Liquidity Risk and the Cross-Section of Hedge-Fund Returns*

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Abstract

This paper demonstrates that liquidity risk as measured by the covariation of fund returns with unexpected changes in aggregate liquidity is an important determinant in the cross-section of hedge-fund returns. Using the aggregate liquidity risk factor in Sadka (2006), this paper shows that funds that significantly load on liquidity risk subsequently outperform low-loading funds by about 8% annually over the period 1994–2007. This outperformance is independent of the illiquidity of a fund as measured by lockup and redemption notice periods. These findings are also robust to risk controls, portfolio rebalancing frequency, and potential return smoothing. The results highlight the importance of understanding systematic liquidity variations in the evaluation of hedge-fund performance.

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Introduction

Over the past decade the asset management industry has experienced a tremendous growth of hedge-fund asset value to almost two trillion dollars by the end of 2007. Much of the finance literature about hedge funds has focused on understanding their risk-reward relation. Unlike asset-pricing models developed for equities or fixed-income securities, the risk attribution for hedge funds is more complex because they may hold a variety of asset classes and typically apply sophisticated financial instruments, often times with illiquid securities. For example, many hedge funds implement dynamic trading strategies which could lead to time-varying risk exposures. Fung and Hsieh (2001) and Agarwal and Naik (2004) find that option-based factors can be used to control for dynamic risk exposure. The performance analysis of hedge funds therefore typically considers linear multi-factor models that include exposures to a range of equity, bond, commodity, and option-based indices.

Recent events such as the Quant crisis of August 2007 (see, e.g., Khandani and Lo (2007, 2008)) and the present credit crunch have raised questions about our understanding of hedge-fund risks. Much of the debate surrounding the risk-reward relation is the amount of a fund's returns that are attributable to alpha versus beta, i.e. a manager's talent versus the exposure to systematic risk. This is especially important given the incentive and fee structure applied in the industry, which largely compensates the manager for skill and essentially assumes a fund's return is mostly due to alpha. Yet, the fact that recent market events have dramatically impacted many funds that have shown little prior exposure to systematic risk suggests the risk model is not complete. For example, even though August 2007 is considered a significant negative shock amongst many hedge-fund managers, the market return during that month was 0.74%—nothing special about that month's market return that would be indicative of a significant liquidity event.

This paper demonstrates that liquidity risk, as measured by the covariation of fund returns with unexpected changes in aggregate liquidity, is an important determinant in the cross-section of hedge-fund returns. Using the aggregate liquidity risk factor in Sadka (2006) brought to date, this paper shows that funds that significantly load on liquidity risk subsequently outperform low-loading funds by about 8% annually over the period 1994–2007. This outperformance is independent of the illiquidity of a fund as measured by lockup and redemption notice periods. These findings are also robust to risk controls, portfolio rebalancing frequency, and potential return smoothing. The

results highlight the importance of understanding systematic liquidity variations in the evaluation of hedge-fund performance.

It is important to emphasize that the focus of this paper is not on the asset-specific liquidity characteristic (the liquidity level), but rather on the concept of market-wide liquidity as an undiversifiable risk factor (the liquidity risk). The stock price literature documents a premium as compensation for holding illiquid assets (e.g., Amihud and Mendelson (1986) that uses bid-ask spreads to measure illiquidity and Brennan and Subrahmanyam (1996) that uses price impacts). In contrast, a few recent studies focus on the systematic component of liquidity (liquidity risk) rather than on its actual idiosyncratic level (i.e. liquidity level). This strand of literature begins with studies that document the fact that firm-specific liquidity fluctuates over time, and also that there is a significant systematic, or market-wide component to these liquidity fluctuations (see, e.g., Chordia, Roll, and Subrahmanyam (2000), Amihud (2002)). Each using a different measure of liquidity, Pástor and Stambaugh (2003), Acharya and Pedersen (2005), and Sadka (2006) show that systematic liquidity risk is a priced risk factor, i.e. assets whose returns covary highly with aggregate liquidity earn higher expected returns than do assets whose returns exhibit low covariation with aggregate liquidity. This paper applies the Sadka (2006) liquidity factor, which is based on intraday price impact of stock trades, to the cross-section of hedge funds and shows it is priced in this universe as well.[1]

This paper measures liquidity risk using the funds' monthly reported return series. Since fund holdings are not available, it is not possible to compare this measured risk to the liquidity risk, as well as liquidity level, of the assets that the funds actually hold. Nevertheless, Aragon (2007) uses share restrictions, such as lockup and redemption notice periods, to proxy for fund illiquidity, and shows that illiquid funds typically outperform liquid funds by about 4–7% per year.[2] To investigate the impact of share restriction on the liquidity risk findings here, funds are sorted into high- versus low-liquidity loading within each share restriction group. The results indicate that the premium for the liquidity risk is apparent in each category of share restriction (as proxied by lockup and redemption notice periods). The results therefore suggest that the liquidity a fund provides to its investors need not necessarily reflect on the fund's exposure to aggregate liquidity variations.

[1] The measures of Pástor and Stambaugh (2003) and Acharya and Pedersen (2005) are also studied here; they exhibit similar, yet weaker results.

[2] Getmansky, Lo, and Makarov (2004) develop a return-based stale-price measure to proxy for the illiquidity of funds' assets. Aragon (2007) finds a positive correlation between this measure of illiquidity and lockup restrictions.

The paper provides additional analysis and discussion to highlight the significance of the results. First, the liquidity-risk strategies are analyzed across different investment styles. Although some style indices are more sensitive to liquidity risk than others (for example, Convertible Arbitrage, Emerging Markets, Event Driven, Fixed Income Arbitrage, and Long/Short Equity exhibit a significant loading on the liquidity factor), the high-liquidity-loading funds outperform low-liquidity loading funds within most investment styles. Second, risk-adjusted returns are computed using the market return, an overall hedge fund index return, and an investment style index return as benchmarks. The returns to the high-minus-low liquidity loading portfolio remains significant relative to these benchmarks. Third, to allow for hedge-fund return "smoothing", the performance of liquidity-risk strategies are analyzed for different length of holding periods from one month up to twelve months. The rebalancing frequency does not significantly impact the profitability of the strategies. Fourth, a close attention is paid to the summer of 2007. The liquidity-risk strategy seems to capture this liquidity event as it underperforms over August-October (-5%), which further strengthens the use of the liquidity factor as an indicator of market conditions. Moreover, August 2007 has a significant impact on some investment styles (Event Driven, Fixed Income Arbitrage, Global Macro, Long/Short Equity, and Multi Strategy) and less on others, providing further insight into the economic drivers of this event.

Finally, the results of this study have several implications. First, they emphasize the robustness of liquidity pricing because the same liquidity factor that pertains to the cross-section of stock returns also affects the broader universe of hedge-fund returns. Second, from a risk management standpoint, the paper provides a useful tool for evaluating a fund's exposure to liquidity risk. Third, from an asset-allocation perspective, a fund-of-funds manager can structure products that either load on or hedge liquidity risk using the liquidity loadings of individual funds. Last, some doubt the reliability of hedge-fund data because these data are mostly self-disclosed, and therefore subject to return smoothing or self-selection biases; yet, the fact that many funds have significant exposure to liquidity risk and that liquidity risk systematically impacts the cross-section of hedge-fund returns suggests that even if such biases are present, liquidity risk is not one of their important sources.

The rest of this paper is organized as follows. Section 1 describes the data used for this study. Section 2 investigates the exposure of various investment styles to liquidity risk, while Section 3 extends the analysis to the cross-section of individual funds. Additional tests are provided in Section 4. Section 5 concludes.

1 Data

Monthly hedge-fund return data are obtained from the TASS database for the period 1994–2007. The sample includes both operating, "Live" funds and "Graveyard" funds (that no longer report to TASS), which reduces the impact of survivorship bias. Only funds that report their returns on a monthly basis and net of all fees (management, incentive, and other expenses) are kept in the sample. The returns are based on US dollar, and are excess of the risk-free rate. For further details on the construction of the data sample see Klebanov (2008).

Table 1 reports some summary statistics of the sample used for this study. Overall, the sample includes 10,038 hedge funds, varying from 1,095 in 1994 to 6,727 in 2007. The average monthly hedge-fund return is 49 basis points and the average monthly cross-sectional standard deviation is 5.92%. Comparing the return distribution across the sample years, Panel A shows that the minimum and the percentiles 1, 25, 50, 75, and 99, are similar across all years. Interestingly, the return distribution during 2006–2007 seems to include some very high returns: the maximum return is about an order magnitude higher than that during previous years. This is also reflected in the magnitude of the standard deviations: about 12% during 2006–2007 compared to about 5% during 1994–2005. It is not clear whether the extreme high returns during 2006–2007 are actual returns or a result of a data error. The tests throughout the paper use the full sample of returns, yet it is important to note that unreported analysis confirms that excluding the extreme returns during the last two years of the sample does not change the results.

Panel B of Table 1 reports the summary statistics by investment style. Each fund in the sample characterizes itself as one of the following 11 investment styles: Convertible Arbitrage, Dedicated Short Bias, Emerging Markets, Equity Market Neutral, Event Driven, Fixed Income Arbitrage, Fund of Funds, Global Macro, Long/Short Equity, Managed Futures, and Multi-Strategy (see the Appendix for further details).[3] Although this classification provides a general idea about a fund's investment style, the ambiguity about the investment specifics as well as the fact that funds self-classify have been a focus of debate in the academic literature. Nevertheless, the different styles exhibit some cross-sectional variation in average returns, which would be valuable for testing the potential impact of liquidity risk.

[3] Funds of funds are kept in the sample and are treated as a separate investment style because they can be viewed as targets of investment by a fund-of-funds-of-funds.

The primary liquidity measure used here is based on the price-impact factors constructed in Sadka (2006). These measures are extracted from the Trades and Quotes (TAQ) tick-by-tick data following the empirical market microstructure model of Glosten and Harris (1988), along with various empirical findings in the literature (such as adjustments for block trades and possible auto-correlation in the order flow). The Glosten and Harris model allows the separation of price impact into permanent and transitory price effects. The distinction between permanent and transitory components of liquidity is achieved by classifying transaction-price changes into those whose effects persist in the following transaction versus those that vanish. A permanent change in the stock price is associated with a change in its perceived intrinsic value (i.e., informational effect) and is dependent on both the amount of informed trading and the amount of noise trading (see Kyle (1985) and Admati and Pfleiderer (1988)). In contrast, a transitory price change corresponds to market-making costs, such as the costs associated with inventory maintenance and order processing or search (i.e., the non-informational effect). In addition, the Glosten and Harris model allows each of the permanent and transitory components to have a fixed and a variable cost with respect to trade size.

The four components of price impact, permanent-fixed, transitory-fixed, permanent-variable, and transitory-variable, are estimated in Sadka (2006) for the period 1983–2001. Here I use the same procedure to update the factors through December 2007. First, the components of price impact are estimated monthly, by stock, for the remaining period 2002–2007 using tick-by-tick data, which generally provide hundreds or even thousands of observations per month. Then, these firm-specific estimates are aggregated to form monthly market-wide estimates of each component of liquidity. As liquidity is highly persistent, I follow the literature to generate a time series of uncorrelated shocks for each price-impact component by applying an AR(3) model over the sample period 1994–2007 and using the residuals as proxies of shocks.[4] Finally, since price impacts measure illiquidity rather than liquidity, I add a negative sign to each time series, so that a positive shock can be interpreted as an improvement to market liquidity. Sadka shows that only the permanent-variable component is priced in the cross-section of momentum and post-earnings-announcement-drift portfolios. This paper therefore also focuses on the permanent-variable component, while other measures of liquidity including the other three components of price impact are investigated in a

[4]The literature typically applies an adjustment with only two lags (e.g. Pástor and Stambaugh (2003)), however over 1994–2007 liquidity seems to be more persistent and therefore AR(3) seems to work better in estimating shocks. Using AR(2) or first differences only strengthens the results of this paper.

later section. The permanent-variable component is henceforth simply referred to as the liquidity factor.

Figure 1 plots the liquidity factor over the sample period. Consistent with the notion of liquidity dryouts, the most negative shocks to liquidity occur on September 1998 and August 2007, corresponding to the Russian bond default and the fall of LTCM in 1998 and the Quant liquidity crisis of summer 2007. Interestingly, two additional negative liquidity shocks are apparent: January 2001 and October 2007. The first is somewhat counter intuitive, because the decimalization on NYSE that began in January 2001 would imply improvement in market liquidity. In contrast, the transitory-fixed liquidity factor, which is likely highly related to the bid-ask spread, significantly increases during January 2001. The opposite pattern of the permanent-variable component during January 2001 suggests that although bid-ask spreads dropped considerably following decimalization, the variable price-impact cost has increased. One possible explanation is that the reduction in bid-ask spread forced many relatively small liquidity providers to exit the market, and with less liquidity providers price impact increases.

In addition to the liquidity factor, the paper also includes various factors shown to be important in the hedge-fund literature (see, e.g., Fung and Hsieh (2001, 2004) and Fung, Hsieh, Naik, and Ramadorai (2008)). These are: MKT-RF and SMB of Fama and French (1993), the change in the term spread (the monthly change in the 10-year treasury constant maturity yield), the change in the credit spread (the monthly change in Moody's Baa yield less 10-year treasury constant maturity yield), and the trend-following factors of Fung and Hsieh (2001, 2004), namely, PTFSBD (bonds), PTFSFX (currencies), and PTFSCOM (commodities).[5] I also include the change in the volatility index, VIX. Table 2 presents the pairwise time-series correlation of these factors. The main conclusion pertaining to liquidity is that liquidity does not seem to significantly covary with any of the other factors. The factor most correlated with liquidity (in absolute value) is credit spread—the correlation is -0.31. This negative correlation suggests that deterioration in credit (credit spread widening) is contemporaneously correlated with a drop in liquidity, which is consistent with some views about the driving forces of the liquidity crisis of August 2007. Interestingly, both the market return and VIX do not exhibit a significant correlation with liquidity. For example, the market return during September 1998 and August 2007 is 5.92% and 0.74%, respectively. In other words,

[5] I thank Ken French and David Hsieh for providing their risk factors on their respective web sites: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html and http://faculty.fuqua.duke.edu/~dah7/DataLibrary/TF-FAC.xls.

there is nothing special about the market return during these months that would indicate they exhibit the most negative liquidity shocks during the sample period. Similarly, the trend-following factors also do not correlate significantly with liquidity. Given concerns about low power for tests that use relatively short time series, and the low correlation with liquidity, in what follows I do not include SMB and the three trend-following factors in the analysis.

2 Investment Style Exposure to Liquidity Risk

I begin the analysis of hedge-fund returns and liquidity risk with an examination of the different hedge-fund indices. Table 3 reports the results of two time-series regressions for each investment style index: (1) regression of index returns on the market return and the liquidity factor, and (2) the latter regression while adding the change in term spread, the change in credit spread, and the change in VIX. The results indicate that five of the eleven indices (Convertible Arbitrage, Emerging Markets, Event Driven, Fixed Income Arbitrage, and Long/Short Equity) exhibit a positive and significant loading on the liquidity factor for regression (1), while three remain significant after including the additional variables in regression (2). Two indices (Dedicated Short Bias and Managed Futures) have negative, albeit statistically insignificant, liquidity loadings.

Generally, the liquidity risk of the different indices makes economic sense. For example, strategies based on corporate news such as the post-earnings-announcement drift would be included in the Event Driven investment style. Sadka (2006) shows this earnings momentum strategy significantly loads on liquidity risk, the intuition being that such a strategy requires relatively high turnover; therefore an arbitrageur following this strategy would be averse to unexpected market liquidity declines that increase the cost of rebalancing the portfolio. Thus, it is perhaps not surprising that the Event Driven investment style is also significantly related to liquidity risk. Another example is the Dedicated short bias investment style. This style has a negative loading on liquidity risk, which suggests managers whose funds are characterized under this style engage in short positions in assets whose value decreases when market liquidity drops.

Nevertheless, as style definitions are quite broad and hedge funds typically engage in multiple strategies, the analysis in Table 3 may be viewed as a way of understanding the actual liquidity risk imbedded in each style, rather than a confirmation of our prior notion of liquidity risk of each style. From a practical standpoint, the fact that liquidity loading varies across investment styles is

important for the viability of liquidity as a potential pricing factor in the space of hedge funds—if all investment styles were to exhibit a similar liquidity loading then liquidity risk would not be able to explain the difference in their performances. Figure 2 plots the average monthly return (excess of risk-free rate) of each investment style along with its liquidity loading. Dedicated Short Bias has both the lowest return and liquidity loading, while the top two performing indices, Emerging Markets and Long/Short Equity, exhibit the top two liquidity loadings. Although not a formal test, the evidence is consistent with the pricing of liquidity risk in the cross-section of hedge-fund styles: the higher the liquidity loading the higher the average performance. A more formal test can be obtained using the cross-sectional regression framework of Fama and MacBeth (1973). Using the eleven investment style portfolios, I use the full-sample factor loadings reported in Table 3 (using all factors) to run cross-sectional regressions of monthly style returns on the factor loadings each month (168 months). Then, the time-series means and t-statistics of each factor are calculated. The results of this test indicate liquidity risk is significantly priced with 24 basis points per month per one unit of standard deviation of liquidity loading and a t-statistic of 2.13.

3 Liquidity Risk Sorted Portfolios

The previous section investigates liquidity risk at the investment style level. This section and those that follow investigate the pricing of liquidity risk using individual hedge funds and allowing for time variation in liquidity loadings. Specifically, I form ten portfolios of hedge funds every month (with equal number of funds in each portfolio) using two-year rolling liquidity factor loadings (funds are kept in the portfolios for one month). The liquidity loading of each fund is calculated using a simple regression of the fund's monthly return on the market return and the liquidity factor. In any given month, I only include funds with at least 18 non-missing return observations over the prior 24 months. Two years provide sufficient observations to estimate the liquidity loading, while allowing for time variation, and without losing too many years in the beginning of the sample. Note the results below are robust to using longer rolling windows, and to the inclusion of the other factors in Table 3 in the rolling regressions (provided a sufficiently long rolling window). Portfolio formation therefore begins January 1996 and ends December 2007 (144 monthly observations).

Figure 3 plots the average monthly portfolio return (excess of risk-free rate) of each liquidity-loading decile (in bars) along with their respective t-statistics (in symbols). The figure shows that

the high-liquidity-loading portfolio has the highest average monthly return (0.99%) and the low-liquidity-loading portfolio has the lowest average monthly return (0.30%), while the rest of the portfolio returns generally increase with liquidity loading. The figure also includes the high-minus-low portfolio, whose average monthly return is 0.69% with a t-statistic of 3.22. The performance of the portfolio spread suggests that high-liquidity-loading funds significantly outperform low-liquidity-loading funds in the future, consistent with the interpretation of an expected return premium to holding liquidity risk.

A couple of comments here. First, the portfolio analysis provides a simple way of gauging the economic magnitude of the impact of liquidity risk in the cross-section of hedge-fund returns. The spread is about 8.3% annually, and the t-statistic of 3.22 is quite high considering the short time period of 12 years. For comparison, many studies in asset-pricing that utilize monthly stock returns span across about three times the number of months in this study, which makes the t-statistic comparable to 5.58 over a 36-year time period ($\sqrt{3} \times 3.22 = 5.58$). The annualized Sharpe ratio is 0.93. Sadka (2006) reports an average return spread (high minus low) of 0.44% per month or 5.3% annually, with a t-statistic of 2.43, using liquidity-loading portfolios of equities (for the period 1988–2001). Interestingly, liquidity risk seems to have stronger impact in the cross-section of hedge funds than in equities, suggesting hedge-fund investment strategies significantly vary in their exposure to liquidity risk, while funds that assume liquidity risk are well compensated over the sample period. Second, the high-minus-low portfolio of hedge funds is shown to emphasize the significant difference in the cross-section of funds, yet, in contrast to equities, its construction is not straightforward in practice. For example, some funds may be closed for new investors, and even if open—may not provide entering points every month. In addition, the monthly portfolio rebalancing would require frequent redemptions, which are subject to notice periods and lockups (addressed below). Finally, short selling a hedge fund is not possible, although a negative position with respect to a particular hedge fund can be achieved by assuming the opposite positions to those in which the particular hedge fund is invested, provided information about the fund's positions.

Table 4 reports the performance of liquidity-loading sorted portfolios using all funds, as in Figure 3, and separately using the funds in each investment style (these are dependent sorts—the funds in each style are divided into ten equal size groups each month). The results show that the returns to the high-minus-low portfolio is significant for the styles Emerging Markets, Event Driven, and Fund of Funds. Equity Market Neutral, Managed Futures, and Multi-Strategy funds exhibit

t-statistics a bit above 1, and the rest of the styles are insignificant. In other words, nine of the eleven styles exhibit positive returns—the other two, Dedicated Short Bias and Global Macro, earn negative yet insignificant returns. Note that as an index, Dedicated Short Bias exhibits a negative liquidity loading (Table 3), yet the insignificant return spread suggests these type of funds do not vary much in their exposure to liquidity risk (also, this style only contains 45 funds throughout the sample period). Most notable is the Emerging Markets style that exhibits a 2.64% monthly return spread (31.68% annually), which implies quite a large difference in the liquidity-risk exposure of hedge funds in this style.

The analysis so far focuses on average return, without controlling for potential risk. The literature on hedge-fund risk is still in early stages of development. A well-accepted model is that of Fung and Hsieh (2001, 2004), which includes seven risk factors (also discussed earlier in the paper). The model is quite helpful in analyzing risk attribution in the hedge fund space, but some factors are non-traded (as is the liquidity factor) and therefore the regression intercepts using such factors are not easily interpretable. Therefore, in this paper I control for risk by using an overall hedge-fund index as well as investment style indices (the indices are computed using all funds, and of a particular style; equally weighted). There are several advantages for using this method to control for risk: (1) Since the Fung and Hsieh factors explain style index returns (Fung and Hsieh (2004)) including these indices as benchmarks would effectively control for the Fung and Hsieh factors; (2) the indices are returns and therefore the regression intercepts can be interpreted as risk-adjusted returns; and (3) the use of hedge-fund style indices as benchmarks for performance is increasingly popular among fund-of-funds managers as a way of identifying funds that outperform their peers.

Table 5 reports the risk-adjusted returns of the liquidity-loading portfolio spreads (high-minus-low). The strategy that uses all funds earns a risk-adjusted return of 0.47% per month after controlling for the market return, and 0.43% when the hedge-fund index is added (t-statistics are 2.29 and 1.92, respectively). The portfolio spread that uses funds within a particular investment style is regressed on the market portfolio, the hedge-fund index, and that particular style index. Generally, the loadings on the market return, the hedge-fund index and the style index are quite low, and the regression R^2 are close to zero. This is consistent with other findings in the asset-pricing literature about long-short portfolio spreads (see, e.g., Grundy and Martin (2001) for the case of price-momentum strategies). Overall, the risk-adjusted returns are somewhat lower than the average returns calculated in Table 4, yet some, for example the monthly risk-adjusted returns

of Emerging Markets (2.31%) and Event Driven (0.70%), remain statistically significant.

4 Additional Tests

The previous sections introduce the main result of the paper about the impact of liquidity risk exposure on the cross-section of hedge-fund returns. In what follows the paper provides additional analysis and discussion to highlight the significance of the results.

4.1 Share Restrictions

This paper emphasizes the role of liquidity risk as measured by the covariance of hedge-fund returns with unexpected changes in aggregate liquidity. Yet, a comparison to a fund's level of illiquidity, as viewed by investors, is naturally called for. For example, funds may include a lockup provision that requires that all initial monies allocated to the fund not be withdrawn before the end of a pre-specified period (lockup period). Also, funds typically include a redemption notice period, which is the amount of notice investors are required to provide before redeeming shares. Unlike the lockup period, the notice period is a rolling restriction and applies throughout the investor's tenure. These restrictions provide a well-defined window in which investors could redeem their shares, and therefore may well proxy the degree of share illiquidity for hedge fund investors. Lockup and notice periods are easily observable on by reviewing a funds' limited partnership agreements and they are readily available on the TASS database. Aragon (2007) investigates the impact of share restrictions on fund performance. He finds that funds that include a lockup period outperform funds that do not include lockups. Similarly, the longer the redemption notice period the higher the fund's return. These finding suggest investors are compensated for investing in illiquid funds, which is analogous to the illiquidity premium observed for stocks (see, e.g., Amihud and Mendelson (1986)).

To investigate the relation of share restrictions and exposure to liquidity risk, funds are separated into groups according to their lockup and redemption notice periods and then the funds in each group are sorted into ten liquidity-loading portfolios as in Table 4. I generally follow Aragon (2007) in the construction of the lockup and redemption notice period variables. Since lockups are heavily clustered around zero and 12 months, in the tests below lockup is assigned a value of 0 if there is no lockup period, and 1 otherwise. As for redemption notice periods, funds are divided into groups corresponding to intervals using 0, 30, 60, 90, and 365 days. Note that 9,370 funds of the 10,030

included in the sample report a lockup period and a redemption notice period. These variables remain constant for each fund throughout the sample period. Ex-ante, the relation between the illiquidity of a fund and the fund's liquidity risk is not obvious. For example, the performance of a fund with high liquidity risk and weak share restriction may suffer during a market-wide liquidity shock if investors pull out rapidly, which would cause additional price pressure thereby exacerbating the fund's losses. A fund that has more time to "work the trades" may experience less losses, however, such a fund may choose to invest in more illiquid assets to begin with.

The results are reported in Table 6. First noticeable is that the results in Aragon (2007) for 1994–2001 continue to hold throughout 2007: Panel A shows that for each liquidity loading portfolio, the funds with a lockup value of 1 outperform those with a value of 0. The results in Panel B are a bit weaker insofar as the funds with long redemption notice periods generally outperform those with short periods, but only for notice periods of up to 60 days. Nevertheless, the main results about liquidity risk remain significant within each share restriction group. The returns to the high-minus-low liquidity-loading portfolio varies in the range 0.59–0.78% per month (statistically significant), with the exception of funds with notice periods of above 90 days, which exhibit yet a higher monthly return spread of 1.30% (albeit a t-statistic of 1.44). The results therefore suggest that the impact of liquidity risk on the cross-section of hedge-fund returns is independent of the share restriction effect. The conclusion is that the liquidity a fund provides to its investors need not necessarily reflect on the fund's exposure to aggregate liquidity variations.

4.2 Long-Run Performance

The voluntary nature of a fund's reporting to TASS and its impact on the reliability of the reported returns has been a center of debate in the literature. One effect that is often mentioned is return "smoothing". The underlying reasoning is that a fund applies discretion while reporting its returns, typically resulting with returns that are smoothed over a few months, which reduces the fund's measured volatility. This is possible particularly when a fund holds illiquid, infrequently traded assets that are not marked-to-market often. Such "smoothing" suggests that measuring a fund's performance over a long period may be more indicative of its performance. To study this effect, Table 7 reports long-run returns of the liquidity-loading portfolios of Table 4. Specifically, the table uses multiple month cumulative returns computed for non-overlapping intervals. For example, to calculate a three-month holding period return, portfolios are rebalanced only in the beginning of

January, April, July, and October of each year. The reported returns are annualized to facilitate easy comparison across different holding periods. Overall, the results indicate that the performance of the liquidity-loading portfolios does not significantly vary with the holding period and rebalancing frequency. The high-minus-low return spread varies over 6.89–8.96% per year, which is comparable to the 8.3% obtained using monthly rebalancing (Table 4). From a practical point of view, the long-run performance of the high-minus-low return spread also relaxes some concerns about the monthly portfolio rebalancing, which would require redemptions subject to notice periods and lockups.

Figure 4 provides another way of presenting these results. Each panel plots the time series of the returns to the high-minus-low return spread assuming the portfolio is formed in the beginning of each month, yet returns are cumulated over the following few months without rebalancing. For example, Panel C plots the 12-month-ahead return for the high-minus-low portfolio while keeping the funds fixed for 12 months, and the portfolio is reformed in each month. In other words, the return for March 2003 is the return to the strategy over March 2003 through February 2004 (funds are kept for 12 months), then in April 2003 the portfolio is formed again (according to the prior 24-month liquidity loading) and the return for April 2003 is computed for April 2003 through March 2004. This is a way of gauging the profitability of the strategy over longer holding periods without a particular starting month. Panel C suggests that no matter when the portfolio is formed during the sample period, as long as it is not rebalanced for 12 months, it is likely to earn positive profits most of the time. This result reflects the fact that extreme negative liquidity shocks are rare during the sample period (see more discussion below).

4.3 Hedge-Fund Persistence

As discussed above, one of the potential effects of fund return smoothing is that it induces a bias in the measurement of risk. For stock returns, some methods have been suggested to mitigate the effects nonsynchronous trading, e.g., the Scholes and Williams (1977) betas and the Dimson (1979) correction. These methods typically consider lags of market return in addition to the contemporaneous return as means of identifying price reactions to information among illiquid securities which do not trade often. In a similar spirit, Getmansky, Lo, and Makarov (2004) develops a measure of illiquidity of hedge funds based on a funds return autocorrelation.

Given that the liquidity-loading portfolios formed in this paper use a relatively short rolling window, I implement a simple way to address the return persistence issue by adding lag market

return when calculating the liquidity loading. Since each regression estimates three loadings (market, lag market, and liquidity) and an intercept, I use a three-year rolling window instead of two years (portfolios are therefore formed from January 1997 through December 2007, 132 months). The results of the analysis are presented in Table 8, using various holding periods as in Table 7. Similar to the results of Tables 4 and 7, average returns generally increase from the low- to the high-loading portfolio, resulting with statistically significant high-minus-low return spreads. The magnitudes of the spreads are about half of those obtained without adding lag market return in the rolling regression used to estimate the liquidity loading. The evidence therefore implies that even though considering hedge-fund return persistence reduces the magnitude of the effect, liquidity risk remains an important factor in the cross-section of hedge-fund returns.

4.4 The Quant Crisis of August 2007

I would like to pay a closer attention to the events of August 2007 (see Khandani and Lo (2007) for a potential explanation for this liquidity crisis). It is difficult to apply formal tests given a single event, nevertheless some simple statistics pertaining to liquidity risk may prove useful for our understanding of this event. Table 9 reports the three-month cumulative returns of the high-minus-low liquidity-loading return spread portfolio over 2007; funds are kept in the portfolios for three months; and portfolios are formed each month. The portfolio that uses all funds seems to underperform when it is formed in August compared to the rest of the months: the August-October return is -5% while the rest of the three-month returns do not drop below -1.76% (for February formation month). Thus, not only does the liquidity factor exhibit a significant drop during August 2007 as mentioned earlier in the discussion of Figure 1, but also the liquidity-loading sorted portfolio captures the same liquidity event.

Additional insight can be drawn from analyzing the portfolios of different investment styles. Eyeballing the returns reported in Table 9 suggests that some investment styles are more affected by this liquidity event than others. It seems that August 2007 has significant impact on the styles Event Driven, Fixed Income Arbitrage, Global Macro, Long/Short Equity, and Multi-Strategy and less impact on the other styles. This evidence suggests that the August 2007 effect is not necessarily concentrated in a single strategy. Some may view the evidence as suggesting that the style classification is not sufficiently fine to significantly distinguish between fund strategies, and/or that funds that self-classify in a particular style apply multiple strategies, some of which may be

related/exposed to other styles. Nonetheless, the results are consistent with conventional wisdom suggesting that at the heart of the crisis were Multi-Strategy funds suffering loss of credit, and securitized, structured, and real-estate related portfolios (Fixed Income Arbitrage), which were forced to meet Value-at-Risk (VAR) requirements and margin calls by liquidating their more liquid strategies (Long/Short Equity and quantitative strategies).

4.5 Alternative Measures of Aggregate Liquidity

It is well recognized that liquidity can be measured in various ways. Some measures may produce somewhat different results because they may capture different aspects of liquidity (see Korajczyk and Sadka (2008)). Table 10 repeats the liquidity-loading portfolio sorts of Table 4 with five additional measures of liquidity: Pástor and Stambaugh (2003), Acharya and Pedersen (2005), and the other three price-impact components of Sadka (2006).[6] The results show that the most significant high-minus-low return spread is obtained using the transitory-fixed factor (0.40% per month with a t-statistic of 1.68), while none of the other measures produce significant return spreads. The fact that of the four price-impact measures only the permanent-variable affects the cross-section of hedge funds is perhaps not surprising given similar results in the cross-section of stock returns (Sadka (2006)). Yet, the fact that the measures of Pástor and Stambaugh (2003) and Acharya and Pedersen (2005) do not produce significant return spreads is perhaps more puzzling. Nevertheless, two comments are noteworthy in this respect. First, the return spread is positive for both measures, and returns seem to increase from the low to the high decile portfolio but the difference is not statistically significant. Second, the Pástor and Stambaugh (2003) measure is based on price reversals, while the Amihud (2002) measure used in Acharya and Pedersen (2005) is highly correlated with the bid-ask spread (also typically associated with reversals, temporary price effects). Therefore, the evidence may also suggest that the aspect of liquidity associated with permanent rather than transitory effects is important for pricing. The intuition from Kyle (1985) and Admati and Pfleiderer (1988) about the economic interpretation of permanent price effects may imply that the exposure to the variation in the informed to uninformed ratio is important for understanding the cross-section of hedge-fund returns.

[6] The aggregate measure of Pástor and Stambaugh (2003) is available via Wharton Research Data Services (WRDS) through December 2006 (the results using this measure are therefore for the period 1994–2006). To obtain the aggregate measure of Acharya and Pedersen (2005), I follow the procedures described in that study using data through December 2007.

5 Conclusion

This paper provides empirical evidence for the importance of considering liquidity as a risk factor in hedge-fund returns. Funds that significantly load on liquidity risk earn high future returns during 1994–2007, suggesting that the performance of many funds over this time period may be due to beta (systematic liquidity risk) rather than alpha (risk-adjusted returns; management skill). The results of this study have several implications. First, they emphasize the robustness of liquidity pricing because the same liquidity factor that pertains to the cross-section of stock returns also affects the universe of hedge-fund returns. Second, from a risk management standpoint, the paper provides a useful tool for evaluating the liquidity risk the fund is exposed to. Third, from an asset allocation perspective, a fund-of-fund manager can structure products that either load on or hedge liquidity risk using the liquidity risk attributes of individual funds. Last, some doubt the reliability of hedge-fund data because they are mostly self-disclosed, and therefore subject to return smoothing or self-selection biases; yet, the fact that many funds have significant exposure to liquidity risk and that the liquidity risk systematically impacts the cross-section of hedge-fund returns suggests that even if such biases are present, liquidity risk is not one of their important sources.

Appendix

The investment styles used in TASS are based on the definitions of Credit Suisse Tremont Index LLC's series of sub-indices, which are designed to track the primary categories of investment styles used by hedge fund managers. Below are the definitions of the different styles.

- Convertible Arbitrage: This strategy is identified by hedge investing in the convertible securities of a company. A typical investment is to be long the convertible bond and short the common stock of the same company. Positions are designed to generate profits from the fixed income security as well as the short sale of stock, while protecting principal from market moves.

- Dedicated Short Bias: Dedicated short sellers were once a robust category of hedge funds before the long bull market rendered the strategy difficult to implement. A new category, short biased, has emerged. The strategy is to maintain net short as opposed to pure short exposure. Short bias managers take short positions in mostly equities and derivatives. The

short bias of a manager's portfolio must be constantly greater than zero to be classified in this category.

- Emerging Markets: This strategy involves equity or fixed income investing in emerging markets around the world. Because many emerging markets do not allow short selling, nor offer viable futures or other derivative products with which to hedge, emerging market investing often employs a long-only strategy.

- Equity Market Neutral: This investment strategy is designed to exploit equity market inefficiencies and usually involves being simultaneously long and short matched equity portfolios of the same size within a country. Market neutral portfolios are designed to be either beta or currency neutral, or both. Well-designed portfolios typically control for industry, sector, market capitalization, and other exposures. Leverage is often applied to enhance returns.

- Event Driven: This strategy is defined as equity-oriented investing designed to capture price movement generated by an anticipated corporate event. There are four popular sub-categories in event-driven strategies: risk arbitrage, distressed securities, Regulation D and high yield investing.

  Risk Arbitrage: Specialists invest simultaneously in long and short positions in both companies involved in a merger or acquisition. Risk arbitrageurs are typically long the stock of the company being acquired and short the stock of the acquirer. The principal risk is deal risk, should the deal fail to close.

  Distressed Securities: Fund managers invest in the debt, equity or trade claims of companies in financial distress and generally bankruptcy. The securities of companies in need of legal action or restructuring to revive financial stability typically trade at substantial discounts to par value and thereby attract investments when managers perceive a turn-around will materialize.

  Regulation D, or Reg. D: This subset refers to investments in micro and small capitalization public companies that are raising money in private capital markets. Investments usually take the form of a convertible security with an exercise price that floats or is subject to a look-back provision that insulates the investor from a decline in the price of the underlying stock.

  High Yield: Often called junk bonds, this subset refers to investing in low-graded fixed-income securities of companies that show significant upside potential. Managers generally buy and

hold high yield debt.

- Fixed Income Arbitrage: The fixed income arbitrageur aims to profit from price anomalies between related interest rate securities. Most managers trade globally with a goal of generating steady returns with low volatility. This category includes interest rate swap arbitrage, US and non-US government bond arbitrage, forward yield curve arbitrage, and mortgage-backed securities arbitrage. The mortgage-backed market is primarily US-based, over-the-counter and particularly complex.

- Global Macro: Global macro managers carry long and short positions in any of the world's major capital or derivative markets. These positions reflect their views on overall market direction as influence by major economic trends and/or events. The portfolios of these funds can include stocks, bonds, currencies, and commodities in the form of cash or derivatives instruments. Most funds invest globally in both developed and emerging markets.

- Long/Short Equity: This directional strategy involves equity-oriented investing on both the long and short sides of the market. The objective is not to be market neutral. Managers have the ability to shift from value to growth, from small to medium to large capitalization stocks, and from a net long position to a net short position. Managers may use futures and options to hedge. The focus may be regional, such as long/short US or European equity, or sector specific, such as long and short technology or healthcare stocks. Long/short equity funds tend to build and hold portfolios that are substantially more concentrated than those of traditional stock funds.

- Managed Futures: This strategy invests in listed financial and commodity futures markets and currency markets around the world. The managers are usually referred to as Commodity Trading Advisors, or CTAs. Trading disciplines are generally systematic or discretionary. Systematic traders tend to use price and market specific information (often technical) to make trading decisions, while discretionary managers use a judgmental approach.

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Table 1
Summary Statistics

This table reports summary diagnostics for the sample of hedge funds in TASS. The statistic N is either the number of different hedge funds each year (Panel A) or for each investment style over the entire sample period (Panel B). The rest of the statistics (minimum; 1, 25, 50, 75, and 99 percentiles; maximum; and standard deviation) are time-series averages of monthly cross-sectional statistics: In Panel A statistics are averages over the 12 months of each year; in Panel B the statistics are first obtained each month from the cross-section of hedge funds in each investment style and then averaged over the 168 months of the sample. Panel C reports the total number of hedge funds in the samle as well as other statistics averaged over the 168 months of the sample.

	N	Min	P1	P25	P50	P75	P99	Max	Std
Panel A. All funds, per year									
1994	1,095	-0.3243	-0.1284	-0.0228	-0.0024	0.0160	0.1381	0.3703	0.0477
1995	1,382	-0.3803	-0.1108	-0.0102	0.0061	0.0236	0.1557	0.8627	0.0559
1996	1,693	-0.4420	-0.1173	-0.0089	0.0078	0.0256	0.1617	0.4852	0.0498
1997	1,959	-0.3820	-0.1419	-0.0110	0.0083	0.0282	0.1639	0.5953	0.0530
1998	2,264	-0.5454	-0.1975	-0.0224	0.0012	0.0239	0.1726	0.8985	0.0668
1999	2,613	-0.4268	-0.1300	-0.0093	0.0099	0.0333	0.2111	0.6728	0.0596
2000	2,972	-0.4861	-0.1762	-0.0214	0.0025	0.0254	0.1972	0.5598	0.0642
2001	3,497	-0.4164	-0.1406	-0.0139	0.0019	0.0166	0.1434	0.6530	0.0491
2002	4,085	-0.3889	-0.1083	-0.0104	0.0026	0.0180	0.1207	0.5292	0.0401
2003	4,841	-0.3168	-0.0654	-0.0013	0.0108	0.0292	0.1227	0.6461	0.0362
2004	5,775	-0.2620	-0.0646	-0.0048	0.0060	0.0188	0.0894	0.3676	0.0277
2005	6,505	-0.5271	-0.0686	-0.0124	0.0015	0.0139	0.0880	0.4343	0.0304
2006	6,879	-0.3882	-0.0664	-0.0052	0.0067	0.0204	0.0921	7.9542	0.1241
2007	6,727	-0.4796	-0.0801	-0.0075	0.0056	0.0199	0.1023	7.8496	0.1243
Panel B. Full sample, by investment style									
Convertible Arbitrage	219	-0.0767	-0.0626	-0.0036	0.0041	0.0121	0.0706	0.0821	0.0224
Dedicated Short Bias	45	-0.0861	-0.0861	-0.0275	-0.0001	0.0251	0.0821	0.0821	0.0443
Emerging Markets	486	-0.1705	-0.1271	-0.0199	0.0048	0.0329	0.1893	0.2785	0.0564
Equity Market Neutral	544	-0.0921	-0.0672	-0.0070	0.0046	0.0185	0.0884	0.1321	0.0290
Event Driven	674	-0.1335	-0.0682	-0.0040	0.0053	0.0156	0.1073	0.2084	0.0306
Fixed Income Arbitrage	412	-0.1114	-0.0903	-0.0041	0.0049	0.0142	0.0886	0.1044	0.0278
Fund of Funds	2,900	-0.1639	-0.0675	-0.0079	0.0040	0.0164	0.0753	0.1792	0.0264
Global Macro	457	-0.1699	-0.1363	-0.0172	0.0032	0.0246	0.1519	0.2069	0.0483
Long/Short Equity	2,807	-0.2681	-0.1104	-0.0139	0.0076	0.0308	0.1471	1.4211	0.0742
Managed Futures	821	-0.2759	-0.1492	-0.0235	0.0036	0.0307	0.1697	0.3452	0.0603
Multi-Strategy	673	-0.1562	-0.1070	-0.0080	0.0055	0.0199	0.1218	0.1971	0.0379
Panel C. All funds, full sample									
	10,038	-0.4119	-0.1140	-0.0115	0.0049	0.0223	0.1399	1.6342	0.0592

Table 2
Correlations

The table reports the pairwise time-series correlations of various aggregate measures used for the analysis. The variables are the market portfolio (excess of risk-free rate), SMB of Fama and French (1993), change in term spread, change in credit spread, change in VIX, the trend-following factors, PTFSBD (bonds), PTFSFX (currencies), and PTFSCOM (commodities) of Fung and Hsieh (2001), and the permanent-variable liquidity factor in Sadka (2006). The sample period is January 1994 to December 2007.

	MKT-RF	SMB	ΔTERM	ΔCREDIT	ΔVIX	PTFSBD	PTFSFX	PTFSCOM
SMB	0.21							
ΔTERM	0.07	0.14						
ΔCREDIT	-0.17	-0.29	-0.05					
ΔVIX	-0.69	-0.14	-0.18	0.12				
PTFSBD	-0.15	-0.03	0.05	0.08	0.28			
PTFSFX	-0.10	0.02	-0.06	0.13	0.16	0.16		
PTFSCOM	-0.07	-0.01	0.01	0.05	0.07	0.16	0.26	
Liquidity	-0.02	0.06	-0.03	-0.31	-0.09	-0.07	0.00	0.08

Table 3
Time-Series Regressions of Hedge Fund Returns on Different Factors

The table reports the results of time-series regressions of hedge-fund returns portfolios on various factors. Hedge funds are sorted monthly into eleven portfolios according to investment style (portfolio returns are equally weighted). Monthly portfolio returns are regressed on the market portfolio, the change in the term spread, the change in the credit spread, the change in VIX, and the Sadka (2006) liquidity factor. The analysis includes the hedge-fund universe on TASS for the period January 1994 to December 2007.

Investment Style	Intercept	MKT-RF	ΔTERM	ΔCREDIT	ΔVIX	Liquidity	R-Square / Adj. R-Square
Convertible Arbitrage	0.0036	0.1229				0.4763	0.21
	[4.32]	[6.22]				[2.18]	0.20
	0.0035	0.1445	0.0019	-0.0127	0.0005	0.3981	0.24
	[4.19]	[5.23]	[0.70]	[-1.82]	[1.52]	[1.73]	0.21
Dedicated Short Bias	0.0049	-1.0372				-0.5604	0.75
	[2.54]	[-22.48]				[-1.10]	0.75
	0.0051	-1.0724	-0.0096	-0.0180	-0.0005	-0.8160	0.76
	[2.61]	[-16.47]	[-1.48]	[-1.09]	[-0.68]	[-1.50]	0.75
Emerging Markets	0.0047	0.6350				1.7891	0.42
	[1.86]	[10.60]				[2.70]	0.41
	0.0049	0.6243	0.0016	-0.0580	0.0003	1.2296	0.45
	[1.97]	[7.49]	[0.19]	[-2.75]	[0.35]	[1.77]	0.43
Equity Market Neutral	0.0056	0.0569				0.1685	0.09
	[9.56]	[4.04]				[1.08]	0.08
	0.0054	0.0879	-0.0048	0.0015	0.0005	0.2204	0.16
	[9.21]	[4.55]	[-2.48]	[0.31]	[2.07]	[1.36]	0.14
Event Driven	0.0056	0.2219				0.7945	0.52
	[7.66]	[12.71]				[4.12]	0.51
	0.0057	0.2238	-0.0010	-0.0272	0.0003	0.5391	0.58
	[8.07]	[9.60]	[-0.44]	[-4.60]	[0.95]	[2.77]	0.56
Fixed Income Arbitrage	0.0041	0.0452				0.5720	0.08
	[5.36]	[2.46]				[2.82]	0.07
	0.0039	0.0860	-0.0048	-0.0235	0.0008	0.4043	0.23
	[5.34]	[3.58]	[-2.01]	[-3.87]	[3.02]	[2.02]	0.20
Fund of Funds	0.0030	0.2012				0.5092	0.28
	[2.78]	[7.84]				[1.80]	0.27
	0.0026	0.2556	-0.0061	-0.0212	0.0010	0.3828	0.35
	[2.48]	[7.36]	[-1.74]	[-2.41]	[2.57]	[1.32]	0.33
Global Macro	0.0032	0.1670				0.3632	0.16
	[2.50]	[5.49]				[1.08]	0.15
	0.0027	0.2303	-0.0066	-0.0104	0.0011	0.3513	0.21
	[2.13]	[5.48]	[-1.57]	[-0.98]	[2.23]	[1.00]	0.18
Long/Short Equity	0.0072	0.4883				0.7184	0.62
	[5.70]	[16.20]				[2.16]	0.61
	0.0067	0.5571	-0.0002	-0.0106	0.0012	0.7326	0.63
	[5.34]	[13.28]	[-0.05]	[-0.99]	[2.54]	[2.09]	0.62
Managed Futures	0.0047	-0.0348				-0.1904	0.00
	[2.05]	[-0.63]				[-0.31]	-0.01
	0.0041	0.0254	-0.0191	0.0055	0.0008	-0.0939	0.05
	[1.77]	[0.33]	[-2.49]	[0.28]	[0.89]	[-0.15]	0.02
Multi-Strategy	0.0047	0.2337				0.2426	0.44
	[5.48]	[11.42]				[1.07]	0.44
	0.0045	0.2553	-0.0043	-0.0088	0.0004	0.1832	0.46
	[5.24]	[8.91]	[-1.51]	[-1.21]	[1.20]	[0.77]	0.45

Table 4
Liquidity-Beta Sorted Portfolios

Each month hedge funds are sorted into 10 equally weighted portfolios according to historical liquidity beta. The liquidity beta is calculated using a regression of monthly portfolio returns on the market portfolio and the Sadka (2006) liquidity factor, using the 24 months prior to portfolio formation. Portfolio returns begin January 1996, using funds with at least 18 months of returns during the prior years. The table reports the average monthly excess return (in percent) for the decile portfolios, as well as the high-minus-low portfolio. The portfolios are separately formed using hedge funds in particular investment styles as well as the entire universe of hedge funds. T-statistics are in square brackets. The analysis includes the hedge-fund universe on TASS for the period January 1994 to December 2007.

Investment Style	Liquidity Beta Deciles										
	1 [low]	2	3	4	5	6	7	8	9	10 [high]	10 - 1
Convertible Arbitrage	0.40	0.36	0.36	0.39	0.37	0.35	0.42	0.53	0.36	0.55	0.16
	[2.20]	[3.02]	[3.98]	[4.46]	[3.84]	[3.43]	[4.75]	[4.04]	[1.87]	[1.78]	[0.60]
Dedicated Short Bias	-0.03	-0.92	-0.25	-0.30	-0.40	-0.08	-0.21	-0.08	0.02	-0.24	-0.21
	[-0.04]	[-1.27]	[-0.41]	[-0.51]	[-0.88]	[-0.17]	[-0.42]	[-0.14]	[0.04]	[-0.28]	[-0.22]
Emerging Markets	0.10	0.38	0.38	0.64	0.68	0.85	0.94	1.20	1.21	2.74	2.64
	[0.18]	[1.14]	[1.05]	[1.97]	[2.09]	[2.40]	[2.51]	[3.00]	[2.57]	[4.25]	[4.91]
Equity Market Neutral	0.44	0.48	0.43	0.41	0.48	0.49	0.34	0.42	0.40	0.69	0.25
	[3.08]	[3.92]	[4.16]	[5.19]	[5.90]	[5.71]	[3.06]	[3.93]	[3.65]	[3.56]	[1.08]
Event Driven	0.53	0.49	0.41	0.49	0.48	0.46	0.54	0.68	0.69	1.25	0.72
	[2.56]	[3.95]	[4.50]	[5.53]	[5.00]	[4.17]	[4.87]	[5.47]	[4.73]	[5.12]	[3.60]
Fixed Income Arbitrage	0.32	0.29	0.48	0.26	0.37	0.29	0.41	0.23	0.45	0.34	0.02
	[1.82]	[2.10]	[4.76]	[2.80]	[4.40]	[2.69]	[3.76]	[1.32]	[3.25]	[1.62]	[0.08]
Fund of Funds	0.00	0.36	0.46	0.47	0.46	0.51	0.60	0.59	0.53	0.57	0.57
	[-0.02]	[2.40]	[3.22]	[3.29]	[3.58]	[3.88]	[4.38]	[3.77]	[3.22]	[2.40]	[2.26]
Global Macro	0.31	0.34	0.36	0.24	0.46	0.42	0.60	0.48	0.37	0.06	-0.25
	[1.18]	[2.13]	[2.20]	[1.58]	[2.87]	[2.43]	[2.67]	[2.21]	[1.54]	[0.15]	[-0.66]
Long/Short Equity	0.92	0.82	0.75	1.21	0.63	0.75	0.79	0.85	0.85	0.98	0.05
	[3.20]	[3.16]	[3.63]	[2.20]	[3.28]	[4.05]	[3.77]	[3.89]	[3.59]	[3.22]	[0.24]
Managed Futures	0.35	0.19	0.34	0.35	0.36	0.39	0.41	0.54	0.76	0.87	0.52
	[0.85]	[0.57]	[1.25]	[1.42]	[1.48]	[1.68]	[1.61]	[2.07]	[2.50]	[2.36]	[1.25]
Multi-Strategy	0.66	0.62	0.56	0.43	0.58	0.64	0.69	0.70	0.61	0.95	0.29
	[2.62]	[3.16]	[3.98]	[2.94]	[5.08]	[6.51]	[5.65]	[4.81]	[3.39]	[3.30]	[1.02]
All	0.30	0.38	0.43	0.60	0.54	0.55	0.61	0.69	0.71	0.99	0.69
	[1.52]	[2.34]	[3.22]	[3.27]	[4.55]	[4.37]	[4.57]	[4.71]	[4.14]	[3.98]	[3.22]

Table 5
Risk-Adjusted Performance

Each month hedge funds are sorted into 10 equally weighted portfolios according to historical liquidity beta. The liquidity beta is calculated using a regression of monthly portfolio returns on the market portfolio and the Sadka (2006) liquidity factor, using the 24 months prior to portfolio formation. Portfolio returns begin January 1996, using funds with at least 18 months of returns during the prior years. The portfolios are separately formed using hedge funds in particular investment styles as well as the entire universe of hedge funds. The table reports the results of regressions of monthly returns of the high-minus-low portfolio on the market portfolio, overall hedge-fund index, and investment-style index (all excess of risk-free rate). The hedge-fund index and the investment-style index are constructed by equal-weighting the sample funds (all and by style). T-statistics are in square brackets. The analysis includes the hedge-fund universe on TASS for the period January 1994 to December 2007.

Investment Style	Intercept (%)	MKT-RF	HF-RF	Style-RF	R-Square / Adj. R-Square
Convertible Arbitrage	-0.17	0.31			0.14
	[-0.63]	[5.10]			0.14
	-0.17	0.34	-0.34	0.65	0.19
	[-0.59]	[4.55]	[-2.17]	[2.44]	0.17
Dedicated Short Bias	0.09	-0.27			0.01
	[0.10]	[-1.29]			0.00
	-0.75	-0.37	0.95	0.17	0.03
	[-0.75]	[-0.85]	[1.90]	[0.48]	0.02
Emerging Markets	2.31	-0.04			0.00
	[4.36]	[-0.30]			-0.01
	2.38	-0.21	-0.35	0.44	0.04
	[4.15]	[-1.26]	[-1.08]	[2.46]	0.02
Equity Market Neutral	0.22	0.03			0.00
	[0.86]	[0.57]			0.00
	-0.16	-0.11	0.51	-0.06	0.09
	[-0.53]	[-1.61]	[3.58]	[-0.17]	0.07
Event Driven	0.70	0.07			0.01
	[3.65]	[1.49]			0.01
	0.43	-0.04	-0.11	0.61	0.06
	[1.93]	[-0.58]	[-0.88]	[2.81]	0.05
Fixed Income Arbitrage	0.20	0.01			0.00
	[0.66]	[0.12]			-0.01
	-0.38	-0.05	0.03	1.25	0.12
	[-1.17]	[-0.55]	[0.17]	[3.88]	0.10
Fund of Funds	0.45	0.09			0.02
	[1.85]	[1.65]			0.01
	0.38	0.08	0.15	-0.13	0.02
	[1.39]	[1.08]	[0.75]	[-0.49]	0.00
Global Macro	-0.55	0.29			0.07
	[-1.52]	[3.43]			0.07
	-0.83	0.19	0.36	-0.04	0.09
	[-2.08]	[1.88]	[1.36]	[-0.14]	0.07
Long/Short Equity	-0.04	0.08			0.02
	[-0.21]	[1.68]			0.01
	0.08	0.18	0.08	-0.24	0.03
	[0.32]	[2.24]	[0.57]	[-1.58]	0.02
Managed Futures	0.16	0.29			0.06
	[0.40]	[3.17]			0.06
	-0.03	0.16	0.43	-0.30	0.10
	[-0.06]	[1.41]	[1.84]	[-2.20]	0.08
Multi-Strategy	0.29	0.11			0.01
	[0.84]	[1.32]			0.00
	0.21	0.07	-0.05	0.20	0.01
	[0.54]	[0.65]	[-0.22]	[0.54]	-0.01
All	0.47	0.14			0.06
	[2.29]	[3.01]			0.05
	0.43	0.13	0.04		0.06
	[1.92]	[2.25]	[0.39]		0.04

Table 6
Share Restriction

Each month hedge funds are sorted into 10 equally weighted portfolios according to historical liquidity beta. The liquidity beta is calculated using a regression of monthly portfolio returns on the market portfolio and the Sadka (2006) liquidity factor, using the 24 months prior to portfolio formation. Portfolio returns begin January 1996, using funds with at least 18 months of returns during the prior years. The table reports the average monthly excess return (in percent) for the decile portfolios, as well as the high-minus-low portfolio for different holding periods for funds with different share restrictions. Portfolios are sorted within each category of share restriction. In Panel A, lockup period is 1 if there exists some positive lockup period, and zero in case of no lockup. Redemption notice period is measured in days, for example (0,30] includes funds with a redemption notice period of above zero days and less than or equal to 30 days. The variable N indicates the number of funds within each share restriction category. T-statistics are in square brackets. The analysis includes the hedge-fund universe on TASS for the period January 1994 to December 2007.

Share Restriction	Liquidity Beta Deciles										
	1 [low]	2	3	4	5	6	7	8	9	10 [high]	10 - 1
Panel A. Lockup Period											
0	0.20	0.35	0.38	0.64	0.49	0.54	0.56	0.66	0.68	0.89	0.68
[N=7,128]	[0.99]	[2.19]	[2.80]	[2.65]	[4.20]	[4.11]	[4.22]	[4.53]	[3.79]	[3.47]	[3.02]
1	0.85	0.66	0.57	0.67	0.68	0.71	0.69	0.76	0.97	1.43	0.58
[N=2,242]	[3.16]	[3.77]	[3.65]	[5.59]	[5.78]	[6.20]	[4.47]	[4.92]	[5.47]	[5.51]	[2.32]
Panel B. Redemption Notice Period (days)											
0	-0.18	0.11	0.21	0.26	0.34	0.39	0.51	0.44	0.71	0.60	0.78
[N=1,239]	[-0.60]	[0.55]	[1.19]	[1.60]	[2.14]	[2.31]	[3.07]	[2.13]	[3.11]	[1.93]	[2.37]
(0,30]	0.36	0.47	0.45	0.80	0.51	0.61	0.63	0.78	0.75	1.06	0.69
[N=4,466]	[1.72]	[2.91]	[3.17]	[2.35]	[4.26]	[4.48]	[4.14]	[4.94]	[4.03]	[4.11]	[2.98]
(30,60]	0.66	0.47	0.56	0.59	0.58	0.57	0.70	0.68	0.91	1.25	0.59
[N=2,378]	[2.71]	[2.93]	[4.22]	[4.82]	[5.05]	[4.59]	[5.75]	[4.74]	[5.43]	[4.26]	[2.57]
(60,90]	0.49	0.65	0.53	0.62	0.51	0.65	0.58	0.64	0.60	1.11	0.61
[N=1,042]	[1.91]	[4.81]	[4.00]	[6.16]	[4.55]	[5.70]	[4.67]	[4.55]	[3.37]	[4.29]	[2.13]
(90, 365]	0.25	0.66	0.45	0.49	0.59	0.44	0.78	0.79	0.45	1.55	1.30
[N=245]	[0.65]	[1.91]	[5.29]	[4.13]	[6.51]	[3.22]	[4.23]	[3.46]	[1.15]	[1.86]	[1.44]

Table 7
Long-Run Performance

Each month hedge funds are sorted into 10 equally weighted portfolios according to historical liquidity beta. The liquidity beta is calculated using a regression of monthly portfolio returns on the market portfolio and the Sadka (2006) liquidity factor, using the 24 months prior to portfolio formation. Portfolio returns begin January 1996, using funds with at least 18 months of returns during the prior years. The table reports the average excess return (in percent, annualized) for the decile portfolios, as well as the high-minus-low portfolio for different holding periods. The portfolios use non-overlapping returns, for example, the 3-month holding period sorts hedge funds in the beginning of January, April, July, and October. T-statistics are in square brackets. The analysis includes the hedge-fund universe on TASS for the period January 1994 to December 2007.

Holding period	Liquidity Beta Deciles										
	1 [low]	2	3	4	5	6	7	8	9	10 [high]	10 - 1
3 months	3.79	4.84	4.92	6.22	6.25	6.43	8.31	8.61	9.26	12.75	8.96
	[1.56]	[2.69]	[2.99]	[4.23]	[4.06]	[3.61]	[3.83]	[4.18]	[3.80]	[3.66]	[2.99]
6 months	4.65	5.42	5.27	5.79	6.06	5.81	7.03	7.18	8.99	11.54	6.89
	[2.12]	[4.09]	[3.66]	[4.49]	[4.88]	[4.18]	[4.26]	[4.36]	[4.24]	[4.05]	[2.20]
12 months	4.61	6.03	5.64	5.77	6.40	6.29	6.92	7.39	9.09	11.82	7.22
	[2.26]	[3.34]	[3.52]	[3.68]	[4.31]	[4.00]	[3.42]	[3.23]	[3.35]	[3.61]	[3.43]

Table 8
Robustness to Hedge-Fund Persistence

Each month hedge funds are sorted into 10 equally weighted portfolios according to historical liquidity beta. The liquidity beta is calculated using a regression of monthly portfolio returns on the market portfolio (contemporaneous and lag) and the Sadka (2006) liquidity factor, using the 36 months prior to portfolio formation. Portfolio returns begin January 1997, using funds with at least 18 months of returns during the prior years. The table reports the average excess return (in percent, annualized) for the decile portfolios, as well as the high-minus-low portfolio. T-statistics are in square brackets. The analysis includes the hedge-fund universe on TASS for the period January 1994 to December 2007.

Holding period	Liquidity Beta Deciles										
	1 [low]	2	3	4	5	6	7	8	9	10 [high]	10 - 1
1 month	6.49	6.17	6.58	5.69	6.52	5.50	6.07	5.89	7.01	10.91	4.42
	[2.43]	[2.98]	[3.91]	[3.58]	[4.47]	[3.71]	[3.85]	[3.51]	[3.39]	[3.15]	[1.72]
3 months	6.31	6.12	6.17	6.17	6.48	5.72	6.06	6.46	7.75	11.96	5.65
	[2.30]	[3.06]	[3.35]	[3.54]	[4.19]	[3.50]	[3.10]	[3.43]	[3.18]	[3.26]	[2.36]
6 months	5.47	6.43	6.12	6.15	6.39	5.60	5.53	5.75	7.67	9.54	4.07
	[2.18]	[3.93]	[3.50]	[4.20]	[4.95]	[4.11]	[3.85]	[3.62]	[3.98]	[3.96]	[2.03]
12 months	6.32	6.34	5.93	6.19	6.23	5.59	6.30	6.91	8.02	9.83	3.50
	[2.15]	[3.00]	[2.82]	[3.62]	[4.08]	[3.15]	[3.17]	[3.07]	[3.03]	[3.32]	[1.78]

Table 9
The Liquidity Crisis of Summer 2007

During each of the first ten months of 2007 hedge funds are sorted into 10 equally weighted portfolios according to historical liquidity beta. The liquidity beta is calculated using a regression of monthly portfolio returns on the market portfolio and the Sadka (2006) liquidity factor, using the 24 months prior to portfolio formation. Portfolios are constructed using funds with at least 18 months of returns during the prior two years, and funds are kept in the portfolios for three months. The table reports the three-month cumulative return (in percent) for the top-minus-bottom decile portfolio. For example, the August column reports the portfolio cumulative return over August-October; the October column reports return over October-December. The portfolios are separately formed using hedge funds in particular investment styles as well as the entire universe of hedge funds.

Investment Style	Portfolio Formation Month									
	January	February	March	April	May	June	July	August	September	October
All	-1.24	-1.76	2.06	3.64	1.92	0.24	-0.89	-5.00	-1.56	0.29
Convertible Arbitrage	0.93	-3.98	-5.14	-4.47	-3.88	-8.88	-9.48	-11.53	-10.52	-15.17
Dedicated Short Bias	11.29	16.23	13.64	3.03	-6.30	-6.50	0.17	18.56	19.28	13.87
Emerging Markets	2.49	0.27	-0.36	3.89	1.27	4.25	4.63	-1.24	0.83	-1.85
Equity Market Neutral	-3.15	-6.18	-2.36	-3.14	-2.46	-1.49	-2.54	-4.87	-1.31	-0.59
Event Driven	0.00	0.62	1.86	2.19	2.10	2.25	1.13	-6.30	-4.47	-4.31
Fixed Income Arbitrage	0.35	-2.57	-0.15	0.09	4.62	5.97	0.07	-9.06	-9.73	-3.73
Fund of Funds	-0.23	-2.21	1.14	1.09	0.88	-0.54	-1.59	-3.80	-0.77	1.38
Global Macro	-0.52	-1.10	2.51	8.34	2.65	-1.76	-3.22	-11.06	-7.62	-11.35
Long/Short Equity	-0.70	-2.28	-0.23	0.85	-0.76	-2.27	-0.74	-4.24	-4.50	-1.34
Managed Futures	-15.52	-5.96	9.69	16.49	-6.44	-10.39	-7.31	-3.31	7.24	8.18
Multi-Strategy	-1.03	-4.30	-1.77	3.77	4.51	2.55	-4.09	-8.79	-2.56	-3.19

Table 10
Alternative Measures of Liquidity

Each month hedge funds are sorted into 10 equally weighted portfolios according to historical liquidity beta. The liquidity beta is calculated using a regression of monthly portfolio returns on the market portfolio and a liquidity factor, using the 24 months prior to portfolio formation. The liquidity factors considered are the permanent-fixed, transitory-fixed, and transitory-variable constructed in Sadka (2006), the aggregate liquidity measure in Pástor and Stambaugh (2003), and the Amihud (2002) measure in Acharya and Pedersen (2005). Portfolio returns begin January 1996, using funds with at least 18 months of returns during the prior years. The table reports the average monthly excess return (in percent) for the decile portfolios, as well as the high-minus-low portfolio. T-statistics are in square brackets. The analysis includes the hedge-fund universe on TASS for the period January 1994 to December 2007.

Liquidity measure	Liquidity Beta Deciles										
	1 [low]	2	3	4	5	6	7	8	9	10 [high]	10 - 1
Permanent-fixed	0.78	0.45	0.43	0.39	0.53	0.59	0.65	0.67	0.62	0.69	-0.08
	[3.94]	[4.25]	[4.25]	[3.86]	[5.01]	[4.94]	[4.35]	[3.87]	[2.84]	[2.13]	[-0.30]
Transitory-fixed	0.51	0.59	0.43	0.48	0.48	0.53	0.58	0.64	0.66	0.91	0.40
	[2.11]	[2.99]	[3.55]	[4.73]	[4.38]	[4.50]	[4.26]	[3.89]	[3.50]	[3.57]	[1.68]
Transitory-variable	0.91	0.64	0.58	0.55	0.51	0.45	0.48	0.51	0.46	0.71	-0.21
	[3.93]	[4.03]	[3.77]	[4.29]	[4.25]	[4.31]	[4.35]	[3.47]	[2.59]	[2.24]	[-0.67]
Pástor-Stambaugh	0.52	0.45	0.51	0.55	0.48	0.54	0.53	0.58	0.69	0.78	0.26
	[1.70]	[2.53]	[3.47]	[4.30]	[4.04]	[4.77]	[4.42]	[4.03]	[3.69]	[2.91]	[0.79]
Acharya-Pedersen	0.49	0.47	0.58	0.46	0.47	0.58	0.61	0.62	0.66	0.84	0.35
	[3.33]	[4.45]	[3.60]	[4.99]	[4.65]	[4.67]	[4.03]	[3.45]	[2.93]	[2.49]	[1.15]

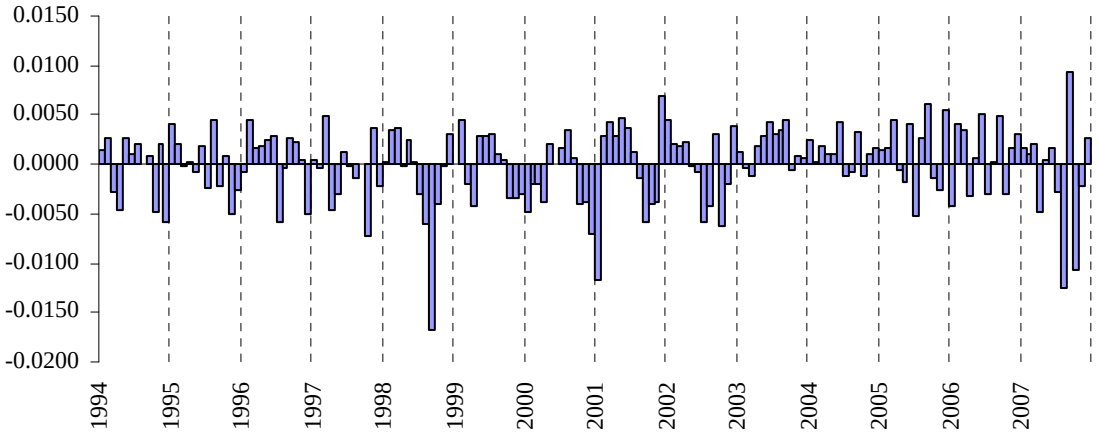


Figure 1. The time series of liquidity innovations. The graph presents the unexpected changes in the permanent-variable component of price impact (Sadka 2006)) for the period January 1994 to December 2007. The vertical dotted lines represent January of each calendar year.

Figure 2. Average hedge fund portfolio excess returns and liquidity beta. Hedge funds are sorted monthly into eleven portfolios according to investment style (portfolio returns are equally weighted). The liquidity beta is calculated using a regression of monthly portfolio returns on the market portfolio, the change in the term spread, the change in the credit spread, the change in VIX, and the Sadka (2006) liquidity factor. The analysis includes the hedge-fund universe on TASS for the period January 1994 to December 2007.

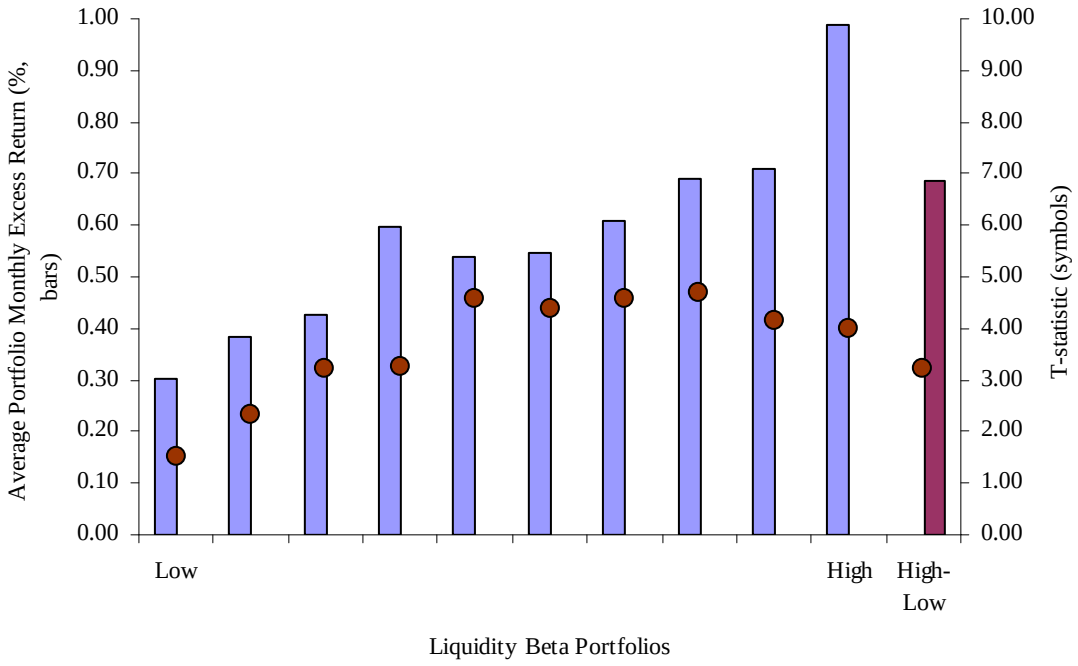
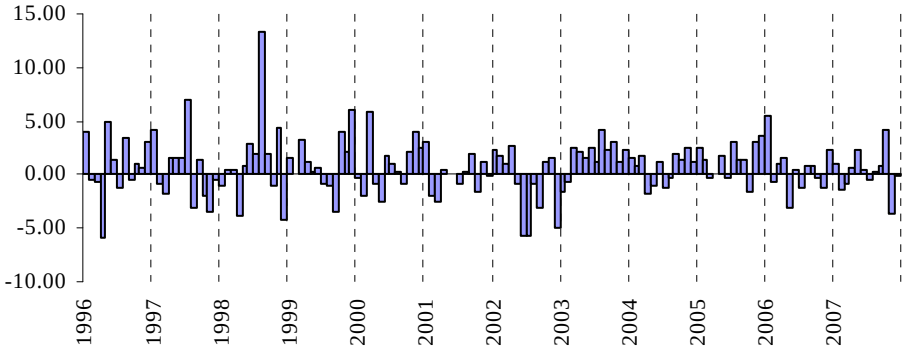
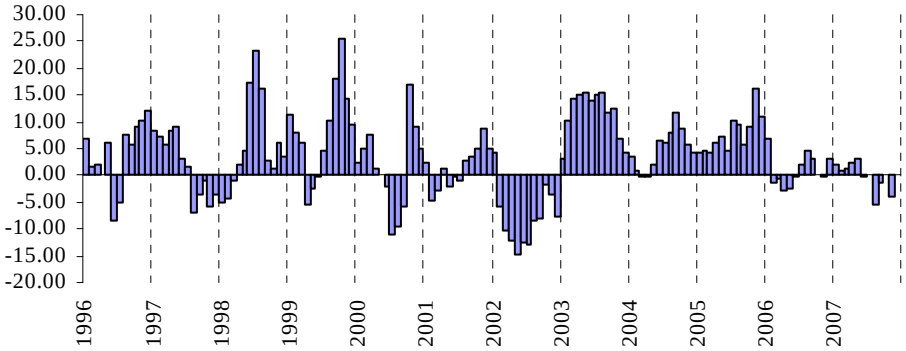


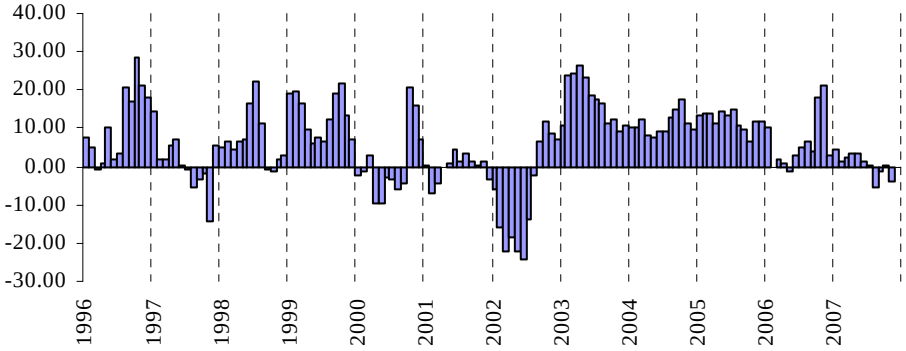
Figure 3. Average excess returns of liquidity-beta sorted portfolios of hedge funds. Each month hedge funds are sorted into 10 equally weighted portfolios according to historical liquidity beta. The liquidity beta is calculated using a regression of monthly portfolio returns on the market portfolio and the Sadka (2006) liquidity factor, using the 24 months prior to portfolio formation. Portfolio returns begin January 1996, using funds with at least 18 months of returns during the prior years. The bars represent portfolio returns and the symbols present their respective *t*-statistics. The figure also displays the high-minus-low liquidity-beta portfolio. The analysis includes the hedge-fund universe on TASS for the period January 1994 to December 2007.



Panel A. One-month holding period



Panel B. Six-month holding period



Panel C. Twelve-month holding period

Figure 4. The time series of high-minus-low liquidity beta portfolios. Each month hedge funds are sorted into 10 equally weighted portfolios according to historical liquidity beta. The liquidity beta is calculated using a regression of monthly portfolio returns on the market portfolio and the Sadka (2006) liquidity factor, using the 24 months prior to portfolio formation. Portfolio returns begin January 1996, using funds with at least 18 months of returns during the prior years. The panels plot the returns to the high-minus-low portfolio for periods of one, six, and twelve months after portfolio formation. The figure also displays the high-minus-low liquidity-beta portfolio. The analysis includes the hedge-fund universe on TASS for the period January 1994 to December 2007.