Do Hedge Funds Provide Liquidity When It Is Most Needed?

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Abstract

We test the hypothesis that when the level of market liquidity is low, liquidity provision by arbitrageurs might be hindered because lenders restrict trade funding, especially for high volatility securities. We document that hedge funds reduce their long equity exposure by 4% to 7% in periods of low market liquidity. It appears that the ultimate liquidity providers during these periods are non-institutional investors. We find no material reduction in short interest during these periods, suggesting that hedge funds did not reduce their positions due to pessimistic beliefs about the future returns. Consistent with the idea that financial constraints drive equity selloffs, we find that hedge funds are more likely to sell high volatility stocks in low liquidity episodes.

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1. Introduction

It is widely believed that hedge funds provide liquidity to markets (Fung and Hsieh 1997, Asness, Krail, and Liew 2002, Bernanke 2006, Agarwal, Fung, Loon, and Naik 2007, Brown, Goetzmann, and Park 2009). According to this view, hedge funds engage in trades when the demand for risky assets is low, and thus reduce the liquidity premium on assets that are less desirable and eliminate market mispricings.[1] Khandani and Lo (2009) document that returns of hedge funds are correlated with returns of illiquid assets and Aragon (2007) finds that hedge funds earn an illiquidity premium. However, recent theory by Brunnermeier and Pedersen (2009) argues that hedge funds may not be able to provide liquidity during periods of low liquidity in the market because their capital providers would be reluctant to provide funding during these times. A similar idea about the market implications of arbitrageurs who are constrained by their sources of capital is expressed in Gromb and Vayanos (2002), Vayanos (2004), and Hameed, Kang, and Viswanathan (2009). The study of how hedge funds, and arbitrageurs in general, operate in periods of low market liquidity is fundamental to our understanding of financial markets.

In this paper we use micro-level hedge fund holding data and short interest data to test whether hedge funds, and arbitrageurs more generally, provide liquidity to markets in episodes of low liquidity. Specifically, we draw on data from 13F mandatory quarterly filings that provide a detailed picture of long equity holding data for the hedge fund universe and on stock-level short interest data. Our results are mixed. We document that hedge funds reduce their long equity exposure by 4% to 7% when market liquidity is low. The sensitivity to aggregate liquidity is especially high in volatile stocks and for financially-constrained hedge funds. We document that the level of short interest does not change on average in low market liquidity period. This body of evidence is consistent with the idea that hedge funds behave in this way because access to trade capital is restricted in low liquidity times and not because they have bearish views on the market. Nevertheless, it is not clear whether the magnitude of selloffs by hedge funds materially adds to the dry up in the equities market.

[1] For example, Brophy, Paige, and Sialm (2009) present evidence that hedge funds provide liquidity in the specific case of PIPE structures when other classes of investors are reluctant to invest due to the high degree of asymmetry.

Several studies discuss the role of funding in arbitrage activity, and the limitations on efficient arbitrage that funding may cause. Shleifer and Vishny (1997) argue that investors of hedge fund may pull their funds if they are concerned that arbitrage trades may not converge, thus inducing arbitrageurs to avoid long-term arbitrage trades. Gromb and Vayanos (2002) argue that arbitrageurs' funding create an implicit limits-to-arbitrage and impede efficient arbitrage. Vayanos (2004) proposes that financial constraints of arbitrageurs make volatile stocks unattractive in volatile times. Brunnermeier and Pedersen (2009) propose that shocks to arbitrageurs' wealth will limit their ability to provide liquidity. In their model, a decrease in the availability of funds for trading and the deviation of prices from fundamentals forced arbitrageurs to de-lever to meet more stringent margin requirements, which are typically high volatility securities. This process causes a further price shift away from fundamentals which reinforces further breaching margin requirements and further selling by arbitrageurs ("liquidity spirals"). In the process, arbitrageurs rebalance their portfolios towards more liquid assets, which require less capital for trading ("flights to quality"). In relation to this mechanism, Aragon and Strahan (2009) document that the liquidity of stocks held by Lehman-connected hedge funds declined once their funding was cut-off during the bankruptcy of Lehman. Similarly, Hameed, Kang and Viswanathan (2009) show that stock-level liquidity declines following stock price declines. They argue that this relation is driven by the financial constraints that arbitrageurs face following price shocks.

Another stream of the literature argues that arbitrageurs, and specifically hedge funds, act as a *destabilizing* force in financial markets. Consistent with the view that hedge funds may contribute to liquidity dry-ups, Khandani and Lo (2007) provide suggestive evidence that the quant crisis in August 2007 was possibly due to the unwind of a large hedge fund portfolio and to the increased correlation of hedge fund trades. Similarly, Boyson, Stahel, and Stulz (2008) show significant evidence of contagion in the hedge fund sector, which is reinforced at times of low liquidity. Buraschi, Kosowski, and Trojani (2009) present evidence that hedge fund holdings are correlated across trading categories, potentially inducing a high correlation at periods of crisis. Brunnermeier and Nagel (2004) also find evidence consistent with the idea that hedge funds do not provide liquidity and correct mispricings. They document that before the burst of the technology bubble in 2000, hedge funds "rode" the bubble, i.e., invested in overvalued assets (with high investor demand) rather than short-sold them. Finally, Nagel (2009) shows that the

returns to providing liquidity for Nasdaq stocks have increased sharply during the recent financial crisis.

We document that hedge funds and arbitrageurs reduce their equity exposure during times of low liquidity. In the aggregate, hedge fund participation in the equity market reduces by about 0.7% per quarter when aggregate liquidity deteriorates by one standard deviation. Given that hedge funds exit the market during low market liquidity periods, we investigate which investor types subsume hedge funds' positions. We find that non-institutional investors are those who increase their equity exposure during low liquidity times.

We explore why hedge funds exit the market in low liquidity times. We find that this "flight to quality" does not occur because hedge funds are pessimistic about the market. When we examine the changes aggregate short interest in the equity market, we find no material change during low liquidity episodes.

Rather, we find some evidence consistent with the idea that restrictions on trade funding are force funds out of the equity market. Specifically, we report that hedge funds mostly reduce their positions in high volatility stocks, consistent with the idea that margin requirements on these stocks are especially high.

Whether and when hedge funds provide liquidity in low aggregate liquidity states has important policy implications. Since liquidity provision is an important role in general and crucial during periods of market stress, regulators have traditionally maintained low level of supervision on hedge funds (Ackermann, McEnally, and Ravenscraft 1999). Bernanke (2006) notes that increasing the regulation on hedge funds may harm their role as liquidity providers. Hedge funds, however, may impose three negative externalities to the financial system in the form of: (1) counterparty risk to other financial intermediaries, (2) the ability to move prices further away from fundamentals, (3) synchronized capital erosion which compromises aggregate liquidity. Among other things, these externalities may be the outcome of runs on the funds' assets. That is, investors' correlated withdrawals limit hedge funds' ability to provide liquidity. To prevent this, the regulatory debate has contemplated limits on investors' ability to withdraw their funds (Acharya, Pedersen, Philippon, and Richardson, 2009). Supporting this view, Hombert and Thesmar (2009) provide evidence that funds with impediments to withdrawals are better able to ride temporary shocks.

2. Hypotheses

Hedge funds rely on external funding which is typically short-term in nature. Specifically, hedge funds are known for their high leverage, which is typically borrowed on a short-term basis from prime brokers. In addition, hedge funds raise capital from investors, who can withdraw their funds on demand subject to the lock up and redemption notice periods. The reliance on short-term funding may create 'liquidity spirals'. Brunnermeier and Pedersen (2009) predict that once a liquidity event hits the market, capital providers may become more cautious about lending to hedge funds. Hedge funds, in turn, reduce their exposures in order to confirm with their lenders' requirements. In the process of reducing exposure prices decline due to the selling pressure and lenders' demand for their funds become more stringent. Brunnermeier and Pedersen call this process a 'liquidity spiral'. They argue that such positive feedback mechanism allows relatively small shocks, as the subprime defaults in 2007, to spread across the financial system.

The first prediction of the liquidity spirals is that hedge funds exit the market when the general level of liquidity is low.

> **Hypothesis 1: [Aggregate liquidity provision]** Hedge funds reduce their equity stake at times of low aggregate liquidity.

Next, we hypothesize about the mechanism that leads hedge funds to reduce their positions in the equity market. There are two non-mutually exclusive potential mechanisms. The first alternative is that hedge funds are bearish about the equity market and therefore exit. This possibility can be tested with volume of short-sales. If beliefs about asset prices are driving hedge fund behavior then we should expect an increase in short-selling activity.

> **Hypothesis 2a: [Short-selling activity]** Short-selling activity increases during low aggregate liquidity periods.

The second alternative is that hedge funds are constrained by their capital suppliers (lenders or investors) to reduce their equity exposure. In particular, lenders may require hedge funds to decrease their positions in high volatility stocks because these stocks are the least marginable, i.e., tie a greater fraction of hedge funds' capital.

Hypothesis 2b: [High volatility stocks] Hedge funds are more likely to reduce their positions in high volatility stocks during low aggregate liquidity periods.

In concert with this hypothesis, we can also predict that constrained hedge funds are more likely to be forced to liquidate positions. Hedge funds that are financially constrained would not have additional sources of funding and would enter the liquidity spirals. Conversely, unconstrained hedge funds may be able to continue and hold to their high volatility securities.

Hypothesis 2c: [Constrained hedge funds] Hedge funds that are constrained are more likely to shed high volatility stocks during low aggregate liquidity periods.

Put together, the empirical tests of these hypotheses will confirm or reject the liquidity spirals explanation for fast spread of illiquidity across the financial system.

3. Data

We use several sources of data in our study. Our primary data source is a dataset that combines quarterly 13-F institutional holdings mandatory report with a list of hedge funds provided by Thomson, starting 1990. The combined dataset allows us to identify entities in the 13F report which are hedge funds. These include both reporting consolidated firms and managers. Overall, the number of hedge funds varies from several dozens in early 1990 to over 900 at the peak in 2007. Figure 1 presents a chart of the number of hedge funds in our sample. Griffin and Xu (2009) used a similar dataset in their study: a combined dataset of 13F reports and a list of hedge funds. Our data has the advantage of being broader, since Thomson identifies hedge funds at the disaggregated manager level and not at the reported consolidated level. This way, our list of hedge funds is more comprehensive than the one used by Griffin and Xu.

We use several widely-used dataset for market-level and stock-level information. Specifically, we use CRSP and Compustat for stock characteristics. In addition, we employ several liquidity measures. We use NYSE TAQ data in order to measure aggregate and stock-level order imbalance. Order imbalance measures whether trades are conducted more often at the 'bid' or the 'ask', indicating whether there is selling or buying pressure. We compute the order imbalance measure at the stock-quarter level and at the aggregated quarter level. We also use commonly-used aggregate liquidity measures: Pastor and Stambaugh (2003) innovations, Acharya and Pedersen liquidity index (2005), and Sadka liquidity factor (2006).

A downside of these data is that they include long equity holdings only. To overcome this shortcoming, we examine stock-level short-interest data provided by the exchanges.[2] These data includes on a monthly basis the total short interest by all short sellers. When using it, we make the explicit assumption that the general degree of short-selling in the market is correlated with the degree of short-selling by hedge funds. This assumption seems reasonable given that short-selling is often performed by arbitrageurs.

Table 1 presents summary statistics of the datasets used in the study. In Panel A we present the summary statistics of the aggregate stock market participation by hedge funds. The table shows that average level of holdings by hedge funds is about 7% over the sample period, compared with 36% of all institutional investors. Short interest ratio is relatively low in aggregate: about 1.8% on average. Panel B presents a correlation table for the aggregate variables. As expected, the liquidity factors are correlated to some degree among themselves and with the BSI factors as well as with the market return.

We also analyze the cross-section of hedge fund holdings and short interest based on stock-quarter level regressions. These regressions allow us to understand better whether arbitrageurs' activity is reduced due to financial constraints. Panel C of Table 1 shows summary statistics for these data. Panel D provides a correlation table.

We also plan to use the TASS dataset for hedge funds' characteristics and monthly returns. The dataset includes self-reported hedge fund characteristics including investment styles, returns, and lockup periods. These variables are used in the second half of the analysis where we attempt to identify the forces that drive hedge fund behavior. The data covers hedge fund performance and attributes since 1998.

Panel E of Table 1 will present summary statistics for the TASS data.

[2] We recognize that a sizeable fraction of short-selling activity is performed in over-the-counter transactions. Nevertheless, in our work we use changes in short-selling activity. Unless there is a relation between low market liquidity and transition between these two markets, our data should be sufficient for the purpose of our tests.

4. Aggregate Holdings of Equities

4.1. Do Hedge Funds Provide Liquidity During Low Liquidity Periods?

In Figure 2a, we look at total hedge fund equity holdings as a fraction of total stock market capitalization. The most evident feature is an increasing trend, which reveals the dramatic expansion of the hedge fund sector in recent years. The figure shows in dashed lines liquidity events since 1990: e.g., Summer 1998, September 2001, period after Summer 2007 (full list is provided in the appendix). When examining the quarter-on-quarter changes in hedge fund holdings (Figure 2b), it appears that in times of liquidity crisis hedge funds withdraw from the market, especially during the crises of 2008.

Next, we examine the relation between hedge fund holding of stocks (measured as the average change in percentage of stocks held by hedge funds) and aggregate liquidity proxies. We use the following standardized proxies for aggregate liquidity: Pastor and Stambaugh (2003) (PS), Acharya and Pedersen (2005) (AP), and Sadka (2006) (Sadka). We use the versions of the factors that reflect innovations to market liquidity. To ease the interpretation of the results, we multiply the Acharya and Pedersen (2005) time-series by minus one, and standardize all variables by removing the mean and dividing by the standard deviation of each series. Low variable values reflect low market liquidity.

In addition, we construct a buy-sell imbalance (BSI) factor which reflects that the aggregate buying or selling pressure. The factor is computed following Lee and Ready (1991). Using intraday data, we compute the distance of trades from the ask. Trades that are close to the ask reflect market trades that were initiated by buyers, i.e., are expression of supply of liquidity, and trades that are close to the bid reflect market trades that were initiated by sellers, i.e., show demand for liquidity. We average this measure across stock-days, and aggregate across stocks to the quarter level. Later in the analysis, we use a stock-level version of this measure. Since the variable is autocorrelated, we filter out the innovations by running an AR(1) regression and use the residuals. As with the other liquidity factors, we also standardize this variable.

The results of the time-series analysis are presented in Table 2, Panel A. The results show that on average, hedge funds reduce their holdings in quarters in which aggregate liquidity is low. In columns (1) to (4) we use the four liquidity factors, and in columns (5) to (8) we add

contemporaneous market returns. The dependent variable in Panel A is the average change in hedge fund holdings across stocks. The panel shows that average hedge fund holdings are decreasing by about 0.1% to 0.15% per quarter per standard deviation of the liquidity factors. Given, that during liquidity crisis liquidity factors can shift 2 to 3 standard deviations during liquidity crisis (Table 1, Panel A), and that the average level of holdings of hedge funds is about 6.5% over the sample period, this effect is moderate in its magnitude: a large liquidity shock is associated with an average reduction of 4% to 7% in hedge fund equity holdings.

Panel B repeats the analysis of Panel A with a value-weighted the dependent variable. Hence, the left-hand-side variable is the percentage change in holdings of hedge funds, measured as percentage of market capitalization (measured in t–1 dollars). The coefficients in these regressions can be interpreted as the change in the market participation of hedge funds as a function of changes in aggregate liquidity. The table shows that once the dependent variable is value-weighted the effect is halved. This result suggests that the effect is driven by changes in holdings of small firms.

Panel C of Table 2 presents robustness analysis. Columns (1) to (4) show that the relation between hedge fund trades and market liquidity is contemporaneous in nature: both leads and lags of changes in market liquidity have no material effects on hedge fund trades. In columns (5) to (8) we explore whether the effect of changes in market liquidity on hedge fund holdings comes from negative changes in market liquidity or from positive changes. The regressions show that the relation is primarily driven by negative innovations to market liquidity.

4.2. Which Investor Types Provide Liquidity during Low Liquidity Periods?

Since hedge funds reduce their positions in equity during times of low market liquidity, it is interesting to find out who buys their shares. In Table 3, we repeat the regression for other types of investors: mutual funds, and all non-institutional investors. The results are ambiguous for mutual funds; non-institutional investors seem to increase their equity holdings during periods of low aggregate liquidity. Hence, the ultimate liquidity providers in low liquidity periods seem to be non-institutional investors.

5. Why do Hedge Funds Sell during Low Market Liquidity Periods?

Hedge funds can reduce their equity during low market liquidity episodes because two non-mutually exclusive reasons: because they *choose* to do so, or because they *are forced*. The first explanation suggests that hedge funds, as sophisticate investors, might realize that it is better to exit the market rather than to stay, especially if they anticipate grand liquidity events. In this context, Brunnermeier and Nagel (2004) present evidence that hedge fund anticipated the burst of the internet bubble. We test this idea by examining how market-wide short interest varies with the liquidity factors. If hedge funds exit the market because they are pessimistic about future returns, they short selling activity should spike during periods of low market liquidity.

The second explanation is that hedge funds, which are highly-leveraged investors, may be forced to liquidate their positions because their capital providers (e.g., prime brokers, investors) pull their funds (Brunnermeier and Pedersen 2009, Gromb and Vayanos 2002, Vayanos 2004, and Hameed, Kang, and Viswanathan 2009). We test this explanation by exploiting the cross-section of stock volatility. If funding constraints bind hedge funds from holding equities and short-selling, then we expect that this constraint will be more binding for highly-volatile stocks.

5.1. Does Short-Selling Activity Intensify during Low Market Liquidity Periods?

We explore how short selling activity varies with the liquidity factors. Figure 3 presents the time series of short interest. The trend is very similar to the growth in hedge fund holdings as depicted in Figure 2. In fact, the correlation between the changes in hedge fund holdings and changes in short interest is striking: 0.45. This high correlation justifies the use of stock-level short interest as a proxy for the short interest by hedge funds, as many hedge funds pursue long/short strategies.

In Table 4, Panels A and B, we repeat the tests from Table 2 for short selling activity. The dependent variable in these regressions is aggregate short interest, i.e., total market capitalization that is short-sold divided by the total market capitalization at the same point in time. Unlike the hedge fund holding data, the short interest data is available since 1988 on monthly frequency. To keep Tables 2 and 4 comparable, we adjust the frequency of the short interest data to quarterly frequency. The independent variables are the same as in Table 2.

The results show that short interest is not sensitive to aggregate market liquidity. In other words, the evidence is inconsistent with the idea that short interest expands during low liquidity periods. Panel A shows that the average level of short interest does not change during low aggregate liquidity. Panel B value weights the regressions and find similar results: that the total percentage of shares being sold short does not change during episodes of low market liquidity. Panel C shows that while short interest is not related to contemporaneous aggregate market liquidity, it positively correlated with lagged and future aggregate market liquidity.

5.2 Hedge Fund Trading and the Cross-Section of Stocks

Next, we look at the evolution of hedge fund holdings in different groups of stocks, which are formed according to stock level volatility. We focus on return volatility because it is a proxy for the stock margin requirements. Inspired by Vayanos (2004), Brunnermeier and Pedersen (2009), Hameed, Kang, Viswanathan (2009) we conjecture that hedge funds would have trouble in funding trades of volatile stocks in times of low liquidity because margin requirements are generally higher for high volatility stocks.

Figure 4a shows the level of hedge fund holdings of low versus high volatility stocks. The figure shows that hedge funds have increased their share of ownership over time in high volatility stocks. Figure 4b presents the quarterly changes. It appears from the figure that during liquidity episodes, hedge funds reduce their holdings in high volatility stocks more than they do for low volatility stocks.

In Table 5, we report cross-sectional regressions in which we regress the change in hedge fund holdings (measured as the change in the percentage of shares held by all hedge funds) on stock level volatility interacted with the aggregate liquidity measure. Based on Brunnermeier and Pedersen (2009), we anticipate the sign on the interaction would be positive, suggesting that hedge funds reduce their holdings more in high volatility stocks during low market liquidity episodes. The results in Table 5 confirm this prediction: hedge funds are more likely to reduce their positions in high volatility stocks during periods of low aggregate market liquidity.

Another way to understand better the channel through which hedge fund activity is determined is to examine hedge fund behavior around financial crises. In particular, we are interested to examine hedge fund holdings with respect to volatility around major liquidity

events. In Panel B, we restrict the sample to stock-quarter observations in the six months preceding and following select liquidity events. We regress aggregate changes in hedge fund ownership on interactions of stock-level volatility and quarter indicators. The hypothesis is that hedge funds' selloffs are driven by margin calls, which are more intense for high volatility stocks, and therefore there should be greater sensitivity of trades to volatility following the liquidity event.

The results in Panel B show that in most financial crisis there were indeed more dramatic selloffs of high volatility stocks. In particular, except for April 1997, October 1998 and September 2001, there was a greater decline in hedge fund holdings of high volatility stocks. Interestingly, the magnitude of the selloffs of high volatility stocks was in particularly large in the 2008 crisis.

5.3. Short Interest and the Cross-Section of Stocks

We repeat this analysis for stock-level short interest ratio. Again, if short sellers are constraints by the funding of their positions and if funding tightens for high volatility stocks during low aggregate market liquidity, then we should expect positive coefficients on the interaction terms.

Figure 5 presents the time series of the level of short interest, per volatility group. Average short interest has increased steadily over time for high volatility stocks. The level of short interest for low volatility stocks was constant until 2002 and increased dramatically since then. Figure 5b shows the quarterly changes for both groups of stocks.

Panel A of Table 6 shows that indeed short selling activity declines in high volatility stocks at times of low aggregate liquidity. We repeat this analysis around financial crises for short interest. In this analysis, presented in Panel B, the results do not show any particular pattern.

6. Conclusion

The behavior of arbitrageurs in the wake and during financial crises has been of interest to academics and policymakers. In this paper we present evidence showing that hedge funds exit the equity market during low market liquidity periods. The magnitude of the effect is moderate:

during the worst liquidity crisis, hedge funds reduce their positions by an average of 0.2 to 0.5 percentage points of firm capitalization (results are halved when value weighted), which amounts to 4% to 7% of their own total equity holdings. Although these declines in holdings are material, it is not clear whether these declines could cause a market-wide liquidity dry up as the liquidity spirals theory predicts.

We test whether hedge funds choose to reduce their positions or whether they are forced to do so. We document that short interest does not increase when market liquidity is low, and therefore argue that the decline in hedge fund holdings is not due to pessimistic views about the market. Consistent with the liquidity spirals theory we find that hedge funds are more likely to reduce their positions in high volatility (less marginable) stocks during low aggregate liquidity period.

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Appendix

List of liquidity events:

1. Iraq Invasion of Kuwait - 08/1990
2. Asian Crisis - 4/1997 and 12/1997
3. Russian Default and LTCM Crisis 6/1998 and 10/1998
4. Internet Stocks Crisis 03 - 04/2000
5. September 11 - 09/2001
6. Market Confidence Crisis 09 - 10/2002
7. Quant Liquidity Shock 08/2007
8. Bear Stearns Collapse 03/2008
9. Lehman Brothers' Bankruptcy 09/2008

Figure 1: Time-Series of the Number of Hedge Funds

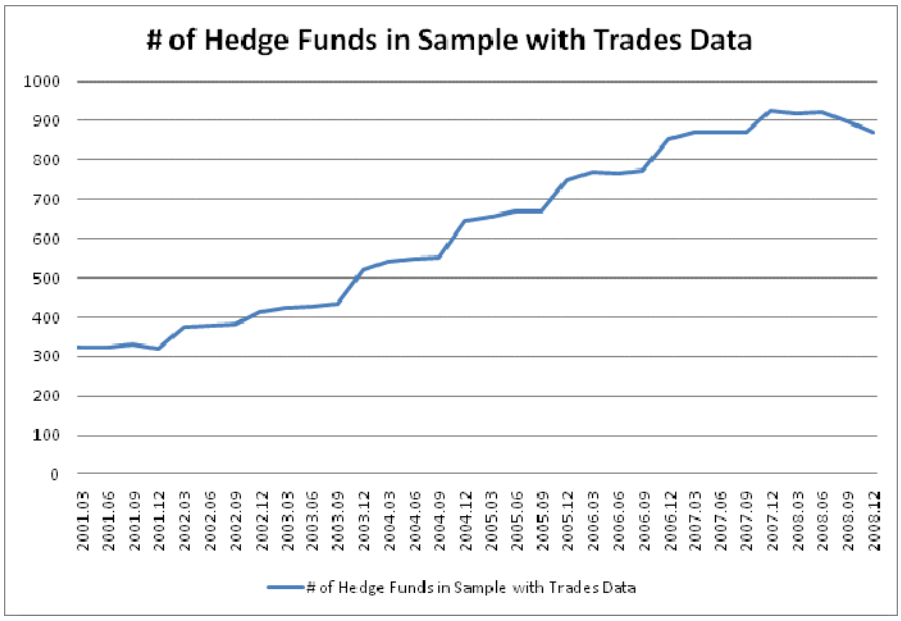

Figure 2: Time-Series of Hedge Fund Holdings

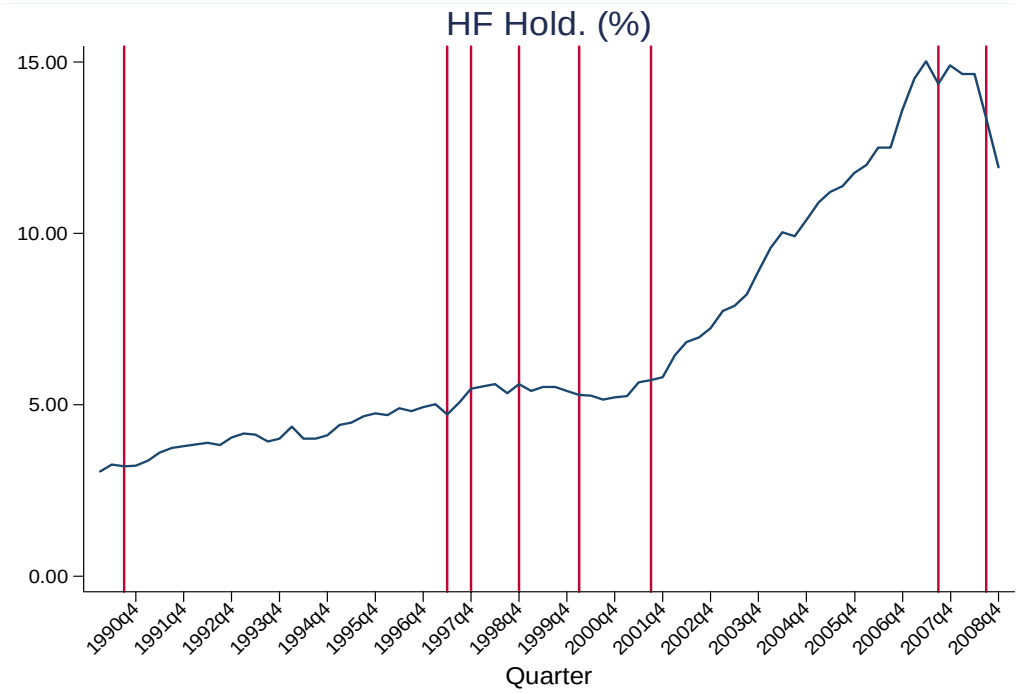

Figure 2a: Time-series of the level of hedge fund holdings. The red lines mark major liquidity events.

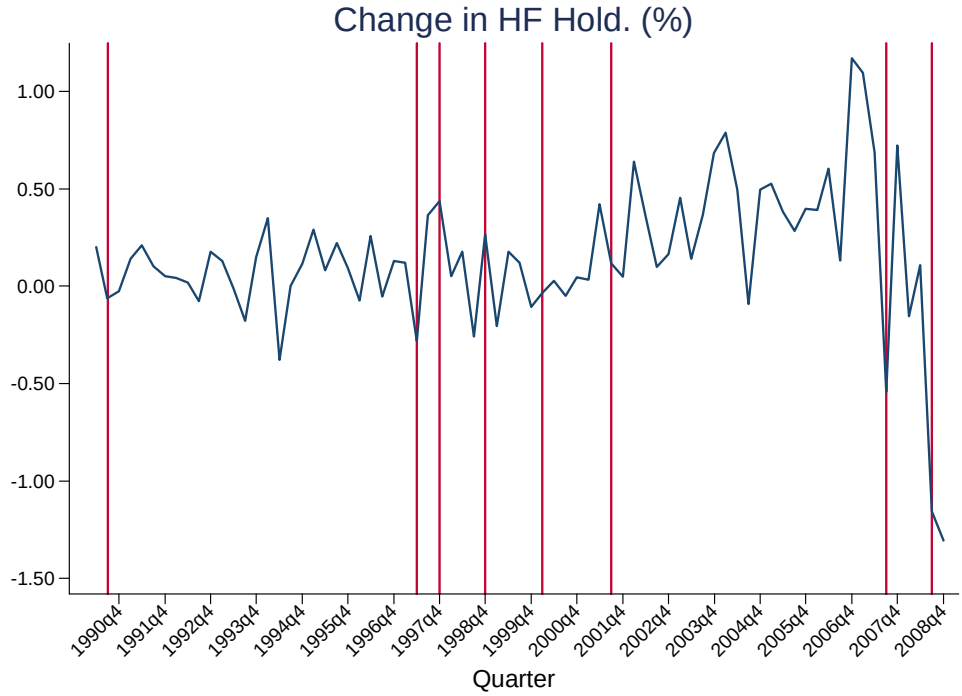

Figure 2b: Time-series of the changes in hedge fund holdings

Figure 3: Time-Series of Short Interest Ratio (SIR)

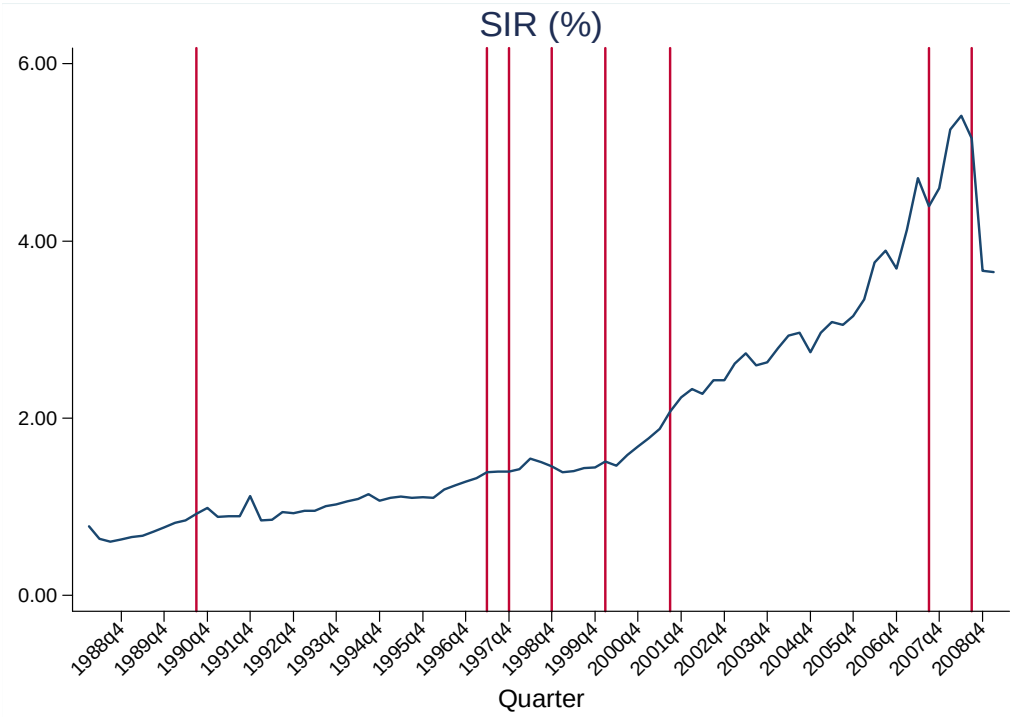

Figure 3a: Time-series of the level of short interest ratio

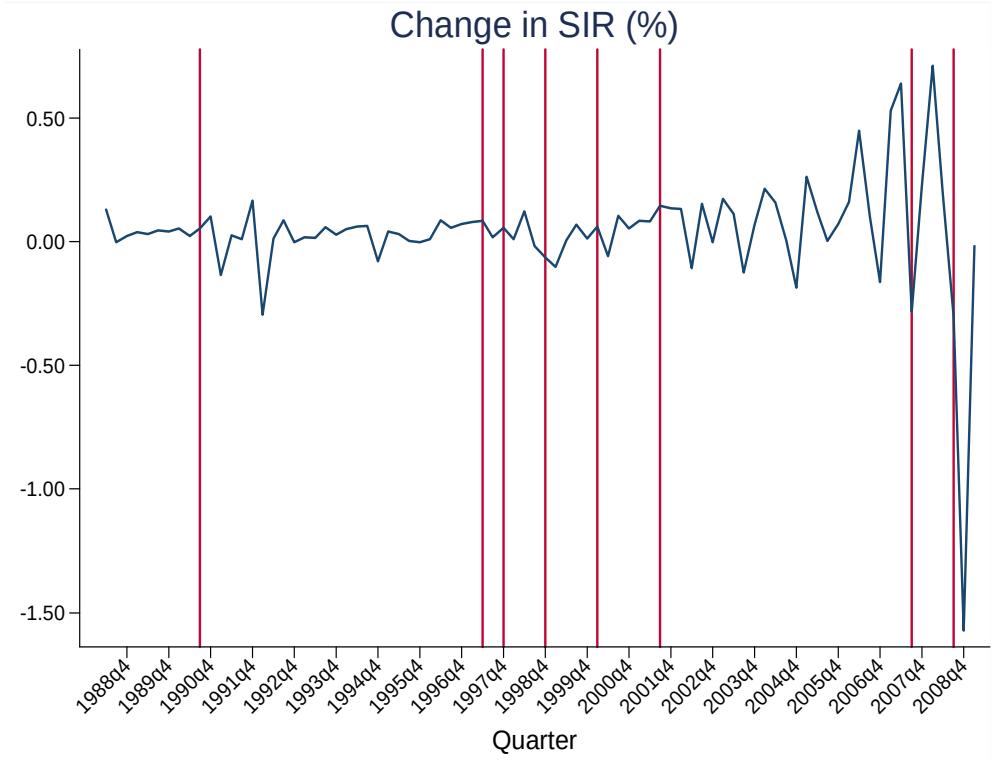

Figure 3b: Time-series of the changes in the short interest ratio

Figure 4: Time series of hedge fund holdings, for low and high volatility quintiles

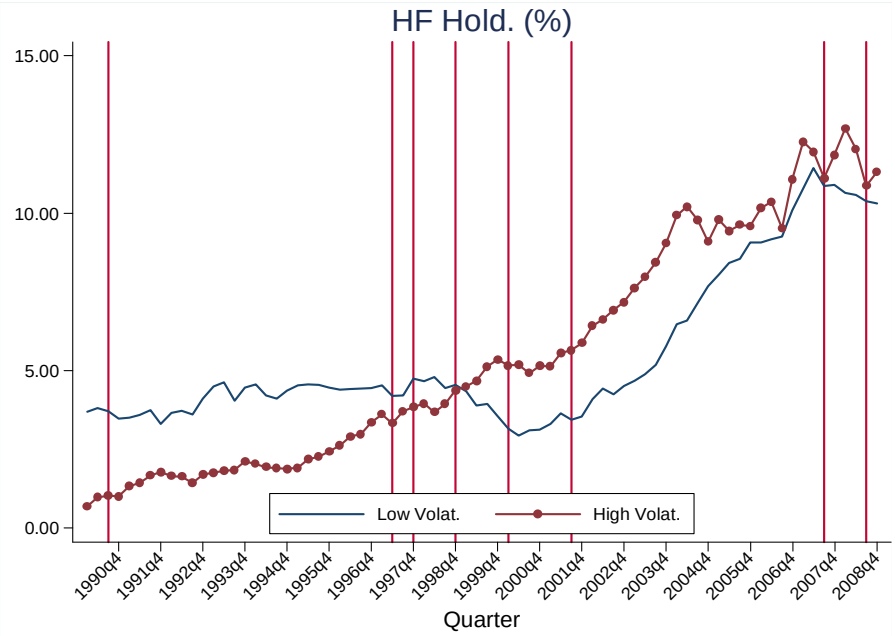

Figure 4b: Time-series of hedge fund holdings, for low and high volatility quintiles

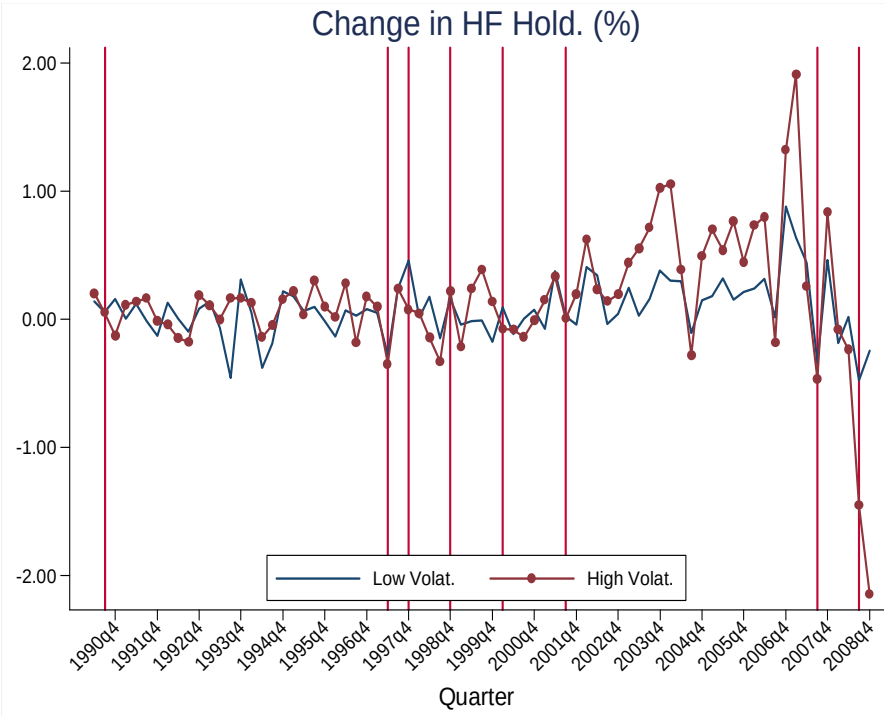

Figure 4b: Time-series of the changes in hedge fund holdings, for low and high volatility quintiles

Figure 5: Time series of short interest ratio, for low and high volatility quintiles

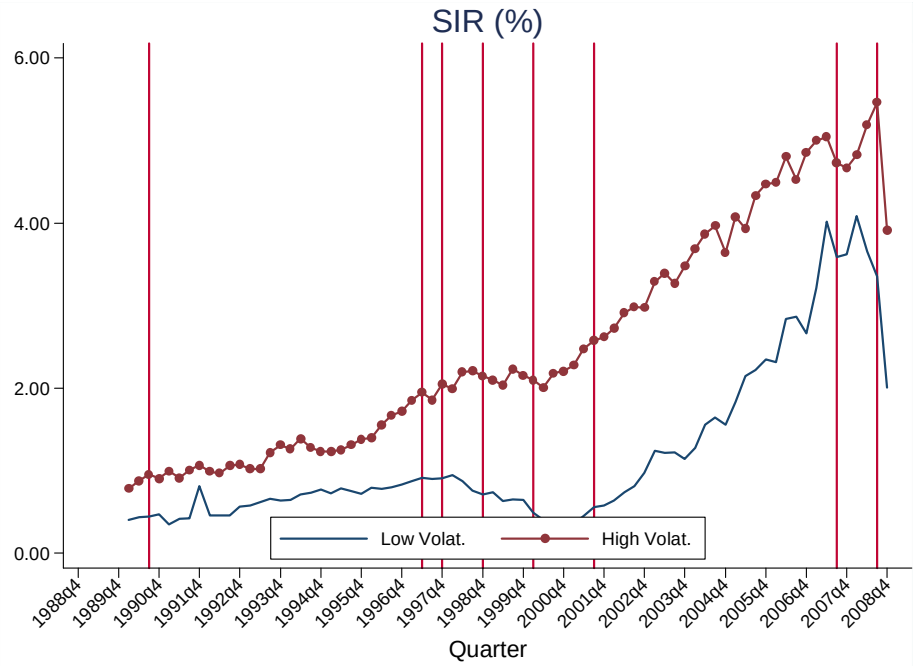

Figure 5a: Time-series of short interest ratio, for low and high volatility quintiles

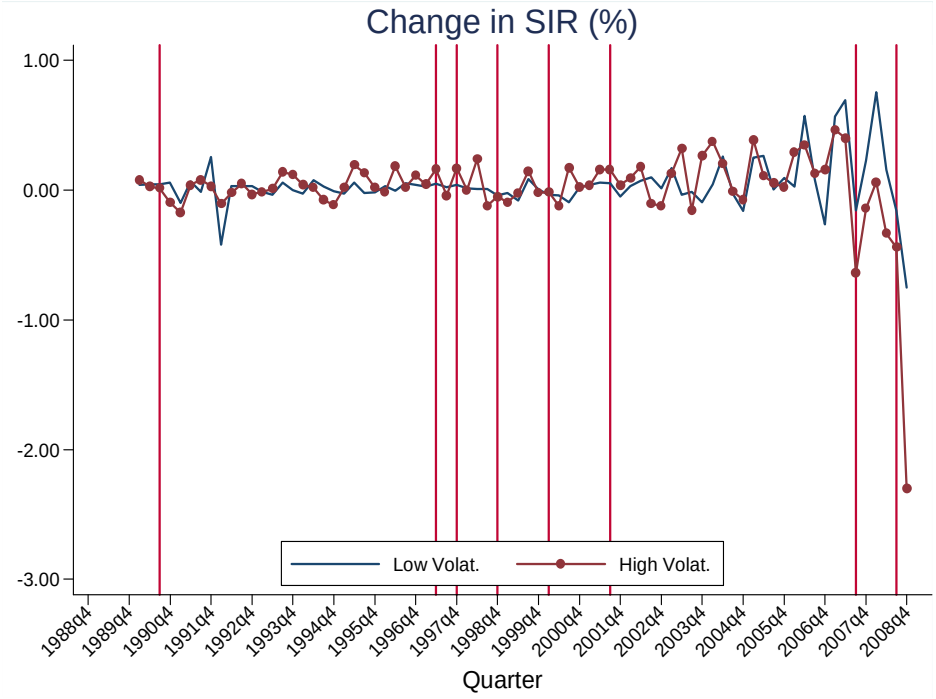

Figure 5b: Time-series of the changes in the short interest ratio, for low and high volatility quintiles

Table 1. Summary Statistics

Panel A: Summary statistics for aggregate sample (quarterly frequency)

		Mean	Median	St.Dev.	Min	Max
Levels	Institutional Holdings (%)	35.904	31.922	10.174	23.23	55.92
	EW Hedge Funds Holdings (%)	6.979	5.408	3.597	3.06	15.01
	VW Hedge Funds Holdings (%)	6.555	6.055	1.339	4.54	9.99
	Mutual Funds Holdings (%)	28.925	26.531	6.638	20.04	41.27
	Non-Institutional Holdings (%)	64.096	68.078	10.174	44.08	76.77
	EW Short interest ratio (SIR) (%)	1.937	1.424	1.239	0.61	5.41
	VW Short interest ratio (SIR) (%)	1.716	1.669	0.810	0.58	4.03
Quarterly Changes	Δ Institutional Holdings (%)	0.443	0.480	1.164	-2.81	4.91
	EW Δ Hedge Funds Holdings (%)	0.151	0.129	0.378	-1.31	1.17
	VW Δ Hedge Funds Holdings (%)	0.019	0.026	0.348	-0.88	1.18
	Δ Mutual Funds Holdings (%)	0.292	0.292	0.995	-2.32	4.13
	Δ Non-Institutional Holdings (%)	-0.443	-0.480	1.164	-4.91	2.81
	EW Δ Short interest ratio (SIR) (%)	0.043	0.053	0.238	-1.57	0.71
	VW Δ Short interest ratio (SIR) (%)	0.031	0.030	0.169	-0.73	0.80
Factors	Pastor-Stambaugh (innovations)	0.007	0.030	0.109	-0.29	0.30
	Acharya-Pedersen (innovations)	-0.526	-0.559	1.749	-5.35	3.39
	Sadka	0.001	0.002	0.007	-0.02	0.01
	Buy-sell imbalance (BSI)	0.000	0.007	0.025	-0.06	0.05
	Mkt - Rf	0.012	0.020	0.084	-0.24	0.20

Panel B: Correlation table for aggregate sample (quarterly frequency)

	Quarterly Changes							Quarterly Factors				
	EW Δ Inst. Hold.	EW Δ HF Hold.	VW Δ HF Hold.	EW Δ MF Hold	EW Δ Non-Inst. Hold.	EW Δ SIR	VW Δ SIR	PS	AP	Sadka	BSI	Mkt - Rf
EW Δ Inst. Hold.	1.000											
EW Δ HF Hold.	0.467	1.000										
VW Δ HF Hold.	0.316	0.754	1.000									
EW Δ MF Hold	0.964	0.214	0.121	1.000								
EW Δ Non-Inst. Hold.	-1.000	-0.467	-0.316	-0.964	1.000							
EW Δ SIR	0.201	0.446	0.107	0.087	-0.201	1.000						
VW Δ SIR	0.086	0.165	-0.088	0.045	-0.086	0.754	1.000					
PS	0.187	0.328	0.141	0.108	-0.187	0.275	0.240	1.000				
AP	0.001	0.354	0.270	-0.106	-0.001	0.118	-0.078	0.293	1.000			
Sadka	0.311	0.464	0.227	0.238	-0.311	0.140	-0.148	0.421	0.342	1.000		
BSI	0.013	0.295	0.049	-0.074	-0.013	0.138	-0.039	0.222	0.417	0.522	1.000	
Mkt - Rf	-0.032	0.060	-0.105	-0.054	0.032	-0.109	-0.214	0.440	0.179	0.353	0.483	1.000

Panel C: Summary statistics for stock-level sample (quarterly frequency)

	Mean	Median	St.Dev.	Min	Max
Hedge Funds Holdings (%)	6.624	3.829	8.168	0.00	57.91
Δ Hedge Funds Holdings (%)	0.143	0.000	2.848	-52.98	57.91
Short interest ratio (SIR) (%)	2.640	0.421	6.298	0.00	100.00
Δ Short interest ratio (SIR) (%)	0.043	0.000	2.455	-92.31	89.52
Volatility (%)	14.943	12.508	9.362	0.00	50.00
BSI stock (%)	-3.663	-1.188	21.540	-100.00	100.00
Mkt Cap ($m)	1705.648	128.231	10464.8	0.04	602000
Past Ret 12 (%)	15.135	3.349	86.866	-99.88	5868.00

Panel D: Correlation table for stock-level sample (quarterly frequency)

	HF Hold.	Δ HF Hold.	SIR	Δ SIR	Volatility	BSI stock	Mkt Cap	Past Ret 12
HF Hold.	1.000							
Δ HF Hold.	0.195	1.000						
SIR	0.273	-0.005	1.000					
Δ SIR	0.045	0.144	0.156	1.000				
Volatility	0.006	0.013	0.058	-0.027	1.000			
BSI stock	0.078	0.016	0.128	0.057	-0.042	1.000		
Mkt Cap	-0.073	-0.008	-0.037	-0.004	-0.142	0.069	1.000	
Past Ret 12	0.000	0.092	-0.029	0.080	0.217	0.109	0.000	1.000

Table 2. Hedge Fund Trades and Aggregate Liquidity

Panel A: Average hedge fund trades and aggregate liquidity measures

	Dependent Variable: Δ Avg HF holdings (%)							
	PS	-AP	Sadka	BSI	PS	-AP	Sadka	BSI
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Liquidity Factor	0.157***	0.097***	0.103***	0.105**	0.135***	0.098***	0.104***	0.060
	(3.979)	(2.793)	(3.953)	(2.047)	(3.093)	(2.705)	(3.832)	(1.064)
Mkt Ret					0.619	-0.043	-0.028	1.142*
					(1.181)	(-0.093)	(-0.085)	(1.773)
Observations	75	71	63	63	75	71	63	63
Adj. R^2	0.167	0.089	0.191	0.049	0.171	0.075	0.178	0.081

Panel B: Changes in hedge fund market participation and aggregate liquidity measures

	Dependent Variable: Δ Aggregate HF market participation (%)							
	PS	-AP	Sadka	BSI	PS	-AP	Sadka	BSI
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Liquidity Factor	0.077*	0.091**	0.063	0.022	0.090**	0.106**	0.075*	0.024
	(1.971)	(2.316)	(1.579)	(0.445)	(2.065)	(2.601)	(1.844)	(0.436)
Mkt Ret					-0.354	-0.701	-0.643	-0.058
					(-0.678)	(-1.362)	(-1.287)	(-0.092)
Observations	75	71	63	63	75	71	63	63
Adj. R^2	0.038	0.059	0.024	-0.013	0.030	0.070	0.034	-0.030

Panel C: Average hedge fund trades and aggregate liquidity measures, robustness

	Dependent Variable: Δ Avg HF holdings (%)							
	PS	-AP	Sadka	BSI	PS	Sadka	Sadka	BSI
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Liquidity Factor	0.130***	0.106***	0.082***	0.132**				
	(3.280)	(2.831)	(3.081)	(2.510)				
Liquidity Factor (t-1)	-0.071	0.062	0.027	0.172***				
	(-1.636)	(1.573)	(1.043)	(3.184)				
Liquidity Factor (t+1)	-0.005	0.026	0.069**	-0.003				
	(-0.117)	(0.653)	(2.614)	(-0.058)				
Liquidity Factor^{+}					0.049	-0.014	0.143**	0.175
					(0.608)	(-0.186)	(2.418)	(1.420)
Liquidity Factor^{-}					0.165**	0.187***	0.074	0.027
					(2.466)	(2.694)	(1.507)	(0.301)
Mkt Ret	0.003	0.034	-0.130	0.260				
	(0.005)	(0.072)	(-0.396)	(0.432)				
Mkt Ret (t-1)	1.009**	0.290	0.287	0.004				
	(2.016)	(0.595)	(0.892)	(0.006)				
Mkt Ret (t+1)	0.323	-0.426	-0.765**	0.623				
	(0.665)	(-0.919)	(-2.379)	(1.022)				
Mkt Ret^{+}					-0.962	-0.382	-0.026	-1.680
					(-1.108)	(-0.498)	(-0.045)	(-1.505)
Mkt Ret^{-}					2.043**	0.321	0.027	3.360***
					(2.276)	(0.367)	(0.039)	(3.474)
Observations	74	70	62	61	75	71	63	63
Adj. R^2	0.158	0.110	0.271	0.199	0.212	0.092	0.158	0.179

Table 3. Who Provides Liquidity?

Panel A: Mutual Funds, Non-Institituional Investors

	Dependent variable: Δ Avg holdings of mutual funds (%)				Dependent variable: Δ Avg holdings of non-institutional investors (%)			
	PS	-AP	Sadka	BSI	PS	-AP	Sadka	BSI
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Liquidity Factor	0.139	-0.086	0.260*	-0.112	-0.273*	-0.012	-0.364**	0.051
	(1.099)	(-0.689)	(1.977)	(-0.712)	(-1.897)	(-0.089)	(-2.578)	(0.282)
Mkt Ret	-0.124	-0.230	-1.449	1.152	-0.495	0.273	1.477	-2.294
	(-0.082)	(-0.145)	(-0.897)	(0.645)	(-0.285)	(0.155)	(0.851)	(-1.104)
Observations	75	71	63	63	75	71	63	63
Adj. R^2	-0.008	-0.021	0.033	-0.022	0.040	-0.029	0.071	-0.012

Table 4. Short-Selling Activity

Panel A: Average changes in short-selling interest ratio

	Dependent Variable: Δ Avg short interest ratio (SIR) (%)							
	PS	-AP	Sadka	BSI	PS	-AP	Sadka	BSI
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Liquidity Factor	0.003	0.003	-0.001	-0.001	0.003	0.003	-0.001	0.013
	(0.354)	(0.524)	(-0.268)	(-0.075)	(0.473)	(0.603)	(-0.273)	(1.400)
Mkt Ret					-0.003*	-0.002*	-0.000	-0.006**
					(-1.845)	(-1.673)	(-0.375)	(-2.589)
Observations	251	240	215	188	248	240	215	188
Adj. R^2	-0.004	-0.003	-0.004	-0.005	0.006	0.004	-0.008	0.025

Panel B: Changes in aggregate short-selling interest

	Dependent Variable: Δ Aggregate short interest (%)							
	PS	-AP	Sadka	BSI	PS	-AP	Sadka	BSI
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Liquidity Factor	0.008	-0.001	-0.003	0.002	0.008	-0.001	-0.003	0.009
	(1.453)	(-0.195)	(-0.709)	(0.388)	(1.469)	(-0.131)	(-0.711)	(1.308)
Mkt Ret					-0.002*	-0.001	-0.000	-0.003*
					(-1.884)	(-1.009)	(-0.237)	(-1.771)
Observations	236	225	200	183	233	225	200	183
Adj. R^2	0.005	-0.004	-0.003	-0.005	0.010	-0.004	-0.007	0.007

Panel C: Changes in short-selling activity as a function of changes in liquidity, in the cross-section

	Dependent variable: Δ Avg short interest ratio (SIR) (%)							
	PS	-AP	Sadka	BSI	PS	-AP	Sadka	BSI
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Liquidity Factor	0.005	0.004	0.005	0.013				
	(0.818)	(0.681)	(1.342)	(1.482)				
Liquidity Factor (t-1)	0.014**	0.004	0.009**	0.008				
	(2.190)	(0.812)	(2.557)	(0.924)				
Liquidity Factor (t+1)	0.017***	0.001	0.007*	0.007				
	(2.657)	(0.242)	(1.764)	(0.697)				
Liquidity Factor^{+}					-0.008	0.018	0.002	0.011
					(-0.497)	(1.143)	(0.098)	(0.642)
Liquidity Factor^{-}					0.017	-0.009	-0.001	0.006
					(1.355)	(-0.618)	(-0.049)	(0.368)
Mkt Ret	-0.003**	-0.002	-0.001	-0.006***				
	(-2.318)	(-1.387)	(-0.705)	(-2.925)				
Mkt Ret (t-1)	-0.005***	-0.004***	-0.004***	-0.004				
	(-3.313)	(-2.895)	(-4.415)	(-1.586)				
Mkt Ret (t+1)	0.000	-0.000	0.000	0.001				
	(0.208)	(-0.281)	(0.277)	(0.654)				
Mkt Ret^{+}					0.001	0.000	0.001	-0.000
					(0.309)	(0.038)	(0.148)	(-0.025)
Mkt Ret^{-}					-0.006*	-0.005	-0.005	-0.006
					(-1.746)	(-1.332)	(-1.439)	(-1.540)
Observations	247	239	214	186	254	254	254	254
Adj. R^2	0.075	0.020	0.087	0.049	0.001	-0.001	-0.006	-0.003

Table 5. Hedge Fund Trades and Stock Volatility

Panel A: Hedge fund trades and stock volatility

	Dependent variable: Δ HF holdings (%)							
	PS	-AP	Sadka	BSI	PS	-AP	Sadka	BSI
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Liquidity Factor × Volatility	0.179***	0.243***	0.218***	0.387***				
	(3.841)	(4.757)	(4.520)	(6.917)				
Liquidity Factor^{+} × Volatility					-0.159*	0.044	0.360***	1.036***
					(-1.768)	(0.397)	(3.335)	(7.531)
Liquidity Factor^{-} × Volatility					0.440***	0.427***	0.119	-0.107
					(5.815)	(4.095)	(1.432)	(-0.965)
Volatility	-0.034	0.033	-0.046	-0.029	0.202***	0.188**	-0.139*	-0.532***
	(-0.621)	(0.603)	(-0.877)	(-0.471)	(2.640)	(2.003)	(-1.695)	(-4.612)
log(mktcap)	0.003	0.003	0.000	0.000	0.004*	0.003	0.000	0.000
	(1.412)	(1.292)	(0.177)	(0.138)	(1.655)	(1.310)	(0.188)	(0.043)
Past Ret 12	0.238***	0.234***	0.232***	0.252***	0.237***	0.234***	0.232***	0.254***
	(44.795)	(44.714)	(46.105)	(41.108)	(44.409)	(44.675)	(46.061)	(41.381)
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	391038	374056	339087	332269	391038	374056	339087	332269
Adj. R^2	0.021	0.017	0.014	0.022	0.021	0.017	0.014	0.022

Panel C: Hedge fund trades and stock volatility, around financial crises

	Dependent variable: Δ HF holdings (%)							
	Aug-90	Apr-97	Dec-97	Oct-98	Mar-00	Sep-01	Aug-07	Sep-08
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Volatility × Qtr -2		-0.227	0.079	-1.731***	0.367	1.955***	5.125***	0.452
		(-0.523)	(0.179)	(-3.683)	(0.886)	(6.390)	(5.333)	(0.476)
Volatility × Qtr -1	-0.063	-0.108	-0.319	0.091	1.412***	0.202	0.698	-1.139
	(-0.217)	(-0.252)	(-0.724)	(0.198)	(3.744)	(0.653)	(0.714)	(-1.236)
Volatility × Qtr 0	0.275	0.193	-1.561***	-0.468	-1.433***	0.192	-1.675*	-3.266***
	(0.943)	(0.448)	(-3.497)	(-1.084)	(-4.117)	(0.610)	(-1.647)	(-3.627)
Volatility × Qtr +1	-0.712**	-0.283	0.083	-0.337	-0.867***	1.116***	2.453**	-6.171***
	(-2.431)	(-0.659)	(0.183)	(-0.808)	(-2.596)	(3.548)	(2.440)	(-7.344)
Volatility × Qtr +2	0.387	-1.503***	-2.051***	-0.159	-0.716**	0.338	0.992	
	(1.527)	(-3.451)	(-4.412)	(-0.392)	(-2.236)	(1.001)	(0.976)	
log(mktcap)	0.022***	-0.025***	-0.026***	0.005	-0.012	0.029***	0.034**	-0.011
	(3.545)	(-2.903)	(-2.862)	(0.538)	(-1.412)	(3.547)	(2.181)	(-0.724)
Past Ret 12	0.403***	0.381***	0.320***	0.302***	0.123***	0.431***	0.407***	0.476***
	(18.688)	(16.252)	(13.697)	(13.030)	(10.835)	(18.978)	(6.661)	(6.432)
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	19498	31284	31626	31208	28879	27246	21579	16982
Adj. R^2	0.028	0.017	0.015	0.013	0.007	0.022	0.027	0.033

Table 6. Short Interest and Stock Volatility

Panel A: Changes in short interest and stock volatility

	Dependent variable: Δ short interest ratio (SIR) (%)							
	PS	-AP	Sadka	BSI	PS	-AP	Sadka	BSI
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Liquidity Factor × Volatility	0.205***	0.170***	0.254***	0.149***				
	(6.619)	(5.072)	(7.899)	(4.146)				
Liquidity Factor^{+} × Volatility					-0.068	0.024	0.173*	0.719***
					(1.117)	(0.327)	(2.407)	(8.132)
Liquidity Factor^{-} × Volatility					0.416***	0.302***	0.310***	-0.283***
					(8.212)	(4.458)	(5.624)	(3.982)
Volatility	-0.008	0.062	0.069*	-0.033	0.187***	0.175**	0.122*	-0.474***
	(0.206)	(1.716)	(1.968)	(0.818)	(3.563)	(2.819)	(2.225)	(6.385)
log(mktcap)	0.016***	0.016***	0.013***	0.016***	0.016***	0.016***	0.013***	0.015***
	(9.573)	(9.724)	(8.027)	(8.769)	(9.861)	(9.741)	(8.018)	(8.632)
Past Ret 12	0.116***	0.111***	0.103***	0.126***	0.114***	0.111***	0.104***	0.128***
	(32.498)	(32.417)	(31.488)	(32.210)	(32.062)	(32.375)	(31.510)	(32.665)
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	362143	345160	310236	313468	362143	345160	310236	313468
Adj. R^2	0.031	0.014	0.008	0.034	0.031	0.014	0.008	0.035

Panel B: Changes in short interest and stock volatility, around financial crises

	Dependent variable: Δ Short interest ratio (SIR) (%)							
	Aug-90	Apr-97	Dec-97	Oct-98	Mar-00	Sep-01	Aug-07	Sep-08
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Volatility × Qtr -2	0.130	0.344	0.604*	0.729**	0.598*	0.436**	1.975**	-3.314***
	(0.446)	(1.436)	(2.371)	(2.809)	(2.545)	(2.580)	(3.254)	(4.377)
Volatility × Qtr -1	0.001	0.472*	0.331	-0.895***	-0.432*	0.772***	0.008	-1.806*
	(0.004)	(2.014)	(1.309)	(3.434)	(2.030)	(4.514)	(0.013)	(2.441)
Volatility × Qtr 0	-0.282	0.688**	0.842**	0.507*	-0.124	0.28	-1.787**	-0.813
	(0.953)	(2.899)	(3.287)	(2.101)	(0.630)	(1.611)	(2.778)	(1.125)
Volatility × Qtr +1	-0.640*	0.403	0.326	-0.236	-0.523**	0.138	-0.343	-4.199***
	(2.139)	(1.711)	(1.263)	(1.013)	(2.754)	(0.787)	(0.538)	(6.214)
Volatility × Qtr +2	0.015	0.925***	1.142***	-0.454*	0.710***	0.198	-2.202***	
	(0.056)	(3.883)	(4.340)	(1.999)	(3.920)	(1.055)	(3.454)	
log(mktcap)	0.004	0.024***	0.017***	-0.020***	0.010*	0.046***	0.095***	-0.010
	(0.734)	(4.922)	(3.296)	(4.056)	(2.052)	(9.922)	(9.598)	(0.803)
Past Ret 12	0.103***	0.133***	0.126***	0.151***	0.038***	0.167***	0.160***	0.465***
	(5.743)	(10.295)	(9.360)	(11.718)	(6.034)	(13.420)	(4.145)	(7.823)
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	18128	29675	30133	29557	27207	25659	21558	16983
Adj. R^2	0.008	0.006	0.005	0.008	0.004	0.013	0.046	0.124

Table 7. Hedge Fund Trades and the Funding Channel

[Coming Soon]

Hedge funds trading and the sensitivity to volatility, per hedge fund liquidity constraints

** Regressions of changes in HF holdings on volatility interacted with liquidity measures and with HF financial constraints.

Alternatively, run regressions of changes in HF holdings on volatility interacted with liquidity measures once for financially constrained HFs, and once for unconstrained.

HF financial constraints: past returns (TASS), redemption notice period, lock up period