-sale volumes of announcing firms (competing firms). For the equation explaining short-sale volumes of announcing firms (competing firms), the coefficient for the first-lagged quote revision of competing firms (announcing firms) is -0.01557 at 5% significance level (-0.01639 at 5% significance level). This suggests that a negative signal from declining quotes prompts investors to take short positions as a hedge and provides evidence that information of announcing firms is reflected in the short-sale volume of competing firms. Second, we observe from Table 3 that hedging effects are also evidenced in the same-stock setting for both

announcing firms and competing firms, suggesting informed investors with unfavorable news of a firm may hedge their long positions by taking short positions in the same firm. For the equation explaining short-sale volumes of announcing firms (competing firms), the coefficient for the first-lagged quote revision of announcing firms (competing firms) is -0.03140 at 1% significance level (-0.02987 at 1% significance level).

Table 3
Short-sale volume and quote revision of announcing and competing firms around earnings announcements

	Announcing firms v_t^a	Competing firms v_t^c
	Coeff.	Coeff.
r_{t-1}^a	-0.03140***	-0.01639**
r_{t-2}^a	0.00375	-0.00137
v_{t-1}^a	0.19414***	0.04332***
v_{t-2}^a	0.08371***	0.01736***
r_{t-1}^c	-0.01557**	-0.02987***
r_{t-2}^c	-0.00294	0.00676
v_{t-1}^c	0.03262***	0.17811***
v_{t-2}^c	0.01112*	0.08068***
R^2	0.07400	0.06270
N	31,732	31,732

Note: This table presents regression results of equation (2). Explanatory variables up to 6 lags are used in the regression. We report regression coefficients for the first 2 lags (intercepts and Lags 3-6 are not reported for brevity). *** denotes significance level at 1%;   ** denotes significance level at 5%; * denotes significance level at 10%.

4.4. Impacts of short-sale constraints

Since there is no transparent market for borrowing stock, data on stock lending fee are not publicly available. Many researchers use option status (Figlewski and Webb, 1993; Danielsen and Sorsecu, 2001; Boehme et al., 2010) to proxy short sale constraint. Boehme et al. (2010) note that in the opaque stock lending market, active participants enjoy much lower borrowing cost than less active participants. As active participants, writers of put options hedge their positions by short selling the underlying stocks with lower borrowing costs (see also Danielsen and Sorsecu, 2001;   Evans, Geezy, Musto and Reed, 2003). As a result, the availability of exchange-traded put options lowers the cost of short selling, all else being equal. Within the context of cross-stock short selling, a question of interest to us is how short-sale constraints such as the unavailability of exchange-traded put options impact the direction of information flow between announcing firms and competing firms.

Table 4 presents regression results where the dependent variable is the quote revision over the 5-minute interval *t* during a 5-day period from -2 to 2 relative to the announcement day. Independent variables are lagged quote revisions and both contemporaneous and lagged short-sale volumes of announcing firms *without CBOE- traded put options* and randomly selected competing firms. The option status of announcing firms is obtained from the Chicago Board of Options Exchange. In contrast to the "pooling equilibrium" in which short selling of announcing firms and

competing firms have information contents for each other (see Table 2), Table 4 suggests that only short selling activities in competing firms have information content for subsequent quote revision of announcing firms. For example, for the equation explaining quote revision of announcing firms, the coefficient for the first-lagged short-sale volume of competing firms is -0.02370 at 5% significance level. Interestingly, none of the coefficients for lagged short sale volumes and quote revisions of announcing firms has information content for subsequent quote revision of competing firms. Our results indicate that in the

presence of short sale constrain on announcing firms, competing firms in the same industry become the venue of choice for short sellers and short selling of competing firms contain information on the subsequent quote revision of announcing firms.

Table 4
Quote revision and short-sale volume of announcing firms and randomly selected competing firms

	Announcing firms without traded put options, r_t^a	Randomly selected competing firms r_t^c
	Coeff.	Coeff.
r_{t-1}^a	-0.05616***	-0.00070
r_{t-2}^a	-0.03477***	-0.01925
v_t^a	0.09548 ***	0.00080
v_{t-1}^a	-0.00750	0.00990
v_{t-2}^a	-0.01499	0.00813
r_{t-1}^c	0.02766***	-0.07242***
r_{t-2}^c	0.00552	-0.00516
v_t^c	-0.01843	0.11126***
v_{t-1}^c	-0.02370**	-0.00325
v_{t-2}^c	0.01465	-0.01213
R^2	0.02220	0.02050
N	6,877	6,877

Note: This table presents regression results of equation (1). Independent variables are lagged quote revision and both contemporaneous and lagged short-sale volume in announcing firms *without traded put options* and randomly selected competing firms. Explanatory variables up to 6 lags are used in the regression. We report regression coefficients for the contemporaneous (when applicable) and first 2 lags (intercepts and Lags 3-6 are not reported for brevity). *** denotes significance level at 1%;   ** denotes significance level at 5%; * denotes significance level at 10%.

    Using a proprietary dataset, D'Avolio (2002) shows that loan fee associated with borrowing stock decreases with the market capitalization. We use market capitalization as a proxy to further investigate the impact of short sale constraints on the direction of information flow in cross-stock short selling. Table 5 presents regression results where the dependent variable is the quote revision over the 5-minute interval *t* during event period, defined as a 5-day period from -2 to 2 relative to the announcement day. Independent variables are lagged quote revisions and both

contemporaneous and lagged short-sale volumes of *lowest-quintile announcing firms ranked by market capitalization* and randomly selected competing firms. The impact of low market capitalization on the direction of information flow is shown Table 5. The results are similar to those in Table 4. In the presence of significant short sale constraint on the stocks of announcing firms, informed investors tend to short sale stocks of competing firms in the same industry. Information stemming from short selling flows one way from competing firms to announcing firms and not vice versa.

Table 5
Quote revision and short-sale volume of announcing firms ranked by market capitalization and competing firms

	Lowest-quintile announcing firms r_t^a	Randomly selected Competing firms r_t^c
	Coeff.	Coeff.
r_{t-1}^a	-0.06204***	0.00422
r_{t-2}^a	-0.01986	0.01756
v_t^a	0.10481	0.01220
v_{t-1}^a	-0.11930	0.00187
v_{t-2}^a	0.00238	-0.00685
r_{t-1}^c	0.02812**	-0.06985***
r_{t-2}^c	-0.02794	-0.00386
v_t^c	-0.01679	0.12252***
v_{t-1}^c	-0.05026***	0.00313
v_{t-2}^c	0.01159	-0.03499**
R^2	0.02460	0.02710
N	6,360	6,360

Notes: This table presents regression results of equation (1). Independent variables are lagged quote revision and both contemporaneous and lagged short-sale volume in *lowest-quintile announcing firms ranked by market capitalization* and randomly selected competing firms. Explanatory variables up to 6 lags are used in the regression. We report regression coefficients for the contemporaneous (when applicable) and first 2 lags (intercepts and Lags 3-6 are not reported for brevity). *** denotes significance level at 1%;   ** denotes significance level at 5%; * denotes significance level at 10%.

4.5. Summary

Table 6 summarizes, in a 4 by 4 matrix, the interrelationship between quote revisions and short-sale volumes for announcing firms and competing firms.   Table 6 reveals several interesting cross-stock relationships between announcing firms and competing firms.   (1) the negative impact of short-sale volume of competing firms on quote revisions of announcing firms, (2) the negative impact of short-sale volume of announcing firms on quote revisions of competing firms, (3) the positive impact of quote revisions of competing firms on quotes revisions of announcing firms, (4) the positive impact of quote revisions of announcing firms on quotes revisions of competing firms, (5)

the negative impact of quote revisions of competing firms on the short-sale volumes of announcing firms, and (6) the negative impact of quote revisions of announcing firms on the short-sale volumes of competing firms. The first four findings are consistent with the information transmission between announcing firms and competing firms. The last two findings result from hedging effects but are also related to information effects in that information contained in quote revisions is transmitted through short-sale volume.

Table 6
Summary of interrelationship between quote revisions and short-sale volume in announcing firms and competing firms

	Explanatory variables (lagged terms)			
Dependent variables	Announcing firm quote revisions	Competing firm quote revisions	Announcing firm short-sale volume	Competing firm short-sale volume
Announcing firm quote revisions	negative	positive	negative	negative
Competing firm quote revisions	positive	negative	negative	negative
Announcing firm short-sale volume	negative	negative	positive	positive
Competing firm short-sale volume	negative	negative	positive	positive

Table 6 also reveals a number of own-stock relationships for announcing firms and competing firms. (1) the negative autocorrelations of quote revisions of announcing firms and competing firms, (2) the negative impact of short-sale volume on quote revisions, and (3) negative impact of quote revisions on short-sale volume. The first finding is consistent with inventory control effects; the second finding is consistent with both information effects and inventory control effects; and the third finding is consistent with hedging effects. Overall, our evidence indicates that both short-sale volume and quote revisions contain information. There are also evidence of inventory control effects and hedging effects.

We also examine the impact of short sale constraints on the direction of information flow. Our results indicate that, in the presence of significant short sale constraint on the stocks of announcing firms, informed investors tend to short competing firms in the same industry. Information stemming from short selling flows one way from competing firms to announcing firms and not vice versa.

4.6. Robustness test

Previous studies (Jones, Kaul, and Lipson, 1994; Chan et al., 2002) suggest that movements of quotes are more sensitive to the number of trades than trade volume. As a robustness check, we repeat our analysis using the number of short trade instead of short-sale volume. The results are reported in Table 7. Note that these results are very similar to those with short-sale volume (Table 2). In particular, the number of short trades of competing firms (announcing firms) can predict subsequent quote revisions of announcing firms (competing firms). In addition, we observe

significant hedging effect in both cross-stock setting and own-stock setting both announcing firms and competing firms. Furthermore, we observe similar uptick rule effect and inventory control effect.

Table 7
Quote revision and number of short trades of announcing and competing firms around earning announcements

	Announcing firms r_t^a	Competing firms r_t^c
	Coeff.	Coeff.
r_{t-1}^a	-0.04438***	0.03078***
r_{t-2}^a	-0.00565	0.01123*
s_t^a	0.15053***	0.01300***
s_{t-1}^a	0.00585	-0.00236
s_{t-2}^a	-0.01426**	-0.01374**
r_{t-1}^c	0.02523***	-0.03686***
r_{t-2}^c	-0.00680	-0.01070**
s_t^c	0.01562***	0.20213***
s_{t-1}^c	-0.00400	-0.00020
s_{t-2}^c	-0.01582**	-0.01943***
R^2	0.03500	0.03340
N	31,732	31,732

Notes: This table presents regression results equation (1)   Independent variables are lagged quote revision and both contemporaneous and lagged number of short trades in announcing firms and competing firms. Explanatory variables up to 6 lags are used in the regression. We report regression coefficients for the contemporaneous (when applicable) and first 2 lags (intercepts and Lags 3-6 are not reported for brevity).   *** denotes significance level at 1%;   ** denotes significance level at 5%.

5. Concluding remarks

We examine the intraday response of market professionals to short selling within the context of 127 earnings announcements in 63 industries. We find strong evidence that the interaction between NYSE specialists and short sellers forms a channel of intra-industry information flow. Both quote revision and short selling of competing firms have strong predictive ability for subsequent quote revision of announcing firm. We also find that quote revision of competing firms can predict short-sale volumes of both announcing firms and competing firms, indicting hedging effect in both cross-stock and same-stock settings Our results suggest that some short sellers with information of announcing firms short competing firms first.   Furthermore, we examine the impact of short-sale constraints on the direction of information flow. Our results indicate that, in the presence of significant short-sale constraint in the stocks of announcing firms, short sellers tend to short competing firms.

References

Allen, F. and D. Gale, 1992, Stock-price manipulation. *Review of Financial Studies* 5, 503-529.
Aitken, M. A. Frino, M. McCorry and P. Swan, 1998, Short sales are almost instantaneously bad news: Evidence from the Australian Stock Exchange. *Journal of Finance* 53, 2205-2223.
Asquith , P. and L. Meulbrock, 1995, An empirical investigation of short interest. Working paper, Harvard University.

Ayres, I. and J. Bankman, 2001, Substitutes for insider trading. *Stanford Law Review* 54, 235-294.

Baginski, S. 1987, Intra-industry information transfer associated with management forecast of earnings. *Journal of Accounting and Research* 25, 196-213.

Bittlingmayer, G. and T. Hazlett, 2000, Has antitrust action against Microsoft created value in the computer industry? *Journal of Financial Economics* 55, 329–359.

Bettis, J., J. Coles, and M. Lemmon, 2000, Corporate policies restricting trading by insiders. *Journal of Financial Economics* 57, 191-220.

Boehme, R., B. Danielsen and S. Sorescu, 2010, Short sale constraints, differences of opinion, and overvaluation. Working paper, Texas A&M University.

Chan, K., Y. Chung, and W. Fong, 2002, The informational role of stock and option volume. *Review of Financial Studies* 15, 1049-1075.

Christophe, S., M. Ferri and J. Angel, 2004, Short-selling prior to earnings announcement. *Journal of Finance* 59, 1845-1875.

D' Avolio, G., 2002, The market for borrowing stock. *Journal of Financial Economics* 66, 271-306.

Danielsen, B. and S. Sorescu, 2001, Why do option introductions depress stock prices? A study of diminishing short-sale constraints. *Journal of Financial and Quantitative Analysis* 36, 451-484.

Deasai, H., K. Ramesh, S. Thiagarajan, and B. Balachandran, 2002, An investigation of the information role of short interest in the Nasdaq market. *Journal of Finance* 52, 2263-2287.

Diamond, D. and R. Verrecchi, 1987, Constraints on short-selling and asset price adjustment to private information. *Journal of Financial Economics* 18, 277-311.

Diether, K, C. Malloy, and A. Scherbina, 2002, Differences of opinion and the cross-section of stock returns. *Journal of Finance* 57, 2113-2141.

Diether, K., I. Werner and K. Lee, 2009, Short-sale strategies and return predictability, *Review of Financial Studies* 22, 575-607.

Easley, D., M. O'Hara, and P. Srinivas, 1998, Option volume and stock prices: Evidence on where informed traders trade. *Journal of Finance* 53, 431-465.

Efendi, J., M. Kinnery and E. Swanson, 2005, Can short sellers predict accounting restatements? Working paper, Texas A&M University.

Evans, R., C. Geczy, D. Musto, and A. Reed, 2003, Failure is an option: Impediments to short-selling and option prices. Working paper, University of North Carolina.

Figlewski, S. and G.P. Webb, 1993, Options, short sales, and market completeness. *Journal of Finance* 48, 761-777.

Firth, M., 1996, Dividend changes, abnormal returns and intra-industry firm valuations, *Journal of Financial and Quantitative Analysis* 31, 189-211.

Forster, G., 1981, Intra-industry information transfer associated with earning releases. *Journal of Accounting and Research* 3, 201-219.

Freeman, R. and S. Tse, 1992, An earnings prediction approach to examine inter-company information transfers. *Journal of Accounting and Economics* 23, 106-122.

Gebhardt, W., C. Lee, and B. Swaminathan, 2001, Toward an implied cost of capital. *Journal of Accounting Research* 39, 135-176.

Hasbrouck, J., 1991, Measuring the information contents of stock trades. *Journal of Finance* 46, 179-207.

Hasbrouck, J., 2007, Empirical market microstructure. Oxford University Press.

Ho, T., and H. Stoll, 1983, The dynamics of dealer markets under competition. *Journal of Finance* 38, 1053-1074.

Huang, R. and H. Stoll, 1994, Market microstructure and stock return predictions. *Review of Financial Studies* 7, 179-213.

Jones, C., 2008, Shorting restriction: revisiting the 1930's. Working papers, Columbia University.

Jones, C., G. Kaul, and M. Lipson, 1994, Transaction, volume, and volatility. *Review of Financial Studies* 7, 631-651.

Lang, L., and R. Stulz, 1992, Contagion and competitive intra-industry effects of bankruptcy announcements, *Journal of Financial Economics* 32, 45–60.

Laux, P., L. Starks, and P. Yoon, 1998, The relative importance of competition and contagion in intra-industry information transfers: An investigation of dividend announcements. *Financial Management* 27, 5–16.

Manhavan, A., 2002, Market microstructure: A practitioner's guide, Financial Analysts Journal, 58, 28-42.

Miller, E., 1977, Risk, uncertainty, and divergence of opinion, *Journal of Finance* 32, 1151-68.

Nagel, S., 2005, Short sales, institutional investors and the cross-section of stock returns. *Journal of Financial Economics* 78, 277-309.

O'Hara, M., 1997, Market microstructure theory, Blackwell.

Tookes, H., 2008, Information, trading, and product market interaction: cross-sectional implication of informed trading. *Journal of Finance* 58, 379-412.

Wu, J., 2007, Short selling and the information efficiency of prices, Working paper, Texas A&M University.