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Myopic or Dynamic Liquidity Management?

A Study of Hedge Funds around the 2008 Financial Crisis

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NETSPAR

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Abstract

In this paper, we show that hedge funds repurchased a large amount of liquid stocks and continued to sell illiquid stocks as the 2008 financial crisis mitigated. It complements existing empirical evidence that institutional investors sold more liquid than illiquid assets during the crisis period. This new empirical evidence confirms the trade-off in theoretical literature between selling liquid assets to minimize contemporary trading costs and selling illiquid assets to keep a "liquidity cushion" (e.g. Scholes 2000; Duffie and Ziegler 2003; Brown, Carlin, and Lobo 2010). Consistently, hedge funds' portfolio composition shows a delayed "flight to liquidity": the proportion of hedge funds' liquid stock holdings decreased slightly at the peak of the crisis and then increased substantially to a highest level ever since 2007. For comparison, we show that pension funds have a nearly constant portfolio composition of liquid versus illiquid stocks through the entire crisis.

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In this paper, we show that hedge funds repurchased a large amount of liquid stocks and continued to sell illiquid stocks as the 2008 financial crisis mitigated. It complements existing empirical evidence that institutional investors sold more liquid than illiquid assets during the crisis period. This new empirical evidence confirms the trade-off in theoretical literature between selling liquid assets to minimize contemporary trading costs and selling illiquid assets to keep a "liquidity cushion" (e.g. Scholes 2000; Duffie and Ziegler 2003; Brown, Carlin, and Lobo 2010). Consistently, hedge funds' portfolio composition shows a delayed "flight to liquidity": the proportion of hedge funds' liquid stock holdings decreased slightly at the peak of the crisis and then increased substantially to a highest level ever since 2007. For comparison, we show that pension funds have a nearly constant portfolio composition of liquid versus illiquid stocks through the entire crisis.

1 Introduction

In the previous decade, the theoretical literature of dynamic portfolio choice with trading costs[1] has developed rapidly. After experiencing the financial crises in 1998 and 2008, more and more scholars started to notice the important role of liquidity management in portfolio choice, especially during times of liquidity crisis. For example, Scholes (2000) suggests that financial institutions should sell liquid assets first for urgent liquidity needs to reduce the transaction costs, and he emphasizes the need to build "a dynamic liquidity cushion" for future liquidity needs. Duffie and Ziegler (2003) investigate numerically the trade-off between selling off an illiquid asset to keep a "cushion of liquid assets", and selling a liquid asset to maximize short-term portfolio value. In accordance with this trade-off, Brown, Carlin, and Lobo (2010) solve a two-period model and show that it is optimal for a myopic investor to sell more liquid assets, but a dynamic investor may sell less liquid assets if they expect a large liquidity shock in the second period. However, there is no direct empirical evidence to this trade-off in the crisis yet.

Among all types of investors, hedge funds might be the group of investors that care most about their liquidity management. It is because clients of hedge funds are mainly sophisticated institutional investors which react quickly to market changes. Moreover, the use of leverage and short positions makes hedge funds more sensitive to fund outflows than other investors.

In this paper, we analyze the quarterly stock holdings of 60 largest hedge funds in U.S. before, during and after the 2008 financial crisis, and document the liquidity composition of their portfolios. We find that consistent with the trade-off between myopic and dynamic liquidity management, hedge funds sold more liquid than illiquid stocks at the peak of the 2008 financial crisis (when there was large amount of redemption), and they repurchased a large amount of liquid stocks and continued to sell illiquid stocks when the crisis mitigated. For comparison, we do a similar analysis for pension funds.

First, we study the changes of hedge funds' aggregate equity holdings from 2007 to 2010.

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[1]The groundbreaking paper in this thread of literature is Constantinides (1986), and other well-known papers include Liu (2004), Lo, Mamaysky and Wang (2004), Jang, Koo, Liu and Loewenstein (2007), Lynch and Tan (2011), Gârleanu and Pederson (2012) etc..

Figure 1 presents both the total equity holdings of hedge funds and the S&P 500 index. It shows that the equity holdings of hedge funds dropped severely in the second half of 2008 and reversed strongly in 2009 and 2010 Q1. The reversal of hedge funds' equity holdings started even one quarter before the reversal of the S&P 500 index. Different from hedge funds, pension funds reduced their equity holdings gradually from 2007 to 2010. There was no sudden drop or reversal in their equity holdings. It might be because, unlike hedge funds, pension funds did not face large urgent liquidity needs at that time, and attempt to time the market.

[Insert Figure 1 about here]

Second, to investigate whether hedge funds trade liquid and illiquid stocks differently around the crisis, we sort stocks into deciles based on their ILLIQ values, a liquidity measure proposed in Amihud (2002). We find that hedge funds sold more liquid than illiquid stocks at the peak of the crisis for forced sales, as the selling pressure mitigated, they repurchased a large amount of liquid stocks and continued to sell illiquid stocks in order to build a "liquidity cushion"[2]. In accordance, the portfolio composition of hedge funds shows a delayed "flight to liquidity". The fraction of relatively liquid stocks held by hedge funds decreased slightly at the peak of the crisis (the second half of 2008), from 40% to 38%, and increased substantially to 48% in 2009. Different from hedge funds, pension funds did not trade liquid and illiquid stocks differently around the crisis.

Finally, we do a stock-level regression to control for other effects. For each stock, we regress the change of hedge funds' ownership on stock liquidity, where we control for a set of variables and other stock characteristics, including volatility, size, book-to-market, past 6-month return variables, and previous hedge fund holdings. We do the analysis for the crisis period (2008 Q3 and Q4) and the reversal period (2009 and 2010 Q1) separately. Hedge funds' myopic and dynamic liquidity management both survive this robustness check and become even more substantial.

This paper contributes to at least three threads of literature.

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[2]Figure 3 in Ben-David, Franzoni and Moussawi (2012) shows that fund outflow was the highest in 2008 Q4 and 2009 Q1, and it decreased since 2009 Q2. Because hedge funds usually require a notice period of 1 to 3 months for redemption. The forced sales were mostly in 2008 Q3 and Q4.

First, to our best knowledge, it provides the first direct empirical evidence to the trade-off between myopic and dynamic liquidity management in the theoretical literature of dynamic portfolio choice with trading costs (e.g. Scholes 2000; Duffie and Ziegler 2003; Brown, Carlin, and Lobo 2010). We show that as the pressure of forced selling in the 2008 financial crisis decreased, the balance of this trade-off shifted from selling more liquid stocks (to reduce trading costs) to selling less liquid stocks (to build "liquidity cushion" for future crisis).

Second, it contributes to the literature documenting institutional investors' dynamic behavior. Because of the availability of data, this thread mainly focuses on mutual funds. There are only few papers about hedge funds. Brunnermeier and Nagel (2004) show that hedge funds successfully ride the technology bubble in 2000; Ben-David, Franzoni and Moussawi (2012) present that hedge funds faced large fund outflows in 2008 financial crisis and reduced their equity holdings significantly; and Ang, Gorovyy, and van Inwegen (2011) report that hedge fund deleverage substantially at the same period. In this paper, we document hedge funds' dynamic behavior from the perspective of their liquidity management across individual stocks both during and after the crisis period, which provides evidence for both their myopic and dynamic liquidity management.

Third, this paper contributes to the theoretical literature on the limits of arbitrage which emphasizes the role of financial institutions. This thread of literature investigates how costs and financial constraints faced by arbitrageurs can prevent them from eliminating mispricing and providing liquidity to other investors. Simultaneously, financial institutions are the source of many non-fundamental demand shocks (Gromb and Vayanos 2002, 2009, Brunnermeier and Pedersen 2009). In this sense, financial institutions do not necessarily correct anomalies but can also cause them. Brunnermeier and Nagel (2004) find that because of predictable investor sentiment and limits to arbitrage, hedge funds ride bubbles instead of correcting them. For crisis periods, this paper confirms the finding in Ben-David, Franzoni and Moussawi (2012) that there are even more fire sales in hedge funds than other investors. Our paper complements their findings by showing that, to keep a liquidity buffer for future crisis, hedge funds continued to sell their illiquid stocks during the market reversal. It, in

4

theory, would further enlarge the underpricing of illiquid stocks and delay the price reversal.

This paper proceeds as follows. Section 2 summarizes the data sources and provides the summary statistics for both hedge funds and pension funds. Section 3 analyzes the dynamics of liquid stock holdings v.s. illiquid stock holdings around the crisis for both hedge funds and pension funds. Section 4 offers concluding remarks and possible directions for extensions.

2   Data and Sample Characteristics

2.1   Data Source

2.1.1   Holding Data of Hedge Funds and Pension Funds

We use the Thomson-Reuters Institutional Holdings (13F) Database for the equity holdings of hedge funds (HFs), and for pension funds (PSs) as well. It provides institutional common stock holdings, as reported on form 13F filed with the SEC. This database is formerly known as CDA/Spectrum database, and contains ownership information by institutional managers with $100 million or more in assets under management. This data allows us to track positions in individual stocks at a quarterly frequency.

Since 1978, all institutions with more than $100 million under discretionary management are required to disclose their holdings in U.S. stocks and a few other securities to the SEC each quarter on form 13F. This concerns all long positions greater than 10,000 shares or $200,000 over which the manager exercises sole or shared investment discretion. The 13F filings do not contain information on short positions or derivatives, which is a limitation of our analysis. The 13F reporting requirements apply regardless of whether an institution is regulated by the SEC or not, and it also applies to foreign institutions if they "use any means or instrumentality of United States interstate commerce in the course of their business." Hence, it also applies to HFs, provided that their holdings of U.S. stocks exceed the specified thresholds.

In this paper, we investigate the HF managing firms included in "Hedge Fund Top 100" in 2010 from the website "www.institutionalinvestor.com". This rank is based on the size

of the assets under management, which serves our research interest. Since large trades have larger price impacts than small trades, large funds are more sensitive to stock liquidity than small funds do. Following the procedure in Brunnermeier and Nagel (2004), we discard some managing firms because HF assets only make up a small part of their aggregated institutional portfolio. For each manager, we check whether the firm is registered as an investment adviser with the SEC. Registration is a prerequisite to conduct non-hedge-fund business such as advising mutual funds and pension plans. We search whether it is registered investment adviser. If the firm is not registered, we include it in our sample. If the firm is registered, we obtain registration documents (Form ADV). For a registered firm to be eligible for our sample, we require (1) that at least 50% of its clients are "Other pooled investment vehicles (e.g., hedge funds)" or "High net worth individuals", and (2) that it charges performance-based fees, according to Form ADV. This process leaves us with 70 HF managers. Commonly, each firm manages multiple funds, so our sample comprises stock holdings of probably several hundreds different HFs. Second, we look up each candidate HF managing firm by name in the Thomson-Reuters 13F database. We find records for 68 managing firms. Only 60 managing firms have complete holding data around the crisis, from 2007 Q1 to 2010 Q4.[3] The total holding of these 60 HF managing firms is $240 billion in 2008 Q1, and $250 billion in 2010 Q4. BarclayHedge shows that the total assets under management in the HF industry is $1457.9 billion in 2008 and $1795.8 billion in 2011 Q1. It suggests that our data capture a significant part of total HF stock holdings.

For PFs, we follow the classification of institutional investors on Brian Bushee's web-site[4], where corporate (private) PFs and public PFs are identified from "other institutional investors" with type code 5 in Thomson-Reuters Institutional Holdings (13F) Database. Similarly, we only keep the PFs which have complete holding data from 2007 Q1 to 2010

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[3]Since we only include HF managing firms which have complete holding data from 2007 to 2010, our sample is exposed to survivorship bias. Luckily, the survivorship bias here serves, rather than hurts, our research question. Since the survivors are more likely to be those HFs who managed their liquidity properly during the 2008 crisis. Even if our sample bias toward those HFs who survive for reasons other than liquidity management (such as, stock picking skill, market timing skill or purely luck), it does not affect the main finding of this paper that a significant subset of HFs manage their liquidity dynamically around the 2008 financial crisis. Those alternative stories are not consistent with the fact that they continue to sell the illiquid stocks after the crisis.

[4]"http://acct3.wharton.upenn.edu/faculty/bushee/"

Q4. It leaves us with 56 PFs in total.

Wilshire consulting estimates that the cash and securities holdings of the 126 largest public-employee pensions were $2.217 trillion in 2010. State pension portfolios have, on average, a 65.6% allocation to equities, including real estate and private equity. Among them, the allocation to U.S. equity is 31.1%, which is about $689.49 billion. The total equity holdings of our sample are $446.5 billion. Among them, $348.5 billion are held by public PFs. Our sample thus captures about half of PFs' total equity holdings in the market.

2.1.2 Stock Returns and Firm Accounting Data

We use the data of stock returns and accounting information from CRSP and Compustat. The stock data from different databases are linked by "Ticker" on 2008 June 30. The criteria used to filter the stocks are as below:

(1) We include the stocks that are ordinary common shares (CRSP sharecodes 10 and 11), excluding ADRs, SBIs, certificates, units, REITs, closed-end funds, companies incorporated outside the U.S., and Americus Trust Components.

(2) We include the stocks that have return data for more than 18 months in 2008 & 2009 and complete return data from 2008 Q3 to 2009 Q2.

3636 stocks, from NYSE, AMEX and Nasdaq and fulfilling these three criteria, are included into our scope of analysis.

2.2 Summary Statistics

Next we summarize equity holdings of HFs and PFs at the aggregate level and the characteristics of stocks held by them.

2.2.1 Summary of Hedge Funds and Pension Funds' equity holdings

[Insert Table 1 about here]

Table 1 provides the summary of HFs' total equity holdings in our sample. They held about three quarters of the stocks in the market (2727 to 3032, out of 3636 stocks in our sample), and 0.3%-0.6% of total market capitalization. The smaller than 1 percent total market ownership is not surprising, as aggregate stock holdings of HFs in our sample (about $115 billion to $325 billion) are dwarfed by holdings of other institutional investors such as mutual funds and PFs. Consistent with Figure 1, HFs released their equity holdings substantially in 2008 q3 and q4, from 0.52% of the total market capitalization to 0.34%, and they repurchased those equity holdings strongly in 2009 and 2010 Q1, to 0.50% of the total market capitalization. Similarly, the last column shows that HFs' aggregate dollar equity holdings decreased substantially in 2008 q3 and q4, from $250 billion to $115 billion, and reversed in 2009 and 2010 Q1 to $235 billion. These changes are caused by both the trades of HFs and the changes of the stock prices. In section 3.1, we fixed the stock price to estimate the trades made by HFs.

[Insert Table 2 about here]

Table 2 shows that the PFs in our sample held about five-sixth of the stocks in the market (3027 to 3398, out of 3636 stocks in my), and about 0.91%-1.18% of total market capitalization. Note that different from HFs, PFs constantly reduced their equity holdings since the second quarter of 2007, from 1.18% to 0.91% in 2010 q4. The last row shows that the total dollar amount of PFs' equity holdings decreased in 2008 Q3 & Q4 and 2009 Q1, from $519 billion to $300 billion, and reversed slightly in the last three quarters of 2009 and 2010 Q1, from $300 billion to $446 billion. Since PFs' equity holdings as a fraction of the market size decreased continuously instead, the reversal of the total dollar holdings is caused by the reversal of the market stock price rather than their trades.

2.2.2 Summary of Stock Characteristics

The definitions and calculations of stock characteristics are listed in Table 3. Because we want to study the trades of HFs rather than the changes of characteristics for each stock, we

do not allow those measures of stock characteristics to change over time[5]. We use the data just before the crisis to construct those measures. Since Lehman's bankruptcy happened in the third quarter of 2008, we use the data on 2008 June 30 (for "*Hedge Fund Ownerships*", "*Market Cap*" and "*Book-to-Market*"), and the daily data in the first half of 2008 (for "*Share turnover*", "*Bid-Ask Spread*", "*ILLIQ*", "*Past Return*" and "*Return Variability*"). Only the "*Market Beta*" is calculated using the return data from 2001 January 1 to 2011 June 30.

[Insert Table 3 about here]

In Table 4, we summarize the characteristics of the whole sample of stocks, the stocks held by HFs and the stocks held by PFs separately. The average percentage of shares held by HFs (Hedge Funds Ownership) for the whole samples is 2.7%, and that for the stocks held by HFs is 3.3%, which are obviously larger than 0.5% to 0.8%, the fraction of total market capitalization held by HFs reported in Table 1. The main reason is that the numbers in Table 4 are calculated as equally weighted, while those in Table 1 are value weighted. For the same reason, the average percentage of shares held by PFs (Pension Funds Ownership) reported in the second row, 1.7% for the whole sample and 1.9% for those held by PFs, are also larger than the 0.9% to 1.2% reported in Table 1. Because PFs put more shares in large stocks than HFs do, the average stock ownership of PFs reported in Table 4 is smaller than that of HFs. The other average stock characteristics of HFs' and PFs' holdings are quite similar.

[Insert Table 4 about here]

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[5]We use time-varying measures of stocks liquidity, ILLIQ values, for robustness check. The results are quite similar.

9

3 Hedge Funds' Liquidity Management around 2008 Financial Crisis

3.1 Hedge Funds' aggregate equity holdings around 2008 Crisis

First, we aggregate all equity holdings of HFs in our sample and present its time variation from 2007 Q1 to 2010 Q4. As we know, both the changes of shares held by HFs and the changes of the stock prices can lead to the variation of HFs' equity holdings over time. To estimate the trades (changes of shares) of HFs, we need a measure of HFs' equity holdings that is insensitive to the price changes. Figure 1 measures HFs' aggregate equity holdings as the fraction of the total market capitalization, which is insensitive to the fluctuations of market price. However, the price changes of stocks held by HFs relative to the price changes of other stocks in the market can still affect this measure. To eliminate the effect of price changes on HFs' equity holdings, we fix all stock prices to their levels at the end of 2008 q2. For each stock in each quarter, we calculate the fixed-price dollar amount of HFs' equity holding as the number of shares held by HFs at the end of that quarter times the stock price per share at the end of 2008 q2. This fixed-price dollar amount changes with the number of shares held by HFs and does not change with stock prices. For brevity, we will call the equity holdings based on the stock prices at the end of 2008 q2 "fixed-price equity holdings" in the rest of the paper.

Figure 2 plots HFs' total fixed-price equity holdings in billion $s over time. Similar to Figure 1, Figure 2 shows significant decline in HFs' holdings around Lehman Brothers' bankruptcy (2008 Q3 & Q4), about 66.7 billion $s, and a quick and large reversal in 2009 and 2010 Q1, about 54.7 billion $s. The magnitude of the reversal is about 81.9% of the drop in 2008 Q3 and Q4.

[Insert Figure 2 about here]

The large drop of HFs' fixed-price equity holdings in 2008 Q3 and Q4 is consistent with the forced deleveraging proposed by Vayanos (2004) and Brunnermeier and Pedersen (2009). Ben-David, Franzoni and Moussawi (2012) document that redemption and margin calls were the primary drivers of those selloffs.

10

Surprisingly, HFs' fixed-price equity holdings reversed substantially in 2009, still the darkest hours of the crisis. Ben-David, Franzoni and Moussawi (2012) show that HFs still had significant funds outflows in this period, and Ang, Gorovyy, and van Inwegen (2011) show that after the deleveraging in the second half of 2008, the average leverage ratios of HFs, including equity funds, were still low in 2009. In this case, why did HFs increase their equity holding in this period?

One possible explanation is that HFs increased their holdings of liquid stocks to prepare for their potential liquidity needs in the near future (dynamic liquidity management hypothesis). This hypothesis is strongly supported by our empirical findings in the next subsection. There are alternative explanations to the increase of stock holdings. For example, HFs might be good at timing the market reversal, so they buy stocks just before and during the market reversal to benefit from the stock market upturn; or, HFs managers might decide to gamble the market upturn because of their concave payoff function, which means they benefit more from superior fund performances. Figure 1 has shown that the reversal of HFs' fixed-price equity holdings started one quarter before the reversal of the S&P 500 index. Thus they captured much of the upturn.

In fact, the dynamic liquidity management hypothesis is not exclusive to those other explanations. It is true that if HFs want to reduce the transaction costs of building up the portfolio in a short time, they would trade liquid stocks rather than illiquid stocks. But the fact that HFs continued to sell illiquid stocks during the market reversal (will be shown in the next subsection) supports the dynamic liquidity management hypothesis only, and conflicts with the other explanations.

To compare with HFs, we also plot PFs' aggregate equity holdings from 2007 q1 to 2010 q4 in Figure 3. Panel A of Figure 3 plots it as a percentage of total U.S. stock market capitalization; and Panel B plots their fixed-price equity holding based on the stock prices at the end of 2008 q2. Thus the fluctuations in Figure 3 stand for the trades of PFs instead of the changes of stock prices. Both Panel A and B in Figure 3 show that PFs reduced their equity holdings gradually before, during and even long time after the crisis, from 2007q2 to 2010q4. It seems that PFs neither reduced their equity holdings at the peak of the crisis nor

11

increased their holdings to capture the reversal. Instead, they strategically reduced their equity holdings gradually over time. It might because PFs have less urgent liquidity needs than HFs and mutual funds do, and they seldom time the market.

[Insert Figure 3 about here]

3.2 Hedge funds' holdings of liquid stocks vs. illiquid stocks

In this section, we study HFs' equity holdings of liquid stocks vs. illiquid stocks around the 2008 financial crisis, where we find that HFs sold more liquid than illiquid stocks at the peak of the crisis, and they repurchased a large amount of liquid stocks during the upturn but continued to sell illiquid stocks.

Following Amihud (2002), we use ILLIQ to measure stock liquidity. An individual stock's ILLIQ value is calculated as the ratio of the absolute value of daily returns to daily dollar trading volume, which measures the average price impact of trades. Though currently there is no sole measure of liquidity capturing all aspects of stock illiquidity, Korajczyk and Sadka (2008) show that ILLIQ is highly correlated with most mainstream liquidity measures, such as bid-ask spread, Kyle's lambda, etc., both in cross section and in time series. For each individual stock, we calculate its average ILLIQ value using the daily return data from 2008 January 1 to 2008 June 30. Then we sort all 3636 stocks within our sample into deciles based on their average ILLIQ values. It gives us approximately 364 stocks in each ILLIQ decile[6]. ILLIQ decile 1 is for the most liquid stocks and ILLIQ decile 10 for the most illiquid stocks.

Table 5 reports the summary of the stock characteristics for all ILLIQ deciles. The first row shows that HFs' total equity holdings differs a lot across ILLIQ deciles, from \$149 billion to \$0.2 billion. Consistent with our sorting criteria, the mean of "ILLIQ" increases across ILLIQ deciles, "Bid-Ask Spread" increases across ILLIQ deciles, and "Share Turnover" decreases across ILLIQ deciles. "Market Cap" also decreases from ILLIQ decile 1 to decile 10 since the size and the stock liquidity are highly correlated in cross section.

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[6]We also do the same analysis with time-varying ILLIQ deciles constructed every quarter. More than 50% of stocks stay at the same ILLIQ deciles within our sample period, and the results of our analysis are similar.

[Insert Table 5 about here]

To show how HFs trade liquid stocks and illiquid stocks differently around the crisis, Figure 4 plots the cumulative percentage changes of HFs' fixed-price equity holdings for each ILLIQ decile, using the holdings at the end of 2008 Q2 as a benchmark. It ranges from 2007 Q1 to 2010 Q4. We can see from Figure 4 that HFs sold both liquid and illiquid stocks substantially in 2008 Q3 & Q4. This result is consistent with the forced deleveraging documented in Ben-David, Franzoni and Moussawi (2012). Surprisingly, in 2009 and 2010 Q1, they bought large amount of extremely liquid stocks, stocks in ILLIQ decile 1, but continued to sell relatively illiquid stocks, stocks in ILLIQ decile 6 to 10. The large purchases of liquid stocks and the continuous selling of illiquid stocks strongly support our dynamic liquidity management hypothesis that HFs built liquidity cushion for future liquidity shocks. The continuous selling of illiquid stocks indicates that HFs not only purchased more liquid stocks, they also shifted some of their holdings from illiquid stocks to liquid stocks. In 2009 and 2010 Q1, HFs' total fixed-price equity holdings of the stocks in ILLIQ decile 1 increased 46.59 billion dollars (31.3% of HFs' equity holdings at the end of 2008 Q2). We have shown in previous subsection (Figure 2) that the reversal of HFs' total fixed-price equity holding (for both liquid and illiquid stocks) is 54.65 billion dollars. It means 85.3% (46.59/54.65) of such reversal can be attributed to the purchases of extremely liquid stocks, stocks in ILLIQ decile 1. They continued to sell both liquid and illiquid stocks only since 2010 Q2.

[Insert Figure 4 about here]

[Insert Table 8 about here]

To have a direct comparison between the changes of equity holdings across ILLIQ deciles, we document the percentage changes of HFs' fixed-price equity holdings for each ILLIQ decile in two periods, 2008 Q3 & Q4 and 2009 Q1 to 2010 Q1, separately. Table 8 reports that HFs reduced a larger proportion of their holdings of liquid stocks (around 30% for ILLIQ decile 1 to 6) than that of illiquid stocks (around 15% for ILLIQ decile 7 to 10) in 2008 Q3 & Q4, which is in accordance with our previous finding. And in 2009 and 2010

Q1, they purchased liquid stocks (positive numbers in the second row for ILLIQ decile 1 to 5), but continued to sell illiquid stocks (negative numbers in the second row for ILLIQ decile 6 to 10). Moreover, the reversal of HFs' fixed-price equity holdings of extremely liquid stocks (ILLIQ decile 1) is substantial, 41.1% of their holdings at the end of 2008, and 131.3% the drop of their holdings in 2008 Q3 & Q4. HFs held even more liquid stocks than just before the crisis. To make these findings more visualized, Figure 5 plots the changes of HFs' fixed-price equity holdings across ILLIQ Deciles for drop and reversal separately. Consistently, Panel A of Figure 5 presents a rough increasing trend; and Panel B of Figure 5 presents a rough decreasing trend.

[Insert Figure 5 about here]

Since we assigned equal number of stocks in each decile, the ILLIQ decile 1 accounts for about two-thirds of their total equity holdings in dollar amounts, and the other 9 ILLIQ deciles all together account for the rest one-third only. Such imbalance makes current ILLIQ deciles inappropriate for the analysis of HF's portfolio composition of liquid holdings versus illiquid holdings over time. Therefore, we construct ILLIQ dollar-quintiles where HFs' equity holdings are the same at the end of 2008 Q2 for each quintile. Table 7 summarizes the stock characteristics for ILLIQ dollar-quintiles. The first row of Table 7 reports the number of stocks in each ILLIQ dollar-quintile, it varies largely from 70 stocks for ILLIQ dollar-quintile 1 to 2351 stocks for ILLIQ dollar-quintile 5. HFs holdings actually concentrate in a small number of liquid stocks. The second row reports similar HFs' total dollar equity holdings at the end of 2008 Q2 for each ILLIQ dollar-quintile, approximately $50 billion, and the third row report that the average value of ILLIQ increases monotonically from 0.000226 for ILLIQ dollar-quintile 1 to 0.385 for ILLIQ dollar-quintile 5, which are both consistent with our sorting criteria. And the Market Cap decreases monotonically from ILLIQ dollar-quintile to ILLIQ dollar-quintile 5.

[Insert Table 7 about here]

Figure 6 plots HFs' fixed-price equity holdings for each ILLIQ dollar-quintile as a percentage of HFs' total fixed-price equity holdings. It shows a clear delayed "flight to liquid-

14

ity": the percentage of HFs' fixed-price equity holdings in relatively liquid stocks, ILLIQ dollar-quintile 1 & 2, decreased slightly in 2008 Q3 (from 40% to 38%) and increased substantially in the period from 2008 Q4 to 2010 Q1 (to 47%), and it decreased gradually since 2010 Q2. This result further confirms the dynamic liquidity management hypothesis.

[Insert Figure 6 about here]

3.3 Pension funds' holdings of liquid stocks vs. illiquid stocks

In this section, we do the analysis for PFs' holdings of liquid stocks versus illiquid stocks using the same methodology as for HFs. We find only slight changes of PFs' equity holdings when compared with those of HFs. First, we study PFs' fixed-price equity holdings across ILLIQ deciles. Table 8 shows that PFs reduced their holdings of both liquid stocks and illiquid stocks in both periods. At the peak of the crisis (08 Q3 & Q4), PFs' fixed-price equity holdings decreased for 8 out of 10 deciles, and the magnitudes of the only two increases are quite small. During the market upturn (2009 and 2010 Q1), PFs' fixed-price equity holdings decreased for 10 out of 10 deciles. Besides, the changes of PF's fixed-price equity holdings did not show a clear increasing or decreasing trend across ILLIQ deciles. It indicates that PFs did not trade liquid stocks and illiquid stocks differently. In general, there is no evidence that PFs managed the liquidity of their equity portfolios actively around the 2008 financial crisis.

[Insert Table 8 about here]

[Insert Figure 7 about here]

To have a closer look at PFs' average portfolio composition of liquid stocks versus illiquid stocks, we also sort stocks into ILLIQ dollar-quintiles, where PFs' equity holdings for all ILLIQ dollar-quintiles are the same at the end of 2008 Q2. PFs' total equity holdings is roughly 83 billion $ at the end of 2008 Q2 for each ILLIQ dollar-quintile. Figure 7 plots PFs' fixed-price equity holdings for each ILLIQ dollar-quintile as a percentage of PFs' total fixed-price equity holdings. We find that PFs' aggregate portfolio composition of liquid and

illiquid stocks is almost constant from 2007 to 2010, which is fundamentally different from the aggregate portfolio composition of HFs as expected.

3.4 Regression Analysis

Besides trading more liquid stocks, HFs may tend to trade more volatile stocks and apply momentum strategies and value strategies as well around the crisis period. We did not control for those effects in previous section. In this section, we do a stock-level cross-sectional regression to analyze HFs' trading of liquid stocks versus illiquid stocks during and after the crisis formally, where we control for other effects. Specifically, we regress the changes of HF ownership on variables of stock characteristics and previous HF ownership. We do the analysis for the drop (2008 Q3 & Q4) and the reversal (2009 and 2010 Q1) periods separately. The change of HF ownership is computed as the changes of number of shares held by HFs in that period scaled by the total number of shares outstanding. For stock characteristics, we calculate stocks' ILLIQ values, "ILLIQ", standard deviations of daily returns, "SD" and the past 6-month returns, "past 6-month return", using the half year data just before the period of our analysis. Market capitalization, "size", book-to-market ratios, "book-to-market ratio", and previous HF ownerships, "Previous HF holdings(%)" are based on the data just before the analysis period. We take the natural logarithmic values of ILLIQ, size and book-to-market ratio, and we normalize the mean values of all the stock characteristics to 0 and standard deviations to 1. As the changes of holdings, the "Previous HF holdings(%)" is measured as a percentage of shares outstanding for each stock.

[Insert Table 9 about here]

As shown in Table 9 Column (1), the coefficient of "ln(ILLIQ)" is 0.174 and significant at 1% significance level when other variables are included as controls. HFs actually sold more liquid than illiquid stock at the peak of the crisis (in 2008 Q3 and Q4). The drops of HF ownerships (holdings as a percentage of the total shares outstanding) are 0.174% larger on average for stocks with a liquidity level 1 standard deviation higher. Considering the

average HF ownership is only 2.7% at the end of 2008 Q2. This difference is economically significant. In addition, Column (3) reports an even larger difference between the holding changes of liquid stocks and illiquid stock in 2009 and 2010 Q1. HF increased 0.446% more on average for stocks with a liquidity level 1 standard deviation higher. In Column (2) and (4), we also include the market capitalization, "ln(size)" into the regression. It shows that coefficients of "ln(ILLIQ)" remain significant, and their signs do not change.

Similar to our findings on HF sales in 2008 Q3 & Q4, Ben-David, Franzoni and Moussawi (2012) also find that HFs sold more liquid stocks than illiquid stocks in the same period. Jotikasthira, Lundblad, and Ramadorai (2009) document that during fire sales, mutual funds and HFs tend to reduce price impact, and Manconi, Massa, and Yasuda (2010) show that in the 2007 crisis, mutual funds sold liquid bonds first. Complementing their results, we document HFs created a liquidity cushion just after their large selloffs.

Besides, some theoretical papers, such as Vayanos (2004) and Brunnermeier and Pedersen (2009), indicate that volatile stocks should be sold first since they require high margins and may increase overall portfolio volatility. Consistently, Ben-David, Franzoni and Moussawi (2012) find that HFs sold more volatile stocks than stable ones during the crisis. Different from Ben-David, Franzoni and Moussawi (2012), we find only weak evidence that HFs sold more volatile stocks than stable stocks at the peak of the crisis (2008 Q3 & Q4). The coefficient of "SD", standard deviation of returns, is only significantly negative when "ln(size)" is added. Since small stocks are in general more volatile, there might be some multi-collinearity problem. No significant evidence were found even when we use the same measure of stock volatility (past 24-month volatility of monthly returns) as they do. However, we find that in 2009 and 2010 Q1, HF holdings as a percentage of the total shares outstanding increased 0.166% more on average for stocks with "ln(SD)" (standard deviations of returns in 2008 Q3 & Q4) 1 standard deviation higher. It might because given the large losses during the crisis, some HFs increased their risk exposures by holding stocks which were more volatile during the crisis. They bet the stocks which were most volatile during the crisis should reverse more during market upturn. Besides, there is also evidence that HFs purchased more value stocks than growth stocks during the market reversal.

17

Column (2) and (4) include the size indicator into the explanatory variables. Stock market capitalization "ln(size)" measures both the liquidity and risk of stock, and it is highly negatively correlated with the liquidity measure "ln(ILLIQ)" across individual stocks. The correlation between "ln(size)" and "ln(ILLIQ)" is as large as -0.88. Thus our regressions in Column (2) and (4) have multi-collinearity problems for the coefficients of "ln(ILLIQ)" and "ln(size)". Consistently, the adjusted R squares are almost the same for the regressions with and without size variable "ln(size)". However, including size variable into the regression makes the coefficients of liquidity variable "ln(ILLIQ)" even larger for both HF sales in 2008 Q3 and Q4 and HF purchases in 2009 and 2010 Q1. The evidence of HFs' liquidity management survives both during and after the crisis.

To sum up, the result of regression analysis (where other stock characteristics are controlled) provides even stronger supports to both the myopic and dynamic liquidity management.

4 Conclusions

Since Constantinides published the groundbreaking paper of dynamic portfolio choice with trading costs in 1986, the theoretical literature in this thread has developed rapidly, (e.g. Liu 2004, Lo, Mamaysky and Wang 2004, Jang, Koo, Liu and Loewenstein 2007, Lynch and Tan 2011, Gârleanu and Pederson 2013 etc..) After the financial crises in 1998 and 2008, a lot more scholars started to notice the important role of liquidity management in portfolio choice. However, the size of empirical literature in this thread is nowhere nearly comparable to the size of theoretical literature, and there is no empirical evidence on the trade-off between myopic and dynamic liquidity management yet. This paper studies the liquidity management of hedge funds before, during and after the 2008 financial crisis. The liquidity management of pension funds is also analyzed for comparison.

Specifically, we sort stocks into deciles based on the their liquidity levels and find that hedge funds sold more liquid stocks than illiquid stocks at the peak of the crisis. Moreover, they repurchased a large amount of liquid stocks since the market started to recover in 2009, and they continued to sell illiquid stocks in the same period. Consistently, the proportion

of relatively liquid (versus illiquid) stocks in hedge funds' portfolio decreased slightly at the peak of the crisis, from 40% to 38%, and increased substantially to 48% in 2009 and 2010 Q1. It shows a delayed "flight to liquidity". Overall, these empirical results of hedge funds are consistent with existing theories about the trade-off between myopic and dynamic liquidity management (e.g. Scholes 2000, Duffie and Ziegler 2003 and Brown, Carlin, and Lobo 2010). As the pressure of forced selling mitigates, the balance of trade-off shifts from selling more liquid stocks (to reduce trading costs) to selling less liquid stocks (to build "liquidity cushion" for future crisis).

Those findings are confirmed by our stock-level regression analysis, where other stock characteristics, such as stock size, book-to-market ratio, past returns, return volatility etc., are controlled for. In addition, different from hedge funds, pension funds held a constant proportion of liquid stocks versus illiquid stocks from 2007 to 2010. They sold both liquid and illiquid stocks gradually since 2007.

The analysis of hedge funds' liquidity management in this paper is largely limited by the availability of hedge funds' holding data. Thomson Reuters (13F) database provides only hedge funds' stock holding data. It is on the level of hedge fund managing firms, and quarterly based. It would be interesting to include hedge funds' holdings of other types of assets, such as bonds and cash equivalents, into the analysis, to see whether they shifted from relatively illiquid types of assets to liquid ones during the crisis period, and it is also interesting to do more studies using fund level data or data with higher frequency.

5 Appendix
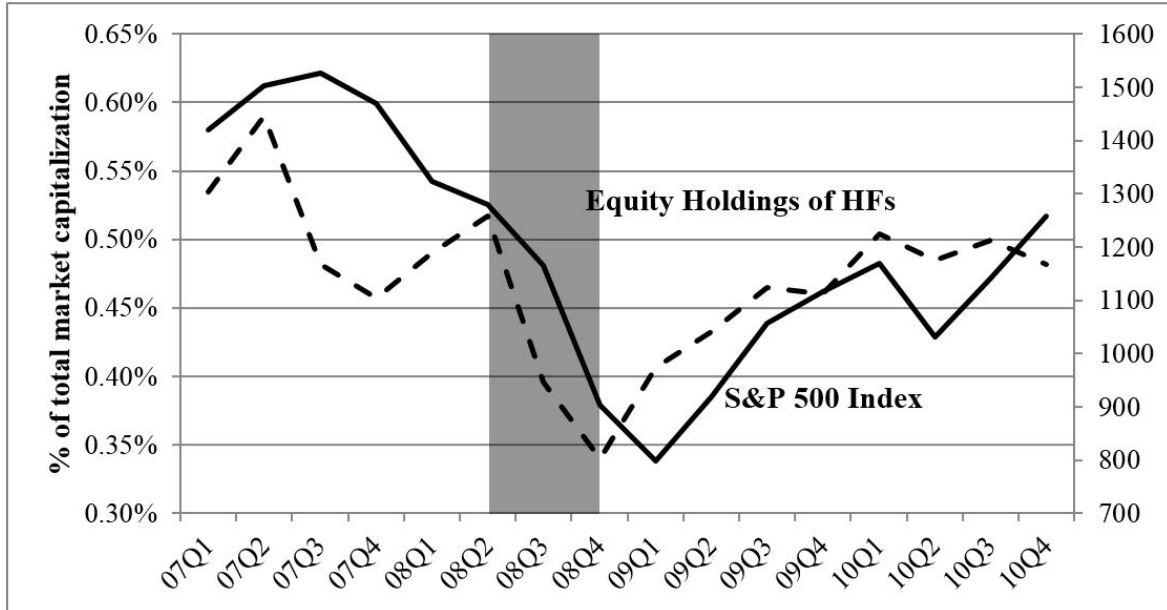
Figure 1: Hedge Funds' Equity Holdings and S&P 500 Index

This figure plots the total equity holdings of hedge funds in our sample (as a percentage of total U.S. stock market capitalization) and the S&P 500 index. The vertical axis on the left side is for equity holdings of hedge funds (dashed line), and the one on the right side is for the S&P 500 index (solid line). The data ranges from 2007 Q1 to 2010 Q4. Only equity holdings of "the largest 100 hedge fund managers in 2010" (from website: "www.institutionalinvestor.com") are included. "Wilshire 5000 Total Market Index" is used as the measure of total market capitalization. The shaded area marks the quarters around Lehman Brothers' bankruptcy (2008 Q3 & Q4).
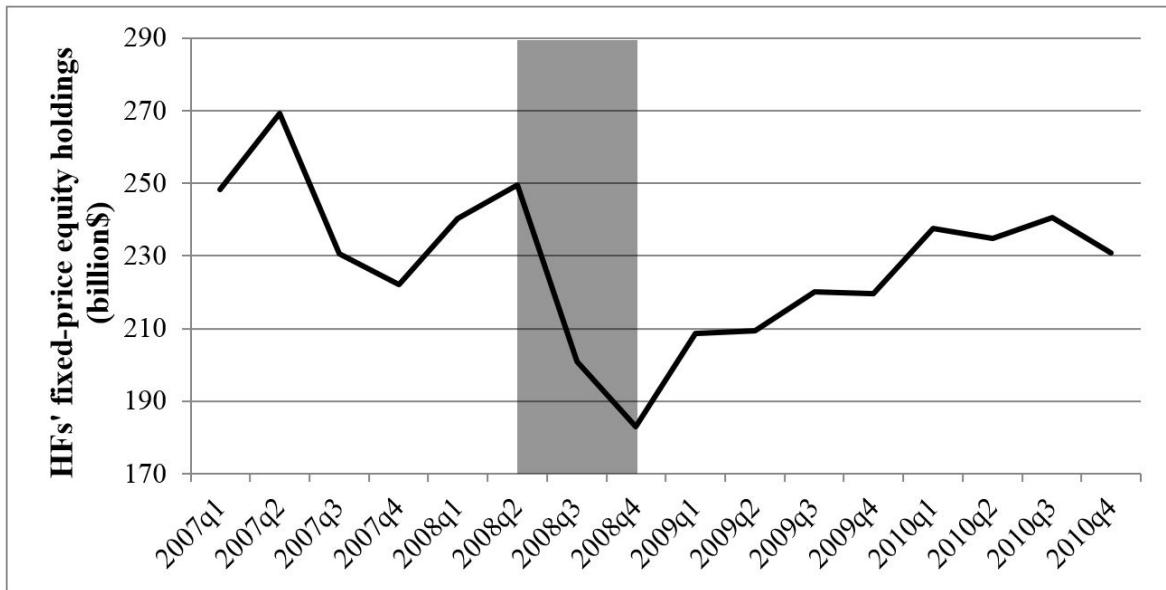
Figure 2: Hedge Funds' Total Fixed-Price Equity Holdings

The figure plots the total fixed-price dollar amount of equities held by hedge funds in our sample. We calculate the fixed-price equity holding as the total number of shares held by hedge funds at the end of each quarter times the price per share at the end of 2008 Q2. Therefore, the time variation of this curve represents the changes of shares held (proxy for trades) but not the changes of stock prices. The data ranges from 2007 Q1 to 2010 Q4. The shaded area marks the quarters around Lehman Brothers' bankruptcy (2008 Q3 & Q4).
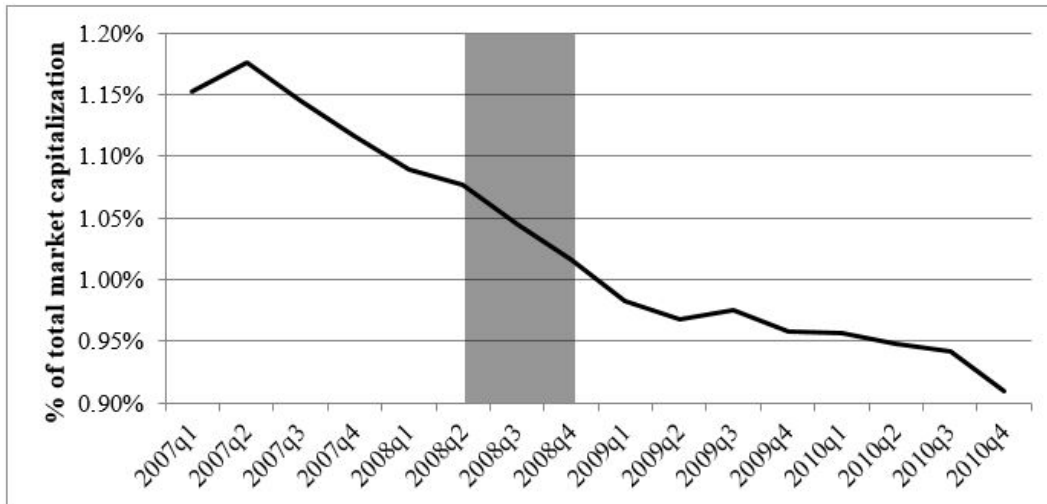
Panel A:

Panel B:

Figure 3: Pension Funds' Aggregate Equity Holdings

This figure plots pension funds' aggregate equity holdings in our sample. Panel A plots it as a percentage of total U.S. stock market capitalization. "Wilshire 5000 Total Market Index" is used as the measure of total market capitalization. Panel B plots pension funds' total fixed-price equity holdings. We calculate the fixed-price equity holding as the total number of shares held by pension funds at the end of each quarter times the price per share at the end of 2008 Q2. Therefore, the time variation of this curve represents the changes of shares held (proxy for trades) but not the changes of stock prices. The data ranges from 2007 Q1 to 2010 Q4. The shaded area denotes the quarters around Lehman Brothers' bankruptcy (2008 Q3 & Q4).
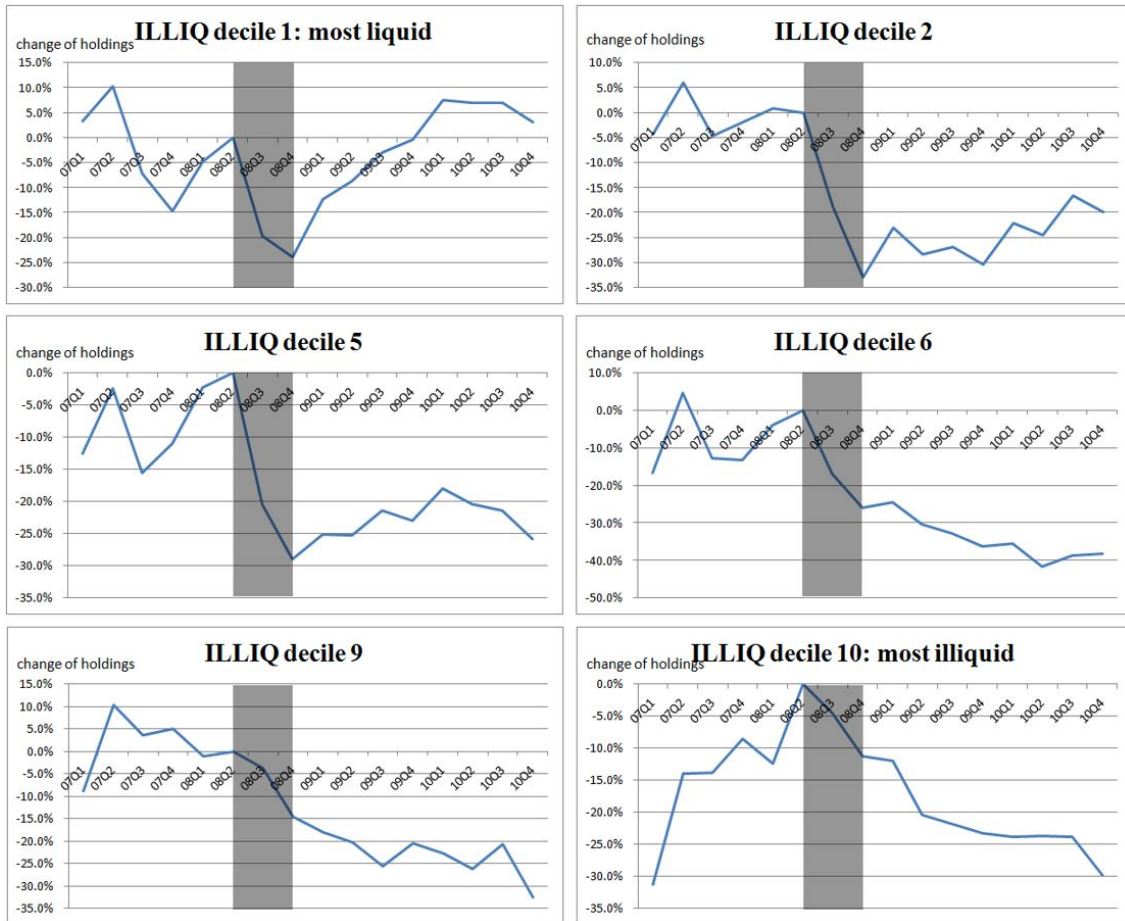
Figure 4: Cumulative Percentage Changes of Hedge Funds' Fixed-Price Equity Holdings for each ILLIQ Decile

The figure plots the cumulative percentage changes of HFs' fixed-price equity holdings for each ILLIQ decile separately, using the holdings at the end of 2008 q2 as a benchmark. We calculate the fixed-price equity holding as the total number of shares held by hedge funds at the end of each quarter times the price per share at the end of 2008 Q2. The data ranges from 2007 Q1 to 2010 Q4. The shaded areas mark the quarters around Lehman Brothers' bankruptcy (2008 Q3 & Q4).
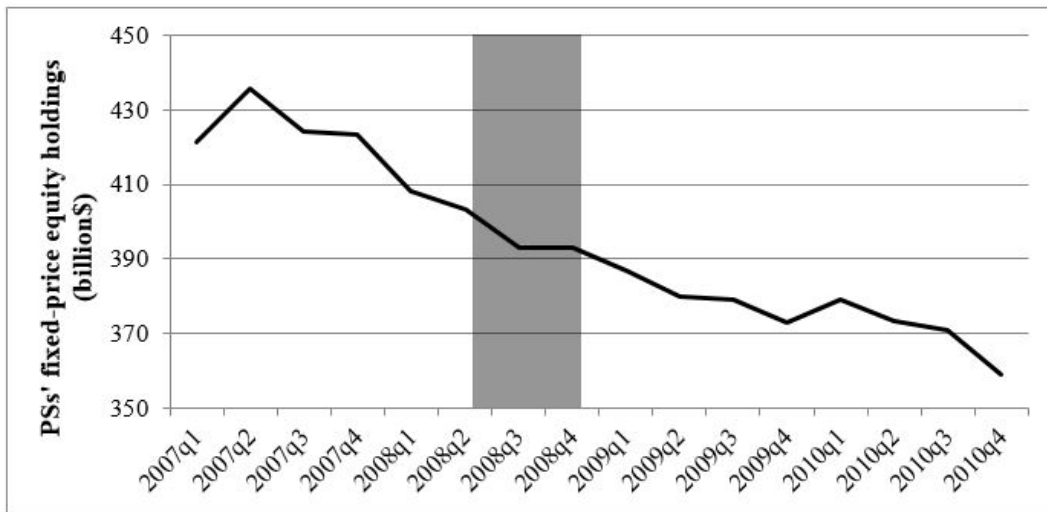
Panel A: Panel B:

Drop of HFs' holdings in 2008 Q3 & Q4, across ILLIQ deciles

Change of HFs' holdings from 2009 Q1 to 2010 Q1, across ILLIQ deciles
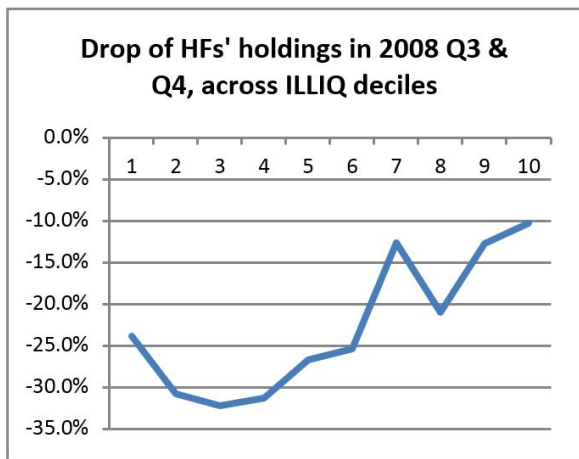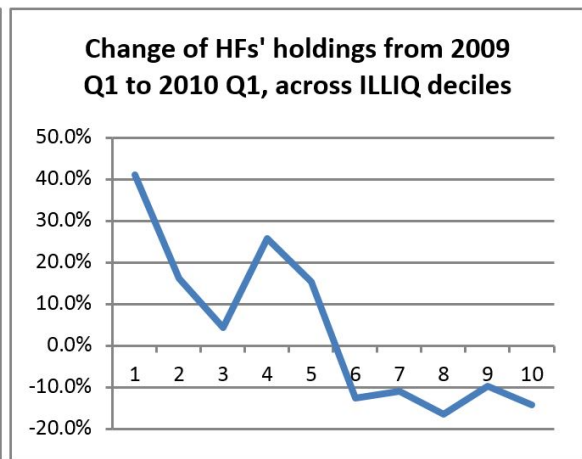
Figure 5: Changes of Hedge Funds' Equity Holdings across ILLIQ Deciles

Panel A plots the percent drops of hedge funds' holdings in 2008 Q3 Q4 across ILLIQ deciles (The first row of Table 8). Panel B plots the percent changes of hedge funds' holdings from 2009 Q1 to 2010 Q1 across ILLIQ deciles (The second row in Table 8).
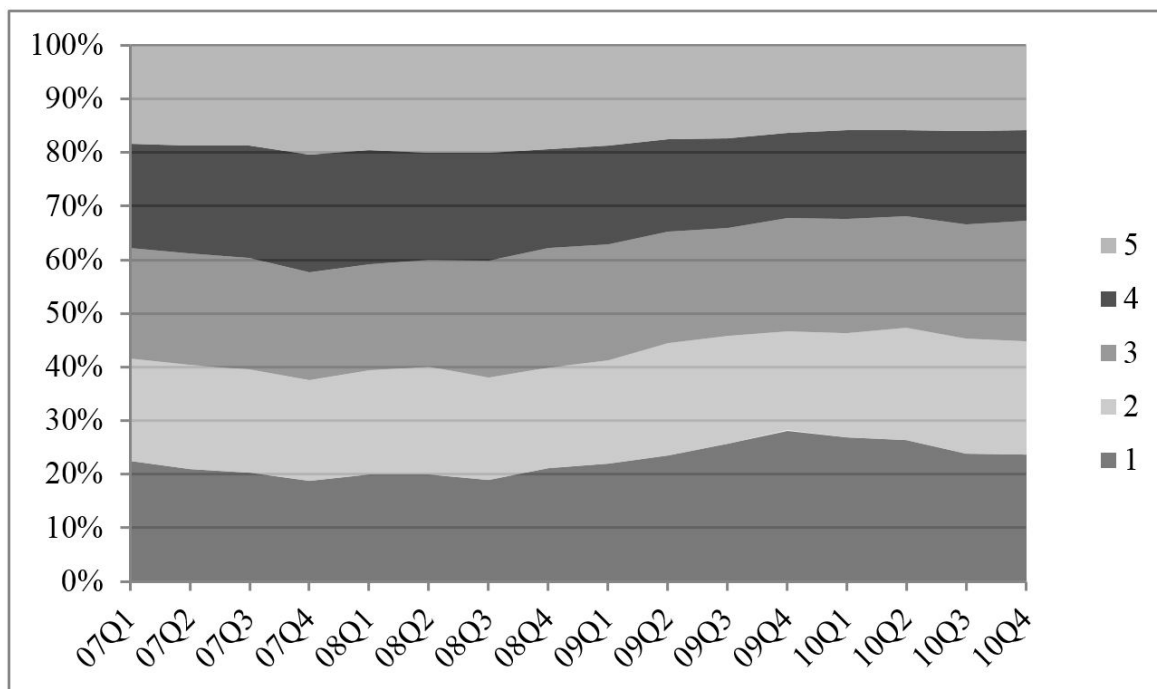
Figure 6: Hedge Funds' Portfolios Composition of Liquid Stocks versus Illiquid Stocks (by ILLIQ dollar-quintiles)

This figure plots hedge funds' fixed-price equity holdings for each ILLIQ dollar-quintile as a percentage of hedge funds' total fixed-price equity holdings. We sort stocks into 5 ILLIQ dollar-quintiles based on their values of ILLIQ, where hedge funds' equity holdings in each ILLIQ dollar-quintile is the same at the end of 2008 Q2. We calculate the fixed-price equity holding as the total number of shares held by hedge funds at the end of each quarter times the price per share at the end of 2008 Q2. Therefore it represents the changes of shares (trades) but not the changes of prices. The data ranges from 2007 Q1 to 2011 Q4.
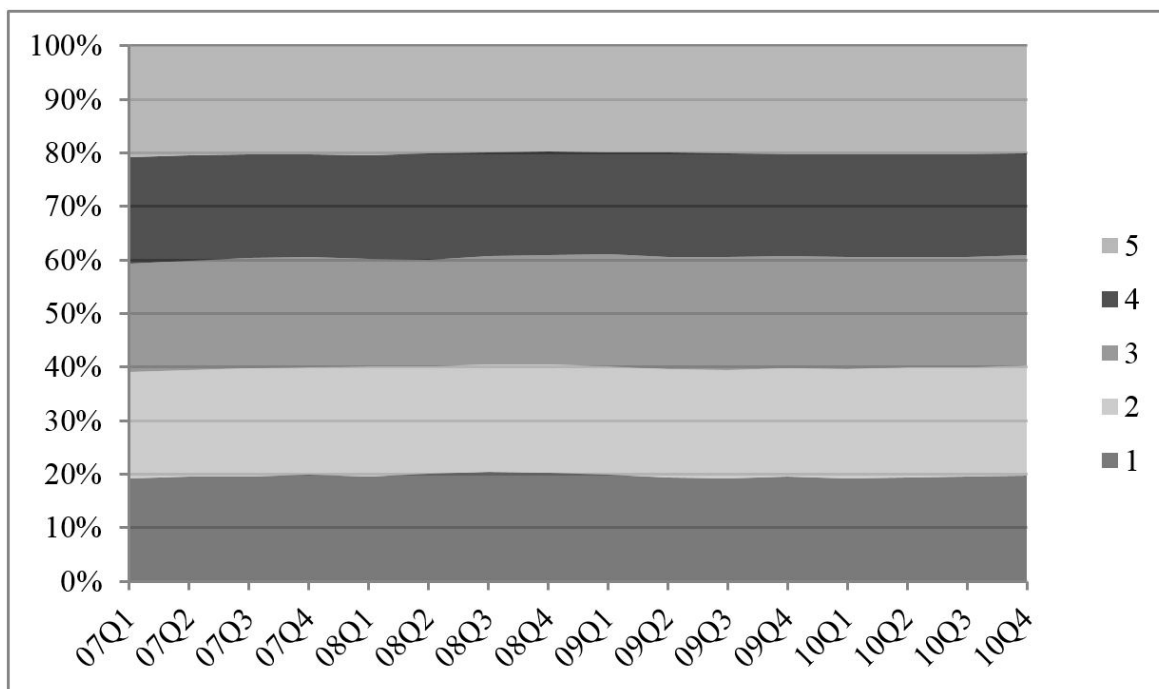
Figure 7: Pension Funds' Portfolios Composition of Liquid Stocks versus Illiquid Stocks (by ILLIQ dollar-quintiles)

This figure plots pension funds' fixed-price equity holdings for each ILLIQ dollar-quintile as a percentage of pension funds' total fixed-price equity holdings. We sort stocks into 5 ILLIQ dollar-quintiles based on their values of ILLIQ, where pension funds' equity holdings in each ILLIQ dollar-quintile is the same at the end of 2008 Q2. We calculate the fixed-price equity holding as the total number of shares held by pension funds at the end of each quarter times the price per share at the end of 2008 Q2. Therefore it represents the changes of shares (trades) but not the changes of prices. The data ranges from 2007Q1 to 2010Q4.

26

Table 1: Summary of Hedge Funds' Equity Holdings

This table sample comprises 60 hedge fund (HF) managing firms for which we have holding data in Thomson Reuters Institutional Holdings (13F) Database. The period is from 2007 Q1 to 2010 Q4. The "Number of stocks held" in the third column refers to the total number of stocks held by those HF managing firms in each quarter, out of 3636 stocks within the scope of our analysis. The "Fraction of total MC (%)" is the total dollar amount of the shares held by those HF managing firms as a fraction of the entire equity market measured by "Wilshire 5000 Total Market Index". "$ amount (bill$)" is the total dollar amount of equities held by those HF managing firms.

Total equity holdings of hedge funds (HFs)				
Year	Quarter	Number of stocks held	Fraction of total MC (%)	$ amount (bill$)
2007	1	2727	0.53%	278
	2	2850	0.59%	325
	3	2909	0.48%	269
	4	3010	0.46%	247
2008	1	3015	0.49%	240
	2	3032	0.52%	250
	3	3004	0.40%	174
	4	2956	0.34%	115
2009	1	2966	0.41%	124
	2	2921	0.43%	154
	3	2933	0.46%	193
	4	2932	0.46%	202
2010	1	2898	0.50%	235
	2	2932	0.49%	201
	3	2906	0.50%	232
	4	2829	0.48%	250

Table 2: Summary of Pension Funds' Equity Holdings

This table sample comprises 56 pension funds for which we have holding data in Thomson-Reuters Institutional Holdings (13F) Database. The period is from 2007 Q1 to 2010 Q4. "Number of stocks held" in the third column refers to the total number of stocks held by pension funds in each quarter, out of 3636 stocks within the scope of our analysis. "Fraction of total MC (%)" is the total dollar amount of shares held by pension funds as a fraction of the entire equity market measured by "Wilshire 5000 Total Market Index". "$ amount (bill$)" is the total dollar amount of equities held by pension funds.

Total equity holdings of pension funds (PFs)				
Year	Quarter	Number of stocks held	Fraction of total MC (%)	$ amount (bill$)
2007	1	3027	1.15%	599
	2	3093	1.18%	648
	3	3130	1.15%	640
	4	3235	1.12%	605
2008	1	3320	1.09%	533
	2	3374	1.08%	519
	3	3301	1.05%	460
	4	3195	1.02%	345
2009	1	3398	0.98%	300
	2	3363	0.97%	345
	3	3325	0.98%	404
	4	3308	0.96%	421
2010	1	3303	0.96%	446
	2	3277	0.95%	394
	3	3282	0.94%	437
	4	3197	0.91%	471

Table 3: Description of Stock Characteristics

Characteristics	Description
Hedge Fund (HF) Ownership	Percentage of shares outstanding held by hedge funds. Period: 2008 June 30; Source: 13F filling data
Pension Fund (PF) Ownership	Percentage of shares outstanding held by pension funds. Period: 2008 June 30; Source: 13F filling data
Market Cap	Company's shares outstanding multiplies current market price (in millions of dollars). Period: 2008 June 30; Source: CRSP
Book-to-Market	Book value of common equity divided by the market value of equity. Period: Quarterly report from 2008 April to June; Source: Compustat, merged by Ticker.
Share Turnover	Average value of daily volume of shares transacted divided by the number of shares outstanding. Period: Average from 2008 January 1 to 2008 June 30; Source: CRSP
Bid-Ask Spread	Average difference between bid and ask quotes divided by the daily price. Period: Average from 2008 January 1 to 2008 June 30; Source: CRSP
Market Beta	CAPM beta. Period: From 2001 January 1 to 2011 June 30; Source: CRSP
Past Returns	Annualized average daily stock returns. Period: From 2008 January 1 to 2008 June 30; Source: CRSP
Return Variability	Standard deviation of daily stock returns. Period: From 2008 January 1 to 2008 June 30; Source: CRSP
ILLIQ	ILLIQ is calculated as the average ratio of the absolute value of daily returns to daily dollar trading volume (Amihud 2002). Period: From 2008 January 1 to 2008 June 30; Source: CRSP

Table 4: Summary of Stock Characteristics

This table presents descriptive statistics of the stock returns and characteristics for all stocks in our sample, stocks held by hedge funds, and stocks held by pension funds separately. We obtain ownership data from Thomson Reuters, stock information from CRSP and accounting information from COMPUSTAT. The Ownerships and the stock Market Cap are based on the data at the end of 2008 Q2. The descriptions of other stock characteristics are in Table 3. All mean values of stocks characteristics are calculated as equally weighted.

Stock Characteristics	Entire Sample			Held by Hedge Funds			Held by Pension Funds		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
Hedge Funds Ownership	3636	2.7%	4.4%	3032	3.3%	4.7%	-	-	-
Pension Funds Ownership	3636	1.7%	2.5%	-	-	-	3374	1.9%	2.5%
Market Cap	3636	3661	16292	-	4252	17556	3374	3834	16689
Book-to-Market	3371	0.69	0.75	2857	0.66	0.78	3166	0.68	0.76
Share Turnover	3636	0.9%	1.0%	3032	1.1%	1.0%	3374	1.0%	1.0%
Bid-Ask Spread	3636	1.1%	2.0%	3032	0.6%	1.1%	3374	0.9%	1.7%
Market Beta	3636	1.15	0.68	3032	1.23	0.66	3374	1.17	0.66
Past Return	3636	-28.7%	109.4%	3032	-31.3%	109.9%	3374	-29.2%	107.8%
Return Variability	3636	3.5%	1.6%	3032	3.4%	1.4%	3374	3.4%	1.4%
ILLIQ	3636	0.31	1.22	3032	0.2	0.72	3374	0.24	0.75

Table 5: Summary of Stock Characteristics for ILLIQ Deciles

This table presents descriptive statistics of stock and firm characteristics by ILLIQ deciles, ILLIQ decile 1 for most liquid stocks and ILLIQ decile 10 for most illiquid ones. We sort all stocks in our sample (3636 stocks) into ILLIQ deciles based on their average ILLIQ values in the first half of 2008. ILLIQ value, the liquidity measure of individual stocks proposed in Amihud (2002), is calculated as the ratio of the absolute value of daily return to daily dollar trading volume. We obtain ownership data from Thomson Reuters, stock information from CRSP and accounting information from COMPUSTAT. "HFs' total holding (bill$)" reports hedge funds' total equity holdings at the end of 2008 Q2. The descriptions of stock and firm characteristics are in Table 3.

Stock Characteristics	N	ILLIQ Decile 1 Mean	SD	ILLIQ Decile 2 Mean	SD	ILLIQ Decile 3 Mean	SD	ILLIQ Decile 4 Mean	SD	ILLIQ Decile 5 Mean	SD
HFs' total holding (bill$)	364	149	-	53.6	-	25.5	-	9.1	-	5.4	-
HFs Ownership	364	2.3%	4.5%	4.5%	6.3%	4.0%	5.8%	3.2%	4.6%	3.2%	4.8%
Market Cap	364	27306	42215	3485	1789	1534	795	764	325	425	183
Book-to-Market	338	0.42	0.32	0.5	0.33	0.52	0.42	0.63	0.54	0.61	0.49
Share Turnover	364	1.1%	0.7%	1.4%	0.9%	1.5%	1.1%	1.4%	1.1%	1.1%	1.0%
Bid-Ask Spread	364	0.1%	0.1%	0.2%	0.1%	0.2%	0.2%	0.2%	0.4%	0.4%	0.5%
Market Beta	364	0.95	0.51	1.09	0.6	1.19	0.58	1.27	0.7	1.24	0.65
Past Return	364	-20.5%	64.5%	-8.8%	77.5%	-10.5%	90.9%	-29.7%	100.0%	-29.7%	100.4%
Return Variability	364	2.2%	0.8%	2.5%	0.8%	2.9%	0.9%	3.2%	1.0%	3.2%	0.9%
ILLIQ	364	0.001	0.001	0.006	0.002	0.015	0.003	0.03	0.006	0.055	0.009

Stock Characteristics	N	ILLIQ Decile 6 Mean	SD	ILLIQ Decile 7 Mean	SD	ILLIQ Decile 8 Mean	SD	ILLIQ Decile 9 Mean	SD	ILLIQ Decile 10 Mean	SD
HFs' total holding (bill$)	364	3.5	-	2	-	1.1	-	0.4	-	0.2	-
HFs Ownership	364	2.9%	5.2%	2.7%	5.1%	2.3%	4.3%	1.8%	4.6%	1.4%	2.6%
Market Cap	364	267	136	170	81	101	46	57	29	24	21
Book-to-Market	338	0.76	0.63	0.83	1.23	0.82	0.94	0.94	1	1.03	1.07
Share Turnover	364	0.9%	0.9%	0.7%	0.7%	0.5%	0.8%	0.3%	0.4%	0.4%	1.5%
Bid-Ask Spread	364	0.6%	0.8%	0.9%	1.0%	1.7%	1.6%	2.7%	2.2%	5.2%	3.8%
Market Beta	364	1.24	0.75	1.17	0.73	1.09	0.8	1.09	0.86	1.04	0.79
Past Return	364	-45.3%	121.0%	-47.2%	118.7%	-49.7%	114.4%	-56.9%	159.7%	-16.8%	171.3%
Return Variability	364	3.5%	1.3%	3.7%	1.5%	4.0%	1.4%	4.5%	1.8%	5.9%	2.4%
ILLIQ	364	0.091	0.013	0.15	0.022	0.258	0.047	0.513	0.118	2.756	3.836

Table 6: Change of Hedge Funds' Fixed-Price Equity Holdings across ILLIQ Deciles

This table presents the percent changes of hedge funds' fixed-price equity holdings for each ILLIQ decile in two periods, 2008 Q3 & Q4 and 2009 Q1 to 2010 Q1, separately. "Change of holding in 08 Q3 & Q4" is reported as a fraction of the hedge funds' equity holdings at the end of 2008 Q2, which is calculated as (holding in 2008 Q4 - holding in 2008 Q2)/(holding in 2008 Q2). "Change of holding from 09 Q1 to 10 Q1" is reported as a fraction of the hedge funds' equity holdings at the end of 2008 Q4, which is calculated as (holding in 2010 Q1 - holding in 2008 Q4)/(holding in 2008 Q4). The last row of reports the "Reversal as a percentage of the Drop", the dollar change of holding from 2009 Q1 to 2010 Q1 as a percentage of the dollar change of holding in 2008 Q3 & Q4, which is calculated as (holding in 2010 Q1 - holding in 2008 Q4)/(holding in 2008 Q2 - holding in 2008 Q4).

ILLIQ Decile	1 liquid	2	3	4	5	6	7	8	9	10 illiquid
Change of holding in 08 Q3 & Q4	**-23.8%**	**-33.0%**	**-29.5%**	**-32.6%**	**-29.0%**	**-26.1%**	-14.7%	-18.9%	-14.5%	-11.2%
Change of holding from 09 Q1 to 10 Q1	**41.1%**	**16.2%**	**4.3%**	**25.8%**	**15.4%**	-12.6%	-11.0%	-16.6%	-9.7%	-14.2%
Reversal as a percentage of drop	**131.3%**	32.9%	10.3%	53.3%	37.7%	-35.7%	-64.2%	-71.2%	-57.3%	-112.8%

32

Table 7: Summary of Stock Characteristics for ILLIQ Dollar-Quintiles

This table presents descriptive statistics of stock and firm characteristics by ILLIQ dollar-quintiles. We sort all stocks in our sample (3636 stocks) into ILLIQ dollar-quintiles, making hedge funds' equity holdings in each ILLIQ dollar-quintile the same at the end of 2008 Q2. ILLIQ dollar-quintile 1 is for most liquid stocks and ILLIQ dollar-quintile 5 for most illiquid ones. We obtain ownership data from Thomson Reuters, stock information from CRSP and accounting information from COMPUSTAT. "HFs' total holding (bill$)" reports hedge funds' total equity holdings at the end of 2008 q2. The descriptions of stock and firm characteristics are in Table 3.

Stock Characteristics	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
# of Stocks	70	-	105	-	186	-	320	-	2351	-
HFs' total holding (bill$)	49.7	-	49.67	-	49.85	-	49.92	-	50.31	-
ILLIQ	0.0002	0.0001	0.0007	0.0002	0.0020	0.0006	0.0051	0.0015	0.3850	1.3440
Hedge Funds Ownership%	1.0%	0.9%	2.0%	2.0%	3.1%	5.7%	3.9%	5.0%	3.3%	4.7%
Market Cap	86312	72736	24051	9661	9334	4762	3959	1841	482	654
Book-to-Market	0.39	0.28	0.43	0.24	0.43	0.35	0.48	0.34	0.75	0.81
Share Turnover	0.9%	0.7%	1.0%	0.6%	1.2%	0.8%	1.4%	0.8%	0.9%	1.1%
Bid-Ask Spread	0.1%	0.2%	0.1%	0.0%	0.1%	0.0%	0.1%	0.1%	1.3%	2.2%
Market Beta	0.87	0.47	0.87	0.44	1.02	0.54	1.13	0.58	1.18	0.7
Past Return	-30.3%	50.5%	-9.6%	61.6%	-23.2%	64.7%	-8.4%	77.2%	-32.0%	116.7%
Return Variability	1.9%	0.6%	2.1%	0.7%	2.3%	0.7%	2.5%	0.7%	3.7%	1.6%

Table 8: Change of Pension Funds' Fixed-Price Equity Holdings across ILLIQ Deciles

This table presents the percent changes of pension funds' fixed-price equity holdings for each ILLIQ decile in two periods, 2008 Q3 & Q4 and 2009 Q1 to 2010 Q1, separately. "Change of holding in 08 Q3 & Q4" is reported as a fraction of the pension funds' equity holdings at the end of 2008 Q2, which is calculated as (holding in 2008 Q4 - holding in 2008 Q2)/(holding in 2008 Q2). "Change of holding from 09 Q1 to 10 Q1" is reported as a fraction of the pension funds' equity holdings at the end of 2008 Q4, which is calculated as (holding in 2010 Q1 - holding in 2008 Q4)/(holding in 2008 Q4).

ILLIQ Decile	1 liquid	2	3	4	5	6	7	8	9	10 illiquid
Change of holding in 08 Q3 & Q4	-2.8%	0.1%	-1.6%	-5.5%	-4.6%	-4.9%	-2.7%	-6.9%	-2.3%	3.4%
Change of holding from 09 Q1 to 10 Q1	-2.5%	-8.1%	-7.4%	-11.5%	-4.4%	-9.6%	-19.1%	-5.8%	-22.9%	-9.7%

Table 9: Hedge Funds' Trading and Stock Characteristics during the Crisis

The table reports the results of 4 stock-level cross-sectional regressions. For Columns (1) and (2), the dependent variable is the change of hedge fund (HF) ownership in 2008 Q3 & Q4 (the change in HFs' total equity holdings in 2008 Q3 & Q4 as a percentage of shares outstanding). In Columns 3 and 4, the dependent variable is the change of HF ownership in 2009 & 2010 Q1 (the change in HFs' total equity holdings in 2009 & 2010 Q1 as a percentage of shares outstanding). The explanatory variables include a set of stock characteristics and previous HF ownership. We calculate the ln value of stock ILLIQ ratio, "ln(ILLIQ)", the standard deviation of daily return, "SD" and the past 6-month returns, "past 6-month return", using the half year data just before the analysis period. The ln value of market capitalization, "ln(size)", the ln value of book-to-market ratio, "ln(book-to-market ratio)" and previous HF ownerships, "Previous HF holdings(%)" are based on the data just before the analysis period. We normalize the mean values of all the stock characteristics to 0 and standard deviations to 1. t-statistics are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable:	Δ HF ownership in 08Q3&Q4(%)		Δ HF ownership in 09&10Q1(%)	
	(1)	(2)	(3)	(4)
ln(ILLIQ)	**0.174*****	**0.698****	**-0.446*****	**-0.669*****
	(4.27)	(2.32)	(-10.23)	(6.32)
SD	-0.051	-0.128**	0.166***	0.150***
	(-1.24)	(-2.13)	(3.62)	(3.23)
ln(size)		0.496*		-0.249**
		(1.76)		(-2.31)
ln(book-to-market ratio)	-0.026	-0.014	0.134***	0.131***
	(-0.72)	(-0.40)	(3.25)	(3.17)
past 6-month return	0.065*	0.024	0.045	0.061
	(1.88)	(0.58)	(1.07)	(1.43)
Previous HF holdings (%)	-0.239***	-0.239***	-0.269***	-0.272***
	(-31.51)	(-31.57)	(-25.63)	(-25.72)
Constant	-0.047	-0.046	0.622***	0.628***
	(-1.27)	(-1.22)	(14.36)	(14.48)
Observations	3636	3636	3636	3636
Adj R^2	0.2447	0.2452	0.1803	0.1814

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