

Hedge Funds: Portfolio, Investor, and Financing Liquidity

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ABSTRACT

By some estimates, hedge funds held net assets in excess of \$3 trillion at the end of 2016. Despite the economic importance of this industry, very little is known publicly about the illiquidity of a hedge fund's assets (portfolio illiquidity) and the liquidity terms the fund has arranged with its investors (investor illiquidity) and creditors (financing illiquidity). We shed light on hedge fund liquidity using the quarterly filings of recently instituted Form PF over 2013-2015. Regarding this sample our main findings can be summarized as follows: 1) on average, it appears that 34% of a fund's assets can reasonably be liquidated within one day without fire sale discounting, and the average portfolio illiquidity is 71 days; 2) nearly 80% of a typical fund's investors are "locked in" beyond 30 days, and the average investor illiquidity is 173 days; 3) 100% of borrowing and cash financing is committed for only one day for 51% of our sample, and the average financing illiquidity is 53 days; and 4) in 84% of our sample, hedge fund balance sheets display a liquidity cushion, such that portfolio illiquidity is strictly less than the combined investor and financing illiquidity. We also find that average illiquidity varies significantly across funds in our sample, but less so over our time.

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1. Introduction²

Significant market events over the last two decades have highlighted liquidity risk as an important determinant of hedge fund performance. Many hedge funds experienced large losses during periods of financial distress, including the Asian Contagion (1997), Long-Term Capital Management demise (1998), the bursting of the Tech Bubble (2001-2002), and the 2008 Global Financial Crisis. A number of studies have investigated this phenomenon and found that illiquidity was one of the most significant risks during financial crises (Getmansky, Lee, and Lo (2015)). Illiquid investment strategies and the absence of long-term commitments from investors and creditors are potential risk factors for hedge funds that could increase the risk of selling assets at fire-sale prices to meet redemption requests and margin calls. Hedge funds' significant footprint in financial markets and the potential transmission of their funding shocks to underlying security prices makes it important to provide a careful measurement of hedge fund liquidity.³

We recognize that a complete liquidity profile for a hedge fund includes both sides of its balance sheet. First, on the asset side, a hedge fund's portfolio illiquidity captures the illiquidity of its assets and measures how quickly the assets can be liquidated without significant fire sale discounting. Therefore, portfolio illiquidity depends on both the composition of a fund's underlying assets (e.g., stocks versus bonds) and also market conditions. Second, on the liability side, a hedge fund's financing illiquidity captures the terms of a fund's borrowing and measures the period during which a creditor has contractually committed to provide financing to the fund.⁴ Therefore, funds with short financing illiquidity are potentially more susceptible to sudden margin calls. Finally, a hedge fund's investors are the "equity" holders of a hedge fund. As a result, investor illiquidity captures the period within which fund investors can redeem their shares.

We study hedge funds' portfolio, investor, and financing illiquidity using Form PF regulatory filings.⁵ Since mid-2012, Form PF filings are required by all Securities and Exchange Commission (SEC)-registered investment advisers with at least \$150 million in private fund (PF) assets. The information reported in Form PF is nonpublic and contains

² The Form PF information and statistics discussed in this study are aggregated and/or masked to avoid potential disclosure of proprietary information of individual Form PF filers.

³ Hedge fund assets have more than doubled since the 2007-08 global financial crisis, increasing from \$1.5 trillion in 2009 to an all-time high of over \$3 trillion at the close of 2016.

Source: https://www.barclayhedge.com/research/indices/ghs/mum/Hedge_Fund.html

⁴ This paper does not quantify the actual 'amount' of unused, committed sources of credit available to hedge funds, but rather analyzes the liquidity terms of total available financing (both used and unused). Theories of corporate liquidity management argue that available lines of credit provide insurance against liquidity risk. Aragon, Ergun, Getmansky, and Girardi (2017) examines how hedge funds manage over time the liquidity of their funds by adjusting the amount of cash and available borrowing in response to financial distress as measured by poor performance and investor outflows.

⁵ Illiquidity of a fund's assets, liabilities, and equity are taken from Questions 32, 50, and 46(b), respectively, in Form PF.

information about each individual private fund under management, including the fund's identity, investment strategy and performance, assets under management, and borrowing. Most importantly, for our purposes, Form PF allows us to directly measure portfolio, investor, and financing illiquidity. As a result, this is the first paper to capture the liquidity landscape of a hedge fund encompassing both sides of the balance sheet. An important advantage of our Form PF setting is that most liquidity variables are reported directly by the fund adviser and measured in the same units, thus allowing for direct comparison and aggregation.

Despite the importance of measuring hedge fund liquidity, research on this topic is limited due to the nature of the available current data covering the industry. Currently, the literature relies on commercially available databases for academic research of the hedge fund industry.⁶ Although many hedge funds voluntarily report to one or several commercial databases, none of these datasets provide a complete picture of fund liquidity, and information on liquidity terms from these datasets is limited. For example, prior studies usually obtain estimates of a hedge fund's portfolio illiquidity based on style categories and/or autocorrelation in returns that are voluntarily reported to commercial hedge fund databases. In contrast, responders to Form PF filings report directly on portfolio illiquidity and provide a detailed "term structure" of the liquidity of the hedge fund's assets. In addition, the investor liquidity variables used in many hedge fund studies provide only a static summary measure for a given hedge fund. Instead, Form PF provides a complete breakdown and term structure of a fund's investor liquidity that allows liquidity to vary across a fund's investors and, thus, provides a finer picture of investor liquidity.⁷ Lastly, a hedge fund's financing liquidity has to do with the committed terms of its used and unused borrowing obtained from its creditors. Such information is not available in any commercial databases but is reported directly on Form PF. In conclusion, Form PF allows us to study the liquidity profile for a given hedge fund and for hedge fund styles.

Our analysis of hedge fund liquidity is based on the quarterly filings of Form PF over 2013Q1-2015Q3 for private funds that report their fund type as "Hedge Fund" and

⁶ These databases include Lipper TASS, Morningstar Hedge/CISDM, Hedge Fund Research (HFR), Barclay Hedge, Albourne, Eurekahedge, eVestment Alliance, HedgeFund.net, HedgeCo.net, Mercer, Russell Mellon, U.S. Offshore Funds Directory, and Wilshire (Odyssey) with the first three being largely used in most of hedge fund academic research.

⁷ The ability to invest or withdraw money from a hedge fund is often a subject to different investor restrictions such as subscription period, advance notice period, redemption period, and lock-up period. In addition, during periods of financial distress, hedge fund managers sometimes impose "gates", temporary restrictions in withdrawal of investor capital.

answer Section 2b of Form PF.⁸ Our main findings are aggregated, anonymized and can be summarized as follows:

- Sixty percent of a typical fund’s net asset value can be liquidated within 30 days without fire-sale discounting, and the average term of portfolio illiquidity is 71.2 days.⁹
- The terms of investor illiquidity are relatively long-term: nearly 80% of investors’ shares in a typical fund cannot be redeemed within 30 days and the average term of investor illiquidity is 172 days.
- On the liabilities side, hedge funds’ financing terms are typically very short: for 51% of our sample, the used and unused borrowing provided by a fund’s creditors is committed for only one day, and the average financing term is 52.9 days.¹⁰
- The average terms of portfolio, investor, and financing illiquidity are relatively stable across our sample period, but there is substantial variation across funds. Between the bottom and top quartiles, portfolio illiquidity ranges from about 5 to 90 days, while investor and financing illiquidity range from 50 to 300 and 1 to 60 days, respectively.
- Hedge fund liquidity variables vary significantly with, leverage usage, fund size, and adviser size, but not in ways that are indicative of heightened liquidity risk.
- Finally, we compute a measure of net balance sheet illiquidity and find that hedge funds typically maintain a liquidity cushion: for 84% of our sample, the average illiquidity of a fund’s non-cash assets is strictly less than the combined terms of commitments of equity capital or loan facilities. However, for 14% of our sample net balance sheet illiquidity display positive values, suggesting that a number of funds may be exposed to liquidity risk. This result appears stable over time and

⁸ Only the so-called *Qualifying Hedge Funds*, which have at least \$500 million in net assets, answer Section 2b. Note that the Form requires aggregating all master-feeder funds, parallel funds, and dependent parallel managed accounts associated with a fund to determine whether it is a Qualifying Hedge Fund or not. However, advisers are allowed to report fund level data separately as well as on an aggregated basis; thus, some Qualifying Hedge Funds may have net assets less than \$500 million (see Form PF General Instructions for reporting and aggregation requirements). Some results in this paper, and the conclusions we draw from them, could conceivably change if our sample included information from all funds, not just the Section 2b filers.

⁹ Information about a hedge fund’s portfolio liquidity is reported in Form PF - Question 32. This information contains the percentage of value of the fund’s positions that may be liquidated within a set of specified periods. In answering this question, Form PF’s instructions advise hedge funds advisers to use “good-faith estimates based on market conditions and assuming no fire-sale discounting”.

¹⁰ As discussed below, Form PF instructs filers to report their financing terms as “1 day or less” if their creditor is permitted to vary unilaterally the economic terms of the financing or to demand additional collateral in its own discretion, even if the agreement is for a longer term. As such, the estimates calculated here may be considered conservative of hedge funds’ financing liquidity.

also in line with the proportion of NAV of illiquid funds over that of the industry.¹¹

The paper is organized as follows. We discuss the relevant academic literature in Section 2. We provide an overview of the data and definitions of key liquidity variables in Section 3. We discuss the results from our analysis of Form PF data in Section 4. We conclude in Section 5.

2. Related Literature

Prior studies find that liquidity is an important determinant of hedge fund performance. Hedge funds that impose long lockup and redemption notice periods (i.e., high investor illiquidity) tend to earn higher returns (Liang, 1999, Aragon, 2007; Agarwal, Daniel, and Naik, 2009), especially during periods of market crises (Aragon, Martin, and Shi, 2016). Prior work also links investor illiquidity with portfolio illiquidity: funds with higher investor illiquidity tend to hold more illiquid assets (Aragon, Liang, and Park, 2013). This suggests that the higher returns to investor illiquidity result from the efficient management of illiquid assets. The literature also provides evidence that many hedge funds have significant exposure to liquidity risk – the covariance of fund returns with market liquidity. Liquidity risk exposure in hedge funds is associated with higher returns, on average, but significantly lower returns during a market crisis (Sadka, 2010; Ilerisoy, Sa-Aadu, and Tiwari, 2015). Teo (2010) finds significant liquidity risk exposure even among hedge funds offering the most generous liquidity terms, an indication of “excessive” liquidity risk-taking.

Prior studies also show that a hedge fund’s access to capital (i.e., funding liquidity) is an important determinant of fund performance. During crises, many hedge funds experience margin calls and investor redemptions that can lead to fire sales of the fund’s assets and worse performance. A sudden increase in funding illiquidity is related to hedge fund losses (Billio, Getmansky, and Pelizzon (2013), especially among funds holding illiquid assets (Schaub and Schmid, 2013; Getmansky, Lee, and Lo, 2015). Aragon and Strahan (2012) find that the Lehman bankruptcy is associated with a doubling of the failure rate of Lehman’s hedge-fund clients, and a worsening of market liquidity for the stocks that the client funds normally trade. Ben-David, Franzoni, and Moussawi (2012) show that investor redemptions and margin calls were the primary drivers of the selloff during the recent financial crisis. They showed that in 2008 Q3-Q4, hedge funds sold about 29% of their aggregate portfolio.

¹¹ For example, at the end of our sample period (2015Q3), 15% of funds have net illiquidity strictly greater than zero, which is similar to the 14% figure for the full sample of observations. These funds have an aggregate NAV equal to \$194 billion, which is approximately 11% of the total NAV present in our dataset during the same quarter.

A common feature of the above studies is that the information on portfolio and investor illiquidity variables is drawn from commercially available databases. As noted above, commercial databases do not provide complete information on portfolio illiquidity and, as such, this variable must be inferred from available data. For example, Getmansky, Lo, and Makarov (2004) estimate portfolio illiquidity using an econometric model related to the degree of autocorrelation in a fund's reported returns. They find that funds with greater estimates of portfolio illiquidity tend to classify themselves in style categories that are commonly associated with illiquid assets, such as emerging market debt and fixed income arbitrage. The authors do caution that inferring asset illiquidity from returns data is not perfect as return autocorrelation is also a proxy for purposeful return smoothing by fund managers (Getmansky, Lo, and Makarov, 2004; Bollen and Pool, 2008). However, as discussed below, we are able to observe a fund's portfolio illiquidity from Form PF filings.

Our study is also related to a large literature on liquidity transformation among asset managers and banks. This work relates to previous studies measuring the degree of liquidity mismatch between an institution's assets and its liabilities and equity (Berger and Bouwman, 2009; Bai, Krishnamurthy, and Weymuller, 2016; Agarwal, Aragon, and Shi, 2016). In addition, recent work examines whether liquidity mismatch in mutual funds contributes to a greater sensitivity of investor flows to fund performance and, therefore, an indication of fragility (Chen, Goldstein, and Jiang, 2010; and Goldstein, Jiang, and Ng, 2016). We use Form PF to analyze three key dimensions of hedge fund liquidity: portfolio (assets), investor (equity), and financing (liabilities).

3. Data

The main sources of data in our study are the quarterly regulatory filings of Form PF over 2013Q1-2015Q3. Form PF filings are required by all Securities and Exchange Commission (SEC)-registered investment advisers with at least \$150 million in private fund (PF) assets. Our sample only contains filing information for private funds that report their fund type as "Hedge Fund" and are managed by advisers filing Section 2b of Form PF; this Section provides fund-level information that is central to our analysis, such as the fund's asset illiquidity and the committed periods of investor and lender financing.

We also use data from the public Form ADV regulatory filings of hedge fund advisers in our sample, including the adviser's percentage ownership stake in the fund, whether the fund uses an independent administrator to value the fund's assets, and the number of prime brokers used by the fund. Finally, we use VIX data supplied by DataStream. All variables used in our analysis are winsorized each quarter at the 1% and 99% levels and are defined in the Appendix.

In this section we first discuss the key liquidity variables from Form PF, followed by a description of other fund variables used in the study from Form PF and Form ADV filings.

3.1. Portfolio Illiquidity

Information about a hedge fund's portfolio liquidity is reported in Question 32. This information contains the percentage of value of the fund's positions that may be liquidated within a set of specified periods: 1 day or less, 2 – 7 days, 8 – 30 days, 31 – 90 days, 91 – 180 days, 181 – 365 days, or longer than 365 days. In addition, each investment position can be assigned to only one period and advisers are asked to use good-faith estimates based on market conditions and assuming no fire-sale discounting. In addition, cash and cash equivalents are excluded, so that Question 32 focuses on a fund's non-cash assets held in its portfolio.

Effectively, the set of responses to Question 32 provides a complete term structure of liquidity for each hedge fund portfolio and quarter.¹² For each hedge fund, we also calculate an aggregate and anonymized measure of portfolio illiquidity. This is simply the weighted average of the midpoints of each of the seven specified periods, where the weights are the percentage of the fund's portfolio capable of being liquidated within the corresponding period.¹³ For example, for a fund that holds 100% of its net asset value in assets that cannot be liquidated within the year, this variable will assign a portfolio illiquidity of 365 days (i.e., the maximum possible value).

Note that Question 32 allows for a direct measure of portfolio illiquidity. In contrast, in prior studies, the illiquidity of a hedge fund's portfolio assets is inferred based on style categories and autocorrelation in returns that are voluntarily reported to commercial hedge fund databases.¹⁴

3.2. Investor Illiquidity

A hedge fund's investor illiquidity represents the term during which fund investors cannot redeem their shares in the funds. This information is reported in Question 50 of Form PF. Here, advisers are asked to divide the fund's net asset value based on the shortest period within which investors are entitled to withdraw invested funds. Advisers

¹² Note that responses to this and other questions in Form PF rely upon self-reporting and have not been verified by the SEC staff.

¹³ For the first (1 day or less) and last (Longer than 365 days) periods, we use 1 and 365 as the midpoints, respectively.

¹⁴ A few exceptions are Agarwal, Aragon, and Shi (2016), who measure the portfolio liquidity of registered funds of funds using the liquidity restrictions imposed by the underlying hedge funds. Also, Aragon, Ergun, Getmansky, and Girardi (2017) use Question 32 of Form PF to measure portfolio illiquidity.

are asked to report the percentage of net asset value locked for the same specified periods as those in Question 32. In addition, responses to Question 50 are based on the non-discretionary liquidity restrictions (e.g., lockup periods, advance notice periods, redemption frequency) that are specified in the fund documents, and do not factor in the potential for advisers to enact so-called discretionary restrictions like a complete suspension of redemptions.

As we examine below, the symmetry of Questions 32 and 50 allows us to directly compare the liquidity terms of the fund's assets and investors. We calculate an aggregated and anonymized summary measure of hedge fund investor illiquidity from the term structure of investor liquidity. This is the weighted of the midpoints of the specified liquidity periods, where the weights are the corresponding percentage of net asset value that is locked up.

Many commercial databases report the investor illiquidity of hedge funds, including the lockup period, redemption notice period, and redemption frequency. However, the current commercial databases only provide a summary number for investor illiquidity and, therefore, do not show differences in the liquidity terms across investors. In contrast, the information in Question 50 contains a complete term structure.

3.3. Financing Illiquidity

The third component of hedge fund liquidity has to do with the committed terms of used and unused borrowing the fund has obtained from its creditors. This information is provided in Question 46(b) on Form PF. Here, advisers divide a hedge fund's total borrowing and available cash financing (including all drawn and undrawn, committed and uncommitted lines of credit) among specified periods (same as Questions 32 and 50)¹⁵. This division is based on the longest period for which the creditor is contractually committed to provide such financing. In addition, Question 46(b) observes that some arrangements allow a creditor to provide "uncommitted financing," where the creditor has discretion to demand additional collateral or change the economic terms of the financing. In this case, such uncommitted financing should be allocated to the shortest period ("1 day or less").

We also compute an aggregated and anonymized summary measure of a fund's financing illiquidity. Similar to our summary measures for portfolio and investor illiquidity, we calculate the weighted average of the period midpoints from Question 46(b), where the weights are the percentage of total financing for the corresponding period. All three summary variables are measured in days.

¹⁵ We understand that hedge funds may not report obligations under derivatives contracts as "borrowings" in Q12, Q43 or Q 46(b) of Form PF. To the extent that funds do not include these obligations in their PF filings, the liquidity terms reported in Q46(b) may underestimate a fund's overall liquidity exposure.

3.4. Other Variables

Our discussion is also based on several other variables from the Form PF dataset. These include gross and net asset values (Questions 8 and 9), the value of unencumbered cash (Question 33), information about the fund's investment strategy (Question 20), whether investors are subjected to material restrictions or a suspension of withdrawals/redemptions (Question 49(b and c)), the percentage of fund's equity owned by the top 5% owners (Question 15). We also use information from Form ADV, including the percentage of fund ownership held by the fund's adviser and related persons, a dummy variable that equals one if the fund uses an independent administrator, and the number of prime brokers available to the fund.

In addition, we define fund leverage as the ratio of gross and net asset values, cash ratio is the ratio of unencumbered cash and net asset value, and strategy concentration is the Herfindahl (Herfindahl (1950)) index of the fund's eight strategy variables. Finally, we aggregate the net asset values among all hedge funds managed by the same adviser to create an adviser-level size variable.

Our final sample excludes fund/quarter observations with missing values for *Net asset value*, *Gross asset value*, *Portfolio Illiquidity*, *Investor illiquidity*, *Unencumbered cash*, and *Investment strategy*. We also drop observations where *Unencumbered cash* has negative values, *Gross asset value* is strictly less than either *Net asset value* or *Unencumbered cash*, or *Net asset value* is less than or equal to zero.¹⁶ In principle, the sum of percentage values entered across all periods in Q32 (*Portfolio Illiquidity*), Q46(b) (*Financing Illiquidity*), and Q50 (*Investor Illiquidity*) should be 100%. However, we observe some observations where these sums are very different from 100%. Therefore, we drop observations where either sum is either less than or equal to 90% or greater than or equals to 110%.¹⁷ Our final sample contains 12,384 quarterly filings over 2013-2015 made by 1,809 funds of 559 advisers.¹⁸

4. Main Findings

In this section we present aggregated and anonymized summary statistics for the variables in our study, including the key hedge fund liquidity variables. We then examine

¹⁶ We also exclude observations where [Total borrowing available (Form PF, Q46 (a)) - Actual used borrowing (Form PF, Q43 or, if missing, then Q12)] is either missing or negative.

¹⁷ For robustness, we repeated our analysis after applying more (less) restrictive filters by dropping observations where either sum in Q32, Q46(b), or Q50 is either less than or equal to 95% (85%) or greater than or equals to 105% (115%). The results from this robustness check are qualitatively unchanged from those using the 90% – 110% thresholds.

¹⁸ A comprehensive analysis of various practices by hedge funds and advisers that file form PF is provided in the quarterly statistics produced by the SEC Division of Investment Management and available here: <https://www.sec.gov/divisions/investment/private-funds-statistics.shtml>

how hedge fund liquidity varies over time and across funds. All numbers in the tables and figures are obtained after winsorizing all variables (except dummy variables) at the 1% and 99% percentiles.

4.1. Summary statistics

Table 1 shows basic summary statistics of our hedge fund sample. The average net asset value is \$1.72 billion, whereas total gross assets are \$2.96 billion, on average. The difference is due to the fund's leverage ratio, which averages 1.63 in our sample. Seventeen percent of a hedge fund's net assets are held in unencumbered cash, on average, though there is considerable variation as reflected in a standard deviation of 23%.

Table 1 also summarizes information about hedge fund investment strategies. Equity strategies represent 36% of NAV, which is the largest average percentage weight among eight strategy categories. The next largest percentage weight is Other at 21% of NAV. The Herfindahl index measures strategy concentration and has a sample mean of 0.79.¹⁹ This indicates that hedge funds tend to have a more concentrated strategy profile as compared to a portfolio that places equal weight in each of the eight strategies (the equal-weighted strategy will have a Herfindahl index value of 0.125).

Table 1: Summary statistics

| Variable | N | Mean | St.Dev. |
|--|--------|-------|---------|
| Panel A: Size, leverage, and cash variables | | | |
| Gross asset value (\$ billions) | 12,384 | 2.96 | 5.33 |
| Net asset value (\$ billions) | 12,384 | 1.72 | 2.40 |
| Leverage | 12,384 | 1.63 | 1.33 |
| Unencumbered cash (% of NAV) | 12,384 | 0.17 | 0.23 |
| Panel B: Strategy variables | | | |
| Credit | 12,384 | 9.12 | 25.43 |
| Equity | 12,384 | 36.19 | 45.40 |
| Event driven | 12,384 | 11.02 | 27.74 |
| Invests in other funds | 12,384 | 2.06 | 12.24 |
| Macro | 12,384 | 7.59 | 24.17 |
| Managed futures | 12,384 | 1.98 | 13.03 |
| Relative value | 12,384 | 10.62 | 27.74 |
| Other | 12,384 | 21.38 | 38.51 |
| Herfindahl index | 12,384 | 0.79 | 0.34 |

¹⁹ The strategy Herfindahl index is defined as $(\text{Credit})^2 + (\text{Equity})^2 + (\text{Event driven})^2 + (\text{Invests in other funds})^2 + (\text{Macro})^2 + (\text{Managed futures})^2 + (\text{Relative value})^2 + (\text{Other})^2$.

| Panel C: Other hedge fund variables | | | |
|---|--------|-------|-------|
| Adviser hedge fund assets (\$ billions) | 12,384 | 17.59 | 27.16 |
| Discretionary restrictions? | 12,384 | 0.73 | 0.45 |
| Independent administrator? | 12,384 | 0.64 | 0.48 |
| Ownership of five largest investors | 12,384 | 61.30 | 28.08 |
| Ownership of adviser | 9,200 | 12.46 | 23.52 |
| Number of prime brokers | 9,200 | 2.24 | 2.58 |

Source: Form PF. All variables are defined, and the relevant Form PF questions are identified, in the Appendix.

The final panel of Table 1 summarizes other hedge fund variables. The aggregate assets under management for the hedge fund adviser are \$17.59 billion on average.²⁰ Since the average NAV per fund is \$1.72 billion, this suggests that the advisers in our sample manage several individual hedge funds. Seventy-three percent of observations are represented by hedge funds that could potentially use discretionary restrictions, like gates and side pockets, to further restrict investor liquidity. We also see that 64% of observations correspond to hedge funds that use an independent administrator. The next two rows provide additional information about hedge fund ownership. We observe that 61.3% of a hedge fund’s NAV is owned by the five largest investors, and 12.46% of ownership is held by the hedge fund’s adviser. Lastly, hedge funds list 2.24 prime brokers, on average, in their Form ADV filings.

4.2. Term structures of hedge fund liquidity

Table 2 shows the average portfolio, investor, and financing liquidity of our sample for each period specified in Question 32, 50, and 46, respectively. The first row corresponds to the shortest liquidity term. For example, on average, 34% of a hedge fund’s assets can be liquidated in one day or less without fire-sale discounting, while only 6% of investors are entitled to redeem their shares within one day. Compared to investor liquidity, a fund’s financing liquidity is relatively short, since 60% of a fund’s borrowings are not committed beyond one day. When interpreting this result it is important to notice that the data does not allow us to distinguish between filers that agree on one-day-term loans vs. filers that agree on longer terms but are subject to daily revaluation of collateral at the discretion of their creditors. According to form PF instructions: “(If a creditor [...] is permitted to vary unilaterally the economic terms of the financing or to revalue posted collateral in its own discretion and demand additional collateral, then the financing should be deemed uncommitted for purposes of this question. Uncommitted financing should be included under “1 day or less.”)”. Because of this, the figures reported in the

²⁰ This figure includes only an adviser’s hedge fund assets under management (Question 3(a) of Form PF) and excludes other assets such as separate accounts, mutual funds, etc.

last column of Table 2 may be interpreted as conservative estimates of hedge funds' financing liquidity as some filers may report their financing terms as "1 day or less" despite having longer-term agreements in place.

Table 2: Hedge fund liquidity term structure

| Interval | Portfolio (N=12,384) | | Investor (N=12,384) | | Financing (N=9,298) | |
|----------------------|-------------------------|---------|------------------------|---------|------------------------|---------|
| | Mean | St.Dev. | Mean | St.Dev. | Mean | St.Dev. |
| 1 day or less | 0.34 | 0.34 | 0.06 | 0.24 | 0.60 | 0.46 |
| 2 - 7 days | 0.26 | 0.26 | 0.04 | 0.19 | 0.06 | 0.21 |
| 8 - 30 days | 0.12 | 0.17 | 0.12 | 0.31 | 0.06 | 0.18 |
| 31 - 90 days | 0.07 | 0.14 | 0.23 | 0.37 | 0.12 | 0.27 |
| 91 - 180 days | 0.04 | 0.11 | 0.13 | 0.26 | 0.07 | 0.22 |
| 181 - 365 days | 0.04 | 0.15 | 0.12 | 0.22 | 0.03 | 0.16 |
| Longer than 365 days | 0.13 | 0.29 | 0.29 | 0.41 | 0.07 | 0.23 |
| Weighted-avg. (days) | 71.2 | 112.2 | 172.8 | 135.1 | 52.9 | 96.7 |

Source: Form PF Questions 32, 50, and 46(b).

Moving from top to bottom of Table 2 provides a complete picture of the term structure of hedge fund liquidity in our sample. We observe that 60% of a fund's assets can be liquidated within 30 days, while only 13% of positions are classified in the least liquid category (Longer than 365 days). In contrast, investor liquidity is more back-loaded, meaning that nearly 80% of investor funds are locked for at least 30 days. In fact, on average, the longest investor liquidity period (i.e., longer than 365 days) contains the greatest share of a fund's assets (29%). Note also that financing liquidity continues to be significantly near-term. On average, only 30% of a fund's used and unused borrowing is committed beyond 30 days.

The final row of Table 2 presents the three summary measures of the terms of portfolio, investor, and financing liquidity. Note that a higher average corresponds to higher illiquidity, since a longer term corresponds to a less liquid position. We see that the average time to liquidate hedge fund investment positions is 71.2 days, while the earliest time investors can withdraw their invested funds is 173 days on average. On the other hand, the average period of committed financing is just 53 days. Note that these are sample averages and that there is considerable variation across observations. Overall, the summary measures show that hedge fund portfolio illiquidity in our sample lies between that of its invested funds and committed borrowing.

4.3. Average hedge fund illiquidity across time

Figure 1 plots the average portfolio, investor, and financing illiquidity for each quarter in our sample period. Two observations emerge. First, portfolio illiquidity lies between investor and financing illiquidity. This is also consistent with the bottom row in Table 2. Second, the average of each illiquidity variable is fairly stable across time. This suggests that much of the variation in the illiquidity (as reported in Table 2 standard deviations) may be driven by differences across funds rather than over time.

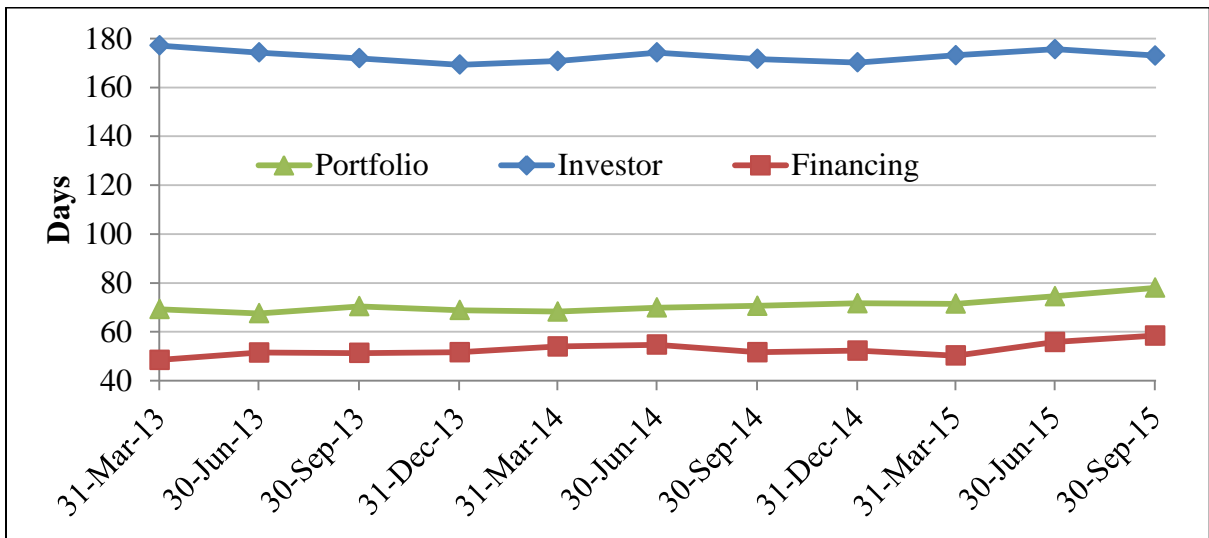


Figure 1: Average term of hedge fund illiquidity, by quarter

Source: Form PF Questions 32, 50, and 46(b).

In Figures 2-4 we plot the 25th, 50th, and 75th percentiles of each illiquidity variable, for each quarter in our sample period. First note from Figure 2 that the median portfolio illiquidity ranges from 15-20 days over the sample period, which is much lower than the sample average of 71.2 days. This suggests that portfolio illiquidity is positively skewed – meaning, most of the funds have low values of portfolio illiquidity (i.e. liquid portfolios) while some funds have extreme high values of portfolio illiquidity. In contrast, Figure 3 shows that the median investor illiquidity is consistently around 150 days and, therefore, relatively near to the sample mean (173 days). This suggests that investor illiquidity is much less skewed than portfolio illiquidity.

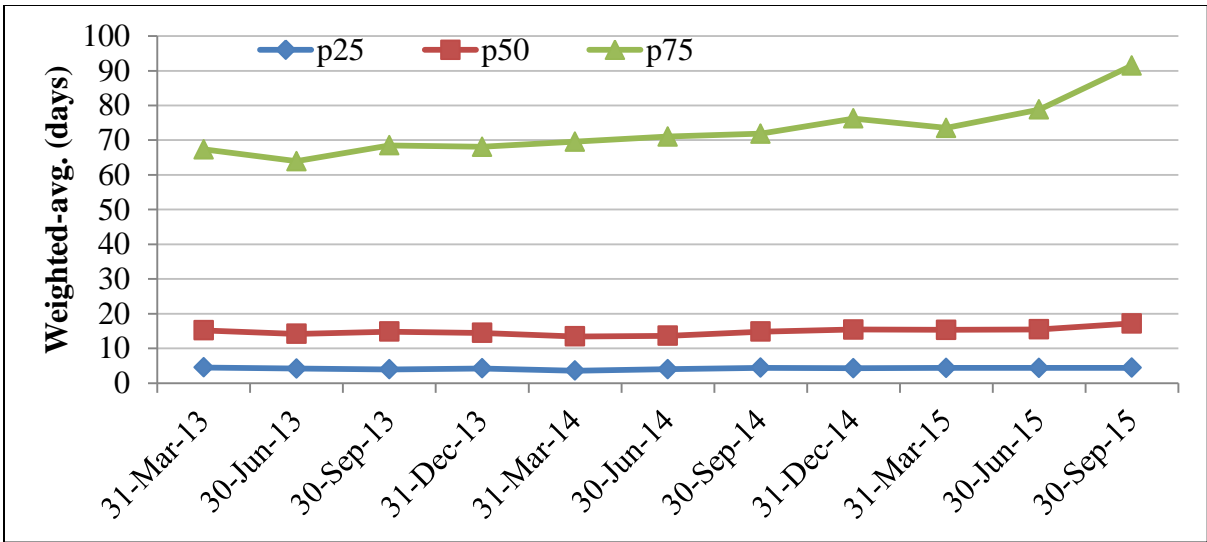


Figure 2: Average portfolio illiquidity, by quarter

Source: Form PF Question 32.

Another takeaway from Figures 2-4 is that only portfolio illiquidity exhibits noticeable time variation. Specifically, the 75th percentile of portfolio illiquidity is 90 at the end of September 2015, but only 70 in March 2013. This is possibly due to the fact that portfolio illiquidity reflects market conditions, in addition to asset composition, and the fact that VIX was much higher in Sept 2015 (24.5) as compared to March 2013 (16.9).

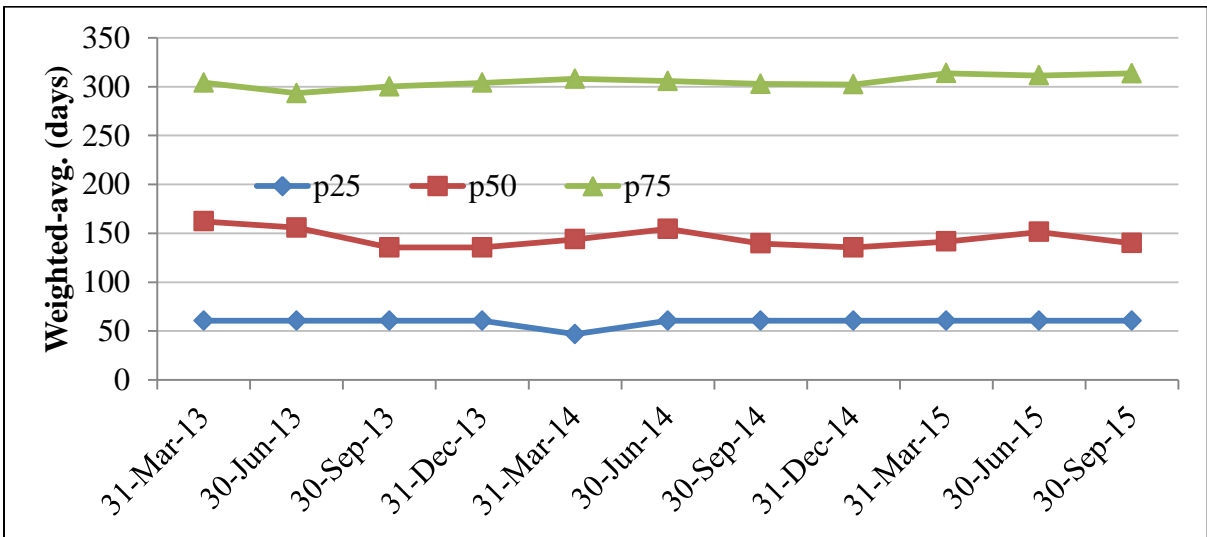


Figure 3: Average investor illiquidity, by quarter

Source: Form PF Question 50.

Finally, from Figure 4 we observe heavy clustering of financing illiquidity at one day since the 25th percentile is the same as the sample median. This finding is consistent throughout our sample period.

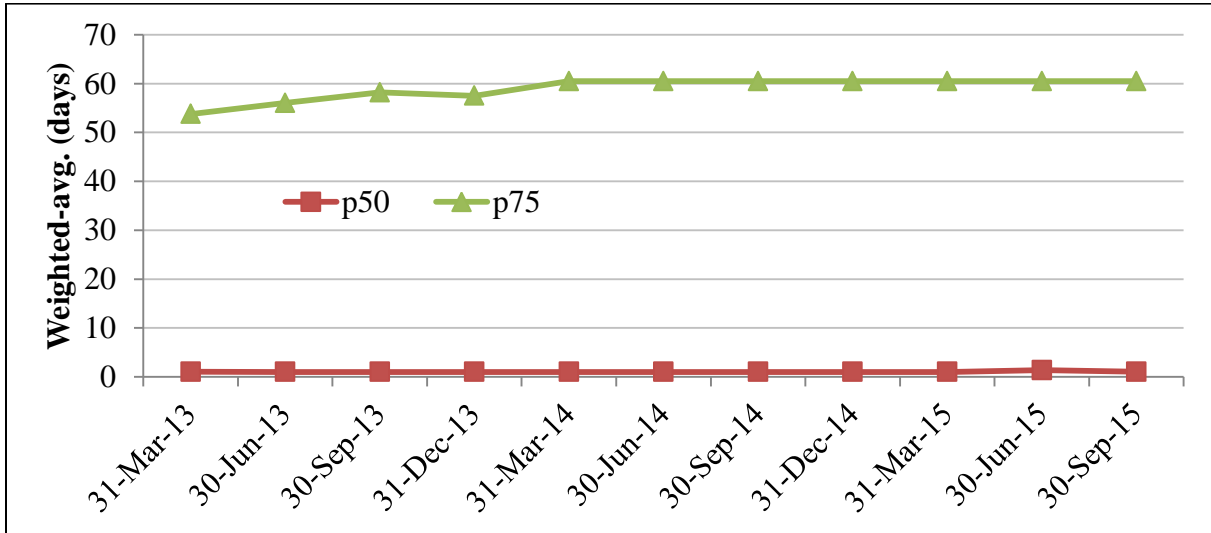


Figure 4: Average financing illiquidity, by quarter

Source: Form PF Question 46(b).

4.4. Average hedge fund liquidity across fund characteristics

In this subsection we examine how hedge fund characteristics vary with portfolio liquidity, leverage usage, fund size, and adviser size in our sample.

4.4.1. Low versus high portfolio illiquidity

Table 3 presents aggregated and anonymized summary statistics for the bottom quartile, interquartile range, and top quartile of portfolio illiquidity in our sample. From Panel A we see that the average portfolio illiquidity in these subgroups is 2.0, 22.3, and 238.3 days, respectively, indicating significant range of portfolio illiquidity across the three groups. We also find that investor illiquidity is just 70.5 days in the low group, as compared to 314.7 days in the high group. A similar result holds for financing illiquidity, which average 23.1 days and 129 days in the low and high portfolio illiquidity groups, respectively. The main takeaway from Panel A is that the high portfolio illiquidity group may not necessarily represent a greater liquidity risk. A longer commitment from a fund’s investors and creditors may help the fund avoid situations in which illiquid assets are sold in fire sales.

Panel B of Table 3 shows that both unencumbered cash and leverage are lower, on average, in the high portfolio illiquidity group, as compared to the low group. However, neither NAV nor GAV vary monotonically across subgroups. From Panel C we see that funds in the low portfolio illiquidity group tend to have a larger weight in style categories that, heuristically, correspond to liquid strategies, including Equity, Managed futures, and Macro. In contrast, Credit, Event driven, and Other are largest, on average, among funds in the high portfolio illiquidity group.

Panel D of Table 3 shows that discretionary restrictions are more frequent among funds with low portfolio illiquidity. In light of the opposite relation between portfolio and investor illiquidity in Panel A, this suggests discretionary restrictions and investor illiquidity are likely to be substitutes. Note also that both the fund adviser ownership stake and the ownership stake of the top 5 largest investors are greatest, on average, among the low portfolio liquidity group.

Table 3: Summary statistics, by portfolio illiquidity

This table reports the average of all listed variables for fund subgroups in our sample based on weighted-avg. portfolio illiquidity.

| | Weighted-avg. portfolio illiquidity | | |
|---|-------------------------------------|---------------------|-------------------|
| | Low (bottom 25%) | Medium (25%-75%) | High (top 25%) |
| Panel A: Illiquidity variables | | | |
| Weighted avg. portfolio illiquidity (days) | 2.0 | 22.3 | 238.3 |
| Weighted avg. investor illiquidity (days) | 70.5 | 153.1 | 314.7 |
| Weighted avg. financing illiquidity (days) | 23.1 | 34.1 | 129.0 |
| Panel B: Size and leverage variables | | | |
| Net asset value (\$ billions) | 1.4 | 2.0 | 1.6 |
| Gross asset value (\$ billions) | 2.6 | 3.6 | 2.0 |
| Leverage | 1.86 | 1.71 | 1.25 |
| Unencumbered cash (% of NAV) | 0.27 | 0.15 | 0.09 |
| Panel C: Investment strategy variables | | | |
| Credit | 4.1 | 9.2 | 13.9 |
| Equity | 46.2 | 41.5 | 15.6 |
| Event Driven | 1.7 | 11.7 | 18.9 |
| Invests in other funds | 2.2 | 1.6 | 2.8 |
| Macro | 17.4 | 6.2 | 0.5 |
| Managed futures | 4.6 | 1.5 | 0.3 |
| Relative value | 9.6 | 13.1 | 6.8 |
| Other | 14.1 | 15.1 | 41.1 |

| | | | |
|---|------|------|------|
| Herfindahl index | 0.9 | 0.8 | 0.7 |
| <hr/> | | | |
| Panel D: Other variables | | | |
| <hr/> | | | |
| Adviser hedge fund assets (\$ billions) | 27.0 | 13.5 | 16.3 |
| Discretionary restrictions? | 0.9 | 0.8 | 0.3 |
| Independent administrator? | 0.6 | 0.7 | 0.5 |
| Ownership of five largest investors | 68.6 | 60.6 | 55.4 |
| Ownership of adviser | 13.1 | 12.8 | 11.2 |
| Number of prime brokers | 1.9 | 2.9 | 1.2 |
| Observations | 3104 | 6184 | 3096 |

Source: Form PF. All variables are defined in the Appendix.

4.4.2. Low versus high leverage

Table 4 presents aggregated and anonymized summary statistics for subgroups in our sample based on hedge fund leverage ratios. From Panel B we see that the average leverage across the low, medium, and high groups is 1.01, 1.24, and 3.04, respectively. We also observe that high leverage tends to correspond to large funds, on average, both in terms of gross and net asset values. Cash ratios are also higher, on average, among the high leverage group. Possibly, the higher cash ratios among funds in this group reflect funds' attempts to manage the portfolio risk inherent in high leverage. Panel C shows that a few style categories are associated with greater leverage, including Credit, Macro, and Relative value. In contrast, the "Invests in other funds" strategy has an average weight of just 0.6% of NAV among the high leverage subgroup.

In Panel D of Table 4 we see that funds in the high leverage group tend to list many prime brokers on Form ADV, on average, and are managed by relatively small hedge fund advisers. In addition, the use of discretionary restrictions and adviser ownership are more common among the high leverage group. Perhaps, this may be due to the potential for greater volatility resulting from higher leverage: the ability to raise gates provides a backstop against investor outflows in the event of a large drawdown in returns, while a greater ownership stake by the fund adviser helps to align the incentive of fund investors and managers.

Panel A of Table 4 summarizes the illiquidity variables for each leverage group. Compared to the low group, the average portfolio illiquidity is lower among the high leverage group, while the average financing illiquidity is greater.²¹ Specifically, it takes on average 38.5 days for assets held by high (top 25%) leverage group to be liquidated.

²¹ Lower portfolio illiquidity helps to reduce fire-sale discounting in the event of a forced deleveraging due to investor redemptions or margin calls, while longer committed financing allows a fund to wait for asset prices to rebound in case of a decline in asset values, so that sales at fire sale prices can be avoided.

In contrast, hedge funds in the low (bottom 25%) leverage group take on average 98.4 days to liquidate their assets. Financing terms are more generous for the high leverage group (61.7 days) compared to the low leverage group (47.2). In contrast, the average investor illiquidity in the low and high leverage groups is of a similar magnitude.

Table 4: Summary statistics, by leverage

This table reports the average of all listed variables for fund subgroups in our sample based on leverage.

| | Leverage | | |
|---|---------------------|---------------------|-------------------|
| | Low (bottom 25%) | Medium (25%-75%) | High (top 25%) |
| Panel A: Illiquidity variables | | | |
| Weighted avg. portfolio illiquidity (days) | 98.4 | 74.0 | 38.5 |
| Weighted avg. investor illiquidity (days) | 167.2 | 181.8 | 160.4 |
| Weighted avg. financing illiquidity (days) | 47.2 | 49.3 | 61.7 |
| Panel B: Size and leverage variables | | | |
| Net asset value (\$ billions) | 1.3 | 1.8 | 1.9 |
| Gross asset value (\$ billions) | 1.4 | 2.4 | 5.6 |
| Leverage | 1.01 | 1.24 | 3.04 |
| Unencumbered cash (% of NAV) | 0.12 | 0.16 | 0.22 |
| Panel C: Investment strategy variables | | | |
| Credit | 7.9 | 9.4 | 9.7 |
| Equity | 35.4 | 34.4 | 40.6 |
| Event Driven | 6.8 | 15.2 | 6.9 |
| Invests in other funds | 4.2 | 1.7 | 0.6 |
| Macro | 6.2 | 7.4 | 9.3 |
| Managed futures | 3.0 | 1.9 | 1.1 |
| Relative value | 4.7 | 10.3 | 17.1 |
| Other | 31.6 | 19.6 | 14.7 |
| Herfindahl index | 0.9 | 0.7 | 0.8 |
| Panel D: Other variables | | | |
| Adviser hedge fund assets (\$ billions) | 20.1 | 18.2 | 13.9 |
| Discretionary restrictions? | 0.6 | 0.7 | 0.8 |
| Independent administrator? | 0.6 | 0.6 | 0.7 |
| Ownership of five largest investors | 65.7 | 59.0 | 61.5 |
| Ownership of adviser | 10.0 | 11.2 | 17.5 |
| Number of prime brokers | 0.9 | 2.2 | 3.6 |
| Observations | 3096 | 6192 | 3096 |

Source: Form PF. All variables are defined in the Appendix.

4.4.3. Small versus large funds

Table 5 provides an aggregated and anonymized summary of fund characteristics for different fund NAV subgroups in our sample. Panel B shows that the average NAV is \$0.2, \$1.0, and \$4.7 billion for the low, medium, and high groups, respectively. Large funds also show higher average leverage (1.7 vs. 1.6) and greater cash ratios (0.18 vs. 0.16). From Panel C we find that, compared to the low group, funds in the high fund NAV group invest a higher percentage of NAV in the Macro and Other strategies, on average, while Credit, Invests in other funds, Managed futures, and Relative value strategies receive a lower weight. The potential to enact discretionary restrictions appears to be more frequent among funds in the larger size group, and larger funds tend to have relations with a higher number of prime brokers (Panel D).

Panel A of Table 5 shows that larger funds have a lower average portfolio illiquidity, but no apparent relation between fund size and the term of investor and creditor financing. Overall, based on these univariate sorts, we do not see a strong connection between fund size and liquidity risk. While larger funds have greater leverage, on average, they also hold more liquid assets (i.e., lower portfolio illiquidity) and hold more cash. Both cash holdings and more liquid assets helps avoid fire sale discounting in the event of a forced deleveraging.

Table 5: Summary statistics, by NAV

This table reports the average of all listed variables for fund subgroups in our sample based on net asset value.

| | Net asset value | | |
|---|---------------------|---------------------|-------------------|
| | Low (bottom 25%) | Medium (25%-75%) | High (top 25%) |
| Panel A: Illiquidity variables | | | |
| Weighted avg. portfolio illiquidity (days) | 87.5 | 67.2 | 62.9 |
| Weighted avg. investor illiquidity (days) | 176.1 | 169.9 | 175.2 |
| Weighted avg. financing illiquidity (days) | 46.8 | 57.7 | 49.3 |
| Panel B: Size and leverage variables | | | |
| Net asset value (\$ billions) | 0.2 | 1.0 | 4.7 |
| Gross asset value (\$ billions) | 0.3 | 1.7 | 8.1 |
| Leverage | 1.61 | 1.61 | 1.70 |
| Unencumbered cash (% of NAV) | 0.16 | 0.16 | 0.18 |
| Panel C: Investment strategy variables | | | |
| Credit | 10.9 | 9.1 | 7.3 |

| | | | |
|---|------|------|------|
| Equity | 36.7 | 35.4 | 37.3 |
| Event Driven | 11.1 | 10.1 | 12.7 |
| Invests in other funds | 2.7 | 2.2 | 1.2 |
| Macro | 6.0 | 7.6 | 9.1 |
| Managed futures | 2.7 | 1.9 | 1.4 |
| Relative value | 11.3 | 11.4 | 8.4 |
| Other | 18.6 | 22.2 | 22.5 |
| Herfindahl index | 0.8 | 0.8 | 0.7 |
| <hr/> | | | |
| Panel D: Other variables | | | |
| <hr/> | | | |
| Adviser hedge fund assets (\$ billions) | 14.3 | 15.7 | 24.6 |
| Discretionary restrictions? | 0.6 | 0.7 | 0.8 |
| Independent administrator? | 0.6 | 0.6 | 0.6 |
| Ownership of five largest investors | 78.7 | 61.4 | 43.6 |
| Ownership of adviser | 14.7 | 11.5 | 12.1 |
| Number of prime brokers | 1.7 | 2.1 | 3.0 |
| Observations | 3096 | 6192 | 3096 |

Source: Form PF. All variables are defined in the Appendix.

4.4.4. Small versus large advisers

Finally, Table 6 presents aggregated and anonymized summary statistics for fund subgroups in our sample based on the aggregated net asset value of hedge funds managed by the fund's adviser. Panel D shows that the average adviser size is just \$1.5 billion in the low group, as compared to \$9.2 and \$50.8 billion in the medium and high groups, respectively. Compared to funds that are managed by smaller advisers, funds in the high group appear to have a higher ownership of the 5 largest investors (64.9 vs. 59.2) and a lower frequency of the potential to use discretionary restrictions (0.7 vs. 0.8). In addition, Panel C shows that funds managed by larger advisers have greater average portfolio weight in Credit and Other investment strategies, and a lower weight in Equity strategies. This suggests a preference among such funds to hold assets with lower liquidity. More evidence of portfolio illiquidity is provided in Panel A, showing that funds managed by larger advisers have an average illiquidity more than double that of funds managed by smaller advisers (94.4 vs. 43.2 days). Investor and financing illiquidity are also higher among funds in the high group compared to the low group, but less than funds managed by medium-sized advisers.

Panel B of Table 6 shows that funds managed by large advisers are larger, on average, use less leverage, and hold more cash. In terms of liquidity risk, again, we do not see a clear relation across groups. While large advisers are associated with funds holding less

liquid assets, they also tend to manage funds with greater cash holdings, lower leverage, and longer committed terms from liability and equity holders.

Table 6: Summary statistics, by adviser hedge fund assets

This table reports the average of all listed variables for fund subgroups in our sample based on adviser hedge fund assets.

| | Adviser hedge fund assets | | |
|---|---------------------------|---------------------|-------------------|
| | Low (bottom 25%) | Medium (25%-75%) | High (top 25%) |
| Panel A: Illiquidity variables | | | |
| Weighted avg. portfolio illiquidity (days) | 43.2 | 73.7 | 94.4 |
| Weighted avg. investor illiquidity (days) | 142.1 | 193.4 | 162.0 |
| Weighted avg. financing illiquidity (days) | 32.6 | 62.3 | 54.7 |
| Panel B: Size and leverage variables | | | |
| Net asset value (\$ billions) | 0.8 | 1.9 | 2.2 |
| Gross asset value (\$ billions) | 1.4 | 3.2 | 3.9 |
| Leverage | 1.75 | 1.62 | 1.55 |
| Unencumbered cash (% of NAV) | 0.16 | 0.14 | 0.23 |
| Panel C: Investment strategy variables | | | |
| Credit | 6.2 | 9.9 | 10.5 |
| Equity | 51.5 | 33.7 | 25.8 |
| Event Driven | 7.4 | 13.5 | 9.7 |
| Invests in other funds | 1.8 | 2.4 | 1.7 |
| Macro | 5.7 | 5.3 | 14.2 |
| Managed futures | 2.8 | 1.9 | 1.3 |
| Relative value | 10.7 | 11.9 | 8.0 |
| Other | 14.0 | 21.4 | 28.9 |
| Herfindahl index | 0.9 | 0.8 | 0.8 |
| Panel D: Other variables | | | |
| Adviser hedge fund assets (\$ billions) | 1.5 | 9.2 | 50.8 |
| Discretionary restrictions? | 0.8 | 0.7 | 0.7 |
| Independent administrator? | 0.7 | 0.6 | 0.6 |
| Ownership of five largest investors | 59.2 | 60.6 | 64.9 |
| Ownership of adviser | 11.8 | 13.8 | 10.4 |
| Number of prime brokers | 2.2 | 2.4 | 2.0 |
| Observations | 3098 | 6219 | 3067 |

Source: Form PF. All variables are defined in the Appendix.

4.5. Net balance sheet illiquidity

Finally, in this section we provide a gauge of the net illiquidity of a hedge fund's balance sheet. Specifically, we calculate the difference between the average portfolio illiquidity and a leverage weighted-average of financing and investor illiquidity in our sample. The formula ensures that a fund with greater leverage will have a greater weight on its financing illiquidity (and a lower weight on its investor illiquidity). This is appropriate because higher leverage implies that a higher proportion of a fund's assets are financed by its creditors.

By construction, net illiquidity ranges from -365 to 365 days. Positive values indicate that a fund's non-cash assets take more time to liquidate (without significant fire-sale discounting) than the average term of committed capital from its creditors and investors. Recall that portfolio illiquidity (as defined in Q32) is based on a fund's non-cash assets. Therefore, our measure will tend to overstate the net illiquidity of the complete hedge fund balance sheet among funds for which cash holdings constitute a significant portion of assets.

Figure 5 plots the distribution of net illiquidity for our sample observations. We see that 14% are greater than zero, and 4% are greater than 30 days, an indication that some funds may have significant exposure to liquidity risk.²² However, the vast majority (84%) of observations is strictly less than zero, which shows that hedge funds typically maintain a liquidity buffer. We find this result to be consistent across all quarters. At the end of our sample period (2015Q3), for instance, 15% of funds have net illiquidity strictly greater than zero, which is similar to the 14% figure for the full sample of observations. These funds represent NAV of \$194 billion, which is approximately 11% of the total NAV present in our dataset during the same quarter.

²² Notice that Form PF does not allow us to distinguish between financing committed for "1 day or less" vs. financing committed for longer periods but subject to daily revaluation of collateral by the creditor. Because of this, the figures reported here may be considered high estimates of hedge funds' exposure to liquidity risk.

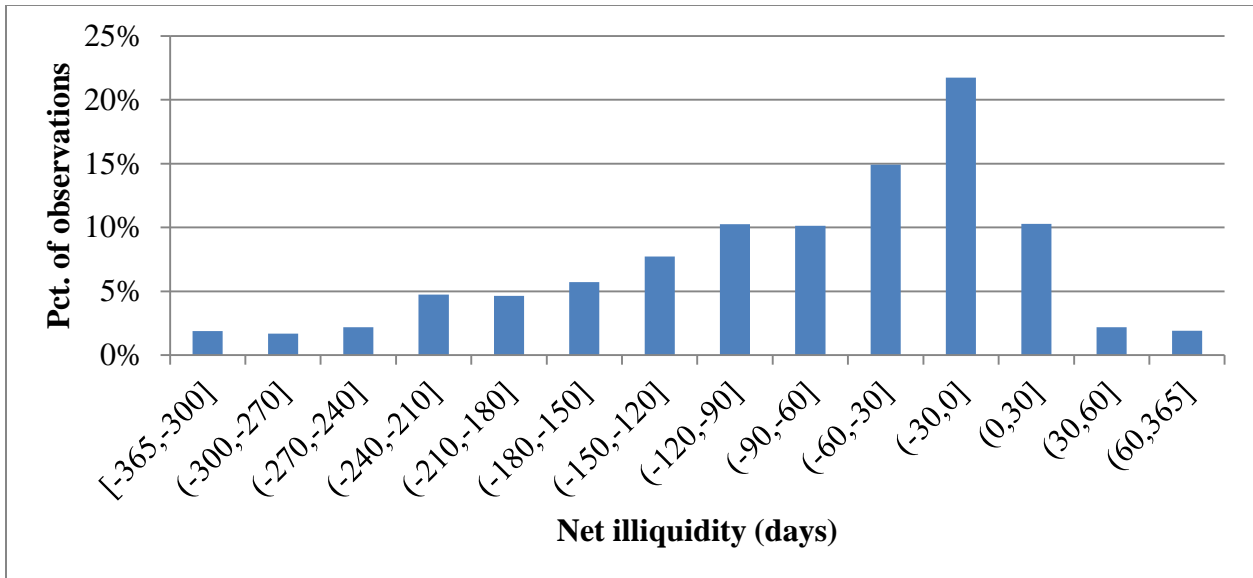


Figure 5: Histogram of average hedge fund net illiquidity

Source: Form PF Questions 8, 9, 32, 50, and 46(b). Net illiquidity is the difference between portfolio illiquidity and the weighted-average of investor and financing illiquidity. The weight on investor illiquidity is the inverse leverage ratio (i.e., net asset value / gross asset value); and the weight on financing illiquidity is one minus the inverse leverage ratio. Portfolio, investor, and financing illiquidity are defined in the Appendix. The sample contains the 9,298 observations with non-missing values of portfolio, investor, and financing illiquidity.

5. Conclusion

Popular accounts and the academic literature identify liquidity risk as an important factor of hedge fund performance, especially during periods of market crisis. However, due to the limitations of publicly available databases, very little is known by the public about the liquidity profile of this industry. By using the recently-implemented Form PF filings over 2013Q1-2015Q3, we are able to summarize three key dimensions of hedge fund liquidity: portfolio (assets), investor (equity), and financing (liabilities). The main advantage of our Form PF setting is that all three components are measured in the same units (days), trace out a complete term structure of liquidity, and are reported directly by the fund manager. In contrast, prior studies rely on self-reported style categories or autocorrelation in reported fund returns to infer the degree of illiquidity in hedge fund portfolios. In addition, conventional methods do not allow for heterogeneity in the redemption rights of fund investors and do not provide any information about the committed terms of financing provided by the fund’s creditors.

In our analysis we make several new findings about hedge fund liquidity. First, the term structures of investor and financing liquidity are very different. The redemption rights of

fund investors are significantly back-loaded – specifically, nearly 80% of investors' shares in the fund cannot be redeemed within 30 days. In contrast, a fund's financing terms is typically very short: for 51% of our sample, the used and unused borrowing provided by a fund's creditors is committed for only one day. On the asset side, 60% of a fund's net asset value can be liquidated within 30 days, on average. To facilitate comparisons, we compute asset-weighted averages of the three liquidity term structures for each observation and find that, on average, portfolio illiquidity (71.2 days) lies between investor (172.8 days) and financing illiquidity (52.9 days). Note that these figures are sample averages and there is significant variation in liquidity variables within our sample.

We also find that the average portfolio, investor, and financing illiquidity are relatively stable across our sample period, but vary substantially across funds. Between the bottom and top quartiles, portfolio illiquidity ranges from about 5 to 90 days, while investor and financing illiquidity range from 50 to 300 and 1 to 60 days, respectively. In addition, our analysis provides some initial evidence on how hedge fund characteristics vary with portfolio liquidity, leverage usage, fund size, and adviser size. Finally, we aggregate the portfolio, investor, and financing illiquidity in our sample and find that the net illiquidity of a hedge fund's balance sheet is typically negative – meaning, a hedge fund's non-cash assets typically have lower average illiquidity than the illiquidity of its capital commitments from investor and creditors. Nonetheless, 14% of our sample display values greater than zero, and 4% greater than 30 days, an indication that some funds may have significant exposure to liquidity risk.

Our results also raise interesting questions regarding liquidity transformation and liquidity management in hedge funds. It would be interesting to construct a global measure of mismatch that accounts for a hedge fund's leverage, cash holdings, as well as its portfolio, investor, and financing illiquidity, and to see whether such liquidity transformation by hedge funds has important consequences for fund investors and the financial system. In addition, our evidence that funds with high portfolio illiquidity tend have longer investor and financing illiquidity is suggestive of liquidity management. It would be interesting to investigate hedge funds' liquidity management policies more broadly and in a dynamic setting that incorporates the committed terms of investor and creditor financing as well as a fund's cash and unused borrowing capacity.

Appendix: Variable definitions

| Variable | Description and data source |
|--|--|
| <i>Adviser hedge fund assets</i> | Adviser HFs AUM (billions). |
| <i>Credit</i> | Percentage of fund's NAV following Credit strategy. Form PF, Q20. |
| <i>Discretionary Restrictions</i> | Dummy equal to 1 if fund can enact discretionary liquidity restrictions. Form PF, Q49(b,c). |
| <i>Equity</i> | Percentage of fund's NAV following Equity strategy. Form PF, Q20. |
| <i>Event Driven</i> | Percentage of fund's NAV following Event Driven strategy. Form PF, Q20. |
| <i>Financing Illiquidity</i> | Average commitment period of available borrowing. Form PF, Q46(b). |
| <i>Gross asset value</i> | Gross asset value (billions). Form PF, Q8. |
| <i>Herfindahl index</i> | Herfindahl-Hirschman Index using NAV percentage weights of seven portfolio strategies. It is defined as $Credit^2 + Equity^2 + EventDriven^2 + InvestsOtherFunds^2 + Macro^2 + ManagedFutures^2 + OtherStrategy^2$. |
| <i>Independent administrator</i> | Dummy variable equal 1 if fund uses an independent administrator. Form ADV. |
| <i>Invests in other funds</i> | Percentage of fund's NAV following Investment in Other Funds strategy. Form PF, Q20. |
| <i>Investor Illiquidity</i> | Average commitment period of equity investors. Form PF, Q50. |
| <i>Leverage</i> | Fund leverage: GAV/NAV |
| <i>Macro</i> | Percentage of fund's NAV following Macro strategy. Form PF, Q20. |
| <i>Managed Futures</i> | Percentage of fund's NAV following managed Futures strategy. Form PF, Q20. |
| <i>Net asset value</i> | Net asset value (billions). Form PF, Q9. |
| <i>Number of prime brokers</i> | Number of prime brokers used by the fund |
| <i>Other</i> | Percentage of fund's NAV following Other strategy. Form PF, Q20. |
| <i>Ownership of adviser</i> | Ownership % of Adviser and Related Persons. Form ADV. |
| <i>Ownership of five largest investors</i> | Percentage of fund's equity own by top 5% owners. Form PF, Q15. |
| <i>Portfolio Illiquidity</i> | Average number of day needed to liquidate fund's non-cash assets. Form PF, Q32. |
| <i>Relative Value</i> | Percentage of fund's NAV following Relative Value strategy. Form PF, Q20. |
| <i>Unencumbered cash (% of NAV)</i> | Unencumbered cash available to the fund at the end of the quarter (Form PF, Q33) divided by fund Net asset value (Form PF, Q9) |

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