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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. The results show that funds that significantly load on liquidity risk subsequently outperform low-loading funds by about 6% annually, on average, over the period 1994–2008, while negative performance is observed during liquidity crises. The returns are independent of the liquidity a fund provides to its investors as measured by lockup and redemption notice periods, and they are also robust to commonly used hedge-fund factors, none of which carries a significant premium during the sample period. These findings highlight the importance of understanding systematic liquidity variations in the evaluation of hedge-fund performance.

1. Introduction

Over the past decade the asset-management industry has experienced a tremendous growth of hedge-fund asset value, peaking at $1.93 trillion at the end of June 2008. 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 could hold a variety of asset classes and typically apply sophisticated financial instruments, oftentimes with illiquid securities. For example, many hedge funds implement dynamic trading strategies that could lead to time-varying risk exposures. Fung and Hsieh (1997, 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 financial crisis of fall 2008 have raised questions about 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,

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i.e., the 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 that the risk model is incomplete. 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 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 aggregate measures of liquidity risk, this paper shows that funds that significantly load on liquidity risk subsequently outperform low-loading funds by about 6% annually, on average, over the period 1994–2008, while negative performance is observed during periods of significant liquidity crises. The performance is independent of the illiquidity of a fund as measured by lockup and redemption notice periods. These findings are also robust to risk controls such as the Fung and Hsieh (2001) factors and to portfolio rebalancing frequency. The results therefore 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, which uses bid-ask spreads to measure illiquidity, and Brennan and Subrahmanyam, 1996, which uses price impacts). In contrast, a few recent studies focus on the systematic component of liquidity (liquidity risk) instead of on its actual idiosyncratic level (i.e., liquidity level). This strand of literature begins with studies showing that firm-specific liquidity fluctuates over time and also that a significant systematic, or market-wide component exists 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. To streamline the exposition, this paper mostly applies the Sadka (2006) liquidity factor and shows liquidity is priced in the universe of hedge funds as well. The measures of Pástor and Stambaugh (2003) and Acharya and Pedersen (2005) are also studied here. They exhibit similar results. Most important, independent of the measure used, the high-minus-low liquidity-loading portfolio underperforms during crisis periods and overperforms during noncrisis periods.

This paper measures liquidity risk using the funds' monthly reported return series. Because fund holdings are not readily 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 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.[1] 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 liquidity risk is apparent in most categories 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. This apparent imbalance of fund liquidity versus the liquidity of its assets is consistent with the observed practices of fund management during the financial crisis of fall 2008, as many liquid funds gated their assets in the face of significant redemption claims by investors.

The paper also distinguishes the liquidity risk factor from the commonly used Fung and Hsieh (2001, 2004) factors. First, risk-adjusted portfolio returns are computed throughout the paper using the Fung-Hsieh seven-factor model, which includes measures of access to credit and leverage (the model is slightly augmented by replacing the latter two factors by appropriate tradable portfolios). The returns to the high-minus-low liquidity-loading portfolio remain significant relative to this model, which further emphasizes the need for a liquidity risk factor, currently absent from typical models of hedge-fund performance. Moreover, the results suggest that none of the Fung and Hsieh factor loadings generates a significant return spread cross-sectionally over the sample period. In this context it is important to note that the Fung and Hsieh factors are originally designed to explain time-series return volatilities of hedge funds, not the cross-sectional variation of their expected returns. For example, these factors explain, on average, 54% of the time-series variation of investment-style index returns. Adding the liquidity factor only increases the explained variance by 2.5%. Yet, this factor generates a significant spread in the cross-section of hedge-fund returns. The reason could be that liquidity crises are infrequent yet violent. The infrequency suggests that the liquidity factor would not explain much of the time-series variation of returns, while the violence implies that the risk associated with liquidity crises is priced in the cross-section, despite the rarity of such crises.

Additional analysis and discussion are provided to highlight the significance of the results. First, the liquidity-risk strategies are analyzed across different investment styles. Although most style indices are sensitive to liquidity risk (for example, Convertible Arbitrage, Emerging Markets,

[1] 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.

Equity Market Neutral, Event Driven, Fixed Income Arbitrage, Funds of Funds, Long/Short Equity, and Multi-Strategy exhibit a significant loading on the liquidity factor), the high-liquidity-loading funds also outperform low-liquidity-loading funds within some investment styles. Second, close attention is paid to three liquidity crises over the sample period: fall of 1998 (Long-Term Capital Management, LTCM, blowup), summer of 2007 (the Quant crisis), and fall of 2008 (the financial meltdown). The liquidity-risk strategy seems to capture these liquidity events as it underperforms over October–December 1998 (−4.32%), August–October 2007 (−4.15%), and October–December 2008 (−14.48%), which further strengthens the use of the liquidity factor as an indicator of market conditions. Moreover, the different liquidity events significantly impact the liquidity-risk strategy implemented within certain investment styles. For example, fall 1998 has a significant impact on Fixed Income Arbitrage funds (−15.97%); August 2007 has a significant impact on Event Driven, Fixed Income Arbitrage, Global Macro, Long/Short Equity, and Multi Strategy; and fall 2008 impacts all investment styles (except for Managed Futures), providing further insight into the economic drivers of these events.

Finally, the results of this study have several implications. First, they emphasize the robustness of liquidity pricing because the same liquidity factors that pertain to the cross-section of stock returns also affect 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. Fourth, 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. Last, the returns to the high-minus-low liquidity risk strategies average about 8% per year through 2007. The financial crisis of 2008 reduces this average to 6% annually. Therefore, even in light of the worst financial crisis since the Great Depression, the liquidity risk premia in the cross-section of hedge funds still seems significant from an economic point of view, further emphasizing the extent to which investors are willing to pay (or demand a premium) to avoid (carry) liquidity risk.

The rest of this paper is organized as follows. Section 2 describes the data used for this study. Section 3 investigates the exposure of various investment styles to liquidity risk, and Section 4 extends the analysis to the cross-section of individual funds. Additional tests are provided in Section 5. Section 6 concludes.

2. Data

Monthly hedge-fund return data are obtained from the TASS database for the period 1994–2008. 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 dollars 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 contains 12,929 hedge funds, varying from 1,095 in 1994 to 8,542 in 2008. The average monthly hedge-fund return is 33 basis points, and the average monthly cross-sectional standard deviation is 6.87%. 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 2006–2008 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 and 20% during 2008 compared with about 5% during 1994–2005. It is not clear whether the extreme high returns during 2006–2008 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 three 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.[2] Although this classification provides a general idea about a fund's investment style, the ambiguity about the investment specifics and 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.

The primary liquidity measure used here is based on the price-impact factors constructed in Sadka (2006), which are extracted from the Trades and Quotes (TAQ) tick-by-tick data. 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 2008. First, the components of price impact are estimated monthly, by stock, for the remaining period 2002–2008 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

[2] 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 institutional investors, such as pension funds and endowments.

Table 1
Summary statistics.

This table reports summary diagnostics for the sample of hedge funds in TASS. The statistic *N* is the number of different hedge funds for 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, statistics are first obtained each month from the cross-section of hedge funds in each investment style and then averaged over the 180 months of the sample. Panel C reports the total number of hedge funds in the sample as well as other statistics averaged over the 180 months of the sample.

	N	Minimum	1st percentile	25th percentile	50th percentile	75th percentile	99th percentile	Maximum	Standard deviation
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
2008	8,542	−0.6765	−0.1850	−0.0443	−0.0185	0.0097	0.1109	13.2450	0.2012
Panel B: *Full sample, by investment style*									
Convertible Arbitrage	258	−0.0936	−0.0767	−0.0067	0.0023	0.0114	0.0740	0.0890	0.0251
Dedicated Short Bias	54	−0.0828	−0.0828	−0.0253	0.0014	0.0266	0.0844	0.0844	0.0440
Emerging Markets	656	−0.1852	−0.1352	−0.0233	0.0024	0.0309	0.1840	0.2746	0.0572
Equity Market Neutral	664	−0.1100	−0.0811	−0.0088	0.0037	0.0183	0.0884	0.1327	0.0308
Event Driven	785	−0.1499	−0.0758	−0.0066	0.0038	0.0148	0.1060	0.2091	0.0321
Fixed Income Arbitrage	501	−0.1262	−0.1013	−0.0066	0.0038	0.0142	0.0939	0.1365	0.0318
Fund of Funds	4,268	−0.1843	−0.0722	−0.0102	0.0023	0.0156	0.0738	0.1978	0.0274
Global Macro	608	−0.1775	−0.1371	−0.0183	0.0027	0.0244	0.1537	0.2166	0.0491
Long/Short Equity	3,574	−0.2812	−0.1161	−0.0164	0.0058	0.0295	0.1446	1.3490	0.0731
Managed Futures	964	−0.2799	−0.1509	−0.0231	0.0040	0.0317	0.1714	0.3443	0.0608
Multi-Strategy	1,177	−0.1832	−0.1134	−0.0104	0.0039	0.0192	0.1203	1.0133	0.0710
Panel C: *All funds, full sample*									
Overall	12,929	−0.4295	−0.1187	−0.0137	0.0033	0.0215	0.1380	2.4082	0.0687

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 1994–2008 and using the residuals as proxies of shocks.[3] Finally, because price impacts measure illiquidity, not 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 the other three components are investigated in a later section, along with the measures of Pástor and Stambaugh (2003) and Acharya and Pedersen (2005). The permanent-variable component is henceforth simply referred to as the liquidity factor.[4]

Fig. 1 plots the liquidity factor over the sample period. Consistent with the notion of liquidity dryouts, most notable are the negative shocks to liquidity that occur in September 1998 and September 2008, corresponding to the Russian bond default and the fall of LTCM in 1998 and the financial crisis and the Lehman Brothers bankruptcy in September 2008. Two additional negative liquidity shocks are apparent: January 2001 and August 2007. The first is

[3] The literature typically applies an adjustment with only two lags (e.g., Pástor and Stambaugh, 2003). However, over 1994–2008 liquidity seems to be somewhat 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. Unreported tests also show that the results remain significant when constructing the liquidity risk series using expanding windows.

[4] The liquidity factor is based on transactions of NYSE-listed equities, while hedge-fund returns could originate from a variety of financial assets. Yet, a fair amount of evidence exists for cross-market liquidity correlation between stocks and bonds (see, e.g., Chordia, Sarkar, and Subrahmanyam, 2005; Goyenko, 2007) and co-movement in stock liquidity across countries over time (see, e.g., Karolyi, Lee, and van Dijk, 2009). Therefore, the liquidity factor used here could reflect a general state of liquidity, including markets other than the NYSE as well.

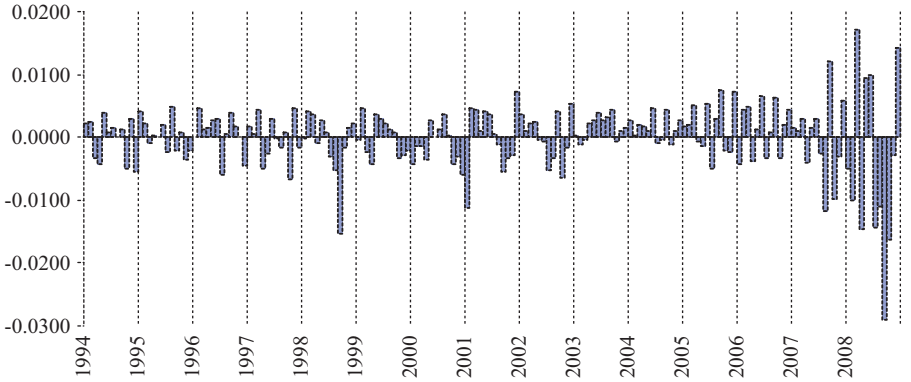

Fig. 1. The time series of liquidity innovations. The graph presents the unexpected changes in the permanent-variable component of price impact (Sadka, 2006) for the period January 1994 to December 2008. The vertical dotted lines represent January of each calendar year.

Table 2
Correlations.

The table reports the pairwise time-series Pearson correlations of the Fung and Hsieh (2001) factors and the permanent-variable liquidity factor in Sadka (2006). The Fung-Hsieh seven factors are the market portfolio (excess of risk-free rate), SMB of Fama and French (1993), change in term spread, change in credit spread, and the trend-following factors: PTFSBD (bonds), PTFSFX (currencies), and PTFSCOM (commodities). *P*-values are reported in square brackets. The sample period is January 1994 to December 2008.

	MKT-RF	SMB	ΔTERM	ΔCREDIT	PTFSBD	PTFSFX	PTFSCOM
SMB	0.21 [0.00]						
ΔTERM	0.03 [0.66]	0.05 [0.48]					
ΔCREDIT	−0.38 [0.00]	−0.23 [0.00]	−0.48 [0.00]				
PTFSBD	−0.17 [0.02]	−0.03 [0.71]	−0.13 [0.04]	0.15 [0.03]			
PTFSFX	−0.19 [0.01]	0.02 [0.79]	−0.17 [0.00]	0.29 [0.42]	0.19 [0.01]		
PTFSCOM	−0.15 [0.05]	−0.01 [0.89]	−0.08 [0.01]	0.19 [0.66]	0.18 [0.02]	0.36 [0.00]	
Liquidity	0.13 [0.08]	0.07 [0.33]	0.08 [0.28]	−0.34 [0.00]	−0.01 [0.89]	−0.10 [0.16]	−0.08 [0.27]

somewhat counterintuitive, 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 fewer liquidity providers price impact increases. The second negative liquidity shock corresponds to the Quant liquidity crisis of summer 2007. It seems this shock marks the beginning of a volatile period in market liquidity, which peaked with the negative shock of September 2008.

In addition to the liquidity factor, the paper includes various factors shown to be important in the hedge-fund literature (see, e.g., Fung and Hsieh, 1997, 2001, 2004).

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] Put together, these seven factors are known as the Fung-Hsieh seven-factor model. Table 2 presents the pairwise time-series correlation of these factors and the liquidity factor. 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 −0.34. 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 and fall 2008. Interestingly, the market return does 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, there is nothing special about the market return during these months that would indicate they exhibit severe liquidity shocks during the sample period. Similarly, the trend-following factors also do not correlate significantly with liquidity.

3. 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 same regression, adding the rest of the Fung-Hsieh factors. The results indicate that eight of the 11 indices (Convertible Arbitrage, Emerging Markets, Equity Market Neutral, Event Driven, Fixed Income Arbitrage, Fund of Funds, Long/Short Equity, and Multi-Strategy) exhibit a positive and significant loading on the liquidity factor for both regression specifications. This result is consistent with the increased likelihood of hedge fund contagion during liquidity shocks shown in Boyson, Stahel, and Stulz (2010). One index (Dedicated Short Bias) has a negative, albeit statistically insignificant, liquidity loading.

Generally, the liquidity risk of the different indices makes economic sense. For example, Convertible Arbitrage strategies typically involve maintaining long positions in illiquid convertible bonds and short positions in the relatively more liquid underlying stocks. When liquidity dries up, the convertible bonds tend to lose more value than the underlying stocks, resulting in a positive liquidity-risk exposure for such strategies. Also, 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 broad and hedge funds typically engage in multiple strategies, the analysis in Table 3 could be viewed as a way of understanding the actual liquidity risk imbedded in each style, instead of as a confirmation of the 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. Fig. 2 plots the average monthly return (excess of risk-free rate) of each investment style along with its liquidity loading (controlling for Fung-Hsieh factors). Dedicated Short Bias has both the lowest return and liquidity loading, while the top three performing indices (Long/Short Equity, Multi-Strategy, and Emerging Markets) exhibit the top three 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 cross-sectional regression of the average investment style return on its liquidity beta yields a slope coefficient of 0.28% with a t-statistic of 2.08).[6]

A more formal test can be obtained using the cross-sectional regression framework of Fama and MacBeth (1973). However, using the cross-section of the 11 investment style portfolios alone does not provide sufficient degrees of freedom for obtaining meaningful cross-sectional estimates of the coefficient of liquidity beta while controlling for Fung-Hsieh seven factors. When I use the entire cross-section of individual funds (with at least 24 monthly return observations over the sample period), estimating each fund's full-sample factor loadings using a single regression of fund return on the seven Fung-Hsieh factors and the liquidity factor, and running cross-sectional regressions (normalized) of monthly fund returns on the factor loadings each month (180 months),

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

[6] Performing a similar analysis using the factors of Pástor and Stambaugh (2003) and Acharya and Pedersen (2005) yields t-statistics of 0.93 and 1.82, repectively.

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 the Fung-Hsieh factors and the Sadka factor. Hedge funds are sorted monthly into 11 portfolios according to investment style (portfolio returns are equally weighted). The Fung-Hsieh factors are the market portfolio (excess of risk-free rate), SMB of Fama and French (1993), the change in the term spread, the change in the credit spread, and the trend-following factors: PTFSBD (bonds), PTFSFX (currencies), and PTFSCOM (commodities). *T*-statistics are reported in square brackets. The analysis includes the hedge-fund universe on TASS for the period January 1994 to December 2008.

Investment style	Intercept	MKT-RF	SMB	ΔTERM	ΔCREDIT	PTFSBD	PTFSFX	PTFSCOM	Liquidity	R^2/ Adjusted R^2
Convertible Arbitrage	0.0016	0.2094							1.2795	0.41
	[1.46]	[8.50]							[6.08]	0.41
	0.0026	0.1232	0.0232	−0.0274	−0.0564	−0.0069	−0.0058	−0.0053	0.7759	0.61
	[2.80]	[5.40]	[0.92]	[−6.15]	[−8.00]	[−1.09]	[−1.13]	[−0.76]	[4.17]	0.59
Dedicated Short Bias	0.0034	−0.9563							0.3272	0.74
	[1.79]	[−22.23]							[0.89]	0.73
	0.0053	−0.9686	−0.4162	−0.0178	−0.0698	0.0018	0.0040	0.0056	−0.1554	0.85
	[3.54]	[−26.06]	[−10.14]	[−2.45]	[−6.07]	[0.18]	[0.48]	[0.49]	[−0.51]	0.84
Emerging Markets	0.0034	0.6414							1.5267	0.48
	[1.44]	[11.91]							[3.32]	0.48
	0.0039	0.5434	0.1882	−0.0034	−0.0358	−0.0334	−0.0003	0.0016	1.1302	0.54
	[1.67]	[9.45]	[2.96]	[−0.30]	[−2.01]	[−2.08]	[−0.02]	[0.09]	[2.41]	0.52
Equity Market Neutral	0.0044	0.0983							0.7026	0.30
	[6.26]	[6.17]							[5.16]	0.29
	0.0049	0.0659	−0.0173	−0.0160	−0.0313	−0.0011	0.0051	0.0016	0.4686	0.45
	[7.54]	[4.11]	[−0.98]	[−5.11]	[−6.32]	[−0.25]	[1.43]	[0.33]	[3.59]	0.42
Event Driven	0.0042	0.2579							0.8787	0.60
	[5.28]	[14.40]							[5.74]	0.60
	0.0048	0.1901	0.0710	−0.0077	−0.0362	−0.0180	0.0039	−0.0030	0.5316	0.76
	[7.43]	[11.97]	[4.05]	[−2.49]	[−7.37]	[−4.06]	[1.10]	[−0.60]	[4.10]	0.74
Fixed Income Arbitrage	0.0026	0.1131							0.9383	0.24
	[2.63]	[5.06]							[4.91]	0.24
	0.0038	0.0303	−0.0176	−0.0269	−0.0631	−0.0042	−0.0047	0.0015	0.3924	0.57
	[4.92]	[1.58]	[−0.83]	[−7.18]	[−10.66]	[−0.78]	[−1.09]	[0.25]	[2.51]	0.55
Fund of Funds	0.0017	0.2394							1.0914	0.43
	[1.54]	[9.50]							[5.07]	0.42
	0.0023	0.1808	0.0726	−0.0203	−0.0462	−0.0058	0.0130	0.0134	0.7393	0.58
	[2.29]	[7.39]	[2.69]	[−4.25]	[−6.11]	[−0.85]	[2.36]	[1.77]	[3.71]	0.56
Global Macro	0.0032	0.1570							0.4228	0.18
	[2.58]	[5.69]							[1.79]	0.17
	0.0030	0.1554	0.0185	−0.0137	−0.0217	−0.0065	0.0337	0.0139	0.3772	0.37
	[2.70]	[5.68]	[0.61]	[−2.56]	[−2.56]	[−0.86]	[5.49]	[1.65]	[1.69]	0.34
Long/Short Equity	0.0065	0.4901							0.9068	0.67
	[5.27]	[17.73]							[3.84]	0.66
	0.0062	0.4472	0.2175	−0.0065	−0.0081	−0.0065	0.0047	0.0100	0.8109	0.76
	[5.73]	[16.75]	[7.38]	[−1.24]	[−0.98]	[−0.87]	[0.78]	[1.21]	[3.73]	0.75
Managed Futures	0.0053	−0.0620							0.3399	0.01
	[2.38]	[−1.24]							[0.79]	0.00
	0.0051	−0.0165	−0.0024	−0.0250	−0.0235	0.0331	0.0397	0.0530	0.3949	0.27
	[2.55]	[−0.34]	[−0.04]	[−2.63]	[−1.56]	[2.43]	[3.64]	[3.53]	[0.99]	0.24
Multi-Strategy	0.0048	0.2702							1.5325	0.35
	[3.05]	[7.65]							[5.08]	0.35
	0.0046	0.2419	0.0787	−0.0401	−0.0261	0.0094	0.0043	0.0139	1.4195	0.49
	[3.19]	[6.80]	[2.00]	[−5.76]	[−2.37]	[0.95]	[0.54]	[1.27]	[4.89]	0.46

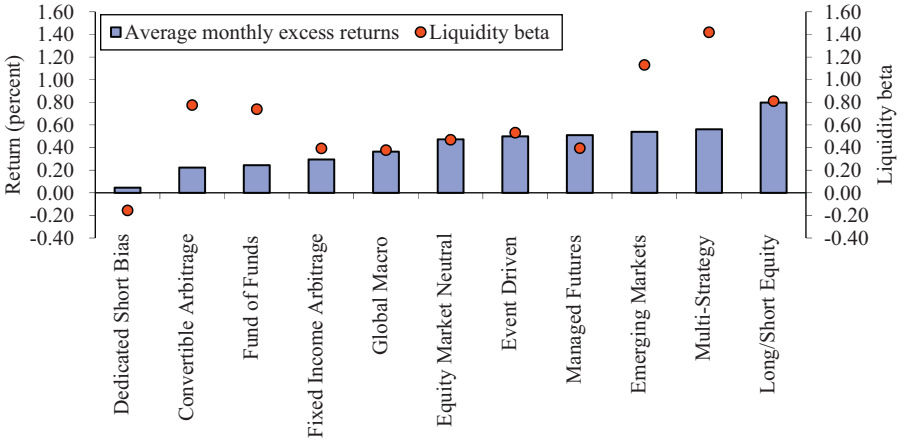

Fig. 2. Average hedge fund portfolio excess returns and liquidity beta. Hedge funds are sorted monthly into 11 portfolios according to investment style (portfolio returns are equally weighted). The liquidity beta is calculated using a regression of monthly portfolio returns on the Fung-Hsieh seven factors and the Sadka factor. The analysis includes the hedge-fund universe on TASS for the period January 1994 to December 2008.

the time-series mean of the liquidity beta coefficient is 1.43% per month (*t*-statistic of 2.24), which indicates that liquidity risk is significantly priced in the cross-section.

4. Liquidity risk sorted portfolios

The previous section investigates liquidity risk at the investment style level. This section and Section 5 investigate the pricing of liquidity risk using portfolios of individual hedge funds while allowing for time variation in liquidity loadings. Specifically, I form 10 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 include only funds with at least 18 nonmissing 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. The results are robust to using longer rolling windows and to the inclusion of some of the other hedge-fund factors in the rolling regressions (provided a sufficiently long rolling window). Portfolio formation therefore begins January 1996 and ends December 2008 (156 monthly observations). This portfolio approach makes it easy to compare the liquidity risk with the risks captured by the Fung-Hsieh factors. Such a comparison can be done by simply regressing the monthly liquidity beta portfolio returns on the seven hedge-fund factors. The intercept of this regression is the Fung-Hsieh alpha.

There is, however, one caveat. Because two of the Fung-Hsieh factors—the changes in the term and credit spreads—are nontraded factors, one cannot interpret the regression intercepts as excess returns. Therefore, to calculate alphas, I replace these two factors by returns of tradable portfolios. Specifically, I use the Lehman (now Barclays Capital) indices to mimic these two factors. To mimic changes in the term spread I use the return spread of 7–10 year Treasury Index minus the short-term rate (the risk-free rate provided by Ken French), and to mimic changes in the credit spread I use the return spread of the Corporate Bond Baa Index minus the 7–10 year Treasury Index. The correlations of the portfolios and the factors whose fluctuations they intend to mimic are −0.64 and −0.77 for the term and credit factors, respectively (the negative correlation reflects the negative relation of yield and price). The Lehman indices are returns of tradable portfolios (they include both price and coupon return) and, therefore, can be used as benchmarks for the calculation of risk-adjusted returns.

Fig. 3 plots the alpha of each liquidity-loading decile (in bars) along with the respective *t*-statistic (in symbols). The figure shows that the high-liquidity-loading portfolio has the highest average monthly risk-adjusted return (0.51%) and the low-liquidity-loading portfolio has the lowest average monthly risk-adjusted return (0.04%), while the rest of the portfolio returns generally increases with liquidity loading. The figure also includes the high-minus-low portfolio, whose monthly alpha is 0.47% with a *t*-statistic of 2.25. 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.

These results are also reported in Table 4. For completion, this table also reports the returns of decile portfolios sorted on factor loadings with respect to each of the Fung-Hsieh factors. For example, funds whose returns are highly sensitive to changes in the credit spread marginally outperform funds with low such sensitivity by 25 basis points per month (*t*-statistic of 0.67). The results indicate that, over the period 1994–2008, none of these factor sensitivities significantly predicts returns (*t*-statistics vary from −1.14 to 0.75 for the

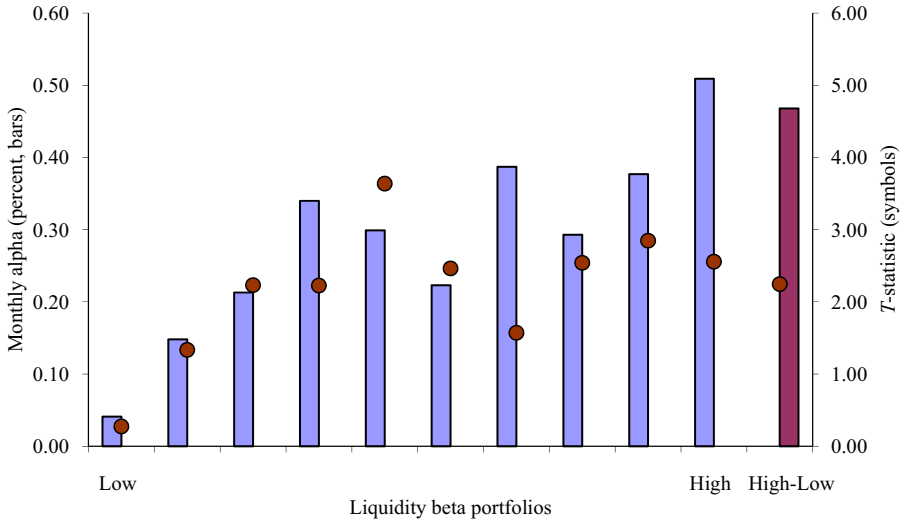

Fig. 3. Risk-adjusted returns of liquidity-beta sorted portfolios of hedge funds. Each month hedge funds are sorted into 10 equally weighted portfolios according to historical liquidity beta. The liquidity beta is calculated using a regression of monthly portfolio returns on the market portfolio and the Sadka 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 monthly portfolio alphas calculated using the Fung-Hsieh factors, where credit and term factors are replaced by appropriate tradable portfolios. The symbols present the respective t-statistics of the alphas. The figure also displays the alpha of the high-minus-low liquidity-beta portfolio. The analysis includes the hedge-fund universe on TASS for the period January 1994 to December 2008.

high-minus-low factor loading portfolio spread).[7] Therefore, although the Fung-Hsieh factors perform well insofar as explaining the time-series variation of hedge-fund returns (as typically reflected by high regression R^2 in the time series), they do not seem to generate a spread in expected returns in the same manner as the liquidity factor. For example, unreported results show that the regression R^2 of style portfolio returns regressed on Fung-Hsieh factors varies in the range 27–85%, with an average of 54%. Adding the liquidity factor only increases the average explained variance by 2.5% (see Table 3). Yet, a cross-sectional regression of the average investment style return on the liquidity loadings (one observation per investment style; 11 observations in total) yields an R^2 of 32%. Therefore, although exposure to liquidity risk could explain relatively little of the time-series variation of portfolio returns (on top of the Fung-Hsieh factors), exposure to liquidity risk explains a significant amount of the cross-sectional variation of average portfolio returns. The reason could be that liquidity crises are infrequent yet violent. The infrequency implies that the time-series R^2 is dominated by noncrisis periods and, hence, the R^2 does not increase much after adding the liquidity factor. The violence implies that the risk associated with liquidity crises is priced in the cross-section, despite the rarity of such crises.

A couple of more comments can be made 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 5.6% annually, and the t-statistic of 2.25 is high considering the short time period of 13 years. 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 (similar magnitudes are reported in Pástor and Stambaugh, 2003; Acharya and Pedersen, 2005). Therefore, liquidity risk seems to have a similar impact in the cross-section of hedge funds and in the cross-section of equities. Second, the high-minus-low liquidity beta 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 could be closed for new investors and, even if open, might not provide entering points every month. In addition, the monthly portfolio rebalancing would require frequent redemptions, which are subject to notice periods and lockups. 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.

5. 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.

5.1. Share restrictions

This paper emphasizes the role of liquidity risk as measured by the covariance of hedge-fund returns with

[7] In comparison, none of the Fung-Hsieh factors exhibits a significant monthly average over the sample period either (t-statistics vary from −1.05 to 1.73).

Table 4
Factor-beta sorted portfolios.

Each month hedge funds are sorted into 10 equally weighted portfolios according to various historical factor betas. The factor beta is calculated using a regression of monthly portfolio returns on the market portfolio and the factor (other than the market portfolio itself), 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 factors analyzed are the Fung-Hsieh seven factors and the Sadka factor. The table reports the average monthly excess return (in percent) of the decile portfolios, as well as of the high-minus-low portfolio. Risk-adjusted return (alpha) is calculated using Fung-Hsieh factors, where credit and term factors are replaced by appropriate tradable portfolios. *T*-statistics are reported in square brackets. The analysis includes the hedge-fund universe on TASS for the period January 1994 to December 2008.

	Factor beta deciles										
Factor	1 [low]	2	3	4	5	6	7	8	9	10 [high]	10-1
MKT	0.44 [1.98]	0.32 [2.97]	0.35 [3.52]	0.28 [2.53]	0.29 [2.21]	0.58 [2.01]	0.37 [1.99]	0.44 [1.94]	0.41 [1.41]	0.45 [1.00]	0.02 [0.03]
SMB	0.34 [1.50]	0.42 [1.34]	0.28 [1.80]	0.29 [2.07]	0.32 [2.28]	0.47 [2.47]	0.40 [2.54]	0.45 [2.48]	0.47 [2.09]	0.48 [1.39]	0.13 [0.36]
ΔTERM	0.67 [2.63]	0.42 [2.63]	0.38 [2.52]	0.35 [2.29]	0.36 [2.73]	0.33 [2.35]	0.36 [2.35]	0.32 [1.71]	0.47 [1.44]	0.26 [0.80]	−0.41 [−1.14]
ΔCREDIT	0.23 [0.68]	0.34 [1.47]	0.61 [1.88]	0.41 [2.41]	0.41 [2.66]	0.33 [2.58]	0.32 [2.56]	0.35 [2.73]	0.45 [2.53]	0.46 [2.72]	0.23 [0.75]
PTFSBD	0.31 [0.83]	0.21 [0.97]	0.39 [1.84]	0.27 [1.72]	0.33 [2.29]	0.36 [2.54]	0.47 [3.31]	0.52 [3.42]	0.51 [2.99]	0.56 [2.31]	0.25 [0.67]
PTFSFX	0.51 [1.80]	0.30 [1.51]	0.52 [1.67]	0.32 [2.23]	0.32 [2.30]	0.33 [2.29]	0.38 [2.48]	0.41 [2.31]	0.34 [1.77]	0.49 [2.01]	−0.02 [−0.06]
PTFSCOM	0.57 [2.14]	0.38 [2.02]	0.43 [2.10]	0.32 [2.18]	0.25 [1.83]	0.29 [2.06]	0.33 [2.10]	0.54 [1.84]	0.32 [1.75]	0.48 [1.60]	−0.09 [−0.26]
Liquidity Return	0.17 [0.88]	0.30 [1.92]	0.29 [2.12]	0.43 [2.32]	0.38 [2.91]	0.30 [2.01]	0.56 [1.89]	0.40 [2.10]	0.45 [2.10]	0.63 [2.16]	0.46 [1.99]
Alpha	0.04 [0.27]	0.15 [1.33]	0.21 [2.23]	0.34 [2.23]	0.30 [3.64]	0.22 [2.46]	0.39 [1.57]	0.29 [2.54]	0.38 [2.85]	0.51 [2.56]	0.47 [2.25]

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 could 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, could well proxy the degree of share illiquidity for hedge fund investors. Lockup and notice periods are easily observable by reviewing a fund's 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 10 liquidity-loading portfolios as in Table 4. I generally follow Aragon (2007) in the construction of the lockup and redemption notice period variables. Because lockups

are heavily clustered around zero and 12 months, in the tests below lockup is assigned a value of zero if there is no lockup period and one otherwise. As for redemption notice periods, funds are divided into groups corresponding to intervals using 0, 30, 60, 90, and 365 days. Note that 12,171 funds of the 12,929 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 could 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" could experience less losses. However, such a fund could choose to invest in more illiquid assets to begin with.

The alphas of the different portfolios are reported in Table 5. The results in Aragon (2007) for 1994–2001 continue to hold throughout 2008. Panel A shows that, for each liquidity loading portfolio, the funds with a lockup value of one outperform those with a value of zero. 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 most share restriction groups. The alphas of the high-minus-low liquidity-loading portfolio varies in the range 0.43–0.67% per month (*t*-statistics above 1.77), with the exception of funds with notice periods of 60–90 days, which exhibits insignificant alpha, and the funds with notice periods of above 90 days, which exhibit a high monthly alpha of 1.39% (*t*-statistic of 1.72). 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.

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. In fact, it seems liquidity risk has a stronger impact within the

Table 5
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 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. Portfolios are sorted within each category of share restriction. The table reports the risk-adjusted returns (alphas) (in percent) for the decile portfolios, as well as the high-minus-low portfolio for different holding periods for funds with different share restrictions. Alpha is calculated using Fung-Hsieh factors, where credit and term factors are replaced by appropriate tradable portfolios. In Panel A, lockup period is one 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* denotes the number of funds within each category. *T*-statistics are reported in square brackets. The analysis includes the hedge-fund universe on TASS for the period January 1994 to December 2008.

	Liquidity beta deciles										
Share restriction	1 [low]	2	3	4	5	6	7	8	9	10 [high]	10-1
Panel A: Lockup period											
0	−0.06	0.12	0.18	0.36	0.25	0.17	0.38	0.28	0.31	0.42	0.48
[*N*=9,693]	[−0.37]	[1.11]	[1.77]	[1.73]	[2.94]	[1.75]	[1.27]	[2.26]	[2.16]	[1.99]	[2.19]
1	0.57	0.36	0.39	0.42	0.52	0.41	0.48	0.42	0.64	1.00	0.43
[*N*=2,478]	[3.51]	[2.96]	[4.16]	[5.37]	[5.67]	[4.59]	[4.73]	[4.02]	[5.31]	[5.13]	[1.77]
Panel B: Redemption notice period (days)											
0	−0.41	−0.24	−0.05	0.09	−0.03	0.09	0.11	0.13	0.15	0.26	0.67
[*N*=2,351]	[−1.65]	[−1.52]	[−0.33]	[0.73]	[−0.24]	[0.71]	[0.78]	[0.81]	[0.77]	[1.05]	[2.30]
(0,30]	0.12	0.19	0.25	0.51	0.34	0.28	0.58	0.35	0.42	0.60	0.49
[*N*=5,324]	[0.68]	[1.72]	[2.43]	[1.73]	[3.93]	[2.99]	[1.08]	[3.00]	[3.06]	[2.83]	[2.15]
(30,60]	0.23	0.28	0.40	0.33	0.35	0.33	0.33	0.42	0.53	0.76	0.53
[*N*=2,866]	[1.48]	[2.50]	[4.08]	[3.79]	[4.15]	[3.40]	[2.91]	[3.62]	[3.89]	[3.80]	[2.35]
(60,90]	0.35	0.40	0.37	0.50	0.39	0.30	0.41	0.35	0.34	0.50	0.14
[*N*=1,294]	[1.94]	[3.55]	[3.55]	[5.81]	[4.32]	[2.95]	[3.43]	[2.99]	[2.17]	[1.63]	[0.43]
(90, 365]	0.27	0.37	0.01	0.35	0.47	0.34	0.35	0.42	0.15	1.66	1.39
[*N*=336]	[0.90]	[0.92]	[0.09]	[3.47]	[3.97]	[2.91]	[2.24]	[2.24]	[0.45]	[2.04]	[1.72]

funds that offer low share restriction. Funds with no lockup exhibit an alpha spread of 0.48%, while funds with lockup earn 0.43%. Similarly, the alpha spread is the highest for funds that offer zero days redemption notice (0.67%), and it seems to decrease with redemption notice period. Overall, these results point to a significant imbalance between the liquidity a fund promises to its investors and the sensitivity of its assets to market liquidity conditions. This conclusion is further strengthened by the observed actions undertaken by hedge-fund managers during the financial crisis of 2008. In their quest for liquidity, many investors in hedge funds turned to Long/Short Equity funds with redemption requests because, until then, such funds were perceived relatively liquid. However, in light of the massive redemption requests, many hedge-fund managers implemented the

Table 6
Liquidity-beta sorted portfolios: style analysis.

Each month hedge funds are sorted into 10equally 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 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. The table reports the average monthly excess return and the risk-adjusted return (alpha) (in percent) of the decile portfolios, as well as the high-minus-low portfolio. Alpha is calculated using Fung-Hsieh factors, where credit and term factors are replaced by appropriate tradable portfolios. *T*-statistics are reported in square brackets. The analysis includes the hedge-fund universe on TASS for the period January 1994 to December 2008.

	Liquidity beta deciles										Decile spreads	
	1 [low]	2	3	4	5	6	7	8	9	10 [high]	10-1	
Investment style	Returns	Returns	Returns	Returns	Returns	Returns	Returns	Returns	Returns	Returns	Returns	Alphas
Convertible Arbitrage	0.17 [0.65]	0.02 [0.15]	0.20 [1.69]	0.09 [0.61]	0.20 [1.42]	0.21 [1.13]	0.18 [0.93]	0.24 [1.30]	0.06 [0.21]	0.13 [0.38]	−0.03 [−0.11]	−0.18 [−0.61]
Dedicated Short Bias	0.33 [0.53]	−0.25 [−0.32]	−0.40 [−0.66]	0.21 [0.39]	−0.35 [−0.74]	−0.11 [−0.25]	0.13 [0.31]	0.24 [0.48]	0.27 [0.53]	−0.11 [−0.13]	−0.44 [−0.50]	−0.16 [−0.19]
Emerging Markets	−0.26 [−0.50]	0.12 [0.39]	0.15 [0.43]	0.23 [0.72]	0.58 [1.75]	0.35 [0.99]	0.72 [1.90]	0.81 [1.89]	0.53 [1.06]	1.92 [2.69]	2.18 [3.87]	2.05 [3.55]
Equity Market Neutral	0.28 [1.89]	0.25 [1.46]	0.36 [3.37]	0.34 [4.81]	0.41 [5.21]	0.36 [3.41]	0.21 [1.57]	0.17 [1.19]	0.29 [1.73]	0.49 [2.18]	0.22 [0.82]	0.24 [0.91]
Event Driven	0.35 [1.62]	0.32 [2.47]	0.27 [2.89]	0.30 [2.82]	0.28 [2.03]	0.31 [2.56]	0.37 [2.57]	0.35 [2.08]	0.41 [2.18]	0.77 [2.65]	0.42 [1.94]	0.57 [3.00]
Fixed Income Arbitrage	0.11 [0.43]	0.22 [1.62]	0.26 [2.81]	0.20 [2.08]	0.27 [2.57]	0.13 [0.77]	0.06 [0.31]	0.09 [0.43]	−0.02 [−0.10]	0.26 [0.75]	0.15 [0.54]	0.37 [1.10]
Fund of Funds	−0.08 [−0.43]	0.24 [1.63]	0.26 [1.77]	0.31 [2.06]	0.24 [1.54]	0.21 [1.23]	0.28 [1.53]	0.35 [1.78]	0.27 [1.24]	0.25 [0.90]	0.33 [1.26]	0.38 [1.63]
Global Macro	0.46 [1.85]	0.19 [1.11]	0.44 [2.71]	0.25 [1.74]	0.14 [0.80]	0.33 [2.10]	0.60 [3.03]	0.24 [1.09]	0.27 [1.02]	−0.10 [−0.28]	−0.56 [−1.51]	−0.63 [−1.90]
Long/Short Equity	0.67 [2.28]	0.73 [2.96]	0.52 [2.37]	0.96 [1.87]	0.62 [3.07]	0.43 [2.08]	0.52 [2.39]	0.54 [2.36]	0.48 [1.84]	0.60 [1.75]	−0.07 [−0.28]	−0.02 [−0.07]
Managed Futures	0.46 [1.20]	0.30 [1.01]	0.34 [1.34]	0.37 [1.61]	0.49 [2.10]	0.51 [2.12]	0.66 [2.71]	0.46 [1.80]	0.89 [2.85]	0.99 [2.54]	0.53 [1.35]	0.36 [0.91]
Multi-Strategy	0.55 [2.15]	0.50 [3.04]	0.39 [2.57]	0.34 [2.21]	0.34 [2.59]	3.18 [1.07]	0.33 [1.78]	0.45 [2.24]	0.47 [2.16]	0.41 [1.24]	−0.14 [−0.46]	0.24 [0.70]

practice of "raising gates," i.e., temporarily not allowing withdrawals, perhaps to protect the value of their investment. This suggests that managers could have invested in illiquid assets all along or that their investment in assets that had been generally perceived liquid in normal times have suddenly turned illiquid during the financial crisis. Either way, the significant negative return spread on the high-minus-low liquidity loading portfolio during the fourth quarter of 2008 (-14.48% across all funds) emphasizes the importance of understanding the liquidity risk assumed by hedge funds.

5.2. Liquidity risk sorted portfolios: style analysis

To provide some insight as to whether liquidity risk pricing is an inter- versus intra-style effect, Table 6 reports the performance (returns and alphas) of liquidity-loading sorted portfolios separately using the funds in each investment style. (These are dependent sorts. The funds in each style are divided into 10 equal size groups each month.) The results show that alpha of the high-minus-low portfolio is significant for the styles Emerging Markets and Event Driven, and the rest of the styles are insignificant. Global Macro earns negative yet insignificant risk-adjusted returns (t-statistic of -1.90). As an index, Long/Short Equity exhibits a significant positive liquidity loading (Table 3), yet the insignificant return spread suggests these type of funds do not vary much in their exposure to liquidity risk (which is plausible if many such funds engage in similar investment strategies). Most notable is the Emerging Markets style, which exhibits a 2.05% monthly risk-adjusted return spread, implying quite a large difference in the liquidity-risk exposure of hedge funds in this style. To summarize, the results in Tables 3 and 6 give a mixed view. For some investment styles such as Long/Short Equity the effect seems to be inter-style, with no return spread observed intra-style, while others such as Emerging Markets exhibit both inter- and intra-style liquidity risk pricing.

5.3. 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 in 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 could 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 at 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 5.90–6.23% per year, which is comparable to the 5.6% 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.

Fig. 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 at the beginning of each month, yet returns are cumulated

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 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 three-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 2008.

	Liquidity beta deciles										
Holding period	1 [low]	2	3	4	5	6	7	8	9	10 [high]	10-1
Three months	2.50	3.49	3.45	3.87	4.18	5.32	4.23	5.41	6.18	8.70	6.20
	[1.02]	[1.70]	[1.84]	[2.13]	[2.27]	[2.13]	[1.82]	[2.06]	[2.12]	[2.12]	[1.95]
Six months	2.73	4.10	3.75	3.80	5.98	4.07	4.28	5.07	5.87	8.64	5.90
	[1.03]	[2.08]	[1.76]	[2.05]	[5.00]	[1.87]	[1.81]	[1.92]	[1.98]	[2.47]	[2.14]
12 months	3.40	3.92	3.91	3.97	4.67	5.48	5.04	5.77	6.70	9.63	6.23
	[1.27]	[1.65]	[1.68]	[1.82]	[2.09]	[3.71]	[1.91]	[2.04]	[1.97]	[2.47]	[3.34]

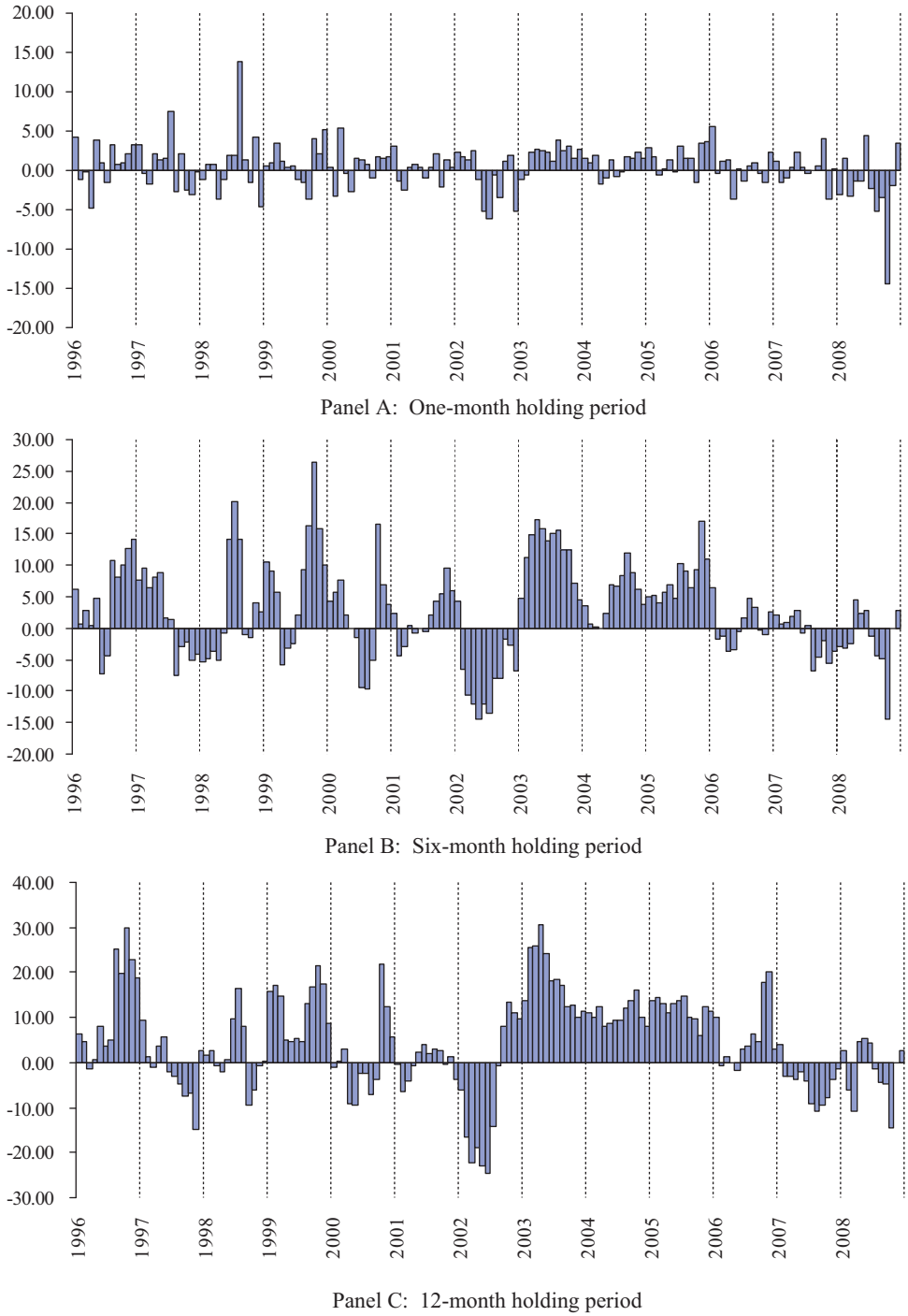

Fig. 4. The time series of high-minus-low liquidity beta portfolios. Each month hedge funds are sorted into 10 equally weighted portfolios according to historical liquidity beta. The liquidity beta is calculated using a regression of monthly portfolio returns on the market portfolio and the Sadka factor, 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 12 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 2008. (Panel A) One-month holding period, (Panel B) six-month holding period and (Panel C) 12-month holding period.

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.

5.4. Crisis versus noncrisis periods: alternative measures

This paper argues that liquidity risk can explain cross-sectional differences of hedge-fund performance. Thus, it seems natural to compare the performance of the liquidity-risk strategy during crisis and noncrisis periods. If a fund's liquidity loading, measured using historical data, measures its sensitivity to liquidity shocks that occur out-of-sample, then the liquidity-risk strategy should earn negative returns during crisis periods and positive returns during noncrisis periods. This subsection repeats the liquidity-loading portfolio sorts of Table 4, with an emphasis on the crisis versus noncrisis periods. The sample period includes three significant liquidity crises: fall of 1998 (LTCM), summer of 2007 (the Quant crisis), and fall of 2008 (the financial meltdown).

Also, it is well recognized that liquidity can be measured in various ways and that some measures could produce somewhat different results because they could capture different aspects of liquidity (see, Korajczyk and Sadka, 2008). Nevertheless, while the paper mainly uses the Sadka liquidity factor, an obvious question is whether the main results hold using other measures of liquidity. Therefore, the analysis in this subsection utilizes five additional measures of liquidity: Pástor and Stambaugh (2003), Acharya and Pedersen (2005), and the other three price-impact components of Sadka (2006).[8] The liquidity factor used in the paper so far (the permanent-variable component) is also added to ease comparison. Over the sample period, the liquidity factor has a correlation of 0.16 and 0.36 with the measures of Pástor and Stambaugh (2003) and Acharya and Pedersen (2005), respectively. Similar to the Sadka factor plotted in Fig. 1, the Pástor-Stambaugh factor exhibits significant liquidity shocks during the three liquidity crises, in September 1998, August 2007, and September 2008. The common significant shocks of the Pástor-Stambaugh and Sadka factors suggest that while each measure could presumably represent a different aspect of liquidity (Pástor-Stambaugh is based on price reversals and Sadka is based on permanent price movements), they both respond to significant liquidity episodes in the same manner. The most negative liquidity shock displayed by the Acharya-Pedersen factor is October 2008.

Table 8 reports the returns of the high-minus-low liquidity-loading portfolio using the different liquidity factors. In addition to reporting performance over the entire sample period, the table separates out crisis months and noncrisis months. The crisis months are September–November 1998 (Long-Term Capital Management crisis), August–October 2007 (Quant crisis), and September–November 2008 (financial crisis).[9] Panel A reports average monthly returns of portfolios that are rebalanced monthly. Panel B reports three-month cumulative returns in the following manner. For the crisis periods, the portfolios are formed at the beginning of each crisis and are held for the three-month crisis period. For the noncrisis periods, portfolios are formed at the beginning of each calendar quarter. Only quarters that do not have any overlap with the crisis periods are used (there are 46 such quarters). For the entire sample period, all calendar quarters are used, similar to the analysis of long-run performance in Table 7 (52 quarters).

The results in Table 8 are mostly statistically insignificant, except for the permanent-variable component. Nonetheless, they seem to deliver the following message (especially Panel B). In periods of crisis, the high-minus-low liquidity-loading portfolio earns negative returns, while positive returns are observed during noncrisis periods. These results seem to hold irrespective of the liquidity measure used (except for the transitory-variable component). Moreover, for most measures, the mean negative returns during crisis periods are significantly higher (in absolute value) than those during noncrisis periods. These results suggest that the method of forming portfolios based on historical covariation of fund return and market-wide liquidity performs well insofar as explaining cross-sectional variation of hedge-fund returns during crisis and noncrisis periods.

5.5. A close look at three liquidity crises

It is difficult to apply formal tests given single events. Nevertheless, some simple statistics pertaining to liquidity risk could prove useful for understanding of the three liquidity events. Table 9 reports the three-month cumulative returns of the high-minus-low liquidity-loading return spread portfolio over 1998, 2007, and 2008. Funds are kept in the portfolios for three months, and portfolios are formed each month.

The portfolio that uses all funds seems to capture the three liquidity events as it underperforms over October–December 1998 (−4.32%), August–October 2007 (−4.15%), and October–December 2008 (−14.48%). Thus, not only does the liquidity factor exhibit a significant drop during these periods (see discussion of Fig. 1), but also the

[8] The aggregate measure of Pástor and Stambaugh (2003) through December 2008 is available on the website of Ľuboš Pástor: http://faculty.chicagobooth.edu/lubos.pastor/research/. To obtain the aggregate measure of Acharya and Pedersen (2005), I follow the procedures described in that study using data through December 2008.

[9] Even though some liquidity crises could have lasted for a relatively short period (for example, the Quant crisis could have lasted for just a few days (see Khandani and Lo, 2007)), each crisis is defined as a three-month period to allow for a potential delayed reaction in the performance of hedge funds, which can be caused by either return smoothing, de-leveraging, or significant outflows.

Table 8
Crisis versus noncrisis periods: 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 Pástor and Stambaugh (2003), Acharya and Pedersen (2005), and the four price-impact components in Sadka (2006). The table reports the average monthly return (in percent) of the high-minus-low decile portfolio spread for the entire sample period, as well as separately for crisis and noncrisis periods. Crisis periods are September–November 1998, August–October 2007, and September–November 2008. Panel A reports monthly returns for portfolios rebalanced monthly, and Panel B reports three-month non-overlapping cumulative returns for portfolios rebalanced quarterly. The quarterly returns of the noncrises quarters include all calendar quarters non-overlapping with crises periods. *T*-statistics are reported in square brackets. The analysis includes the hedge-fund universe on TASS for the period January 1994 to December 2008.

Panel A: Monthly returns

Period	Months	Pástor-Stambaugh	Acharya-Pedersen	Permanent-fixed	Transitory-fixed	Permanent-variable	Transitory-variable
Crises	9	−2.70 [−1.16]	−1.67 [−0.64]	−3.38 [−1.81]	−0.89 [−0.66]	−1.23 [−0.66]	2.04 [1.15]
Noncrises	147	0.06 [0.20]	0.14 [0.49]	−0.13 [−0.48]	0.39 [1.64]	0.56 [2.59]	−0.37 [−1.34]
All	156	−0.10 [−0.29]	0.04 [0.12]	−0.32 [−1.13]	0.32 [1.34]	0.46 [1.99]	−0.24 [−0.83]

Panel B: Three-month cumulative returns

Period	Quarters	Pástor-Stambaugh	Acharya-Pedersen	Permanent-fixed	Transitory-fixed	Permanent-variable	Transitory-variable
Crises	3	−5.32 [−0.85]	−1.81 [−0.25]	−5.31 [−1.46]	−3.87 [−1.73]	−3.69 [−1.78]	8.06 [1.41]
Noncrises	46	1.26 [1.42]	1.29 [1.40]	0.63 [0.72]	1.77 [2.06]	1.88 [2.55]	−1.42 [−1.62]
All	52	−0.28 [−0.24]	0.18 [0.17]	−0.25 [−0.26]	1.31 [1.62]	1.55 [1.95]	−1.06 [−1.25]

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 these liquidity event than others. For example, fall 1998 has a significant impact on Fixed Income Arbitrage funds (−15.97%), which is consistent with the fall of LTCM due to Russia's bond default. It also seems that August 2007 has significant impact on the styles Convertible Arbitrage, 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 could view the evidence as suggesting that the style classification is not sufficiently fine to significantly distinguish between fund strategies or that funds self-classifying in a particular style apply multiple strategies, some of which could be related or 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). As for the most recent financial crisis, it seems that all investment styles exhibit a considerable negative return to the high-minus-low liquidity loading strategy (except for Managed Futures), ranging from −7.84% to −30.15% during the fourth quarter of 2008.

6. 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

Table 9
The high-minus-low liquidity beta strategy during liquidity crises.

During each of the first 10 months of 1998, 2007, and 2008 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 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.

	Portfolio formation month during 1998									
Investment style	January	February	March	April	May	June	July	August	September	October
Convertible Arbitrage	12.70	14.93	2.19	−4.32	−5.41	−15.26	−6.00	−4.41	17.90	7.66
Dedicated Short Bias	7.36	−10.36	−9.40	−0.97	−7.79	38.87	−14.20	−60.83	−79.19	−80.34
Emerging Markets	1.60	1.13	−13.43	−13.58	−11.81	9.30	31.56	49.20	25.31	9.95
Equity Market Neutral	5.58	4.23	2.38	2.33	7.54	6.62	8.76	−3.42	−4.92	3.18
Event Driven	−3.47	−2.93	−4.40	−1.33	−2.02	6.01	5.48	0.84	−1.07	3.74
Fixed Income Arbitrage	−1.86	0.57	−5.28	−5.28	−5.91	−9.87	−21.10	−21.74	−25.36	−15.97
Fund of Funds	2.21	−7.64	−7.36	−7.02	−2.37	13.47	20.37	31.57	9.18	−0.02
Global Macro	1.06	−4.02	−3.50	8.57	3.99	8.67	−7.65	−2.71	−13.24	2.09
Long/Short Equity	5.11	4.27	0.97	4.01	4.47	4.69	−0.41	−6.41	2.94	−9.03
Managed Futures	0.19	4.54	3.26	−0.15	3.98	−0.17	−6.15	−10.05	−3.26	6.44
Multi-Strategy	−0.27	4.33	−1.55	−4.35	1.57	8.67	13.66	10.76	−4.20	−17.49
All	1.24	−0.65	−5.27	−5.93	−1.66	13.66	16.31	15.14	0.12	−4.32
	Portfolio formation month during 2007									
Investment style	January	February	March	April	May	June	July	August	September	October
Convertible Arbitrage	0.93	−3.98	−5.14	−4.26	−3.93	−6.74	−8.74	−11.07	−12.95	−11.03
Dedicated Short Bias	11.29	16.23	13.64	3.03	−6.30	−6.50	0.17	18.56	19.28	15.90
Emerging Markets	2.67	0.30	−0.40	4.03	1.92	4.63	4.07	−2.62	1.01	−1.28
Equity Market Neutral	−2.97	−3.69	−2.04	−3.39	−2.14	−1.18	−2.36	−4.87	−1.67	−0.10
Event Driven	0.37	1.00	1.51	1.54	1.77	1.70	1.60	−3.98	−4.51	−3.90
Fixed Income Arbitrage	0.43	−2.01	−0.21	0.00	4.97	5.24	3.75	−5.17	−10.05	−4.14
Fund of Funds	−0.19	−2.10	1.16	0.79	1.08	−0.22	−1.13	−3.79	−1.02	1.92
Global Macro	−2.02	−1.78	4.28	6.55	3.84	−2.14	−2.10	−8.62	−7.86	−7.74
Long/Short Equity	−0.74	−2.20	−0.03	0.73	−0.06	−1.84	0.35	−4.55	−4.08	0.02
Managed Futures	−15.53	−6.46	10.21	17.89	−6.27	−11.68	−10.17	−0.40	8.58	6.87
Multi-Strategy	−0.66	−3.72	−1.92	3.95	4.21	2.20	−4.38	−6.63	−2.68	−2.53
All	−1.17	−1.77	1.85	3.41	1.79	−0.02	−0.49	−4.15	−1.82	0.80
	Portfolio formation month during 2008									
Investment style	January	February	March	April	May	June	July	August	September	October
Convertible Arbitrage	−21.62	−8.48	8.93	−4.55	1.25	10.00	13.94	7.34	8.56	−30.15
Dedicated Short Bias	−7.87	3.30	−5.43	1.29	−5.27	−12.27	−11.55	13.48	4.71	−13.46
Emerging Markets	−0.28	0.58	−5.68	2.15	7.44	−2.80	−9.92	−5.31	−11.04	−28.13
Equity Market Neutral	−3.85	0.37	0.12	−4.62	−1.84	−3.35	−10.34	−9.21	−10.52	−11.97
Event Driven	−6.52	−4.05	−3.03	−4.75	0.88	2.10	4.42	−10.65	−11.49	−16.41
Fixed Income Arbitrage	−13.63	−7.26	7.94	7.32	1.58	−3.50	−8.05	−3.57	−18.64	−7.84
Fund of Funds	−2.68	1.42	0.04	−2.92	0.84	−0.04	−3.62	−11.03	−14.61	−14.86
Global Macro	−9.19	0.60	−1.95	−5.35	−3.62	−4.74	0.18	−2.93	−3.58	−17.11
Long/Short Equity	−6.99	−2.29	−3.43	−1.50	2.02	2.54	−4.87	−12.63	−8.00	−11.72
Managed Futures	10.73	5.08	0.36	−11.66	1.60	−3.15	−11.99	4.70	22.40	7.18
Multi-Strategy	−4.46	−0.87	−2.96	−1.05	3.85	3.35	−5.54	−10.91	−14.43	−24.94
All	−3.31	−0.32	−1.74	−2.27	2.39	1.23	−3.85	−6.79	−7.04	−14.48

high future returns during 1994–2008, suggesting that the performance of many funds over this time period could 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 factors that pertain to the cross-section of stock returns also affect 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.

References

Acharya, V.V., Pedersen, L.H., 2005. Asset pricing with liquidity risk. Journal of Financial Economics 77, 375–410.

Agarwal, V., Naik, N.Y., 2004. Risks and portfolio decisions involving hedge funds. Review of Financial Studies 17, 63–98.

Amihud, Y., 2002. Illiquidity and stock returns: cross-section and time-series effects. Journal of Financial Markets 5, 31–56.

Amihud, Y., Mendelson, H., 1986. Asset pricing and the bid-ask spread. Journal of Financial Economics 17, 223–249.

Aragon, G.O., 2007. Share restrictions and asset pricing: evidence from the hedge fund industry. Journal of Financial Economics 83, 33–58.

Boyson, N.M., Stahel, C.W., Stulz, R.M., 2010. Hedge fund contagion and liquidity shocks. Journal of Finance, forthcoming.

Brennan, M.J., Subrahmanyam, A., 1996. Market microstructure and asset pricing: on the compensation for illiquidity in stock returns. Journal of Financial Economics 41, 441–464.

Chordia, T., Roll, R., Subrahmanyam, A., 2000. Commonality in liquidity. Journal of Financial Economics 56, 3–28.

Chordia, T., Sarkar, A., Subrahmanyam, A., 2005. An empirical analysis of stock and bond market liquidity. Review of Financial Studies 18, 85–129.

Fama, E.F., French, K.R., 1993. Common risk factors in the returns on stocks and bonds. Journal of Financial Economics 33, 3–56.

Fama, E.F., MacBeth, J., 1973. Risk, return and equilibrium: empirical tests. Journal of Political Economy 81, 607–636.

Fung, W., Hsieh, D.A., 1997. Empirical characteristics of dynamic trading strategies: the case of hedge funds. Review of Financial Studies 10, 275–302.

Fung, W., Hsieh, D.A., 2001. The risk in hedge fund strategies: theory and evidence from trend followers. Review of Financial Studies 14, 313–341.

Fung, W., Hsieh, D.A., 2004. Hedge fund benchmarks: a risk-based approach. Financial Analysts Journal 60, 65–80.

Getmansky, M., Lo, A.W., Makarov, I., 2004. An econometric model of serial correlation and illiquidity in hedge fund returns. Journal of Financial Economics 74, 529–609.

Goyenko, R., 2007. Stock and bond pricing with liquidity risk. Unpublished working paper, McGill University, Motreal, Quebec, Canada.

Karolyi, G.A., Lee, K.-H., van Dijk, M.A., 2009. Commonality in returns, liquidity, and turnover around the world. Unpublished working paper, Ohio State University, Columbus, OH.

Khandani, A.E., Lo, A.W., 2007. What happened to the quants in August 2007? Journal of Investment Management 5, 5–54.

Khandani, A.E., Lo, A.W., 2008. What happened to the quants in August 2007? Evidence from factors and transactions data. Journal of Financial Markets, forthcoming.

Klebanov, M.M., 2008. Betas, characteristics and the cross-section of hedge fund returns. Unpublished working paper, University of Chicago Booth School of Business, Chicago, IL.

Korajczyk, R.A., Sadka, R., 2008. Pricing the commonality across alternative measures of liquidity. Journal of Financial Economics 87, 45–72.

Pástor, Ľ., Stambaugh, R.F., 2003. Liquidity risk and expected stock returns. Journal of Political Economy 111, 642–685.

Sadka, R., 2006. Momentum and post-earnings-announcement drift anomalies: the role of liquidity risk. Journal of Financial Economics 80, 309–349.