
Volume 91, Issue 2, February 2009
ISSN 0304-405X
JOURNAL OF
Financial
ECONOMICS
Managing Editor:
Founding Editor:
MICHAEL C. JENSEN
Advisory Editors:
EUGENE F. FAMA
WAYNE MIKKELSON
JAY SHANKEN
CLIFFORD W. SMITH, JR.
RENÉ M. STULZ
Associate Editors:
JOHN CAMPBELL
HARRY DeANGELO
DARRELL DUFFIE
RICHARD GREEN
JARRAD HARFORD
SIMON JOHNSON
STEVEN KAPLAN
TIM LOUGHRAN
MICHELLE LOWRY
KEVIN MURPHY
LUBOS PASTOR
NEIL PEARSON
JAY RITTER
RICHARD SLOAN
JEREMY C. STEIN
JERRY WARNER
TONI WHITED
KAREN WRUCK
DAVID YERMACK

must give the fund advance notice (e.g., one month) and then only redeem at fixed dates (e.g., every quarter). Hence, some funds try to overcome limits to arbitrage by using financial contracting.

In this paper, we test whether such capital structure decisions help hedge funds avoid liquidating their positions when their trades go against them temporarily. To design such a test, we first build a simple model that generates predictions about the link between capital structure choice and hedge fund returns. We start with the simple framework of Shleifer and Vishny (1997): Hedge funds exploit arbitrage opportunities, but these opportunities are risky because prices can temporarily diverge further from fundamentals. In this case, funds underperform and face outflows. This amplifies underpricing as funds are forced to unwind at the wrong time. To this well-known framework, we add the ingredient that funds can choose the sensitivity of potential outflows to performance. By restricting the investor base to loyal customers, or by imposing contractual impediments to withdrawals, hedge funds can reduce outflows in the case of low performance, but doing so is costly. We then solve the model and explore comparative statics in asset underpricing risk. This leads to three intuitive and easily testable hypotheses. First, conditional on bad performance, funds with low flow-performance sensitivity have higher expected returns. This hypothesis is based on the fact that funds engaging in riskier arbitrage are more likely to protect their capital from temporary underperformance. The second hypothesis is related to the first one: Less volatile funds choose lower flow-performance sensitivity. Finally, conditional on high past returns, all funds should have the same expected returns, irrespective of their capital structure decisions. This last hypothesis comes from the fact that funds with high returns do not face outflows. Our framework, like all limits to arbitrage models, explains the persistence of underpricing, not of overpricing, so our predictions are asymmetric in nature.

We find solid support for these hypotheses using data on hedge fund performance. Since our model makes predictions concerning the cross-sectional link between fund returns and capital structure decisions, we first define four alternative measures of capital structure strength. Our first two measures are the direct contractual limitations to withdrawals: the presence of a lockup period and the presence of low redemption frequencies. We also combine these two measures into a novel "assets under management (AUM) duration" measure that takes into account the fact that lockups only matter if the fund has experienced recent inflows. The resulting measures capture the extent to which it is contractually hard for investors to pull out their investment in the short term. Our fourth measure is the correlation between outflows and past performance. It indirectly captures the effect of contractual impediments, the reputation of the fund, as well as an explicit policy to raise capital from long-term, loyal clients only. For each of these measures, we then find that our three hypotheses hold in the data. Conditional on low past performance, hedge funds with long duration liabilities, or with performance-insensitive outflows, tend to overperform comparable funds without such capital structure characteristics (Hypothesis 1). Funds with such strong capital structure also have more volatile returns (Hypothesis 2). There is, however, no expected difference in returns when past returns have been large (Hypothesis 3). In this case capital structure strength does not matter. These cross-sectional results are robust. They hold for a given fund size, strategy, and age, and in two different hedge fund data sets (EurekaHedge and (TASS)).

This paper belongs to the literature on limits to arbitrage. It provides a test, along with evidence that arbitrageurs seek to overcome these limits. In the theoretical literature, financial intermediaries tend to be financially constrained, which endogenously renders arbitrage risky (Gromb and Vayanos, 2002; Brunnermeier and Pedersen, 2009; Acharya and Viswanathan, 2011).[1] In our paper, we assume that arbitrageurs can partially overcome limits to arbitrage by securing a strong capital structure, although this has costs. On this front, the closest paper to ours is Stein (2009), who also considers arbitrageurs optimizing their capital structure ex ante. The difference between his framework and ours is that we use our model to derive intuitive and easily testable hypotheses, which link return dynamics and funds' capital structure decisions. The prediction that strong capital structure should go with mean-reverting returns is in a sense close, although obtained from different assumptions, to the literature on the comparative advantage of long-term investors, who should specialize in investing in long-term trades (Campbell and Viceira, 2002).

Our empirical results also shed new light on existing evidence from the mutual and hedge fund literatures. First, it has been well documented in the literature, since at least Grinblatt and Titman (1992), that mutual fund performance tends to persist on a risk-adjusted basis. Such persistence is typically interpreted as evidence of managerial skill. In a recent paper, Lou (2012) proposes an alternative interpretation: when funds underperform, they face outflows, which in turn force them to sell stocks. Because of limited liquidity, stock prices decrease and fund returns go down. Forced unwinding and limited liquidity can thus explain the persistence of fund performance. We suggest that the persistence of returns should be somewhat attenuated for mutual funds that overcome limits to arbitrage via strong capital structure. While mutual funds typically do not have lockup periods, nor low redemption frequencies, some of them may have exit fees, which impose penalties on withdrawals. If our model applies to mutual funds, one would expect the flow-induced return persistence identified by Lou (2012) to be less evident for mutual funds that impose exit fees, in particular, on the downside.

We contribute to the hedge fund literature by providing new evidence on mean reversion for hedge fund returns. The literature has focused on the positive relation between return persistence and share restrictions (Aragon, 2007) while we find clear evidence of such a negative relation.

[1] Many additional papers explore the effects of specific assumptions about the type of funding constraints that arbitrageurs face. Gârleanu and Pedersen (2011) focus on margin requirements. Liu and Mello (2009) and Brunnermeier and Oehmke (2013) discuss debt maturity. Chen, Goldstein, and Jiang (2010) model and test bank-run type mechanisms in mutual funds.

The standard interpretation is that funds operating on illiquid markets are more likely to both impose impediments to withdrawals and smooth returns (Getmansky, Lo, and Makarov, 2004). The difference between our study and the rest of the literature is the frequency at which autocorrelation is computed. At the monthly frequency, in our sample like in the rest of the literature, funds with restrictions have more persistent returns: return smoothing dominates. At the annual frequency, however, funds with restrictions have more mean-reverting returns: limits to arbitrage considerations dominate. One potential explanation is that many investors review their investment decisions once per year, because it is both costly and difficult to monitor hedge fund performance on a continuous-time basis. While it is ultimately difficult to test, this explanation is confirmed by the fact that we find a strong association between annual returns and outflows. We propose further evidence consistent with this interpretation. For liquid strategies, our limits to arbitrage mechanism dominate, even at high frequencies, while for illiquid strategies, return-smoothing is observed even at relatively low frequencies.

The rest of the paper follows a simple structure. Section 2 describes the model and derives testable hypotheses. Section 3 tests the model. Section 4 concludes.

2. Model

This section presents a stripped-down version of the Shleifer and Vishny (1997) model in which funds can choose the strength of their capital structure. Our objective is to derive equilibrium relationships between capital structure and the extent of return mean reversion and volatility. We test these relationships in the empirical section.

2.1. Basic set-up

There is one asset in unit supply and two types of market participants: noise traders and a mass one of identical, risk-neutral, competitive arbitrageurs (hedge funds). There are three periods, $t=1,2,3$, and no discounting. At date $t=3$, the price of the asset converges to its fundamental value V with certainty. At dates $t=1,2$, the asset is traded at price p_t by noise traders and hedge funds. Noise trader demand for the asset is equal to $(V-S_t)/p_t$, where $S_t>0$ reflects pessimism about the asset. Hedge funds have assets under management (AUM) F_t that they may invest in the asset or in cash. We denote by θ_t the fraction of AUM invested in the asset. Hence, hedge funds buy $\theta_t F_t$

maximize

$$\mathbb{E}\left[b\frac{F_2 V}{p_2}\right] = bF_1\left\{(1-q)\left(1+(1+a)\theta_1\frac{V-p_1}{p_1}\right) + q\left(1+(1+b)\theta_1\frac{p_2-p_1}{p_1}\right)\frac{V}{p_2}\right\} \tag{2}$$

with respect to flow-performance sensitivity $b \in [0, \bar{b}]$ and asset share $\theta_1 \in [0,1]$. Solving this optimization problem leads to b and θ_1 as functions of current and future prices p_1 and p_2.

Finally, to focus on the choice of b by hedge funds, we make the following assumption.

Assumption 1. (i) F_1 is small; (ii) $\bar{b} = ((1-q)/q)((V-S_2)/V)(1+a)S_1/(S_2-S_1) - 1$; (iii) $((1-q)/q)((V-S_2)/V)((1+a/2)(S_1-(V-S_1)/2)/(S_2-S_1+(V-S_1)/2) > 1$.

Assumption 1 ensures that, in equilibrium, hedge funds use impediment frictions b rather than cash holdings to hedge outflow risk. In this model, cash and withdrawal frictions are partial substitutes. This can be seen formally from the fact that the cross derivative of the objective function with respect to b and θ_1 is negative. Funds with performance-insensitive AUM (b close to 0) do not hold cash ($\theta_1 = 1$). These funds will not lose funds if the asset becomes even more underpriced at $t=2$. As they know that the trade will eventually converge, they invest all of their $t=1$ AUM in the asset, and nothing in cash. Conversely, funds with very performance-sensitive AUM (large b) can lose everything if the trade diverges. To preserve their funds, they will have a strong incentive to invest in cash at $t=1$ ($\theta_1 = 0$), and wait until arbitrage returns are certain. When Assumption 1 holds, funds will not invest in cash and will deal with asset volatility by choosing optimal withdrawal frictions b, which is the subject of this paper.

Intuitively, Assumption 1 is equivalent to saying that underpricing risk is moderate compared to the upside potential of the trade. The probability of price drop q or the size of the drop $S_2 - S_1$ are small enough (condition (iii) in the assumption), so that holding cash is not optimal. The initial underpricing is not arbitraged very much (condition (i)), so the upside potential at $t=1$ makes investment in the asset attractive. The value of $\bar{b}$ is large enough for the optimal choice of b to be an interior solution, but not too large that the fees eventually collected by having extremely sensitive outflows, along with a conservative investment policy, are bounded above (condition (ii)).

Proposition 1 describes the equilibrium under these assumptions.

Proposition 1. Under Assumption 1, in the unique equilibrium, hedge funds hold no cash at date 1, i.e., $\theta_1 = 1$, and

$$b = \frac{1}{2\frac{p_2-p_1}{p_1}}\left(1+\frac{1-q}{q}\left(1+a\frac{V-p_1}{p_1}\right)\frac{p_2}{V}\right), \tag{3}$$

$$p_1 = V - S_1 + F_1, \tag{4}$$

$$p_2 = (V - S_1 + F_1)\left(1 - \frac{S_2 - S_1}{V - S_1 - F_1 b}\right). \tag{5}$$

Proof. See Appendix A.

Together, the equations in Proposition 1 determine the unique rational expectation equilibrium of this model. At date 1, funds hold no cash and choose their outflow-to-performance sensitivity b, for given expected future prices p_1, p_2. Ex post, these prices are determined by the initial choices of the funds. The fixed point of this problem defines the equilibrium of the model.

In equilibrium, all funds choose the same outflow-to-performance sensitivity and have the same returns. In order to generate predictions regarding the relation between fund outflow-to-performance sensitivity and asset returns, Proposition 2 considers the comparative static properties of the equilibrium across asset markets.

Proposition 2. Consider two assets U and N such that underpricing is more severe on asset market U: $S_2^U > S_2^N$. Then, under Assumption 1:

(i) flow-to-performance sensitivity b is lower for hedge funds operating on market U;
(ii) date 2 price p_2 is lower on market U;
(iii) date 1 price p_1 is identical on both markets.

Proof. See Appendix A.

These comparative static results are intuitive. In our model, hedge funds that operate on heavily mispriced markets choose lower flow-to-performance sensitivity. This limits the potential loss of AUM and therefore increases hedge fund profits. A side effect of this decision is to increase the capital available at date 2, which tends to increase prices at this date. This effect is however dominated by the direct impact of noise trader pessimism. Overall, p_2 is decreasing in S_2.

Assumption 1 allows us to focus on the case where hedge funds manage outflows through withdrawal limitations, rather than through cash holdings. In markets where underpricing S_2 is larger, hedge funds may choose to protect themselves against outflows by holding cash during the first period, instead of limiting withdrawals. Under Assumption 1, parameters are such that it is never the case. This ensures that, in the cross-section of funds, stronger underpricing goes with larger withdrawal frictions b, rather than with more cash holdings.

2.2. Hypotheses

Proposition 2 leads to three easily testable hypotheses. The first implication is that, conditional on low past performance, funds with performance–insensitive outflows have higher expected returns. Indeed, on markets where underpricing is more severe, funds protect themselves from potential outflows (Proposition 2 (i)), while the expected return following low performance, $(V - p_2)/p_2$, is larger (Proposition 2 (ii)).

Hypothesis 1. Conditional on low performance, funds with lower flow–performance sensitivity experience higher future returns.

The second implication is that outflow-to-performance sensitivity should be negatively correlated with fund return volatility. Indeed, when pessimism S_2 becomes larger, the date 1 price does not change (Proposition 2 (iii)), but potential underpricing at date 2 is more pronounced (Proposition 2 (ii)). Hence, return volatility as defined for instance by

$$vol = E\left(\left|\frac{p_2 - p_1}{p_1}\right| + \left|\frac{p_3 - p_2}{p_2}\right|\right) \quad (6)$$

is larger on markets where S_2 is larger, which are also the markets where hedge funds have less performance–sensitive outflows (Proposition 2 (i)). Hence,

Hypothesis 2. Funds with lower flow–performance sensitivity have more volatile returns.

The last testable implication is that, conditional on good past performance, future returns are not correlated with flow–performance sensitivity. When first-period performance is high, there is no mispricing left at $t=2$. Past returns are given by $(p_2^+ - p_1)/p_1 = (S_1 - F_1)/p_1 > 0$. Future returns are equal to zero; they do not depend on noise trader pessimism S_2.

Hypothesis 3. Conditional on high past performance, future fund returns are unaffected by flow-to-performance sensitivity.

We now proceed to test these hypotheses using data on hedge fund performance.

3. Empirical evidence

3.1. Data description

We start with a June 2008 download of data from EurekaHedge, a hedge fund data provider. The download includes monthly data from June 1987 until June 2008; 6,070 funds are initially present in the sample, with a total of 366,728 observations. Every month, each fund reports its AUM and net-of-fee returns. We delete all funds that have less than 15 million USD under management. In most of the paper, we work at the annual frequency (we investigate higher frequencies in Section 3.5). We thus collapse the original data set into 4,426 fund-year observations.

Descriptive statistics on returns, AUM, and fund flows are provided in Table 1, Panel A. The mean annual return is about 11% net of fees. We construct a dummy for "high" returns, equal to one when a fund returns more than 20%. We also construct a dummy for "low" returns, equal to one when annual returns are below the risk-free rate as measured by the 3-month Treasury-bill rate. In our sample, about 20% of the observations correspond to either low or high returns. Mean AUM are \$270 million. We also compute net inflows into each fund. Following the literature on fund flows (Chevalier and Ellison, 1997; Sirri and Tufano, 1998), we compute net flows as a fraction of lagged AUM by taking the difference between AUM growth and returns. In the average year, funds receive on average 10% of their AUM as new net inflows. We also define outflows as net inflows if they are negative, and zero else. Average outflows are, by definition, negative and they average to 14% of AUM. In Panel B, we report the breakdown of observations by strategies. "Long–short equity" funds represent 44% of the observations.

Panel C of Table 1 reports descriptive statistics on contractual impediments to withdrawals and flow–performance sensitivity. We use three types of variables to measure these impediments. First, we look at lockup restrictions, which prevent investors from redeeming their shares during a given period after their investment; 22% of the observations correspond to funds that have such provisions. For these funds, the average lockup period is 12 months. The second class of impediments consists of redemption periods. Redemption can only occur at fixed dates: monthly for 51% of the funds, quarterly for 33% of them. In addition to this constraint, investors have to advise the fund in advance of redemptions; the minimum delay between the demand and redemption is the notice period. In our data, this notice period is lower than one month in 27% of the cases and equal to one month in 40% of the cases. The total of redemption frequency plus notice period, a standard measure of impediments (Agarwal, Daniel, and Naik, 2009), is on average 3.3 months.

The results we present in the remainder of the text also hold when using Lipper/TASS, an alternative hedge funds data set. In the main text, we report regression results using EurekaHedge. In Appendix C, we report summary statistics, as well as regression results, using Lipper/TASS. Summary statistics, as well as regression results, are remarkably similar across the two data sets.

3.2. Key explanatory variables

An important aspect of our empirical strategy is measuring how sensitive a hedge fund's outflows are to its past performance. We use four different measures of this sensitivity.

The first two measures are contractual impediments to withdrawals. They are dummy variables for lockups and low redemption frequencies, in line with the literature (Aragon, 2007; Agarwal, Daniel, and Naik, 2009). The "lockup" dummy is equal to one when the fund has a positive lockup period; 22% of the observations have such provisions. The "redemption" dummy is equal to one when the sum of the redemption and notice periods is equal to or longer than a quarter (90 days); it is the case for 42% of the observations. Note that both dummies are positively, but imperfectly correlated. The correlation is 43%, using one data point per fund; 29% of the funds without lockup have long redemption periods. This indicates that these provisions can either be complements, or substitutes.

Our third measure is the "duration" of a fund. It combines information on lockup, redemption date, and notice periods, in order to calculate an effective duration for the assets under management. We define duration as the minimum time an investor has to wait in order to withdraw the average dollar invested in a fund:

$$\text{Duration}_{it} = \text{Notice}_i + \frac{\text{Redemption period}_i}{2} + \frac{1}{\text{AUM}_{it}} \sum_{s=0}^{\text{Lockup period}_i} \text{Net inflow}_{it-s} 1_{\{\text{Net inflow}_{it-s} > 0\}} (\text{Lockup period}_i - s) \quad (7)$$

Table 1
Summary statistics.

EurekaHedge, 1994–2007. Annual data, excluding funds with AUM lower than 15 million USD. Panel A: Returns are net of fees. The dummy for low performance is equal to one if the return is below the yield on the 3-month Treasury-bill. The dummy for high performance is equal to one if the return is above 20%. AUM are measured at the end of the calendar year. Net flows are computed as $AUM_{it} - (1 + r_{it})AUM_{it-1}$. Outflows are defined as the minimum of net flows and zero. Panel B: The classification styles are "Arbitrage," "CTA/Managed futures," "Event driven," "Fixed income," "Long–short equity," and "Multi-strategy." Panel C: The impediments to withdrawals are the lockup period in months, a dummy equal to one if the fund has a lockup, the sum of the notice period and the redemption period in months, a dummy equal to one if that sum is at least equal to three months, the duration in months, and the outflow/loss sensitivity defined as the correlation between the dummy for the fact that the previous annual return was below the risk-free rate and the current year outflows.

Panel A: Time-varying variables	Obs.	Mean	Std. dev.	25th	50th	75th
Return (%)	4,426	11.1	14.0	3.3	9.5	17.1
Return $<$ risk free rate	4,426	0.22				
Return $> 20\%$	4,426	0.20				
AUM (\$ million)	4,426	273	495	53	125	298
Net flows/AUM	4,426	0.10	0.60	0.20	0.00	0.27
Outflows/AUM	4,426	0.14	0.23	0.20	0.00	0.00
Panel B: Strategies						
Arbitrage	4,426	0.09				
CTA/Managed futures	4,426	0.08				
Event driven	4,426	0.06				
Fixed income	4,426	0.06				
Long–short equity	4,426	0.44				
Multi-strategy	4,426	0.09				
Panel C: Impediments to withdrawals						
Lockup period (months)	4,426	2.89	6.30	0.00	0.00	0.00
Lockup dummy	4,426	0.22				
Notice + redemption period (months)	4,426	3.33	3.16	1.50	2.00	4.50
Quarterly notice + redemption dummy	4,426	0.42				
Duration (months)	4,426	3.00	3.32	1.00	1.50	3.50
Outflow/loss sensitivity	1,512	0.22	0.37	0.54	0.27	0.14

The first part of the formula accounts for the effects of the notice period and the redemption date. The implicit assumption is that the distance to the next redemption date is uniformly distributed so that, on average, the distance to the next redemption is equal to the frequency divided by two. The second part of the formula accounts for the effect of lockup periods. For each past net inflow into the fund, it computes the remaining lockup duration (e.g., five-month-old inflows have a duration of seven months if the lockup period is one year). We use monthly data to construct this variable. We define monthly flows as the difference between AUM growth and monthly return, and remove outliers. Overall, the above formula is an approximation. First, past gross inflows are approximated by net inflows, which would lead to an underestimation of actual duration if gross inflows are masked by simultaneous outflows. Second, for funds that are still locked up, notice and redemption periods are ineffective. This leads to an overestimation of actual duration.

To describe this variable in the data, we plot the sample distribution of durations in Fig. 1, and report detailed summary statistics in Table 2. Overall, average duration is three months, as reported in Table 1. If we focus on the subgroup of funds with lockup periods, mean duration is much larger: 8.5 months. For this subgroup of funds, the average dollar under management is secured for almost three quarters. Overall, most professional arbitrageurs have remarkably short horizons, which exposes them to the risk of severe underpricing, the theme of this paper. Duration may, however, underestimate the stickiness of funds, as funds may also rely on investor loyalty or their reputation to limit outflows after poor performance. Because of this, we will also look at effective outflow-to-performance sensitivity as an alternative measure of capital structure strength.

Table 2 shows how duration covaries with key fund observables. The distribution of duration does not seem to be related to size (Panel A) or age (Panel B). At first glance, it does not seem to be the case that reputation, as approximated by size or age, allows funds to demand stricter impediments. Duration does, however, strongly vary across strategies. Funds trading futures, which tend to be very liquid, have lower durations (slightly less than a month, on average). Fixed-income or event-driven strategies, which tend to be lower frequency convergence trades, tend to be operated by funds of longer duration (five months, on average). In our regressions, in order to isolate the effect of impediments, we systematically control for fund age, size, and strategy.

Our fourth measure is simply the effective flow–performance sensitivity. For each fund separately, we compute the correlation between outflows – net inflows set to zero when they are positive – and our "low" performance dummy. This correlation thus measures the sensitivity of outflows to one-year lagged low performance. We find this correlation to be equal, on average, to 22% (see Table 1, Panel C). The outflow-to-loss sensitivity is low (less

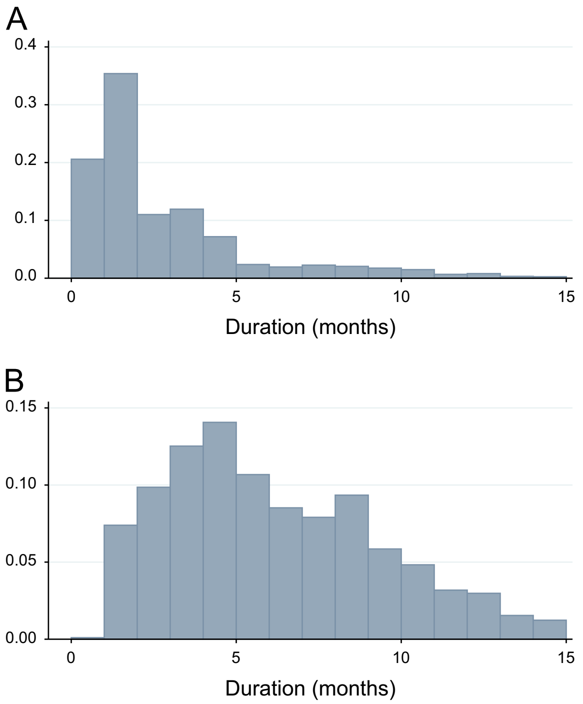


Fig. 1. Duration of fund liabilities. EurekaHedge, 1994–2007, excluding funds with AUM lower than 15 million USD. We plot the distribution of the duration of fund liabilities for all hedge funds (Panel A) and for the subset of funds with a lockup period (Panel B). The duration of fund i in month t is computed as $\text{Notice period}_i + \text{Redemption period}_i/2 + (1/\text{AUM}_{it})\sum_{s=0}^{\text{Lockup period}_i} \max\{\text{Net flow}_{it-s}, 0\}(\text{Lockup period}_i - s)$, where all time periods are measured in months.

negative) when funds impose contractual constraints on withdrawals, or when they have long-term, loyal investors.

3.3. Impediments to withdrawals and outflows

Before running our tests, we check that contractual impediments to withdrawals (directly captured by our first three measures) are correlated with flow–performance sensitivity (captured by our fourth measure). To illustrate, we show in Fig. 2 how fund flows reacted during the convertible arbitrage crisis of 2005. Mitchell, Pedersen, and Pulvino (2007) document that, in 2005, convertible arbitrage funds experienced large withdrawals from institutional investors, which led them to sell their portfolios at a discount, inducing further negative price pressure on the convertible market. Panels A and B of Fig. 2 show cumulative returns of convertible arbitrage funds in our sample. Returns reached their lowest level in May 2005. As a result, the industry experienced negative net flows during the period, as shown by Mitchell, Pedersen, and Pulvino. However, Panels C and D document that outflows were concentrated among funds with weaker contractual limitation to withdrawals (no lockup, short redemption periods). Funds with stronger limitations experienced positive net flows, possibly because of the overall trend towards hedge fund investing until the 2007–2009 financial crisis. For funds with weaker capital structure, the net effect of the meltdown is negative: structural inflows that all strategies received during the period did not compensate the large outflows due to the 2005 meltdown.

We expect this type of effect to be more broadly present in our data. To test for it, we run the following regression on our annual data:

$$\begin{aligned}\text{Outflow}_{it} = \alpha_i &+ \beta\,\text{Low perf}_{it-1} + \gamma\,\text{Low perf}_{it-1} \times \text{Contractual impediment}_{it} \\ &+ \delta X_{it-1} + \zeta\,\text{Low perf}_{it-1} \times X_{it-1} + \varepsilon_{it}, \qquad (3)\end{aligned}$$

where t is a time index and i a fund index. We use as impediment measures each one of our first three variables of contractual restrictions to withdrawal: lockup and redemption dummies, as well as the log of duration. X_{it-1} represents lagged fund observables: log of AUM, log of age, and strategy dummies. The controls interacted with the past low performance variable capture the effect of observable heterogeneity in mean reversion, potentially correlated with impediments. We also include a fund-specific fixed effect and cluster error terms at the year level to capture the fact that returns tend to be correlated. We expect γ to be positive: when performance is poor, funds that are protected by impediments should experience bigger (i.e., less negative) outflows.

Regression results reported in Table 3 show that bad performance triggers smaller outflows in the presence of contractual limitations. We use nine different specifications. Columns 1–3 use the lockup dummy, columns 4–6 the redemption dummy, and columns 7–9 the duration measure. For each measure, we report regressions with no control for interacted fund observables (X_{it-1}), with only age and size controls, and with the full set of controls (size, age, and strategy). We observe that, across specifications, the interaction coefficient is negative and statistically significant. It is also economically significant. For instance, column 4 indicates that, following bad performance, funds with short redemption face outflows as large as 13.4% of their AUM. With long redemption, outflows are reduced by one-quarter, to 13.4–3.8%=9.6% of AUM. We also note that the size and significance of the estimates is unaffected by the presence of our interacted controls. Our results are consistent with Ben-David, Franzoni, and Moussawi (2011), who use a different specification (relative, instead of absolute, returns), but find results similar to ours in times of crisis.

According to our estimates, lockups make hedge fund flows as sticky as mutual fund flows in cases of low performance. As a basis for comparison, we consider the recent paper by Ferreira, Keswani, Miguel, and Ramos (2012), who estimate the flow–performance sensitivity of mutual funds. Their sample covers funds around the world, and is mostly focused on the 2000s, which makes it similar to our hedge fund sample. In their Table 5, they find that net inflows are a piecewise linear function of performance rank. Using their coefficients, a simple calculation shows that funds in the bottom quintile of performance, compared to funds in the average top four quintiles, would receive net inflows lower by 8% of AUM. We can then compare these inflow losses to our estimates from Table 3. In our data, about 20% of the observations correspond to "low performance" fund-years. For funds without lockup, estimates in columns 1 and 2 suggest that

Table 2
Duration.
EurekaHedge, 1994–2007. Annual data, excluding funds with AUM lower than 15 million USD. Summary statistics about duration in months across fund size categories (Panel A), fund age categories (Panel B), and classification styles (Panel C). The duration of fund i in month t is computed as $\text{Notice period}_i + \text{Redemption period}_i/2 + (1/\text{AUM}_{it}) \sum_{s=0}^{\text{Lockup period}_i} \max\{\text{Net flow}_{it-s}, 0\} (\text{Lockup period}_i - s)$, where all time periods are measured in months.

Panel A: By AUM	Obs.	Mean	Std. dev.	25th	50th	75th
		Duration				
0–100 $ million	1,913	3.0	3.4	1.0	1.5	3.5
100–500 $ million	1,924	3.0	3.3	1.2	1.5	3.5
> 500 $ million	589	2.9	3.2	1.0	1.5	3.5
Panel B: By age						
0–3 years	1,396	3.0	3.4	1.0	1.5	3.5
4–6 years	1,608	2.9	3.2	1.0	1.5	3.5
> 6 years	1,422	3.1	3.4	1.1	1.8	3.5
Panel C: By strategy						
Arbitrage	393	3.7	3.4	1.5	3.0	4.5
CTA/Managed futures	345	0.9	1.7	0.2	0.7	1.0
Event driven	264	5.2	4.6	1.6	3.5	8.1
Fixed income	260	3.3	3.3	1.5	2.0	3.6
Long–short equities	1,959	2.8	2.8	1.5	1.5	3.5
Multi-strategy	394	2.7	2.7	1.1	1.7	3.5

low performance funds lose 13% of AUM in assets, compared to other funds. Underperforming funds with lockups lose approximately 7% of AUM. Hence, lockups allow hedge funds to reach the same level of flow "stickiness" as the mutual funds in Ferreira et al.'s data. Without lockup, however, hedge fund flows are more sensitive to bad performance than mutual funds.[4]

3.4. Testing the hypotheses

Before running formal statistical tests, we start by providing graphical evidence that return mean reversion is related to low flow-performance sensitivity (Hypotheses 1 and 3). In Fig. 3, we sort observations into nine buckets of excess returns. For each of these groups, we calculate the average next-year return for two subgroups of funds: funds with strong and funds with weak flow–performance sensitivity. This approach allows us to appraise return dynamics in a "nonparametric" way. Fig. 3 has four panels, one per measure of flow–performance sensitivity. Three patterns consistently emerge. First, for funds with low impediments to withdrawals, future returns are monotonically increasing with past returns. This is consistent with the well-known fact that hedge fund returns are persistent. Secondly, conditional on low returns, future returns of funds with high impediments are larger than future returns of funds with low impediments. This is consistent with Hypothesis 1, which states that funds protect their liabilities when assets are more likely to diverge. For three measures out of four, the effect is nicely monotonic: the worse are past returns, the larger is the positive effect of impediments. Third, when past returns are positive, the two categories of funds have the same future performance. This is true for all buckets of positive returns, and for all measures of impediments. This is consistent with Hypothesis 3. All in all, visual evidence provided in Fig. 3 lends strong support for Hypotheses 1 and 3.

3.4.1. Hypothesis 1: Mean reversion in hedge fund returns following low performance

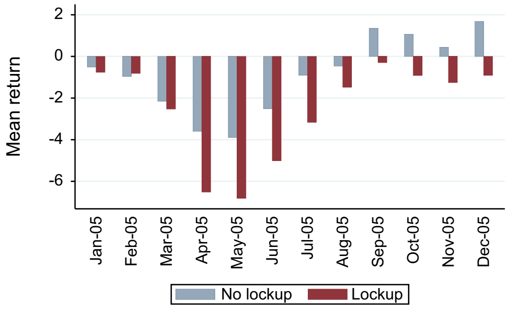
We now statistically test Hypothesis 1. We run the following regression:

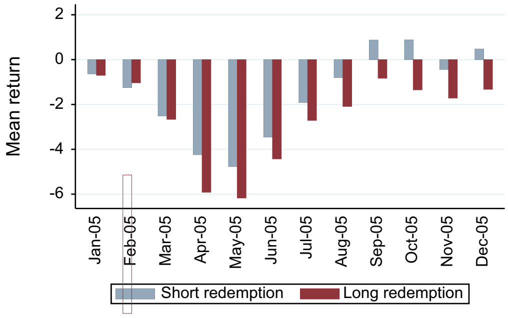
$$\begin{aligned}\text{Return}_{it} = {} & \alpha + \beta \text{ Low perf}_{it-1} + \gamma \text{ Low perf}_{it-1} \\ & \times \text{Flow–perf sensitivity}_{it} \\ & + \delta \text{ Flow–perf sensitivity}_{it} + \zeta X_{it} \\ & + \eta \text{ Low perf}_{it-1} \times X_{it} + \varepsilon_{it},\end{aligned} \tag{9}$$

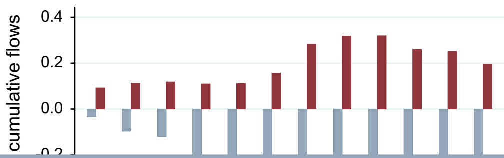
where i is a fund index, t is the time index, and X_{it} is a set of controls that includes fund age, fund size, and strategy. We now use all four measures of flow–performance sensitivity: the three measures of contractual impediments to withdrawals, as well as the effective flow–performance sensitivity. We double-cluster error terms at the year and at the fund levels. If Hypothesis 1 holds in the data, we expect that $\gamma > 0$.

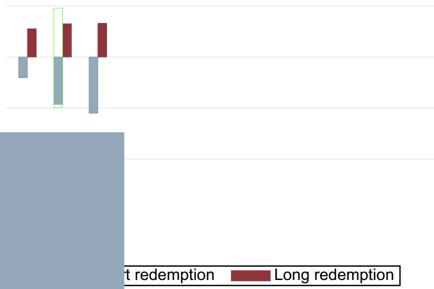
We find strong statistical support for Hypothesis 1. Table 4, Panel A reports the results of estimating Eq. (9) using the four impediment measures; for each measure, we use three different sets of controls, X_{it}. First, note that, consistent with graphical evidence, returns tend to display some persistence. The estimate in the top line indicates that past low returns predict lower future returns. Second, and more to the point of our tests, for ten out of the twelve specifications, we find that the coefficient γ in the above equation is statistically significant at 1%, and is stable across specifications. It is also large. For instance, estimates

[4] Using an older sample of purely U.S.-based mutual funds, Sirri and Tufano (1998) find larger coefficients (their Table 2). Comparing the average underperforming funds (bottom quintile) and the average non-underperforming funds (top four quintiles), this leads to an inflow loss of about 20% of AUM.


Mean return
2
0
-2
-4
-6
Jan-05
Feb-05
Mar-05
Apr-05
May-05
Jun-05
Jul-05
Aug-05
Sep-05
Oct-05
Nov-05
Dec-05
No lockup
Lockup


Mean return
2
0
-2
-4
-6
Jan-05
Feb-05
Mar-05
Apr-05
May-05
Jun-05
Jul-05
Aug-05
Sep-05
Oct-05
Nov-05
Dec-05
Short redemption
Long redemption


cumulative flows
0.4
0.2
0.0


Long redemption

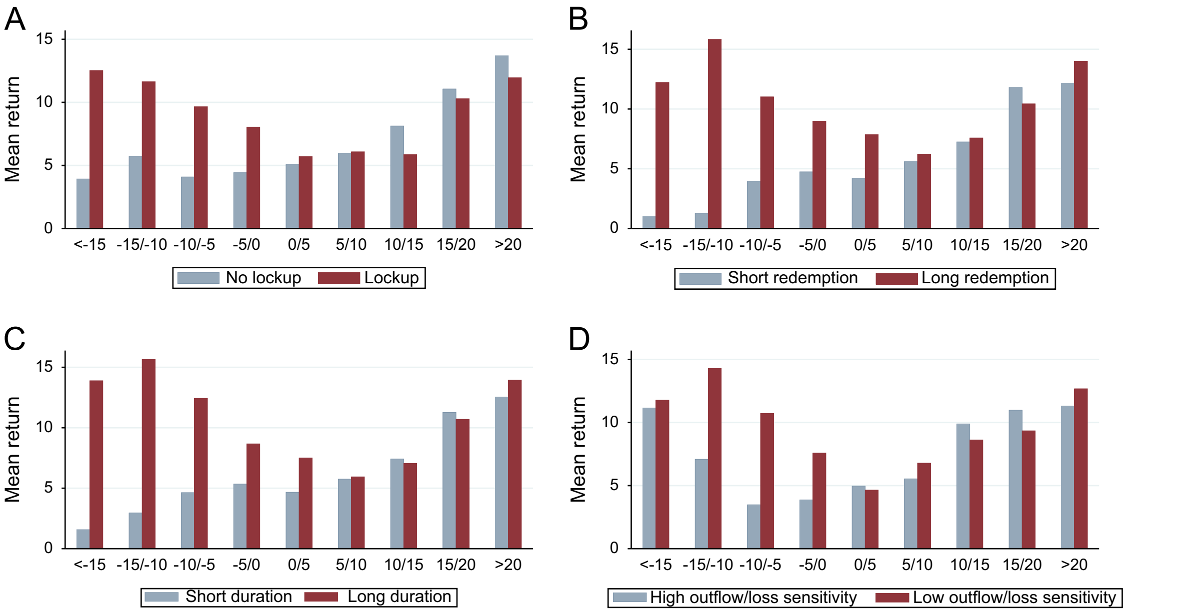


Fig. 3. Conditional returns and impediments to withdrawals. EurekaHedge, 1994–2007. Annual data, excluding funds with AUM lower than 15 million USD. We plot the equal-weighted average annual net-of-fee return in excess of the risk-free rate over funds in the following categories: funds whose past annual return in excess of the risk-free rate lies in ð 1 , 0.15Þ, [0.15, 0.10), [0.10, 0.05), [0.05,0), [0,0.05), [0.05,0.10), [0.10,0.15), [0.15,0.20), and ½0.20, þ1Þ ; for funds with and without a lockup (Panel A); for funds with a sum of the redemption and notice periods above and strictly below three months (Panel B); for funds with a duration above and strictly below three months (Panel C); for funds with a correlation between the dummy for previous year return below the risk-free rate and current outflows above and below the sample median (Panel D). (Panel A) Impediment ¼Lockup, (Panel B) Impediment ¼Quarterly redemption, (Panel C) Impediment ¼Duration and (Panel D) Impediment ¼Outflow/loss sensitivity.

Table 4
Conditional returns and impediments to withdrawals.

EurekaHedge, 1994–2007. Annual data, excluding funds with AUM lower than 15 million USD. The dependent variable is the annual net-of-fee return in excess of the risk-free rate. In column 1, the regressors are a dummy for low past performance equal to one if the past annual excess return was negative, the dummy for the fact that the fund has a lockup, the lockup dummy interacted with the low past performance dummy, the lagged log of AUM, and the log of age. In column 2, we also interact the lagged log of AUM and the log of age with the dummy of low past performance. In column 3, we also interact the dummies for classification styles with the dummy of low past performance. In columns 4–6, the impediments to withdrawals variable is replaced with the dummy for the fact that the sum of the fund's redemption period and notice period is at least equal to three months. In columns 7–9, the impediments to withdrawals variable is the log of duration at the end of previous year. In columns 10–12, impediments to withdrawals are the fund-level correlation between the dummy of past performance below the risk-free rate and current outflows. Error terms are clustered by fund and year. ^{n}, ^{nn}, and ^{nnn} mean statistically different from zero at the 10%, 5%, and 1% levels of significance.

	Dependent variable: Returns											
Impediment:	Lockup			Quarterly redemption			Duration			Outflow/loss sensitivity		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Low past performance	2.8	2.8^{n}	2.8^{n}	3.8^{nn}	3.9^{nnn}	1.2	6.3^{nnn}	6.3^{nnn}	0.0	2.9	3.4	6.7^{nnn}
	(1.6)	(1.7)	(1.8)	(2.5)	(2.6)	(1.1)	(3.2)	(3.4)	(0.0)	(1.0)	(1.1)	(3.4)
Impediment	0.7	0.6	0.5	1.6^{n}	1.6^{n}	2.2^{nnn}	0.7	0.7	1.2^{nnn}	1.8	1.7	1.6
	(0.8)	(0.8)	(0.9)	(1.7)	(1.8)	(4.3)	(1.0)	(1.0)	(3.6)	(1.0)	(1.1)	(1.1)
Low past perf. Impediment	4.6^{nnn}	4.3^{nnn}	2.5	5.4^{nnn}	5.3^{nnn}	4.0^{nnn}	4.5^{nnn}	4.4^{nnn}	2.8^{nnn}	9.6^{nnn}	9.2^{nn}	10.1^{nnn}
	(2.7)	(3.2)	(1.5)	(3.9)	(4.4)	(3.1)	(3.7)	(4.2)	(3.6)	(2.9)	(2.3)	(3.1)
Log(AUM)	0.7^{nnn}	0.5	0.6^{n}	0.7^{nnn}	0.5	0.6^{n}	0.7^{nnn}	0.5	0.6^{n}	1.0^{nn}	1.0^{n}	1.0^{n}
	(2.8)	(1.6)	(1.9)	(2.7)	(1.5)	(1.7)	(2.8)	(1.5)	(1.7)	(2.1)	(1.8)	(1.9)
Log(age)	0.0	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.0	0.1	0.5	0.4
	(0.1)	(0.2)	(0.2)	(0.7)	(0.5)	(0.3)	(0.3)	(0.3)	(0.0)	(0.1)	(0.6)	(0.5)
Low past perf. Log(AUM)		1.0	1.0		1.2	1.1		1.1	1.0		0.0	0.1
		(1.0)	(1.1)		(1.3)	(1.2)		(1.2)	(1.1)		(0.0)	(0.1)
Low past perf. Log(age)		0.2	0.1		0.2	0.0		0.2	0.1		2.2	1.8
		(0.1)	(0.1)		(0.1)	(0.0)		(0.1)	(0.0)		(1.2)	(1.0)
Constant	8.1^{nnn}	8.1^{nnn}	4.7^{nnn}	7.3^{nnn}	7.3^{nnn}	3.3^{nnn}	7.2^{nnn}	7.2^{nnn}	2.9^{nn}	8.1^{nnn}	7.9^{nnn}	6.2^{nnn}
	(11.9)	(11.7)	(3.7)	(9.7)	(9.8)	(2.9)	(7.3)	(7.4)	(2.4)	(5.6)	(5.5)	(2.9)
Low past perf. Style	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
Observations	4,179	4,179	4,179	4,179	4,179	4,179	4,179	4,179	4,179	1,188	1,188	1,188
Adj. R^2	0.01	0.01	0.03	0.02	0.02	0.04	0.02	0.02	0.04	0.02	0.02	0.03

Table 5
Volatility and impediments to withdrawals.
EurekaHedge, 1994–2007. Annual data, excluding funds with AUM lower than 15 million USD and funds with two observations or less. The dependent variable is the absolute difference between annual net-of-fee return and fund average annual net-of-fee return. In column 1, the regressor is the dummy for the fact that the fund has a lockup. In column 2, we add the log of AUM and the log of age. In column 3, we also add dummies for classification styles. In columns 4–6, the impediments to withdrawals variable is the dummy for the fact that the sum of the fund's redemption period and notice period is at least equal to three months. In columns 7–9, the impediments variable is the log of duration at the end of previous year. In columns 10–12, impediments to withdrawals are the fund-level correlation between the dummy of past performance below the risk-free rate and current outflows. Error terms are clustered by fund and year. ^{n}, ^{nn}, and ^{nnn} mean statistically different from zero at the 10%, 5%, and 1% levels of significance.

	Dependent variable: Absolute deviation to average return											
Impediment:	Lockup			Quarterly redemption			Duration			Outflow/loss sensitivity		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Impediment	0.15	0.17	0.04	1.82^{nnn}	1.81^{nnn}	2.48^{nnn}	0.89^{nn}	0.88^{nn}	1.40^{nnn}	0.57	0.63	0.07
	(0.3)	(0.3)	(0.1)	(3.3)	(3.3)	(5.1)	(2.0)	(2.0)	(3.7)	(0.5)	(0.6)	(0.1)
Log(AUM)		0.14	0.10		0.17	0.13		0.15	0.10		0.28	0.24
		(0.5)	(0.3)		(0.6)	(0.4)		(0.6)	(0.4)		(0.9)	(0.8)
Log(age)		0.29	0.35		0.15	0.13		0.25	0.27		1.13	1.01
		(0.5)	(0.6)		(0.2)	(0.2)		(0.4)	(0.4)		(1.2)	(1.0)
Style FE	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
Observations	2,904	2,904	2,904	2,904	2,904	2,904	2,904	2,904	2,904	1,246	1,246	1,246
Adj. R^2	0.00	0.00	0.04	0.01	0.01	0.05	0.00	0.00	0.05	0.00	0.00	0.06

Table 6
Conditional returns and impediments to withdrawals: asymmetric mean reversion.
EurekaHedge, 1994–2007. Annual data, excluding funds with AUM lower than 15 million USD. The dependent variable is the annual net-of-fee return in excess of the risk-free rate. In column 1, the regressors are a dummy for low past performance equal to one if the past annual excess return was negative, a dummy for high past performance equal to one if the past annual return was above 20%, the dummy for the fact that the fund has a lockup, the lockup dummy interacted with the low past performance and the high past performance dummies, the lagged log of AUM, and the log of age. In column 2, we also interact the lagged log of AUM and the log of age with the dummies of past performance. In column 3, we also interact the dummies for classification styles with the dummies of past performance. In columns 4–6, the impediments variable is a dummy for the sum of the fund's redemption period and notice period being at least equal to three months. In columns 4–6, the impediments to withdrawals variable is replaced with the dummy for the fact that the sum of the fund's redemption period and notice period is at least equal to three months. In columns 7–9, the impediments to withdrawals variable is the log of duration at the end of previous year. In columns 10–12, impediments to withdrawals are the fund-level correlation between the dummy of past performance below the risk-free rate and current outflows. Error terms are clustered by fund and year. ^{n}, ^{nn}, and ^{nnn} mean statistically different from zero at the 10%, 5%, and 1% levels of significance.

	Dependent variable: Returns											
Impediment:	Lockup			Quarterly redemption			Duration			Outflow/loss sensitivity		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Low past performance	1.1	1.1	4.1^{nnn}	2.3^{n}	2.4^{n}	2.3^{nn}	4.4^{nnn}	4.4^{nnn}	1.6	4.2	5.0^{n}	9.5^{nnn}
	(0.7)	(0.7)	(2.7)	(1.7)	(1.7)	(2.4)	(2.8)	(2.8)	(1.4)	(1.5)	(1.7)	(4.3)
Impediment	0.3	0.1	0.1	1.4^{n}	1.6^{nn}	2.3^{nnn}	1.0^{n}	1.1^{n}	1.6^{nnn}	1.4	1.6	2.3^{n}
	(0.5)	(0.2)	(0.1)	(1.9)	(2.1)	(5.1)	(1.7)	(1.7)	(4.0)	(1.0)	(1.2)	(1.7)
Low past perf. Impediment	4.2 ^{nnn}	3.8^{nnn}	2.0	5.5^{nnn}	5.3^{nnn}	3.9^{nnn}	4.1^{nnn}	4.0^{nnn}	2.5^{nnn}	9.3^{nn}	9.1^{nn}	10.8^{nnn}
	(2.9)	(3.2)	(1.3)	(5.6)	(6.3)	(3.7)	(4.5)	(4.8)	(3.3)	(2.5)	(2.0)	(2.8)
High past performance	6.4 ^{nnn}	6.7^{nnn}	8.7^{nnn}	6.3^{nn}	6.6^{nnn}	8.8^{nnn}	7.9^{nn}	8.3^{nnn}	10.4^{nnn}	4.1^{nn}	4.6^{nn}	9.9^{nnn}
	(3.6)	(4.4)	(4.2)	(2.6)	(3.1)	(3.3)	(2.4)	(2.7)	(3.1)	(2.0)	(2.4)	(3.7)
High past perf. Impediment	1.6	2.1	1.2	0.7	1.1	0.6	1.6	1.8	1.4	1.6	1.5	1.7
	(0.8)	(1.2)	(0.7)	(0.3)	(0.5)	(0.3)	(0.9)	(1.1)	(1.0)	(0.5)	(0.5)	(0.4)
Log(AUM)	0.8^{nnn}	0.2	0.3	0.8^{nnn}	0.2	0.2	0.8^{nnn}	0.2	0.2	1.0^{nn}	1.1^{n}	1.1^{n}
	(3.1)	(0.9)	(1.0)	(3.0)	(0.7)	(0.7)	(3.1)	(0.8)	(0.9)	(2.1)	(1.7)	(1.9)
Log(age)	0.1	0.4^{nnn}	0.3	0.1	0.6^{nnn}	0.5^{nn}	0.0	0.5^{nnn}	0.4^{nn}	0.1	1.3^{n}	1.6^{nn}
	(0.2)	(2.7)	(1.3)	(0.3)	(3.6)	(2.3)	(0.1)	(3.4)	(2.2)	(0.1)	(2.0)	(2.0)
Low past perf. Log(AUM)		1.3	1.4^{n}		1.5^{n}	1.5^{nn}		1.4^{n}	1.4^{n}		0.1	0.0
		(1.6)	(1.9)		(1.9)	(2.0)		(1.8)	(1.9)		(0.1)	(0.0)
High past perf. Log(AUM)		1.7^{n}	1.6^{n}		1.6^{n}	1.6^{n}		1.7^{n}	1.6		0.4	0.0
		(1.7)	(1.7)		(1.7)	(1.7)		(1.7)	(1.6)		(0.4)	(0.0)
Low past perf. Log(age)		0.5	0.4		0.5	0.4		0.6	0.5		3.1	3.0
		(0.4)	(0.3)		(0.4)	(0.3)		(0.4)	(0.3)		(1.4)	(1.4)
High past perf. Log(age)		1.8	1.7		1.9	1.7		1.9	1.8		1.9	1.7
		(1.0)	(1.0)		(1.1)	(1.1)		(1.0)	(1.1)		(1.1)	(0.9)
Constant	6.5^{nnn}	6.4^{nnn}	3.4^{nnn}	5.8^{nnn}	5.7^{nnn}	2.1^{nn}	5.3^{nnn}	5.2^{nnn}	1.3	6.7^{nnn}	6.3^{nnn}	3.4^{n}
	(8.9)	(8.9)	(2.8)	(7.5)	(7.5)	(2.0)	(5.3)	(5.2)	(1.0)	(5.2)	(5.1)	(1.7)
Past perf. Style	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
Observations	4,179	4,179	4,179	4,179	4,179	4,179	4,179	4,179	4,179	1,188	1,188	1,188
Adj. R^2	0.04	0.04	0.06	0.05	0.05	0.07	0.05	0.05	0.07	0.03	0.03	0.04

Table 7
Conditional returns and impediments to withdrawals: higher frequency evidence.

EurekaHedge, 1994–2007, excluding funds with AUM lower than 15 million USD. The dependent variable is the annual net-of-fee return in excess of the risk-free rate. Panel A uses monthly returns; Panel B uses quarterly returns. In both panels, in columns 1 –4 we use all funds; in columns 5 –8 we restrict the sample to the long –short equity style; in columns 9 –12 we restrict the sample to funds operating in the fixed-income style. In columns 1, 5, and 9, the regressors are a dummy for low past performance equal to one if the previous period excess return was negative, the dummy for the fact that the fund has a lockup, the lockup dummy interacted with the low past performance dummy, as well as the lagged log of AUM and the log of age and their interaction with the low past performance dummy (not reported). In columns 2, 6, and 10, the impediments to withdrawals variable is replaced with the dummy for the fact that the sum of the fund's redemption period and notice period is at least equal to three months. In columns 3, 7, and 11, the impediments to withdrawals variable is the log of duration at the end of previous year. In columns 4, 8, and 12, impediments to withdrawals are the fund-level correlation between the dummy of past performance below the risk-free rate and current outflows. Error terms are clustered by fund and month in Panel A, and by fund and quarter in Panel B. ^{n}, ^{nn}, and ^{nnn} mean statistically different from zero at the 10%, 5%, and 1% levels of significance.

Panel A: Monthly frequency
Dependent variable: Returns

Sample:	All funds				Long –short equity				Fixed income			
Impediment:	Lockup	Quart. redemp.	Duration	Sensitivity	Lockup	Quart. redemp.	Duration	Sensitivity	Lockup	Quart. redemp.	Duration	Sensitivity
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Low past	0.60^{nnn}	0.52^{nnn}	0.44^{nn}	0.81^{nnn}	0.67^{nnn}	0.54^{nnn}	0.52^{nnn}	0.78^{nnn}	0.87^{nnn}	0.85^{nnn}	0.50^{nnn}	0.39^{nn}
performance	(3.7)	(3.2)	(2.2)	(5.4)	(3.5)	(3.0)	(2.6)	(3.4)	(5.1)	(4.8)	(3.2)	(2.0)
Impediment	0.06	0.25^{nnn}	0.11^{nn}	0.09	0.03	0.32^{nnn}	0.11	0.28	0.21^{nn}	0.20^{nn}	0.18^{nnn}	0.19
	(1.0)	(4.7)	(2.3)	(0.5)	(0.3)	(3.5)	(1.5)	(1.2)	(2.3)	(2.2)	(3.1)	(0.5)
Low past perf.	0.13^{n}	0.27^{nnn}	0.17^{nn}	0.08	0.08	0.25^{nn}	0.10	0.39	0.52^{nn}	0.37^{n}	0.42^{nnn}	0.19
Impediment	(1.7)	(3.8)	(2.5)	(0.4)	(0.6)	(2.2)	(1.1)	(1.6)	(2.6)	(1.7)	(3.2)	(0.7)
Observations	113,238	113,238	113,238	18,327	51,211	51,211	51,211	8,112	6,861	6,861	6,861	520
Adj. R^2	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.05	0.05	0.05	0.03

Panel B: Quarterly frequency
Dependent variable: Returns

Sample:	All funds				Long –short equity				Fixed income			
Impediment:	Lockup	Quart. redemp.	Duration	Sensitivity	Lockup	Quart. redemp.	Duration	Sensitivity	Lockup	Quart. redemp.	Duration	Sensitivity
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Low past	0.88^{nn}	0.69^{n}	0.93^{nn}	0.65	1.30^{nnn}	1.09^{nn}	1.94^{nnn}	0.98^{n}	0.36	0.38	0.43	0.22
performance	(2.3)	(1.9)	(2.3)	(1.5)	(2.7)	(2.4)	(4.6)	(1.7)	(0.6)	(0.7)	(0.9)	(0.3)
Impediment	0.26	0.43^{nn}	0.07	0.03	0.70^{nnn}	0.36	0.21	0.71	0.49	0.52	0.54^{nn}	0.97
	(1.4)	(2.2)	(0.4)	(0.1)	(3.1)	(1.3)	(1.1)	(0.9)	(1.5)	(1.5)	(2.2)	(0.8)
Low past perf.	0.58^{n}	0.06	0.18	0.57	1.41^{nnn}	0.52	0.87^{nnn}	0.35	1.48^{nn}	0.88^{n}	0.99^{nn}	1.15
Impediment	(1.9)	(0.2)	(0.7)	(0.8)	(4.7)	(1.6)	(3.2)	(0.4)	(2.4)	(1.8)	(2.4)	(1.0)
Observations	32,775	32,775	32,775	5,830	14,847	14,847	14,847	2,565	2,017	2,017	2,017	166
Adj. R^2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01

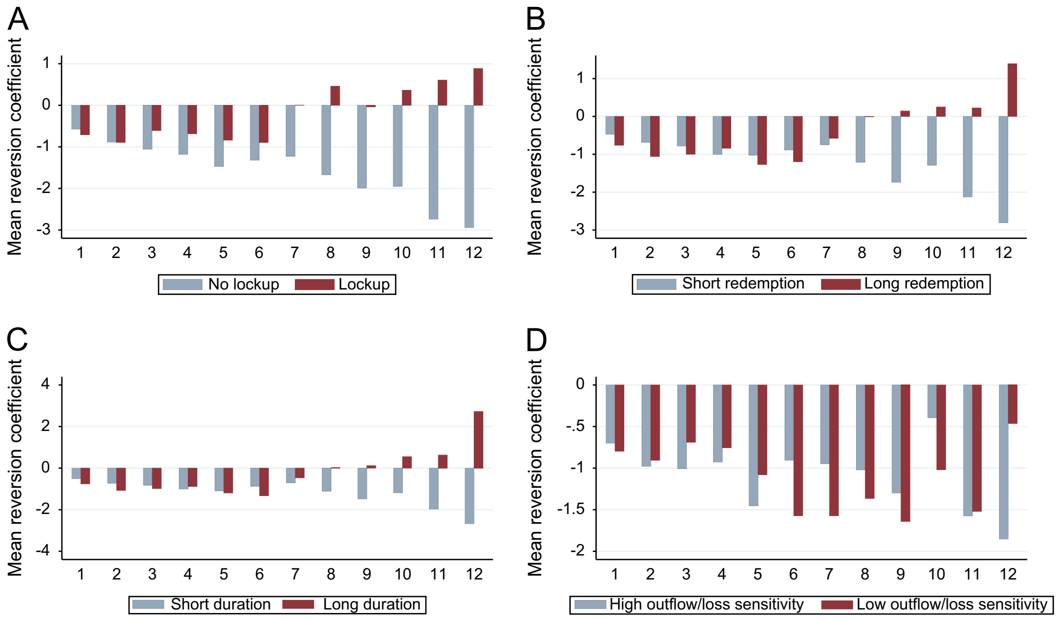


Fig. 4. Conditional returns and impediments to withdrawals: sampling frequency. EurekaHedge, 1994–2007, excluding funds with AUM lower than 15 million USD. We consider the data aggregated at the T-month frequency for all $1 \le T \le 12$. In Panel A, for every sampling frequency, we compute the pooled regression coefficient of the net-of-fee excess return on the dummy for the fact that the previous period return is below the risk-free rate on the sample of funds with a lockup period and on the sample of funds without a lockup period. Then, we plot these two coefficients against the sampling frequency. In Panel B, we replace the impediments to withdrawals dummy by the dummy for the fact that the sum of the redemption and notice periods is at least equal to three months. In Panel C, the impediments to withdrawals dummy is the fact that the duration is at least equal to three months. In Panel D, it is the fact that the fund-level correlation between the dummy for previous year return below the risk-free rate and current outflows is above the sample median. (Panel A) Impediment = Lockup, (Panel B) Impediment = Quarterly redemption, (Panel C) Impediment = Duration and (Panel D) Impediment = Outflow/loss sensitivity.

from column 5 suggest that if a fund with short redemption underperforms in the current year, its future return will be lower by 3.9 percentage points. If redemption plus notice period exceeds a quarter, however, future returns will be higher by 5.3 − 3.9 = 1.4 percentage points. Hence, the expected returns difference between the two categories of funds (5.3 percentage points) is both statistically significant and large economically. Finally, we note that, for three of our four measures of impediments, the estimate of γ is unaffected by the inclusion of controls. Only the lockup dummy seems to be affected by the strategy controls.

Endogenous attrition of funds in our data set may be a concern. In our data, an average of 6% of the funds exit the sample every year. Typically, hedge funds may exit data sets for two reasons: they are liquidated, or they are not seeking new investors. This may generate a mechanical relationship between mean reversion and impediments to outflows. For instance, suppose that funds with lockups that underperform are more easily liquidated. In this case, conditional on bad performance and survival, future returns of locked up funds will be higher for purely mechanical reasons. Alternatively, assume that unlocked funds that are successful are more likely to stop searching for investors. This too would explain that, conditional on being present in the data, funds without lockups are less likely to mean revert, which is also consistent with Hypothesis 1. To address this concern, we empirically check that exit is uncorrelated with past performance interacted with impediment. To do this, we construct a dummy variable equal to one if a fund exits from the data.

We then estimate a logit model to explain the exit dummy with the past low performance dummy interacted with our measures of withdrawal restrictions. We report regression results in Appendix B, Table B1. We find no evidence that the relation between exit and poor performance is correlated with impediments to withdrawal.

3.4.2. Hypothesis 2: Volatility of hedge fund returns

We then test our second hypothesis, namely, that funds with stronger impediments to outflows should have more volatile returns. To perform this test, we run the following regression:

$$|r_{it} - \hat{r}_i| = \alpha + \beta\, \text{Flow–perf sensitivity}_{it} + \gamma X_{it} + \varepsilon_{it}, \qquad (10)$$

where $\hat{r}_i$ is the average return of fund i over its lifetime. We double-cluster error terms at the fund and year levels.

We find that funds with stronger impediments to outflows have more volatile returns. We report estimates of Eq. (10) in Table 6. The sample size is significantly reduced because our equation requires funds to be present at least three full years in the data. This table has 12 columns that correspond to the four impediment measures, times the three sets of controls X_{it}: no control; fund size and age; and size, age, and strategy. In 11 of the 12 specifications, coefficient β is positive; it is statistically significant for six of the 12 specifications. There is thus, in our data, some support for the fact that funds with longer duration liabilities are more volatile, which is Hypothesis 2.

Table B1
Conditional exit and impediments to withdrawals.

EurekaHedge, 2004–2007. Annual data, excluding funds with AUM lower than 15 million USD. A logit model is estimated in which the dependent variable is a dummy equal to one if the fund exits from the data in the current year. In column 1, the regressors are a dummy for low past performance equal to one if the past annual excess return was negative, the dummy for the fact that the fund has a lockup, the lockup dummy interacted with the low past performance dummy, the lagged log of AUM, and the log of age. In column 2, we also interact the lagged log of AUM and the log of age with the dummy of low past performance. In column 3, we also interact the dummies for classification styles with the dummy of low past performance. In columns 4–6, the impediments to withdrawals variable are replaced with the dummy for the fact that the sum of the fund's redemption period and notice period is at least equal to three months. In columns 7–9, the impediments to withdrawals variable is the log of duration at the end of previous year. In columns 10–12, impediments to withdrawals are the fund-level correlation between the dummy of past performance below the risk-free rate and current outflows. Error terms are clustered by fund and year. ^{n}, ^{nn}, and ^{nnn} mean statistically different from zero at the 10%, 5%, and 1% levels of significance.

	Dependent variable: Exit											
Impediment:	Lockup			Quarterly redemption			Duration			Outflow/loss sensitivity		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Low past performance	0.88^{nnn}	0.82^{nnn}	0.15	1.10^{nnn}	1.03^{nnn}	0.46^{nnn}	0.98^{nnn}	0.90^{nnn}	0.19^{nn}	0.15	0.91	14.01^{nnn}
	(6.5)	(4.4)	(0.7)	(8.6)	(6.0)	(7.9)	(4.6)	(3.3)	(2.5)	(1.1)	(0.7)	(19.7)
Impediment	0.36	0.34	0.22	0.53	0.51	0.38	0.35^{n}	0.33^{n}	0.19	0.66^{n}	0.75^{n}	0.45
	(1.5)	(1.3)	(0.8)	(1.4)	(1.2)	(0.9)	(1.9)	(1.7)	(0.9)	(1.9)	(1.8)	(0.7)
Low past perf.	0.24	0.21	0.15	0.65^{n}	0.61^{n}	0.64^{n}	0.11	0.09	0.06	0.41	0.49	1.05^{nn}
Impediment	(1.0)	(0.9)	(1.2)	(1.8)	(1.7)	(1.7)	(0.5)	(0.4)	(0.3)	(0.4)	(0.5)	(2.0)
Log(AUM)	0.35^{nnn}	0.34^{nnn}	0.35^{nnn}	0.35^{nnn}	0.34^{nnn}	0.35^{nnn}	0.36^{nnn}	0.35^{nnn}	0.35^{nnn}	0.89^{nnn}	0.96^{nnn}	0.93^{nnn}
	(4.2)	(25.4)	(19.3)	(3.7)	(21.1)	(21.7)	(3.7)	(23.1)	(28.7)	(4.5)	(2.6)	(3.8)
Log(age)	0.16^{nnn}	0.01	0.00	0.17^{nnn}	0.03	0.01	0.16^{nnn}	0.01	0.00	1.67^{nnn}	2.28^{nnn}	2.27^{nnn}
	(3.0)	(0.6)	(0.2)	(3.6)	(1.1)	(0.5)	(2.8)	(.)	(0.8)	(4.2)	(8.1)	(9.3)
Low past perf.		0.03	0.04		0.03	0.04		0.02	0.03		0.03	0.06
Log(AUM)		(0.1)	(0.1)		(0.1)	(0.2)		(0.1)	(0.1)		(0.1)	(0.2)
Low past perf.		0.43^{nnn}	0.43^{nnn}		0.40^{nnn}	0.40^{nnn}		0.42^{nnn}	0.43^{nnn}		1.47	1.44^{nnn}
Log(age)		(3.1)	(2.9)		(2.7)	(2.7)		(3.3)	(3.0)		(1.2)	(6.4)
Constant	2.45^{nnn}	2.43^{nnn}	2.17^{nnn}	2.61^{nnn}	2.59^{nnn}	2.30^{nnn}	2.77^{nnn}	2.75^{nnn}	2.35^{nnn}	4.39^{nnn}	4.91^{nnn}	4.14^{nnn}
	(15.5)	(15.7)	(7.7)	(55.4)	(67.0)	(19.2)	(47.2)	(52.5)	(25.5)	(18.5)	(10.5)	(5.9)
Low past perf. Style	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
Observations	3,657	3,657	3,598	3,657	3,657	3,598	3,657	3,657	3,598	863	863	630
Pseudo R^2	0.05	0.05	0.07	0.05	0.05	0.07	0.05	0.05	0.07	0.15	0.16	0.20

3.4.3. Hypothesis 3: Mean reversion in hedge fund returns following good performance

We test Hypothesis 3, which states that there should be no difference in expected future returns, conditional on good performance. To test this, we add to Eq. (9) an interaction term between fund flow–performance sensitivity and a dummy equal to one if previous returns are larger than 20% (high performance dummy). We report the results in Table 6. The 12 different specifications correspond to our four impediment measures, times three different sets of fund controls, interacted with the performance dummies (both high and low). Two main features arise from Table 6. First, the coefficient on impediments interacted with low performance is not affected when we add the new control. It remains statistically significant at 5% in 11 of the 12 specifications – and significant at 1% in 9 specifications. Evidence in favor of Hypothesis 1 is thus robust. Second, the coefficient on impediments interacted with good performance is small and never statistically significant. Conditional on high past performance, expected returns are not correlated with impediments to outflows. This holds for all definitions of impediments, and all sets of interacted controls. Hence, the data also lend support to Hypothesis 3.

3.5. Comparison with previous literature

In this section, we show how our results complement the literature on hedge fund returns. While we find that funds with impediments have mean-reverting annual returns, the hedge fund literature has so far emphasized that funds with impediments have persistent monthly returns. We show in this section that these two sets of results coexist in our data.

Previous papers document that funds with impediments to withdrawals tend to have persistent monthly returns. Getmansky, Lo, and Makarov (2004) propose a measure of returns "smoothing" that is conceptually close to the autocorrelation of monthly returns. They argue that if monthly returns are very autocorrelated, then it is likely that funds smooth returns across months to minimize monthly return volatility. Such a strategy is easier to put in place for assets whose prices cannot be easily marked to market. Thus, the smoothing measure is also considered as a proxy for asset illiquidity. Consistent with the idea that impediments to withdrawals help funds to buy illiquid assets, Aragon (2007) and, Aragon, Liang, and Park (forthcoming) show that funds with autocorrelated returns also tend to have share restrictions.

Table C1
Summary statistics, TASS data.

TASS, 1994–2011. Annual data, excluding funds with AUM lower than 15 million USD. Panel A: Returns are net of fees. The dummy for low performance is equal to one if the return is below the yield on the 3-month Treasury-bill. The dummy for high performance is equal to one if the return is above 20%. AUM are measured at the end of the calendar year. Net flows are computed as $AUM_{it}-(1+r_{it})AUM_{it-1}$. Outflows are defined as the minimum of net flows and zero. Panel B: The classification styles are "Convertible arbitrage," "Emerging markets," "Event driven," "Fixed income," "Funds of funds," "Global macro," "Long–short equity," "Managed futures," and "Multi-strategy." Panel C: The impediments to withdrawals are the lockup period in months, a dummy equal to one if the fund has a lockup, the sum of the notice period and the redemption period in months, a dummy equal to one if that sum is at least equal to three months, the duration in months, and the outflow/loss sensitivity defined as the correlation between the dummy for the fact that the previous annual return was below the risk-free rate and the current year outflows.

Panel A: Time-varying variables	Obs.	Mean	Std. dev.	25th	50th	75th
Return (%)	15,669	7.2	17.1	0.1	7.3	14.3
Return < risk free rate	15,669	0.23				
Return > 20%	15,669	0.15				
AUM ($ million)	15,669	286	707	46	102	256
Net flows/AUM	15,669	0.08				
Outflows/AUM	15,669	0.12				
Panel B: Strategies						
Convertible arbitrage	15,669	0.03				
Emerging markets	15,669	0.06				
Event driven	15,669	0.08				
Fixed income	15,669	0.03				
Funds of funds	15,669	0.29				
Global macro	15,669	0.03				
Long–short equity	15,669	0.27				
Managed futures	15,669	0.06				
Multi-strategy	15,669	0.05				
Panel C: Impediments to withdrawals						
Lockup period (months)	15,669	3.69	7.24	0.00	0.00	6.00
Lockup dummy	15,669	0.28				
Notice + redemption period (months)	15,669	4.06	3.52	2.00	3.67	5.00
Quarterly notice + redemption dummy	15,669	0.55				
Duration (months)	15,669	3.16	2.81	1.50	2.50	3.94
Outflow/loss sensitivity	10,370	0.26	0.34	0.54	0.28	0.03

In the previous section, we show that funds with impediments to withdrawals tend to have mean-reverting annual returns. At lower frequencies, assets are easier to price and audit; the scope for window-dressing is reduced. Since returns are less likely to be smoothed, the auto-correlation of returns should be lower. This would explain why our results differ so much from what previous authors have found at the monthly frequency.

We check that, in our data, our results are indeed reversed at higher frequencies, as previous papers relying on different specifications seem to suggest. To do this, we first simply re-run regression (9) using monthly and quarterly data. We report the results in Table 7, Panel A (monthly data) and Panel B (quarterly data). In both panels, columns 1–4 use the whole sample of funds. We then focus on strategies with a priori different degrees of liquidity: long–short equity (columns 5–8) and fixed income (columns 9–12). For each of these subsamples, we provide results for all four measures of impediment with size and age controls. As shown in Panel A, monthly returns are more persistent for funds with impediments. This pattern is present and statistically significant in three of the four specifications for the whole sample. It is also present, and significant in most specifications, for the two strategies we study. At the quarterly frequency, however, the overall picture begins to shift towards mean reversion (our results). For the whole sample, the persistence of quarterly returns is now uncorrelated with impediments. There is some slight evidence of increased persistence for fixed income funds, consistent with the smoothing/illiquidity hypothesis having some bite at the quarterly frequency. For the long–short equity strategy, however, impediments are already correlated with mean reversion for three of the four specifications. This is consistent with the idea that long–short equity funds deal with liquid assets that are easy to mark to market, which makes returns harder to smooth. For these funds, the limits to arbitrage effect dominates the return-smoothing effect at the quarterly frequency.

The shift from persistence to mean reversion for funds with strong impediments occurs continuously. We show in Fig. 4 one way to visualize this feature of the data. For each impediment measure, we split our data set into two groups: High and Low impediments. Then, for each horizon T between 1 and 12 months, we regress T-period returns on a dummy equal to one if past T-period returns were below the risk-free rate. We run a separate regression for each group of funds. We thus obtain a sequence of coefficients $\beta_{H,T}$, $\beta_{L,T}$. These coefficients are more positive when there is higher mean reversion at horizon T. We report these coefficients as a function of T in Fig. 4. Each panel corresponds to one of our four impediment mea-

Table C4
Conditional returns and impediments to withdrawals, TASS data.

TASS, 1994–2011. Annual data, excluding funds with AUM lower than 15 million USD. The dependent variable is the annual net-of-fee return in excess of the risk-free rate. In column 1, the regressors are a dummy for low past performance equal to one if the past annual return was negative, the dummy for the fact that the fund has a lockup, the lockup dummy interacted with the low past performance dummy, the lagged log of AUM and the log of age. In column 2, we also interact the lagged log of AUM, and the log of age with the dummy of low past performance. In column 3, we also interact the dummies for classification styles with the dummy of low past performance. In columns 4–6, the impediments to withdrawals variable is replaced with the dummy for the fact that the sum of the fund's redemption period and notice period is at least equal to three months. In columns 7–9, the impediments to withdrawals variable is the log of duration at the end of previous year. In columns 10–12, impediments to withdrawals are the fund-level correlation between the dummy of past performance and current outflows. Error terms are clustered by fund and year. *, **, and *** mean statistically different from zero at the 10%, 5%, and 1% levels of significance.

	Dependent variable: Returns											
Impediment:	Lockup			Quarterly redemption			Duration			Outflow/loss sensitivity		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Low past performance	7.3*	7.1*	14.4	5.7	5.5	12.7	3.9	3.6	11.6	9.0**	8.6***	16.5*
	(1.8)	(1.8)	(1.6)	(1.5)	(1.4)	(1.3)	(1.1)	(1.0)	(1.2)	(2.5)	(3.0)	(1.8)
Impediment	1.6*	1.6*	1.1	1.5	1.5	1.6***	1.5	1.5	1.6**	1.6*	1.4	1.1
	(1.9)	(1.8)	(1.4)	(1.3)	(1.3)	(2.6)	(1.3)	(1.3)	(2.0)	(1.8)	(1.6)	(1.4)
Low past perf. Impediment	2.3	2.3	2.1	4.3***	4.3***	3.1*	3.4***	3.6***	2.9**	4.8***	5.4***	4.7***
	(1.6)	(1.6)	(1.4)	(3.6)	(3.7)	(1.9)	(4.0)	(4.1)	(2.2)	(5.1)	(7.2)	(12.5)
Log(AUM)	1.1*	1.0	1.1	1.1*	1.1	1.2	1.2*	1.1*	1.2*	1.4***	1.1***	1.1***
	(1.7)	(1.5)	(1.5)	(1.8)	(1.6)	(1.6)	(1.9)	(1.7)	(1.7)	(5.1)	(4.4)	(5.3)
Log(age)	0.9	1.3	1.3	1.0	1.4	1.4*	0.9	1.3	1.3	3.8**	4.1***	4.3**
	(1.1)	(1.5)	(1.6)	(1.1)	(1.6)	(1.7)	(1.0)	(1.5)	(1.6)	(2.6)	(2.6)	(2.6)
Low past perf. Log(AUM)		0.3	0.3		0.4	0.4		0.4	0.5		1.7***	1.6***
		(0.6)	(0.6)		(0.9)	(0.8)		(0.9)	(0.8)		(5.0)	(4.8)
Low past perf. Log(age)		2.3**	2.6**		2.3**	2.5**		2.4***	2.6**		1.8	2.4
		(2.3)	(2.3)		(2.5)	(2.2)		(2.6)	(2.3)		(0.7)	(1.0)
Constant	5.8**	5.8**	6.0***	5.5**	5.5**	5.1***	4.4***	4.4***	4.1**	8.4***	8.5***	8.0***
	(2.4)	(2.4)	(3.0)	(2.5)	(2.5)	(2.7)	(2.7)	(2.8)	(2.4)	(4.4)	(4.5)	(4.4)
Low past perf. Style	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
Observations	15,705	15,705	15,705	15,705	15,705	15,705	15,705	15,705	15,705	8,106	8,106	8,106
Adj. R^2	0.04	0.04	0.06	0.04	0.04	0.06	0.04	0.04	0.06	0.05	0.05	0.06

4. Conclusion

In this paper, we have developed and tested a model of delegated fund management in equilibrium. The starting point was Shleifer and Vishny (1997): Hedge funds exploit arbitrage opportunities, but these opportunities are risky, and may temporarily diverge. This may lead to fund outflows. To this well-known set-up, we add the feature that funds can choose their outflow–performance sensitivity. They can reduce it, for instance, through contractual impediment to withdrawals, or by restricting their shareholder base to loyal investors. This model leads to three intuitive hypotheses: (1) conditional on low past performance, high impediment funds overperform, (2) high impediment funds have more volatile returns, and (3) conditional on high past performance, expected returns are not correlated with impediments. Using a data set of hedge fund returns, we find evidence consistent with all three hypotheses. We also show that our mean reversion effect is reversed at high (monthly) frequencies, which is consistent with the literature.

Our model suggests that, while there are limits to arbitrage, financial intermediaries can attenuate their effects by choosing a stronger capital structure. This generates robust correlations between capital structure strength and the dynamics of asset returns. A natural next step would be to see whether these patterns manifest in the returns of the underlying securities.

Appendix A. Proofs

Proof of Proposition 1. To prove equilibrium existence, we first conjecture that, under Assumption 1, funds do not invest in cash at $t=1$. In this case, Eq. (3) for b comes directly from the maximization of the objective function (2), with $\theta_1 = 1$. Prices are determined in equilibrium by the fact that $p_t = V - S_t + F_t$. Combining these two equations with the fact that F_2 is given by the flow–performance relation (1) leads to Eqs. (4) and (5) for p_1 and p_2.

We then prove that, given the equilibrium relations above, no fund would want to invest in cash at $t=1$. Let us denote $U(b,\theta_1)$ as the objective function defined in (2). Since this function is linear in θ_1, only $\theta_1 = 1$ or $\theta_1 = 0$ can be optimal. We thus need to compare $U(b,0)$ and $U(b,1)$. Given that $U(b,0)$ is linear and that $U(b,1)$ is a convex parabola that reaches its maximum in $b^* > 0$ defined by Eq. (3), then $U(b,0)$ and $U(b,1)$ cross each other twice: in $b=0$ and in $b = ((1-q)/q)(p_1/(p_1-p_2)+1)/V)(1+a)^{-1} \hat{b}$. If $\hat{b} > b^*$, then $U(b,1) > U(b,0)$ for all $b \in (0,\hat{b})$. In this case, setting $\bar{b}$ equal, or close to $\hat{b}^*$ ensures that the optimum is $\theta_1 = 1$ and $b = b^*$. $\hat{b} > b^*$ is equivalent to

$$qV(2(S_2-S_1)+V-S_1) < (1-q)(V-S_2)((1+a)S_1-V)$$

in the limit case where there is little arbitrage capital, $F_1 \to 0$. Assuming F_1 is small enough (Assumption 1 (i)) and

Table C5
Conditional returns and impediments to withdrawals, TASS data: higher frequency evidence.

TASS, 1994–2011, excluding funds with AUM lower than 15 million USD. The dependent variable is the annual net-of-fee return. Panel A uses monthly returns; Panel B uses quarterly returns. In both panels, in columns 1–4 we use all funds; in columns 5–8 we restrict the sample to the long–short equity style; in columns 9–12 we restrict the sample to fixed income funds. In columns 1, 5, and 9, the regressors are a dummy for low past performance equal to one if the previous period return was negative, a lockup dummy, the lockup dummy interacted with the low past performance dummy, as well as the lagged log of AUM and the log of age and their interaction with the low past performance dummy (not reported). In columns 2, 6, and 10, impediments are the dummy for the fund's redemption period and notice period being at least three months. In columns 3, 7, and 11, impediments are the log of duration at the end of previous year. In columns 4, 8, and 12, impediments are the fund-level correlation between the dummy of past performance and current outflows. Error terms are clustered by fund and month in Panel A, and by fund and quarter in Panel B. ^{n}, ^{nn}, and ^{nnn} mean statistically different from zero at the 10%, 5%, and 1% levels of significance.

Panel A: Monthly frequency

	Dependent variable: Returns											
Sample:	All funds				Long–short equity				Fixed income			
Impediment:	Lockup	Quart. redemp.	Duration	Sensitivity	Lockup	Quart. redemp.	Duration	Sensitivity	Lockup	Quart. redemp.	Duration	Sensitivity
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Low past	0.71^{nnn}	0.60^{nnn}	0.52^{nnn}	0.64^{nnn}	0.64^{nnn}	0.57^{nnn}	0.49^{nnn}	0.69^{nnn}	0.63^{nnn}	0.49^{nnn}	0.35^{nn}	0.32
performance	(5.0)	(4.3)	(3.8)	(5.0)	(4.2)	(3.7)	(3.2)	(4.1)	(4.2)	(3.7)	(2.0)	(1.0)
Impediment	0.23^{nnn}	0.28^{nnn}	0.22^{nnn}	0.06	0.15^{nn}	0.29^{nnn}	0.23^{nnn}	0.10	0.09	0.28^{nnn}	0.24^{nnn}	0.03
	(6.1)	(6.4)	(6.8)	(1.2)	(2.6)	(3.9)	(4.1)	(1.0)	(1.1)	(3.8)	(4.5)	(0.2)
Low past perf.	0.15^{nn}	0.32^{nnn}	0.20^{nnn}	0.16^{nn}	0.12^{n}	0.19^{nn}	0.14^{nn}	0.07	0.17	0.39^{nn}	0.30^{nn}	0.59
Impediment	(2.3)	(4.8)	(4.0)	(2.4)	(1.7)	(2.0)	(2.1)	(0.5)	(0.8)	(2.2)	(2.2)	(1.0)
Observations	342,308	342,308	342,308	141,398	88,096	88,096	88,096	40,657	11,088	11,088	11,088	5,337
Adj. R^2	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.03	0.03	0.03	0.02

Panel B: Quarterly frequency

	Dependent variable: Returns											
Sample:	All funds				Long–short equity				Fixed income			
Impediment:	Lockup	Quart. redemp.	Duration	Sensitivity	Lockup	Quart. redemp.	Duration	Sensitivity	Lockup	Quart. redemp.	Duration	Sensitivity
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Low past	1.27^{nn}	1.04^{nn}	1.14^{nn}	0.08	0.95	1.09^{nn}	1.89^{nnn}	0.30	1.45^{nn}	0.92	0.34	0.23
performance	(2.2)	(2.0)	(2.2)	(0.2)	(1.6)	(2.0)	(3.0)	(0.5)	(2.4)	(1.5)	(0.4)	(0.5)
Impediment	0.51^{nnn}	0.68^{nnn}	0.51^{nnn}	0.08	0.14	0.46^{n}	0.26	0.18	0.45^{n}	0.81^{nnn}	0.75^{nnn}	0.04
	(3.5)	(4.2)	(3.9)	(0.6)	(0.7)	(1.9)	(1.2)	(0.7)	(1.6)	(3.2)	(3.8)	(0.1)
Low past perf.	0.25	0.36	0.05	0.23	0.63^{nn}	0.73^{n}	0.91^{nnn}	0.34	0.47	1.43^{nn}	1.16^{n}	1.32
Impediment	(1.0)	(1.3)	(0.3)	(1.2)	(2.3)	(1.8)	(2.9)	(0.8)	(0.7)	(2.2)	(1.8)	(0.7)
Observations	100,023	100,023	100,023	44,980	26,041	26,041	26,041	12,891	3,258	3,258	3,258	1,713
Adj. R^2	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.04	0.03

setting $\bar{b}$ to the value of $\hat{b}$ when F_1 is close to zero: $\bar{b} = (((1-q)/q)(S_2/(S_2-S_1))S_1/V)(1+a) < 1$ (Assumption 1 (ii)), the above condition (Assumption 1 (iii)) ensures that $\theta_1 = 1$ is optimal.

To establish equilibrium uniqueness, we first note that in any equilibrium with no cash, p_1 is uniquely determined by Eq. (4), b is an increasing function of p_2 by Eq. (3), and p_2 is a decreasing function of b by (5). Therefore, there is a unique equilibrium with no cash. Last, assume, by contradiction, that a positive fraction of funds hold some cash. Then, it follows from market clearing that the asset price at $t=1$ would be lower than in the above equilibrium. The flow–performance relation then implies that aggregate assets under management at $t=2$ when sentiment deteriorates are larger than in the above equilibrium, and thus, the asset price in this state of nature is also larger. Taken together, the facts that p_1 is lower and p_2 is larger imply that holding cash is even less attractive than in the above equilibrium. As a result, all funds prefer to have zero cash, hence a contradiction. □

Proof of Proposition 2. b and p_2 are jointly determined by Eqs. (3) and (5). In (3), b is an increasing function of p_2. In (5), p_2 is a decreasing function of b. Since an increase in S_2 shifts the curve (5) downwards, while leaving the curve (3) unchanged, it decreases both p_2 and b. p_1 is determined by Eq. (4) alone, which does not depend on S_2. □

Appendix B. Investigating endogenous attrition

This appendix reports the results regarding how impediments to withdrawals affect the exit–performance relation.

Appendix C. Additional tables using TASS

In this appendix, we replicate our main empirical results using Lipper/TASS as an alternative hedge fund database. First, using a 1994–2011 TASS extract, we replicate the descriptive statistics of Table 1, and report them in Table C1. Returns are on average lower in TASS (7% vs. 11%), but the remaining variables are much more similar across the two data sets. About 20% of the observations have returns either above 20% or below the risk-free rate (as in EurekaHedge). AUM are \$290 million (vs. \$270 million in EurekaHedge). Average net inflows are 8% of AUM (vs. 10%). Impediment to withdrawals measures are also very similar. In TASS, 28% of the observations have lockups (vs. 22% in EurekaHedge); average notice plus redemption period is four months (vs. 3.3). All in all, summary statistics are similar across the two samples. Tables C2 and C3 further document that the two data sets are also comparable in terms of fund domiciliation and coverage of large funds.

Second, we replicate our main regression tables with TASS. We re-run our main regression (9) at the annual frequency and report results in Table C4. We find very similar results as with EurekaHedge both in terms of economic significance and statistical significance. We also re-run our mean reversion regressions at the monthly and quarterly frequencies and report results in Table C5. Again, we obtain similar results as with EurekaHedge.

References

Acharya, V., Viswanathan, S., 2011. Leverage, moral hazard and liquidity. Journal of Finance 66, 99–138.

Agarwal, V., Daniel, N., Naik, N., 2009. Role of managerial incentives and discretion in hedge fund performance. Journal of Finance 64, 2221–2256.

Ang, A., Bollen, N., 2010. Locked up by a lockup: valuing liquidity as a real option. Financial Management 39, 1069–1096.

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

Aragon, G., Liang, B., Park, H., Onshore and offshore hedge funds: Are they twins? Management Science, forthcoming.

Ben-David, I., Franzoni, F., Moussawi, R., 2011. Hedge fund stock trading in the financial crisis of 2007–2009. Review of Financial Studies 25, 1–54.

Brunnermeier, M., Oehmke, M., 2013. The maturity rat race. Journal of Finance 68, 483–521.

Brunnermeier, M., Pedersen, L., 2009. Market liquidity and funding liquidity. Review of Financial Studies 22, 2201–2238.

Campbell, J., Viceira, L., 2002. Strategic Asset Allocation. Oxford University Press, New York.

Chevalier, J., Ellison, G., 1997. Risk taking by mutual funds as a response to incentives. Journal of Political Economy 105, 1167–1200.

Chen, Q., Goldstein, I., Jiang, W., 2010. Payoff complementarities and financial fragility: evidence from mutual fund outflows. Journal of Financial Economics 97, 239–262.

Ferreira, M., Keswani, A., Miguel, A., Ramos, S., 2012. The flow-performance relationship around the world. Journal of Banking and Finance 36, 1759–1780.

Gârleanu, N., Pedersen, L., 2011. Margin-based asset pricing and the law of one price. Review of Financial Studies 24, 1980–2022.

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

Grinblatt, M., Titman, S., 1992. Performance persistence in mutual funds. Journal of Finance 47, 1977–1984.

Gromb, D., Vayanos, D., 2002. Equilibrium and welfare in markets with financially constrained arbitrageurs. Journal of Financial Economics 66, 361–407.

Holmstrom, B., Tirole, J., 1998. Private and public supply of liquidity. Journal of Political Economy 106, 1–40.

Liu, X., Mello, A., 2009. The fragile capital structure of hedge funds and the limits to arbitrage. Journal of Financial Economics 102, 491–506.

Lou, D., 2012. A flow-based explanation of returns predictability. Review of Financial Studies 25, 3457–3489.

Mitchell, M., Pedersen, L., Pulvino, T., 2007. Slow moving capital. The American Economic Review, Papers and Proceedings 97, 215–220.

Shleifer, A., Vishny, R., 1997. The limits of arbitrage. Journal of Finance 52, 35–55.

Sirri, E., Tufano, P., 1998. Costly search and mutual funds flows. Journal of Finance 53, 1589–1622.

Stein, J., 2009. Sophisticated investors and market efficiency. Journal of Finance 64, 1517–1548.