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The Information in Fire Sales

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ABSTRACT

Asset prices remain depressed for prolonged periods of time following mutual fund fire sales. We show that this price pressure from fire sales is partly due to asymmetric information which leads to an adverse selection problem for arbitrageurs. After a flow shock, fund managers *choose* to sell low-quality stocks. To measure this, we use short interest as a proxy variable for the unobservable negative signal managers use when selling. Following flow shocks, managers are significantly more likely to sell stocks which, ex ante, have high short interest. Moreover, these stocks experience future price drops that do not later reverse. In other words, fund managers have stock selling ability. Our findings suggest an explanation for the tendency of asset prices to remain depressed following fire sales: information asymmetries make it difficult for arbitrageurs to disentangle pure price pressure from negative information.

Keywords: adverse selection, asymmetric information, fire sales, information economics, institutional investors, slow moving capital.

JEL Classification Numbers: G12, G14

I. Introduction

It is clear that asset prices remain low for prolonged periods of time following mutual fund fire sales (Coval and Stafford (2007)).[1] What is less clear is *why* these effects persist, given that mutual fund fire sales are, arguably, common knowledge events. Mutual fund holdings are publicly released at regular intervals. Moreover, although mutual fund flows are not instantaneously viewable, a number of papers argue that fire sale price pressure is predictable (e.g., Coval and Stafford (2007), Shive and Yun (2012), Dyakov and Verbeek (2013), Arif, Ben-Rephael, and Lee (2014)). Together, these facts beg an important question: why don't arbitrageurs correct mispricing from fire sales sooner?

In this paper, we offer an explanation for the long-lasting impact of price pressure from mutual fund fire sales. Specifically, we show that mutual fund managers do not randomly sell stocks when they experience a flow shock, but rather, they *choose* to sell those stocks which they believe will perform poorly in the future.[2] Moreover, we find evidence that fund managers have some skill at selling stocks: a subset of the stocks they sell experience severe price drops which do not subsequently rebound. In other words, part of the observed underperformance of fire sales stocks is due to negative fundamental information. As a result, our findings suggest an explanation for the tendency of asset prices to remain depressed following fire sales: information asymmetries make it difficult for arbitrageurs to disentangle pure price pressure from negative fundamental information.

To investigate the persistence of price pressure from fire sales, we first examine the trading motivation of managers following a flow shock. Of course, the information set of fund managers is inherently unobservable, which makes it difficult to know *why* fund managers choose to sell a particular stock. Accordingly, we use a well-established predictor of negative

[1] A number of other papers document empirical evidence of fire sales in a variety of asset classes. See, for example, Pulvino (1998), Ellul, Jotikasthira, and Lundblad (2011), Jotikasthira, Lundblad, and Ramadorai (2012), and Merrill, Nadauld, Stulz, and Sherlund (2014)).

[2] We note that we are not the first to suggest this point. For example, Kisin (2011) and Edmans, Goldstein, and Wang (2015) both develop identification strategies which control for the possibility that managers use private information when selling stocks after outflows.

futures returns as a proxy variable for negative information about each stock.[3] A large literature has shown that short sellers are skilled at identifying overvalued securities; stocks with high short interest today earn lower returns in the future (e.g., Senchack Jr. and Starks (1993); Boehmer, Jones, and Zhang (2008)). More recently, Rapach, Ringgenberg, and Zhou (2015) find that short interest also contains information about aggregate market returns and several papers provide evidence that short sellers are skilled at processing information (e.g., Boehmer et al. (2008); Engelberg, Reed, and Ringgenberg (2012). Hence, we adopt short interest as a measure of negative fundamental information.

Using short interest as a proxy variable for negative information, we find strong evidence that mutual fund managers possess some stock selling ability. Following a flow shock, fund managers are significantly more likely to sell high short interest stocks. In other words, fund managers do not simply sell a prorated fraction of each stock in their portfolio, but rather, they sell more of those stocks which have negative fundamental information.[4] Using a linear probability model we find that a one standard deviation increase in short interest is associated with a 2% increase in the probability that a manager of a distressed fund will sell a stock.

Importantly, we note that our results are related to, but distinct from, existing work which finds that hedge funds and short sellers front-run mutual fund fire sales (e.g., Shive and Yun (2012), Dyakov and Verbeek (2013), Arif et al. (2014)). Our findings show a positive relation between short interest in a *specific* stock and selling behavior by fund managers. Conversely, front-running suggests that short sellers can anticipate which *funds* will be distressed. Absent other private information, however, short sellers should not be able to identify specific stocks that managers will choose to sell in greater than expected proportion. In other words, while the existing literature has documented robust evidence of front-running, our results show

[3]Wooldridge (2010) discusses the conditions under which a proxy variable is valid. We discuss our proxy variable in greater detail in Section II.B, below.

[4]In Section III, below, we note that we cannot distinguish between two competing explanations for this finding: (i) It is possible that fund managers independently uncover the same negative information being used by short sellers. (ii) Alternately, it is possible that fund managers merely condition on short interest when making their trades.

something new: following flow shocks, mutual fund managers choose to sell those stocks that have negative fundamental information.

We also note that our results are related to the long-standing short interest puzzle which questions why short interest data continues to predict future returns even though short interest data is *publicly* available. In our context, the puzzle takes a slightly different form: since investors face an adverse selection problem when they see price pressure from fire sales, why don't they use short interest to separate assets into low-quality and high-quality? There are several possible explanations for our findings. One possibility is that investors face substantial portfolio re-balancing costs such that they do not trade on all information at their disposal.[5] It is also possible that, prior to our findings, investors were unaware of the signal value of short interest in the context of fire sales. Several paper shows that return predictability diminishes after the publication of academic studies (e.g., Schwert (2003) and McLean and Pontiff (2015)). We explore these issues in greater detail in Section III.D of the paper.

Finally, we show that selective selling by fund managers can partly explain the long-lasting impact of price pressure from fire sales. In general, it takes nearly two years for price pressure from fire sales to completely reverse (Coval and Stafford (2007)). However, for stocks with high short interest, we find that depressed prices persist for much longer. In Figure 2, the evidence suggests that prices of high short interest stocks remain low for much longer than two years, while prices for low short interest stocks revert to normal in approximately one year. Moreover, using a linear probability model, we find that high short interest stocks are significantly less likely to revert to their pre-fire sales prices.

Our results are related to an extensive theoretical literature on fire sales. Several papers argue that fire sales occur as a result of limits to arbitrage (e.g., Shleifer and Vishny (1997), Gromb and Vayanos (2002)). Our findings are consistent with the limits to arbitrage explanation in that arbitrageurs may be unable to distinguish pure price pressure from private

[5]This is consistent with Novy-Marx and Velikov (2014) who show that the optimal way to account for trading costs is to have a higher threshold for changing a position then for maintaining a current position.

information which leads to a type of model risk. In that sense, our results are also related to the large literature on adverse selection in the presence of information asymmetries. We document evidence of the classic "lemons" problem as described in Akerlof (1970). In our setting, we argue by revealed preference that fund managers who own a particular stock are likely to have have some information advantage about the value of that asset. In other words, managers choose to buy an asset because they believe they can value it better than other market participants. Following a flow shock, managers must sell some of their holdings and they use their information advantage to optimize this decision. Specifically, they reevaluate their asset holdings and *choose* to sell the stocks they believe will perform poorly in the future, although the magnitude of the flow shock may lead them to sell other (high quality) stocks at the same time. As a result, following a flow shock, managers will sell a mix of low and high-quality assets and other market participants may be unable to distinguish between the two types. This causes all fire sale assets to experience price drops (i.e., they all sell at the "lemon" price).

Our results are also broadly consistent with the predictions of Dow and Han (2015) who model fire sales in a noisy rational expectations equilibrium. In their model, some investors are informed and act as arbitrageurs who buy some (but not all) assets following fire sales. As a result of these informed trades, asset prices are correct and this separates low-quality assets from high-quality assets thereby allowing other, uninformed, investors to buy the remaining supply of fire sale assets at their fundamental value. However, in cases of market stress, the informed investors may be unable to buy assets which then prevents uniformed investors from trading due to the classic lemons problem.[6] Thus, all fire sale assets sell at the lower "lemon" price.

Overall, our paper makes several contributions. First, we provide an explanation for the long-lasting impact of price pressure from fire sales. We are the first to show that following

[6] In Dow and Han (2015), fire sales occur because informed investors are constrained in times of crisis and this generates an adverse selection problem. In our tests, we do not explicitly condition on systematic shocks. However, our results are consistent with an adverse selection problem.

a flow shock, fund managers choose to sell stocks with negative fundamental information. Thus, arbitrageurs face an information asymmetry which makes it difficult for them to disentangle pure price pressure from negative fundamental information. As a result, price pressure takes a long time to correct. Second, and more generally, our results suggests that information asymmetries may help explain the slow moving capital phenomenon as theorized in Duffie (2010). Arbitrage capital has been shown to be slow to react in a wide variety of contexts; our results show that information asymmetries can explain the reluctance of arbitrage capital to correct mispricings. Third, our results provide indirect evidence that fund managers do have some skill, even though academic studies consistently fail to document alpha. In that sense, our results provide indirect evidence consistent with the predictions of Berk and Green (2004).[7] In our context, flow shocks leave mutual funds temporarily out of equilibrium which allows us to document new evidence of stock selling skill by managers.

The rest of the paper proceeds as follows: Section II describes the data and discusses the calculation of key variables. Section III presents the analyses and findings. Section IV concludes.

II. Data

To test whether price pressure from fire sales is a result of adverse selection caused by information asymmetries, we combine data from the Center for Research in Security Prices ("CRSP), Compustat, and Thomson Financial, as discussed in detail below.

A. Sample Construction

Our sample consists of all U.S. firms in Compustat over the period 1990 to 2010. We include all firms that list their common stock on the New York Stock Exchange ("NYSE")

[7]Berk and Green (2004) argue that funds exhibit decreasing returns to scale and in equilibrium investors will allocate more capital to those funds with more skill. As a result, alphas will be driven to zero across all funds even though some managers have more skill than others.

and NASDAQ and we exclude American Depository Receipts ("ADRs"), Exchange Traded Funds ("ETFs"), and Real Estate Investment Trusts ("REITs").[8] To be included in the sample, we require non-missing data on monthly short interest, market capitalization, book-to-market ratio, and institutional ownership.

We obtain monthly short interest data from Compustat. Short interest is the quantity of open short positions (in shares) with settlements on the last business day on or before the fifteenth of a calendar month. Each month, U.S. stock exchanges calculate short interest as of the fifteenth of the month and publicly report the data four business days later.[9] We download historical short interest data from Compustat and express short interest as a fraction of shares outstanding.

In addition to the short interest data, we also obtain firm-level accounting data from Compustat and we match this data to financial market data from CRSP using the CRSP/Compustat merge file. From Compustat, we calculate the book value of equity. We define book equity as total shareholder equity minus the book value of preferred stock plus the book value of deferred taxes and investment tax credit. If total shareholder equity is missing, we calculate it as the sum of the book value of common and preferred equity. If all of these are missing, we calculate shareholder equity as total assets minus total liabilities. From CRSP, we include the bid-ask spread, shares outstanding, stock price, stock return, and volume. We calculate market capitalization as the product of the CRSP share price and the number of shares outstanding.

To measure institutional ownership in each stock, we use data from the Thomson-Reuters Mutual Fund Holdings database (formerly known as CDA/Spectrum). The Thomson-Reuters Mutual Fund Holdings database provides the quantity of shares held by each fund in a given quarter. To construct capital flows into and out of mutual funds, we use the CRSP mutual fund monthly net returns database. The calculation is discussed in detail in Section II.C,

[8] Specifically, we include only assets with CRSP share codes of 10 or 11.

[9] Starting in September of 2007, the exchanges began reporting short interest data twice a month (at the middle and end of the month). For consistency, we keep only the mid-month short interest value, as in Rapach et al. (2015).

below.

To mitigate the impact of illiquid stocks, in each period we drop stocks with a price less than \$5. To mitigate potential data errors, we also drop observations in a period if the stock experienced a split or repurchase in that period. Similar to Khan, Kogan, and Serafeim (2012) the resulting database includes approximately 300,000 observations at the stock-quarter level over our 20 year sample period.

B. Abnormal Short Interest

We define the short interest ratio ($SR_{i,t}$) of firm i in month t as the ratio of shares held short to the number of shares outstanding. The prior literature (e.g., Dechow, Hutton, Meulbroek, and Sloan (2001); Asquith, Pathak, and Ritter (2005)) documents that firm characteristics including the book-to-market ratio, market capitalization, and past stock returns have a significant impact on short interest. Because we are interested in using short interest as a proxy variable for the unobservable information set of fund managers, we want to control for the determinants of short interest that are unrelated to negative information. Accordingly, we calculate a measure of abnormal short interest which isolates the impact of these firm characteristics.

To do this, we first calculate expected short interest and we then define the abnormal short interest ratio (*Abnormal SR*) as the difference between actual and expected short interest as in Karpoff and Lou (2010). To calculate expected short interest, at the beginning of each month we assign each stock to one of 27 portfolios constructed by independently sorting stocks into terciles based on market capitalization, book-to-market, and the prior one-year return, all measured at the end of the previous month. We use the portfolio assignment to define indicator variables which take the value one if a stock is in a particular portfolio and zero otherwise, and we run panel regressions of the form:

$$\begin{aligned} SR_{i,t} = Sizelow_{i,t} + Sizemed_{i,t} + BMlow_{i,t} + BMmed_{i,t} + \\ PastRetlow_{i,t} + PastRetmed_{i,t} + \gamma_k + \epsilon_{i,t}, \end{aligned} \tag{1}$$

where the dependent variable is the short interest ratio ($SR_{i,t}$) of firm i in month t, $Sizelow_{i,t}$ and $Sizemed_{i,t}$ are indicator variables that equal one if firm i is assigned to the portfolio of the bottom and middle third of market capitalization, respectively, $BMlow_{i,t}$, $BMmed_{i,t}$ are indicator variables that equal one if firm i is assigned to the portfolio of the bottom and middle third of book-to-market, respectively, $PastRetlow_{i,t}$ and $PastRetmed_{i,t}$ are indicator variables that equal one if firm i is assigned to the portfolio of the bottom and middle third of past returns, respectively, and γ_k represents k industry fixed effects defined using two-digit SIC codes. We estimate the model and calculate expected short interest (*Expected SR*) as the predicted value from equation (1). Finally, we define *Abnormal* $SR_{i,t} = SR_{i,t} -$ *Expected* $SR_{i,t}$.

We stress that our *Abnormal* $SR_{i,t}$ represents deviations from the expected value of short interest for each stock. As such, in our analyses we are not simply screening on stocks which always have high short interest, but rather, stocks which likely had recent (unexpected) negative signals. As such, we argue that our *Abnormal* $SR_{i,t}$ variable is a valid proxy variable for the true quantity of (latent) negative information about a stock.

Wooldridge (2010) discusses the requirements for a valid proxy variable. Formally, there are two requirements for a variable, z, to be valid proxy variable for a latent variable q:

1. $\mathrm{E}[y \mid x, q, z] = \mathrm{E}[y \mid x, q]$

2. $\mathrm{L}[q \mid 1, x_1, \ldots, x_K, z] = \mathrm{L}[q \mid 1, z]$,

where $\mathrm{E}[\cdot]$ is the expectations operator and $\mathrm{L}[\cdot]$ is a linear projection operator. The first condition says that the proxy variable z is not related to y after accounting for q. In our case, this condition seems uncontroversial and implies that short interest would not be related to fire sales if we could control for the actual quantity of negative information about a stock. The second condition is more complicated, and is similar to an exclusion restriction in a standard instrumental variables model. It requires the correlation between the latent variable q and each covariate x to be zero after we include the proxy variable z. Of course, since q is unobservable, this restriction is inherently untestable. However, Wooldridge (2010) notes that even if z is an imperfect proxy such that the second condition does not hold, it is likely that the Ordinary Least Squares ("OLS") estimator will be better than if no proxy variable is included. Accordingly, we proceed by defining $Abnormal\ SR_{i,t}$ as a proxy variable for unobservable pessimistic information about stock i in month t.

C. Flow-induced mutual fund sales (purchases)

Finally, to quantify the magnitude of fire sales in each stock, we follow Coval and Stafford (2007) and Khan et al. (2012) to construct fund flow induced trading pressure for each stock held by mutual funds during our sample period. Specifically, we define flows for fund j in month s as:

$$Flow_{j,s} = \frac{[TNA_{j,s} - TNA_{j,s-1} \cdot (1 + R_{j,s})]}{TNA_{j,s-1}}, \tag{2}$$

where $TNA_{j,s}$ is total net assets for fund j as of the end of month s and $R_{j,s}$ is the monthly return for fund j in month s. We measure total net assets and returns using the CRSP mutual fund monthly net returns database. To match our estimated $Flow_{j,s}$ variable with quarterly fund holding data from Thomson Financial, we sum the monthly flows over the quarter to obtain quarterly fund flows $Flow_{j,t} = \sum_{s}^{s+2} (Flow_{j,s})$ for each fund j in quarter t. Then, we calculate flow-induced trading pressure for stock i in quarter t as:

$$Pressure_{i,t} = \frac{[\sum_j (max(0, \Delta Holdings_{j,i,t}) | flow_{j,t} > 90th\%) - \sum_j (max(0, -\Delta Holdings_{j,i,t}) | flow_{j,t} < 10th\%)]}{SharesOutstanding_{i,t-1}}. \tag{3}$$

As in Coval and Stafford (2007), stocks in the bottom decile of $Pressure_{i,t}$ are considered to be experiencing excess selling demand from mutual funds with large capital outflows. Accordingly, we define price pressure for intensive sell stocks, *PrcPres(ISP)*, as those stocks with extremely high outflows (below the 10th percentile of price pressure at each date) and price pressure for intensive buy stocks, *PrcPres(IBP)*, as those stocks with extremely high inflows (above the 90th percentile of price pressure at each date).

D. Summary statistics

Table I provides summary statistics for the combined database. All variables are winsorized at the 1st and 99th percentiles to mitigate the impact of outliers and detailed definitions of these variables, except those defined above (abnormal short interest and fund flow-induced fire sales and purchases), are provided in the Table A1 of the Appendix.

The mean (median) short interest ratio (SR) over our sample is 2.5% (1.7%), consistent with the existing literature (e.g., Rapach et al. (2015)). By construction, abnormal short interest (*Abnormal* SR) has a mean of zero, but we note that it is highly right skewed with a 99th percentile of 15.6%. Thus, some stocks experience extremely high abnormal short interest, indicating that there is likely pessimistic information about their valuation. Finally, both the mean and median of price pressure for intensive sell stocks ($PrcPres(ISP)$) are negative, as expected, indicating funds are selling these stocks in large quantities.

III. Results

In this section, we examine whether the magnitude and persistence of price pressure following fire sales can be explained by negative information which leads to selective selling by fund managers. Our findings suggest that price pressure from fire sales can partially be explained by selective selling by fund managers which leads to information asymmetries that make it difficult for arbitrageurs to disentangle pure price pressure from negative information.

We begin by examining the trading motivations of fund managers to determine which stocks they sell (and why) following fire sales. Next, we examine the performance of fire sale stocks, conditional on our proxy variable for negative information. Then, we examine the risk-adjusted returns to a simple-trading strategy to quantify the value of the information in fire sales. Finally, we discuss the implications of our findings.

A. Trading Motivation of Fund Managers

To investigate the persistence of price pressure from fire sales, we first examine the trading motivation of managers following a flow shock. As previously discussed, the information set of fund managers is latent, which makes it difficult to know why fund managers choose to sell a particular stock. Thus, we use short interest, a well-established predictor of negative futures returns, as a proxy variable for negative private information about each stock. A number of papers find that short sellers are informed traders who are skilled at identifying overvalued stocks. As a result, there is robust evidence that high short interest predicts lower future returns, consistent with short interest being a measure of negative information (e.g., Senchack Jr. and Starks (1993); Boehmer et al. (2008), Rapach et al. (2015)).

As discussed in Section II.B, we focus our analyses on *abnormal* short interest to ensure we are capturing stocks which had recent (unexpected) negative signals and not merely persistently high short interest. Figure 1 graphs *Abnormal SR* in event time over a two-year window around fire sales. Interestingly, *Abnormal SR* begins rising approximately one year prior to the fire sale, and peaks in the months immediately before the event, before falling sharply in the months following the fire sale. Table II contains the corresponding data for the mean short interest ratio (SR) and the mean abnormal short interest ratio (*abnormal SR*) in event time.

The event time data on abnormal short interest is consistent with a number of explanations. First, it is possible that short sellers are skilled at anticipating which funds are likely to experience negative flow shocks which will result in forced selling. As a result, short sellers may front-run stocks that are owned by funds which will soon experience fire sales. Indeed, several papers document robust evidence of front-running (e.g., Shive and Yun (2012), Dyakov and Verbeek (2013), Arif et al. (2014)). Second, it is also possible that negative information jointly leads to high short interest *and* selling by fund managers. We note that these two explanations are not mutually exclusive.

To explore the relation between short interest and fire sales, we examine whether managers are more likely to sell stocks which experienced recently high abnormal short interest. Our null hypothesis is that, absent negative information about the fundamental value of each stock, fund managers experiencing a fire sale should sell stocks in proportion to their holdings.[10] For example, if a manager had 40% of their portfolio allocated to GE, 30% allocated to 3M, and 30% allocated to Ford and the manager experienced $10 million in redemptions, then we would expect the manager to sell $4 million of GE, $3 million of 3M, and $3 million of Ford. On the other hand, if the manager has private information that one of these stocks is likely to underperform going forward, we would expect the manager to concentrate their selling in that asset.

To examine this, we explore the determinants of fund manager selling using linear probability panel regressions of the form:

$$\begin{aligned} \mathbb{1}_{[Sell]i,t} = \alpha + \beta_1 AbnormalSR_{i,t-1} + \beta_2 Size_{i,t-1} + \beta_3 B/M_{i,t-1} + \\ \beta_4 PastRet_{i,t-12:t-2} + \beta_5 Bid-Ask_{i,t-1} + \epsilon_{i,t}, \end{aligned} \tag{4}$$

where $\mathbb{1}_{[Sell]i,t}$ is an indicator variable that takes the value 1 if a manager sells stock i in month t, $AbnormalSR_{i,t-1}$ is the abnormal short interest ratio in the month prior to the fire sale, $Size$ is the natural log of market capitalization in the month prior to the fire sale, $B/M_{i,t-1}$ is the book-to-market ratio in the month prior to the fire sale, $PastRet_{i,t-12:t-2}$ is the cumulative return on the stock over the past 11 months, measured from two months

[10]More specifically, we theorize that, absent private information, fund managers would sell stocks in proportion to their holdings *after* accounting for the relatively illiquidity of each asset. Accordingly, we control for illiquidity in our analyses.

before the fire sale to 12 months before the fire sale, and $Bid - Ask_{i,t-1}$ is the difference between the closing ask price and the closing bid price scaled by the closing mid-point of price. Importantly, $Bid - Ask_{i,t-1}$ controls for each stock's liquidity prior to the fire sale. In all models we cluster the standard errors by firm and year-quarter.

The results are shown in Panel A of Table III. In all of the specifications we find strong evidence that fund managers are more likely to sell stocks with abnormally high short interest, our proxy for negative fundamental information. The coefficient of 0.13 on *Abnormal SR* in column (2) suggests that a one standard deviation increase in abnormal short interest is associated with a 2% increase in the probability of sale by a manager. In other words, fund managers sell stocks with negative information in greater than expected proportion. Interestingly, we also find that fund managers are significantly more likely to sell larger stocks, stocks which decreased in value over the previous 2 to 12 months, and stocks which are more liquid. In other words, the results suggest that fund managers strategically *choose* which stocks to sell.

In Panel B of Table III, we repeat the analysis using OLS panel regressions to examine the relation between abnormal short interest and abnormal net trading according to the model:

$$AbnormalTrade_{i,t} = \alpha + \beta_1 AbnormalSR_{i,t-1} + \beta_2 Size_{i,t-1} + \beta_3 B/M_{i,t-1} + \beta_4 PastRet_{i,t-12:t-2} + \beta_5 Bid - Ask_{i,t-1} + \epsilon_{i,t}, \tag{5}$$

where $AbnormalTrade_{i,t}$ is defined as the percentage change in holdings of stock i in month t by a fund less the expected trading in that stock. We calculate the expected trading in the stock based on the dollar flow from the fund prorated across its holdings in each stock as of the beginning of the quarter. In other words, we assume that each fund manager prorates the flow shock across his/her holdings; the dependent variable in equation (5) measures deviations from this benchmark case.

Once again, the positive and significant coefficient on *Abnormal SR* in column (2) suggests that a one standard deviation increase in abnormal short interest is associated with a 1.3% increase in abnormal selling which represents a large increase in selling relative to the unconditional mean abnormal trade of 16.3%. Thus, fund managers are significantly more likely to sell stocks which had negative fundamental information. Moreover, in Panel B we again find that fund managers sell an abnormally large quantity of illiquid stocks and stocks which recently experienced negative returns.

In sum, our evidence suggests that managers selectively *choose* which stocks to sell following a flow shock. As a result, our results are distinct from existing findings that short sellers front-run mutual fund fire sales. We find a positive relation between short interest in a *specific* stock and selling behavior by fund managers. However, the front-running hypothesis suggests that short sellers can anticipate which *funds* will be distressed. But without other private information, short sellers should not be able to identify specific stocks that managers will choose to sell in greater than expected proportion. Thus, while the existing literature has documented significant evidence of front-running, our results document a new fact: following flow shocks, mutual fund managers choose to sell those stocks that have negative fundamental information.

B. Information Content of Selling Decisions

In the previous section, we showed that fund managers were significantly more likely to sell stocks which, ex-ante, had high short interest (our proxy variable for negative fundamental information). In this section, we provide further evidence of the information in fire sales. Specifically, we examine the relation between fire sales and future stock returns. To examine whether fire sale fund managers possess private information which they use when selling stocks, we again condition on ex-ante abnormal short interest as a proxy variable for negative information.

We start with a simple event study of abnormal returns around fire sales. Figure 2 graphs cumulative abnormal returns in event time over an approximately two-year window around fire sales. Table IV contains the corresponding monthly return values as well as t-statistics and the cumulative return values. Similar to the well-known return pattern documented by Coval and Stafford (2007), we find that returns start to fall in the quarter immediately prior to the fire sale. More interesting, however, is the pattern that emerges in later months. We split fire sale stocks into two portfolios: (i) those with ex-ante low abnormal short interest (*Low Abnormal SR*) and (2) those with ex-ante high abnormal short interest (*High Abnormal SR*). Following a fire sale, the *Low Abnormal SR* portfolio stocks experience a modest price drop at t+1 (a negative 90 basis point return), but then the price immediately levels off and even starts drifting upward. By month 18, the cumulative average return is again positive. On the other hand, *High Abnormal SR* stocks experience extreme price drops during the event month and for the next three months. Moreover, the prices of these stocks remain low; they do not revert over our sample. While *Low Abnormal SR* stocks experience a maximum cumulative loss of 3%, *High Abnormal SR* stocks experience a maximum cumulative loss of almost 7%.

The results are generally consistent with models of adverse selection in which fire sales cause managers to sell a mix of both low-quality and high-quality assets (e.g., Dow and Han (2015)). Following a flow shock, managers choose to sell the worst stocks in their portfolio; these stocks experience subsequent price drops that do not later reverse (i.e., the *High SR* stocks). If the flow shock is large enough, fund managers must also sell some high quality assets; these stocks experience temporary price drops (i.e., the *Low SR* stocks).

To explore this pattern further we examine multiple multivariate OLS panel regressions of the form:

$$CAR_{i,t+h} = \beta_1 Pressure_{i,t} + \beta_2 SR_{i,t} + \mu_i + \gamma_t + \epsilon_{i,t+h}, \tag{6}$$

where $CAR_{i,t+h}$ is the cumulative return from time t-3 to time $t+h$, $Pressure_{i,t}$ is price pressure as in Section II, and $SR_{i,t}$ is the short interest ratio at time t. μ_i is a firm fixed effect to control for possible unobserved heterogeneity at the firm level. Similarly, γ_t is a time fixed effect. To examine the relation between fire sales, negative information, and future returns, we run 24 different regressions where the returns are measured from time h=1 (i.e., one month ahead) to h=24 (i., two years ahead).

The results are shown in Table V with *t*-statistics calculated using standard errors clustered by firm and month shown in italics to the right of the coefficient estimates. At all horizons, the coefficient on short interest is negative and for h=1 through h=21 the estimate is statistically significant at the usual levels. Thus, consistent with the existing literature on short selling, we find strong evidence that high short interest stocks underperform in the future. More interestingly, however, the coefficient on *Price Pressure* is never statistically negative. Thus, after controlling for negative information, we no longer find evidence that fire sales stocks underperform in future months. Consistent with the visual evidence in Figure 2, the results suggest that after controlling for negative information, fire sale stocks experience relatively flat returns for several months before eventually drifting upward.

Overall, the totality of the evidence suggests that when faced with a flow shock, fund managers strategically choose which stocks to sell and these choices contain valuable information about future prices. Moreover, our findings suggest that fund managers will choose to sell low-quality assets, but because flow shocks can be large in magnitude, they will also sell some high-quality assets. The resulting mix of low-quality and high-quality asset sales leads to an adverse selection problem similar to the classic lemons problem (Akerlof (1970)). Other investors, who could potentially buy fire sales stocks, must worry that some stocks were sold purely due to flow shocks while others were sold due to negative fundamental information. Faced with this adverse selection problem, all fire sale stocks sell for the low "lemons" price and so prices remain depressed until the true asset type is later revealed. Consistent with theoretical models (e.g., Dow and Han (2015)), our results thus provide an explanation for the magnitude and persistence of price pressure following fire sales.

C. The Value of Fire Sale Information

So far, our results suggest that fund managers have stock selling skill. As such, our findings provide an explanation for the tendency of asset prices to remain depressed following fire sales: information asymmetries make it difficult for arbitrageurs to disentangle pure price pressure from negative information. In this section, we explore the *value* of the information in fund manager selling decisions around fire sales. To do this, we examine risk-adjusted portfolio returns to strategies which condition on fire sales and negative fundamental information (i.e., abnormally high short interest).

We start by forming two portfolios: the first portfolio consists of fire sale stocks with low abnormal short ratios (*Low SR*) while the second consists of fire sale stocks with high abnormal short ratios (*High SR*). We define low (high) short ratios based on whether the monthly abnormal SR measure is below (above) the cross-sectional median among all intensive selling pressure stocks. We then calculate calendar time returns to these portfolios over various horizons, using equal-weighted portfolio returns. Finally, we regress the monthly excess returns of our portfolios on the Fama and French (1993) three factors and the momentum factor.[11]

We examine three different holdings horizons. In Panel A, we examine returns to a portfolio that begins trading 7 months after the event date and holds stocks until month 18. This strategy is motivated by the visual evidence in Figure 2 which shows that fire sales stock prices begin to rise approximately 7 months after the event month. In Panel B, we examine returns to a portfolio that begins trading 1 month after the event date and holds stocks until month 6 (i.e., the complement to the strategy in Panel A). Finally, in Panel C, we examine returns to a portfolio that combines both strategies and buys stocks beginning 7 months after the event date and holds them until month 18 while shorts stocks starting 1 month after the event and holds them until month 6.

The results are shown in Table VII with t-statistics, calculated using Newey and West (1987) standard errors, reported next to the coefficient estimates. In all panels, columns (2)

[11]The monthly Fama and French (1993) factors are from Kenneth French's website.

and (3) present results for the *Low SR* portfolio, columns (4) and (5) present results for the *High SR* portfolio, and columns (6) and (7) present results for a long-short strategy that buys *Low SR* stocks and shorts *High SR* stocks.

In Panel A, column (2), the positive and statistically significant intercept of 0.0043 suggests there is a large positive alpha to buying low short interest stocks following a fire sale. The estimate suggests these stocks earn nearly a 5% annualized four-factor alpha. Moreover, in column (6), the long-short alpha is again positive and statistically significant, although slightly smaller than the long-only alpha.

Interestingly, in Panel B, column (2) and (4), we find the mirror image result. The long-only portfolio earns a statistically insignificant alpha, but the short-only portfolio earns a large and statistically negative alpha of 40 basis points per month (4.7% annualized). Again, the long-short alpha is positive and statistically significant (6% annualized).

Finally, in Panel C, we examine the risk-adjusted returns to a strategy which combines the best of the strategies in Panels A and B. Specifically, we buy stocks beginning 7 months after the event date and hold them until month 18 while simultaneously shorting stocks starting 1 month after the event and holding them until month 6. Admittedly, this strategy benefits from the knowledge already presented. However, such a strategy is feasible given the information available to an investor at each point in time. The results suggest there are large alphas possible from trading on fire sale stocks. In column (6), the coefficient of 0.0083 suggests a statistically and economically significant annualized alpha of nearly 10%.

Overall, the evidence suggests that, following fire sales, managers sell low quality assets. If the flow shock is large enough, the managers may also sell high quality assets, leading to a lemons problem for would-be arbitrageurs. However, by using short interest as a proxy variable for negative fundamental information, it is possible to disentangle the low-quality assets from the high-quality assets, generating large risk-adjusted returns in the process.

D. Discussion and Interpretation

Our results all point to the same conclusion: fund managers selectively choose which stocks to sell following a fire sale and this makes it difficult for arbitrageurs to disentangle pure price pressure from negative information. However, several outstanding issues remain.

First, any statement about the motivation of sales following flow shocks should explain both (i) the choice of assets which are sold and (ii) the timing of those sales. Put differently, if fund managers have negative fundamental information about some of their holdings, why didn't they sell these stocks sooner? There are several possible explanations for this. First, we note that our analyses relied on abnormal short interest, so that our proxy variable for negative information focused on new (abnormal) information about a stock. As such, the negative signal largely arrived proximate to the flow shock, which explains both the choice of assets and the timing of the sale. Second, we also note that fund managers likely face portfolio re-balancing costs (both pecuniary and non-pecuniary). Novy-Marx and Velikov (2014) examine optimal trading strategies in the presence of transaction costs. They find that the optimal trading strategy is biased towards holding a current position. In other words, even if a manager receives a signal, it may not be optimal for them to act on it. In our context, this suggests that fund managers may have negative information about some of their holdings, but choose not to trade on this information right away. Following a flow shock, managers are forced to sell and thus it becomes optimal to use their information when making these trades.

A second issue relates to the long-standing short interest puzzle. A number of papers note that high short interest predicts lower future returns. Since short interest data is publicly available, this begs a question: why don't other investors trade on the signal in short interest until it is arbitraged away? In our context, the short interest puzzle takes a slightly different form. Since investors face an adverse selection problem when they see price pressure from fire sales, why don't they use short interest to separate assets into low-quality and high-quality? One possibility is that, prior to our findings, investors were unaware of the signal value of short interest vis-a-vis fire sales. Several paper shows that return predictability diminishes after the publication of academic studies (e.g., Schwert (2003) and McLean and Pontiff (2015)). As a result, it is possible that price pressure from fire sales will diminish going forward as investors learn to separate low-quality fire sale assets from high-quality fire sale assets.

In sum, our findings contribute to several literatures. First, we provide an explanation for the long-lasting impact of price pressure from fire sales. Following a flow shock, fund managers choose to sell stocks with negative fundamental information and thus arbitrageurs face an information asymmetry which makes it difficult for them to disentangle pure price pressure from negative fundamental information. Second, our results suggest that information asymmetries may help explain the slow moving capital phenomenon as theorized in Duffie (2010). Third, our results provide indirect evidence that fund managers do have some skill, even though academic studies consistently fail to document alpha (e.g., Berk and Green (2004)).

IV. Conclusion

It is now well documented that asset prices remain low for prolonged periods of time following mutual fund fire sales (Coval and Stafford (2007)). Yet, the precise reason for this large and persistent mispricing remains unclear. Mutual fund holdings are publicly released and several papers argue that fire sale price pressure is predictable. Thus, why don't arbitrageurs correct mispricing from fire sales sooner?

We provide an explanation for the puzzling persistence of price pressure from fire sales: information asymmetries make it difficult for arbitrageurs to disentangle pure price pressure from negative information. Following a flow shock, fund managers *choose* to sell low-quality stocks. Using short interest as a proxy variable for manager's unobservable negative signal, we find that managers are significantly more likely to sell stocks low-quality stocks. Moreover, these stocks experience future price drops that do not later reverse. In other words, fund managers have stock selling ability which leads to an adverse selection problem for other investors. Our findings explain the tendency of asset prices to remain depressed following fire sales: information asymmetries make it difficult for arbitrageurs to disentangle pure price pressure from negative information.

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Figure 1. Abnormal Short Interest in Event Time around Fire Sales

The figure plots the abnormal short interest ratio (*Abnormal SR*), in event time, for fire sale stocks using data from 1990 through 2010. The event month is denoted by t=0, and the figure displays the cross-sectional mean of *Abnormal SR* each month from 12 months prior to the fire sale month to 12 months after the fire sale. *Abnormal SR* is calculated as the difference between the raw short interest ratio (*SR*) and the expected short interest ratio (*expected SR*) as discussed in Section II.B of the text.

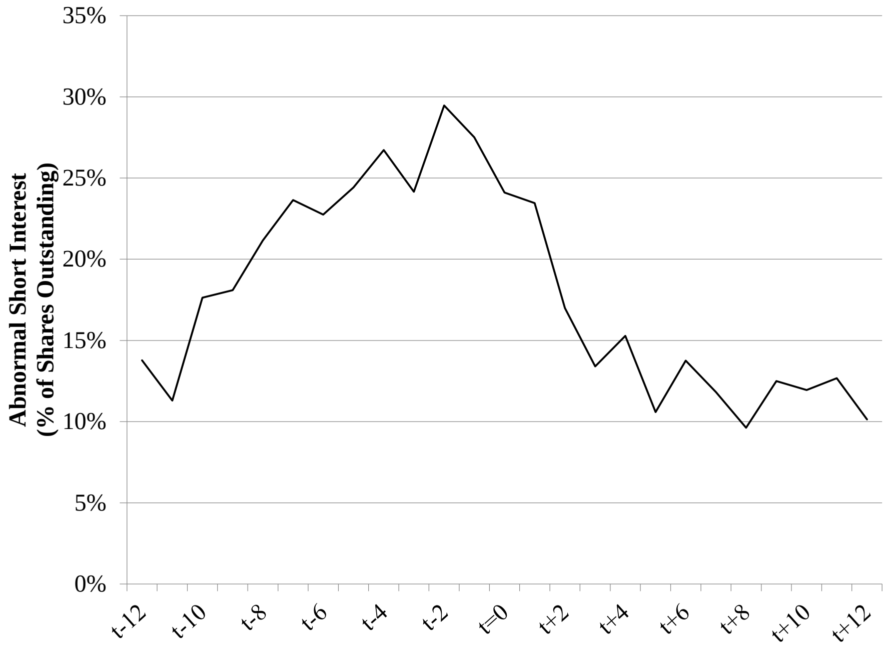

Figure 2. Cumulative Abnormal Returns in Event Time around Fire Sales for High and Low Short Interest Stocks

Each quarter, intensive buy pressure (IBP) stocks and intensive sell pressure (ISP) stocks are grouped into two event portfolios, IBP portfolio and ISP portfolio. Within each portfolio, stocks are further sorted into High short ratio (High SR) and Low short ratio (Low SR) portfolios, based on whether the abnormal SR measure is above (below) the cross-sectional median among all IBP (ISP) stocks. The event quarter is the portfolio formation quarter, and the event month 0 is the last month of the event quarter. For each portfolio, the equal-weighted returns for each portfolio from 3 months before event month 0 till 24 months afterwards. The average mean portfolio abnormal returns in excess of the market returns are calculated, and the 3-month moving average of cumulative abnormal returns (CAR) are reported. Panel solid black line displays results for low short interest stocks, while the dotted-black line displays results for high short interest stocks.

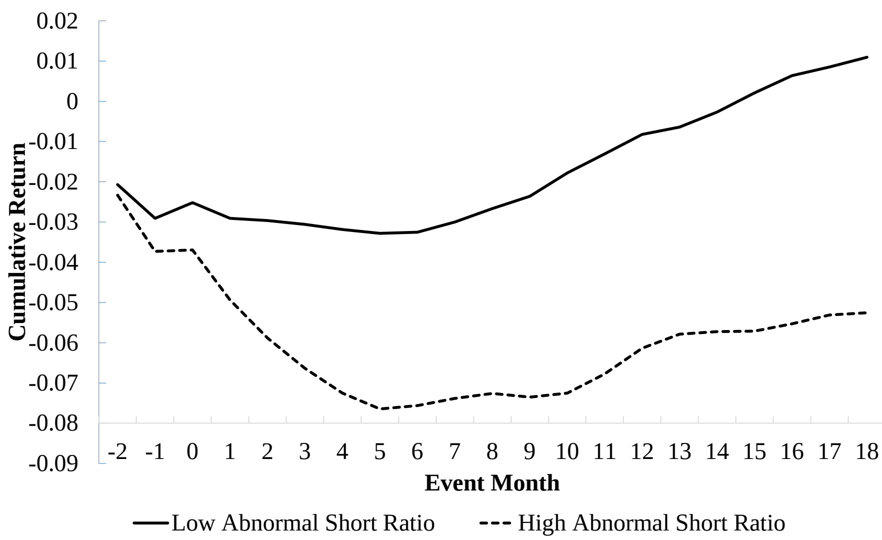

Table I
Summary Statistics

The sample includes all NYSE and NASDAQ stocks with non-missing data on monthly short interest, market capitalization, book-to-market ratio, past 12-month returns, and institutional ownership (13f) over the period January 1990 to December 2010. The time-series mean, median and t-statistics of the cross-sectional average value of the following variables are reported: *SR* (the ratio of month-end short interest over beginning-of-month number of shares outstanding), *Abnormal SR* (estimated in Table A1, model 2), *Size* (market capitalization in millions of U.S. dollars), *B/M* (the ratio of the most recent available book value over the market capitalization), *PastRet* (past 2 to 12 month stock returns), *Bid-Ask Spread* is the monthly bid-ask spread as a fraction of the closing mid-point, and *InstHld* (the ratio of institutional holdings (13f) over the number of shares outstanding. The time-series mean of the cross-sectional standard deviation, the 1st and the 99th percentile values of these variables are also reported. In addition, the corresponding summary statistics for price pressure measures of intensive sell stocks (*PrcPres(ISP)*) are reported. The price pressure measures are defined in equation (3) and based on Coval and Stafford (2007) and Kahn, Kogan, and Serafeim (2012).

(1) **Variable**	**(2)** **Mean**	**(3)** **Median**	**(4)** ***t*-stat**	**(5)** **St. Dev.**	**(6)** **1st %**	**(7)** **99th %**
SR	0.026	0.018	25.210	0.042	0.000	0.201
Abnormal SR	0.000	0.000	4.790	0.037	-0.044	0.156
Size	2,715.420	3088,69	33.840	11,871.570	13.410	47,091.110
B/M	0.642	0.622	86.800	0.766	0.043	2.879
PastRet	0.245	0.215	16.130	0.731	-0.598	2.881
Bid-Ask Spread	0.021	0.021	23.210	0.024	0.001	0.113
InstHld	0.478	0.442	40.730	0.276	0.004	0.990
PrcPres(ISP)	-0.007	-0.007	-19.310	0.006	-0.032	-0.003

Table II
Short Interest in Event Time around Fire Sales

The table displays short interest in event time around fire sales for intensive sell portfolios (ISP). The event quarter is the portfolio formation quarter, and month t=0 is the last month of the event quarter. Columns (2) and (3) display the mean and *t*-statistic for *Raw SR* which is short interest as a fraction of shares outstanding while columns (4) and (5) display the mean and *t*-statistic for *Abnormal SR* which is calculated as the difference between *Raw SR* and the *Expected SR* as calculated in equation (1).

(1)	**(2)**	**(3)**	**(4)**	**(5)**
Event	**Raw SR**		**Abnormal SR**	
Month	**Mean**	**t-value**	**Mean**	**t-value**
t-14	3.44	12.57	0.16	1.63
t-13	3.46	12.91	0.16	1.68
t-12	3.43	13.24	0.15	1.66
t-11	3.45	13.19	0.11	1.25
t-10	3.54	13.03	0.19	1.90
t-9	3.56	12.75	0.19	1.90
t-8	3.63	12.49	0.21	1.98
t-7	3.66	12.34	0.23	2.34
t-6	3.66	12.50	0.23	2.41
t-5	3.69	12.45	0.25	2.43
t-4	3.76	12.53	0.27	2.50
t-3	3.73	12.69	0.24	2.47
t-2	3.77	12.88	0.28	2.85
t-1	3.76	13.05	0.27	2.86
t=0	3.71	13.05	0.23	2.53
t+1	3.70	13.09	0.23	2.57
t+2	3.68	13.07	0.18	2.01
t+3	3.67	13.15	0.15	1.72
t+4	3.68	13.31	0.17	1.94
t+5	3.67	13.40	0.14	1.56
t+6	3.68	13.49	0.17	1.91
t+7	3.65	13.36	0.16	1.73
t+8	3.64	13.36	0.13	1.42
t+9	3.68	13.48	0.15	1.50
t+10	3.65	13.52	0.14	1.40
t+11	3.68	13.22	0.15	1.46
t+12	3.66	13.27	0.12	1.25
t+13	3.64	13.16	0.12	1.27
t+14	3.64	13.14	0.08	0.94
t+15	3.67	13.19	0.10	1.16
t+16	3.65	12.97	0.09	1.03
t+17	3.66	12.93	0.06	0.67
t+18	3.66	12.97	0.05	0.64

Table III
Relation between Short Interest and Selling by Fund Managers

This table reports the panel regression results on the relation between the sell decision of distressed funds on a stock and the previous quarter's abnormal short ratio. The average abnormal short ratio is defined as the average of the monthly abnormal short ratio during the previous quarter. The control variables include $LN(Mktcap)$ (the log of market capitalization) , B/M (the ratio of the most recent available book value over the market capitalization), *Avgret* (past 2-12 month stock returns). In Panel A, the dependent variable is a sell dummy: Sell=1 if during the current quarter the net trading of a stock is negative by all distressed funds hat hold the stock at the beginning of the quarter, and 0 otherwise. Distressed funds are those funds in our sample that experience the top 10% outflow during the same quarter. In Panel B, the dependent variable is the negative of the abnormal net trading of a stock during the quarter by all distressed funds that hold the stock at the beginning of the quarter. The abnormal trading of a stock is defined as the percentage change in holdings by distressed funds, net of the expected trading on the stock. For each stock and each distressed fund that hold the stock at the beginning of the quarter, we calculate the expected number of shares to be sold by the fund based on the dollar flow from the fund proportional to its percentage holdings of the stock at the beginning of the quarter. The expected sales of the stock is then defined as the sum of the expected number of shares to be sold by all these distressed funds, divided by the total number of shares held by the distressed funds at the beginning of the quarter. In all models the standard errors are clustered by stock and year-quarter. The sample spans from January 1990 to December 2010.

Panel A: Dependent Variable = Sell Indicator Variable

(1) **Variable**	**(2)** **Estimate**	**(3)** **S.E.**	**(4)** **t-stat**
Intercept	0.6880	0.0345	19.92
Avg SR	0.1379	0.0384	3.59
LN(Mktcap)	0.0135	0.0042	3.19
B/M	0.0053	0.0059	0.91
PastRet	-0.0162	0.0041	-3.91
Bid-Ask Spread	-2.0726	0.6094	-3.40

Panel B: Dependent Variable = Abnormal Net Trading

Variable	**Estimate**	**S.E.**	**t-stat**
Intercept	0.2018	0.0227	8.90
Avg SR	0.3444	0.0363	9.49
LN(Mktcap)	-0.0040	0.0028	-1.40
B/M	0.0057	0.0042	1.36
PastRet	-0.0307	0.0048	-6.33
Bid-Ask Spread	-1.0102	0.2928	-3.45

Table IV
Abnormal Returns in Event Time around Fire Sales for High and Low Short Interest Stocks

Each quarter, all ISP stocks in our sample are further sorted into Low Abnormal Short Ratio (Low SR) and High Abnormal Short Ratio (High SR) portfolios, based on whether the abnormal SR measure is below (above) the cross-sectional median among all ISP stocks. The event quarter is the portfolio formation quarter, and the event month 0 is the last month of the event quarter. For each portfolio, the equal-weighted returns for each portfolio from 3 months before event month 0 until 18 months afterwards. The average mean portfolio abnormal returns in excess of the market returns are reported, as well as the corresponding t-statistics, and the 3-month moving average of cumulative abnormal returns (CAR) . The sample spans from January 1990 to December 2010.

(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Event	**Low SR**			**High SR**		
Time	**Return**	***t*-stat**	**CAR**	**Return**	***t*-stat**	**CAR**
t-3	-0.25	-0.61	-0.25	-0.01	-0.02	-0.01
t-2	-2.02	-4.75	-2.27	-2.06	-4.42	-2.07
t-1	-0.22	-0.51	-1.67	-0.87	-1.91	-1.67
t=0	0.81	2.07	-2.15	-0.56	-1.39	-2.83
t+1	-0.90	-2.10	-2.25	-1.45	-2.83	-3.79
t+2	0.32	0.75	-2.18	-0.84	-1.80	-4.74
t+3	0.08	0.23	-2.34	-0.50	-1.14	-5.67
t+4	-1.08	-2.31	-2.57	-0.99	-2.08	-6.44
t+5	0.26	0.70	-2.82	0.40	0.82	-6.81
t+6	0.67	1.74	-2.87	0.66	1.44	-6.79
t+7	-0.38	-0.82	-2.68	-0.58	-1.05	-6.63
t+8	0.41	1.04	-2.45	0.09	0.22	-6.57
t+9	0.43	1.18	-2.29	0.02	0.04	-6.73
t+10	0.48	0.92	-1.85	-0.08	-0.16	-6.72
t+11	0.03	0.06	-1.54	1.17	2.48	-6.35
t+12	0.44	1.24	-1.22	0.20	0.53	-5.92
t+13	-0.34	-0.85	-1.18	-0.40	-0.77	-5.59
t+14	0.59	1.48	-0.95	0.27	0.63	-5.57
t+15	0.66	1.68	-0.65	0.39	0.85	-5.48
t+16	-0.16	-0.33	-0.29	-0.40	-0.86	-5.40
t+17	0.08	0.19	-0.10	0.27	0.52	-5.31
t+18	0.83	2.11	0.15	-0.08	-0.20	-5.38

Table V
Relation between Fire Sales, Short Interest, and Future Returns

We estimate panel regressions of the form:

$$CAR_{i,t+h} = \beta_1 Pressure_{i,t} + \beta_2 SR_{i,t} + \mu_i + \gamma_t + \epsilon_{i,t+h},$$

where $CAR_{i,t+h}$ is the cumulative return from time t-3 to time t+h, $Pressure_{i,t}$ is price pressure as in Section II, $SR_{i,t}$ is the short interest ratio at time t, μ_i is a firm fixed effect, and γ_t is a time fixed effect. t-statistics calculated using standard errors clustered by firm and month are shown in italics to the right of the coefficient estimates *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

(1) Event Time	(2) Price Pressure	(3) t-stat	(4) SR	(5) t-stat	(6) N	(7) R^2
t+1	-0.6644	*(-1.29)*	-0.0004***	*(-3.10)*	12,052	0.330
t+2	-0.6458	*(-1.11)*	-0.0004***	*(-3.14)*	11,968	0.339
t+3	-0.3046	*(-0.47)*	-0.0005***	*(-3.90)*	11,893	0.354
t+4	0.0820	*(0.14)*	-0.0005***	*(-3.95)*	11,829	0.365
t+5	-0.0630	*(-0.10)*	-0.0007***	*(-4.66)*	11,742	0.382
t+6	0.4184	*(0.60)*	-0.0007***	*(-4.29)*	11,695	0.389
t+7	0.8860	*(1.30)*	-0.0007***	*(-3.79)*	11,614	0.390
t+8	0.7338	*(0.99)*	-0.0007***	*(-3.56)*	11,556	0.397
t+9	0.8139	*(1.12)*	-0.0008***	*(-3.56)*	11,501	0.402
t+10	0.8936	*(1.25)*	-0.0008***	*(-3.72)*	11,440	0.405
t+11	1.5256**	*(2.16)*	-0.0008***	*(-3.59)*	11,380	0.410
t+12	1.3472*	*(1.76)*	-0.0008***	*(-3.67)*	11,302	0.411
t+13	1.4298*	*(1.78)*	-0.0008***	*(-3.53)*	11,236	0.416
t+14	1.6243*	*(1.95)*	-0.0010***	*(-3.75)*	11,181	0.422
t+15	1.7613**	*(2.15)*	-0.0009***	*(-3.48)*	11,126	0.422
t+16	1.7439*	*(1.93)*	-0.0007**	*(-2.51)*	11,064	0.426
t+17	1.6233*	*(1.78)*	-0.0007**	*(-2.54)*	10,983	0.435
t+18	1.6299*	*(1.69)*	-0.0006**	*(-2.52)*	10,928	0.440
t+19	2.3654**	*(2.34)*	-0.0005**	*(-1.98)*	10,874	0.444
t+20	2.2899**	*(2.14)*	-0.0005*	*(-1.76)*	10,798	0.453
t+21	2.3130**	*(2.25)*	-0.0005*	*(-1.73)*	10,743	0.457
t+22	2.4697**	*(2.29)*	-0.0004	*(-1.33)*	10,688	0.463
t+23	2.7902**	*(2.47)*	-0.0004	*(-1.49)*	10,643	0.464
t+24	2.8920***	*(2.75)*	-0.0003	*(-1.18)*	10,597	0.471

Table VI
Relation between Short Interest and the Duration of Price Pressure Following Fire Sales

The table reports regression results examining the effect of a stock's abnormal short interest as of the quarter-end immediately prior to the stock fire sale quarter on the likelihood that the stock's market-adjusted return reverts back to zero during the 18 months following the fire sales and the length of time (number of months) that the reversion takes. The length of time varies between 1 and 18 if the abnormal returns revert to zero within the 18 months, and is set to be 19 if the reversion does not occur during the time period. In Column (2), we estimate a logit regression where the dependent variable is an indicator variable that equals one if the stock's market-adjusted return reverts to zero during the 18 months and zero otherwise. In Column (3), we estimate a poison regression where the dependent variable is the number of months between the fire sale event date and the first date on which the cumulative return becomes non-zero (i.e., the correction date). Year fixed effects are included in both regressions. Robust standard errors clustered by year are reported below the estimates in parenthesis. *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

(1) Explanatory Variables	**(2) Correction Indicator**	**(3) Number of Months to Correction**
SR	-3.534***	1.431***
	(0.008)	(0.004)
LN(Mktcap)	0.056	-0.024
	(0.415)	(0.346)
AvgRet	0.240***	-0.206***
	(0.006)	(0.000)
B/M	0.099	-0.039
	(0.495)	(0.526)
Bid-Ask Spread	15.993***	-6.429***
	(0.007)	(0.001)
Intercept	0.382	2.331***
	(0.395)	(0.000)
N	3,194	3,194

Table VII

Four-Factor Alphas from Portfolios formed on Short Interest around Fire Sales

The table examines four-factor alphas from portfolios formed by conditioning on short interest during the quarter before fire sales. The Low Abnormal Short Ratio (Low SR) and High Abnormal Short Ratio (High SR) portfolios are based on whether the monthly abnormal SR measure is below (above) the cross-sectional median among all ISP stocks. We regress the monthly excess returns of Low SR and High SR portfolios as well as the return difference (Low SR - High SR) on the Fama and French (1993) three factors and the momentum factor. t-statistics calculated using Newey and West (1987) standard errors are reported next to the coefficient estimates. In Panel A, we examine returns to a portfolio that begins trading 7 months after the event date and holds stocks until month 18. In Panel B, we examine returns to a portfolio that begins trading 1 month after the event date and holds stocks until month 6. In Panel C, we examine returns to a portfolio that combines both strategies and buys stocks beginning 7 months after the event date and holds them until month 18 while shorts stocks starting 1 month after the event and holds them until month 6.

Panel A: Holding period: month 7 - month 18

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Explanatory	**Low SR**		**High SR**		**Low SR - High SR**	
Variable	**Estimate**	***t*-stat**	**Estimate**	***t*-stat**	**Estimate**	***t*-stat**
Intercept	0.0043	2.74	0.0013	0.74	0.0030	2.18
Mkt	0.9680	23.32	1.0645	19.48	-0.0965	-2.9
SMB	0.5363	5.28	0.5603	4.93	-0.0240	-0.53
HML	0.4740	6.37	0.4853	5.48	-0.0113	-0.23
Momentum	-0.1045	-2.32	-0.1597	-3.16	0.0552	1.18

Panel B: Holding period: month 1 - month 6

Explanatory	**Low SR**		**High SR**		**Low SR - High SR**	
Variable	**Estimate**	***t*-stat**	**Estimate**	***t*-stat**	**Estimate**	***t*-stat**
Intercept	0.0011	0.65	-0.0040	-1.98	0.0051	2.59
Mkt	1.0256	26.17	1.1366	19.43	-0.1110	-2.29
SMB	0.4357	3.71	0.6759	5.23	-0.2402	-5.12
HML	0.4516	4.76	0.5267	5.09	-0.0750	-1.2
Momentum	-0.0189	-0.53	-0.1998	-4.21	0.1809	2.89

Panel C: Mixed Holding period (Low SR (month 7 to 18) - High SR (month 1 - 6))

Explanatory	**Low SR**		**High SR**		**Low SR - High SR**	
Variable	**Estimate**	***t*-stat**	**Estimate**	***t*-stat**	**Estimate**	***t*-stat**
Intercept	0.0043	2.74	-0.0040	-1.98	0.0083	4.01
Mkt	0.9680	23.32	1.1366	19.43	-0.1686	-3.4
SMB	0.5363	5.28	0.6759	5.23	-0.1396	-2.3
HML	0.4740	6.37	0.5267	5.09	-0.0527	-0.78
Momentum	-0.1045	-2.32	-0.1998	-4.21	0.0953	1.39

V. Appendix

In this section, we provide supplemental analyses to the main text.

Table A1
Variable Definitions

The table defines key variables used in the paper. The sample properties and databases are discussed in detail in Section II of the text.

(1) Variable	**(2) Source**	**(3) Description**
SR	Compustat	The ratio of month-end short interest over number of shares outstanding
Abnormal SR	Constructed	The difference between the raw short interest ratio and the expected short interest ratio
Size	CRSP	Market Capitalization (in $Millions) calculated as LN(price $\times$ shares outstanding)
B/M	Compustat	The ratio of the most recent available book value over the market capitalization
PastRet	CRSP	Cumlative stock returns from the past 2 to 12 months
Bid-Ask Spread	CRSP	The closing ask price less the closing bid price scaled by the mid-point of the closing price
InstHld	Thomson 13F	The ratio of institutional holdings from 13f filings to the number of shares outstanding from CRSP
PrcPres(ISP)	Thomson 13F	Stocks with extremely high outflows (below the 10th percentile of price pressure at each date)
PrcPres(IBP)	Thomson 13F	Stocks with extremely high inflows (above the 90th percentile of price pressure at each date)

Table A2
Estimation of Abnormal Short Interest

Each month, a firm is assigned into one of the 3x3x3 portfolios independently sorted on the market capitalization (Size), book-to-market ratio (BM), and past 2-12 month return (PastRet), measured at the end of the previous month. SR is then regressed on Size, BM, PastRet, and industry fixed effects according to the model:

$$SR_{i,t} = Sizelow_{i,t} + Sizemed_{i,t} + BMlow_{i,t} + BMmed_{i,t} + PastRetlow_{i,t} + PastRetmed_{i,t} + \gamma_j + \epsilon_{i,t},$$

where $Sizelow_{i,t}$ and $Sizemed_{i,t}$ are indicator variables that equal one if firm i is assigned to the portfolio of the bottom and middle third of market capitalization, respectively, $BMlow_{i,t}$, $BMmed_{i,t}$ are indicator variables that equal one if firm i is assigned to the portfolio of the bottom and middle third of book-to-market, respectively, $PastRetlow_{i,t}$ and $PastRetmed_{i,t}$ are indicator variables that equal one if firm i is assigned to the portfolio of the bottom and middle third of past returns, respectively, and γ_j represents j industry fixed effects defined using two-digit SIC codes. The regressions are for the all US common equity stocks with available SR and information on the explanatory variable, excluding the "event" stocks. In panel A, "event" stocks are defined as the IBP stocks defined in Table 1. In Panel B, "event" stocks are ISP stocks defined in Table 1. We report the time-series average of the coefficient estimates and the t-statistics are shown below in italics.

	Variable	**Sizelow**	**Sizemed**	**BMlow**	**BMmed**	**PastRetlow**	**Pastretmed**	**InstHldlow**	**InstHldmed**
Model 1	Mean	-3.07	-0.42	0.39	-0.34	0.68	-0.14		
	t-Value	-29.69	-6.68	21.27	-18.25	17.98	-8.00		
Model 2	Mean	-1.97	0.05	0.53	-0.28	0.67	-0.17	-1.59	-1.28
	t-Value	-32.94	0.70	32.95	-16.85	18.75	-9.08	-18.48	-17.52