Liquidity Transformation in Asset Management: Evidence from the Cash Holdings of Mutual Funds[*]

Sergey Chernenko
sergey.chernenko@fisher.osu.edu
The Ohio State University

Adi Sunderam
asunderam@hbs.edu
Harvard University and NBER

July 21, 2015

Abstract

Using a novel data set on the cash holdings of mutual funds, we show that cash plays an important role in how mutual funds provide liquidity to their investors. Rather than transacting in equities or bonds, mutual funds use cash to accommodate inflows and outflows. This is particularly true for funds with illiquid assets and at times of low aggregate market liquidity. We show that economies of scale in liquidity provision are limited for mutual funds. Mutual funds are large holders of cash in the aggregate, and thus liquidity provision by mutual funds is highly dependent on liquidity provision by the traditional banking and shadow banking sectors. We provide evidence that, despite their size, cash holdings of mutual funds are not sufficiently large to fully mitigate price impact externalities created by the liquidity transformation that funds engage in.

[*] We thank Lauren Cohen and Jeff Wang for sharing Morningstar data on holdings of bond mutual funds.

I. Introduction

Liquidity transformation, the provision to investors of liquid claims that are backed by illiquid assets, is a key function of many financial intermediaries. Historically, liquidity transformation has been performed primarily by banks, which hold illiquid loans but give investors liquid deposits. However, asset managers also provide similar services through open-ending. For instance, mutual funds may hold relatively illiquid assets such as corporate bonds or bank loans, but they have liquid liabilities: their shares may be redeemed each day at fund's end of day net asset value (NAV). Specifically, mutual funds allow their investors to redeem any number of shares at a fixed NAV. In contrast, investors who directly hold the underlying equities or bonds would face liquidation costs increasing in the size of the transaction if they attempted to sell those assets themselves.

Academics and policymakers have recently started asking whether this kind of liquidity transformation by asset managers could cause financial stability problems in much the same way that liquidity transformation by banks does (e.g., Financial Stability Oversight Committee, 2014; Feroli, Kashyap, Schoenholtz, and Shin, 2014). A key concern is that liquidity transformation increases the scope for fire sale externalities. Fundamental shocks can be amplified if open-ended funds hold illiquid assets. Consider, for example, a negative shock that results in poor returns for an open-ended fund. If fund flows are sensitive to performance, investors will redeem in response to these poor returns. To meet these redemptions, the fund will have to sell its illiquid assets, further depressing security prices and fund returns and stimulating more redemptions. Of course, funds themselves are aware of the potential for these kinds of fire sale dynamics and may take steps to manage their liquidity needs. While there is a growing literature studying fire sales in asset markets (e.g., Coval and Stafford, 2007; Geanapoklos, 2009; Stein, 2012; Merrill, Nadauld, Sherlund, and Stulz 2012), little is known about how asset managers such as mutual funds manage their liquidity to mitigate such problems.

In this paper, we study how mutual funds manage their own liquidity to provide the benefits of open-ending to investors. Using a novel data set on the cash holdings of equity and bond mutual funds, we show that they do not simply act as pass-throughs, buying and selling the fund's underlying assets on behalf of investors. Instead, they use holdings of cash to actively manage their liquidity provision, reducing the impact of their liquidity provision on the prices of the underlying assets. Importantly, our data set covers holdings of both cash and cash substitutes such as money market mutual fund shares. Cash substitutes have become increasingly important sources of liquidity for asset managers in recent years. The IMF estimates that asset managers as a whole hold about $2 trillion of cash, approximately the same amount as US corporations (Pozsar, 2013). Of these asset manager cash holdings, approximately 37% is in the form of money market mutual funds and other cash substitutes.

There are several reasons why mutual funds provide a good laboratory for studying liquidity transformation by asset managers. First, mutual funds account for a large fraction of the overall asset management industry. As of 2015Q1, mutual funds had aggregate assets of $12.9 trillion and held 20.5% of corporate equities and 20.6% of corporate and foreign bonds. [1] Second, while other asset managers have some ability to regulate investor redemptions, most mutual funds are completely open-ended. Thus, there is significant scope for liquidity transformation in the mutual fund sector. This can perhaps most clearly be seen with the recent rapid growth of bank loan funds. These open-ended funds are like banks in many respects: they own illiquid bank loans as assets and have liabilities that are redeemable daily. Over the past ten years, their assets have increased six-fold from $26 to $155 billion.[2]

We present four main results on mutual fund liquidity management. First, cash plays an important role in how mutual funds provide liquidity to their investors. Rather than transacting in equities or bonds, mutual funds use cash to accommodate inflows and outflows.[3] Funds build up cash positions when they receive inflows and draw down cash when they suffer outflows. The magnitudes are economically significant. For each dollar of inflows or outflows in a given month, 15 to 30 cents of that flow are accommodated through changes in cash rather than through trading in the fund's portfolio securities. The magnitudes decline over time, but, even six months later, a dollar of fund flows has a 5-12 cent effect on fund's cash holdings.

Second, asset liquidity affects the propensity of funds to use cash holdings to manage fund flows. In the cross section, funds with more illiquid assets more aggressively use cash to

[1] See tables L.211 and L.212 of the Flow of Funds Financial Accounts of the United States (Federal Reserve data release Z.1). These numbers do not include the assets of money market mutual funds.
[2] Estimates based on mutual fund holdings of syndicated loans to corporate business, Table L.122 of the Flow of Funds Financial Accounts of the United States (Federal Reserve data release Z.1).
[3] For brevity, we use the term cash to refer to both cash and cash substitutes throughout the paper.

meet inflows and outflows. A one-standard deviation increase in asset illiquidity is associated with a 31-54% increase in the fraction of fund flows accommodated through changes in cash. In the time series, there is some evidence that equity (but not bond) funds are more aggressive in using cash to meet outflows when market liquidity is low. A one-standard deviation decrease in aggregate market liquidity is associated with a 20% increase in the amount of cash used to meet recent outflows. These results are consistent with the idea that cash holdings play a critical role in the liquidity transformation performed by mutual funds.

Third, because they use cash and cash equivalents for liquidity management purposes, mutual funds are large holders of cash in the aggregate. As of 2014, their aggregate holdings of cash cumulated to $744 billion, or 5.5% of total assets. By way of comparison, total nonfinancial corporate cash holdings, which have received significant scrutiny from both academics and the press (e.g., Bates, Kahle, and Stulz, 2009), are approximately $2 trillion.[4] We show that the cash holdings of mutual funds are strongly related to the illiquidity of the assets they hold. A one-standard deviation increase in asset illiquidity is associated with a 1.5-3.8% higher cash-to-assets ratio. Consistent with the idea that cash is important for the liquidity transformation performed by mutual funds, the volatility of fund flows is another important determinant of cash holdings. Other key determinants are related to trading practices: higher turnover, the use of derivatives, and the existence of securities lending operations are all associated with higher cash holdings.

In our data, the total cash holdings of mutual funds have remained both high and relatively constant as a fraction of assets over time. In contrast, the cash holdings of banks and other financial intermediaries engaged in liquidity transformation tend to be low and declining over time.[5] A key difference between mutual funds and other intermediaries is that economies of scale in liquidity provision are limited for mutual funds. This is because investor redemptions are much more correlated for mutual funds than for other intermediaries. For most financial intermediaries, individual investor redemptions are relatively uncorrelated, so aggregate redemptions are quite predictable because of the law of large numbers. In contrast, for mutual funds and other asset managers, returns play a key role in coordinating investor redemptions.

[4] See "Record Cash Hoard Concentrated Among Few Companies", Wall Street Journal, June, 11, 2015 http://blogs.wsj.com/cfo/2015/06/11/record-cash-hoard-concentrated-among-few-companies/.

[5] However, in the aftermath of the financial crisis, the cash holdings of banks have risen. This is due both to increased liquidity regulations and to the creation of large quantities of excess reserves by the Federal Reserve.

When returns are high, flows from all investors are more likely to be positive. When returns are low, flows from all investors are more likely to be negative. Thus, mutual funds must keep more cash on hand in order to provide the same liquidity services as other intermediaries.

We do find evidence of some economies of scale being present for equity but not for bond funds. Specifically, equity funds that are part of larger fund families tend to hold less cash. In the time series, increases in family size could be therefore expected to lead to lower cash ratios. We show however that such economies of scale have been fully offset by increases in cash holdings due to changes in investor behavior and sophisticated investment practices. Funds hold more cash to accommodate more volatile fund flows. They also hold more cash to collateralize their positions in sophisticated instruments such as futures and derivatives. An increase in securities lending has similarly played a role in driving up the cash holdings of mutual funds. Overall, these results suggest that as the asset management sector grows, it is unlikely to reap significant benefits from economies of scale in liquidity management and instead is likely to continue to grow as a significant demander of liquidity in the form of cash and cash substitutes.

Finally, we ask whether mutual funds have sufficient cash holdings to fully offset any price impact externalities that they may exert in the market. We provide two pieces of evidence suggesting that they do not, one at the fund level and a second at the fund family level. First, we show that larger funds that hold more illiquid assets tend to also hold more cash. This suggests that larger funds internalize more of the price impact they have transacting in the market than do smaller funds. Second, funds that account for a large share of investment objectives that are important to their fund family hold more cash. This is consistent with the idea that large funds are more cautious about exerting price impact when it may adversely affect other funds in the family.

In summary, our analysis highlights two key properties of liquidity transformation in asset management. First, it is highly dependent on liquidity provision by the traditional banking and shadow banking sectors. In order to provide liquidity to their end investors, mutual funds must hold substantial amounts of cash, bank deposits, and money market mutual fund shares. These holdings do not decrease much with size, suggesting that the economies of scale in liquidity provision are weak in the asset management industry.

Second, despite their size, the cash holdings of mutual funds are not sufficiently large to completely mitigate price impact externalities created by the liquidity transformation that funds engage in. Our evidence suggests that, consistent with theory, funds do not fully internalize the effects that providing investors with daily liquidity has on the prices of the underlying securities. This suggests that the aggregate level of cash holdings in the mutual fund sector is likely to be below the socially optimal level.

Our paper is related to several strands of the literature. First, there is a small but growing literature studying the potential for liquidity transformation among mutual funds to generate run-like dynamics, including Chen, Goldstein, and Jiang (2010), Feroli, Kashyap, Schoenholtz, and Shin (2014), Goldstein, Jiang, and Ng (2015), and Wang (2015). Second, there is a large theoretical and empirical literature studying fire sales in debt and equity markets, including Shleifer and Vishny (1992), Shleifer and Vishny (1997), Coval and Stafford (2007), Ellul, Jotikasthira and Lundblad (2011), Greenwood and Thesmar (2011), Merrill, Nadauld, Sherlund, and Stulz (2012). Also related is Stein (2005), who asks why funds are open-ended despite the fact that open-ending creates fire sale risk. The paper posits that there is excessive open-ending in equilibrium because of an agency problem between fund managers and investors. Our results show how mutual funds use cash holdings to manage their liquidity transformation activities and suggest that they may not hold enough cash to fully mitigate fire sale externalities.

Our paper is also related to the large literature on liquidity transformation in banks, starting with Diamond and Dybvig (1983) and Gorton and Pennacchi (1990). This literature has grown rapidly of late, fueled by the observation that liquidity transformation may also play an important role in explaining the growth of the shadow banking system and the subsequent financial crisis, as suggested by Gorton and Metrick (2010), Krishnamurthy and Vissing-Jorgenson (2015), Nagel (2014), and Sunderam (2015). Finally, there is a broader literature on debt and equity market liquidity, including Roll (1984), Amihud and Mendelsohn (1986), Chordia, Roll, and Subrahmanyam (2001), Amihud (2002), Longstaff (2004), Acharya and Pedersen (2005), Bao, Pan, and Wang (2011), and many others. Our results show how asset managers perform liquidity transformation, providing investors with liquid claims in a manner similar to banks while holding less liquid securities, which they must ultimately trade in the debt and equity markets.

II. Model

A. Setup

To help fix ideas, we begin by presenting a simple model of optimal cash holdings. Consider a single mutual fund that has M investors, each of whom has invested a dollar. Each investor is associated with outflows x_m next period. For simplicity, we assume that these outflows are distributed normally, with mean zero and variance σ^2. Further, assume that the correlation of outflows across investors is ρ. This correlation captures in a reduced form way both that liquidity shocks may be correlated across investors and that flows may be correlated because they respond to past performance (i.e., there is a performance-flow relationship).

The fund may accommodate redemptions in two ways. First, it may choose to hold cash reserves R. These reserves are liquid claims that can be sold costlessly to meet outflows. In practice, these claims are supplied by the traditional banking system or shadow banking system, but for simplicity we model them here as existing in elastic supply. However, each dollar of cash reserves is associated with carrying cost i. One may think of this as the cost of tracking error for the fund. If it does not have sufficient cash reserves, the fund meets outflows by liquidating some of its underlying securities. When it does so, it incurs average cost c per dollar of asset sales.

B. Optimal Cash Reserves for a Single Fund

We now solve for the fund's optimal holdings of cash reserves R. First, note that the total outflows suffered by the fund are

$$x = \sum_m x_m \sim N\left(0, \sigma^2 M \left(1 + \left(M-1\right)\rho\right)\right).$$

The fund chooses its cash holdings to minimize the sum of carry costs i and expected liquidation costs c:

$$iR + \int_R^\infty c\left(x - R\right) dF\left(x\right), \tag{1}$$

where F is the cumulative distribution function of x. Proposition 1 characterizes the optimal reserve holdings R^*.

Proposition 1. Assuming i ≤ c, optimal cash holdings R^* satisfy the first order condition $F\left(R^*\right) = 1 - i/c$. Because x is normally distributed, we have $R^* = k\sqrt{\sigma^2 M\left(1+\left(M-1\right)\rho\right)}$ where $k = \Phi^{-1}\left(1 - i/c\right)$ and Φ is the standard normal cumulative distribution function.

Proof: All proofs are given in the Appendix.

Intuitively, the fund trades off the carrying costs of cash reserves against the expected liquidation costs.[6] These expected liquidation costs depend on the distribution of total outflows, which are determined by the number of investors, the volatility of their individual outflows, and the correlation between the individual outflows.

Let $r^* = R^*/M$ be the optimal cash-assets ratio of the fund. Proposition 2 derives some simple comparative statics.

Proposition 2. Optimal cash holdings R^* and optimal cash-assets ratio r^* satisfy the following comparative statics:

$\partial r^*/\partial c > 0$: Optimal cash-assets ratio increases with asset illiquidity.

$\partial r^*/\partial \sigma > 0$: Optimal cash-assets ratio increases with the volatility of fund flows.

$\partial R^*/\partial M > 0$ and $\partial r^*/\partial M < 0$ $\partial r^*/\partial M < 0$: Optimal cash holdings rise with fund size. As long as $\rho < 1$, optimal cash-assets ratio falls with fund size.

$\partial^2 r^*/\partial M \partial \rho > 0$ $\partial^2 r^*/\partial M \partial \rho > 0$: Optimal cash-assets ratio falls more slowly with fund size when investor flows are more correlated.

The first two comparative statics relate cash holdings to liquidity management. If the fund's assets are more illiquid, so that it has to pay a higher penalty *c* for liquidating its assets, it chooses to hold more cash. Similarly, if the fund faces more volatile flows, it is essentially providing greater liquidity services to its investors. In this case, it also holds more cash.

The second two comparative statics involve economies of scale in liquidity management. As the size of the fund rises, the volatility of dollar outflows rises. Thus, the fund must hold more cash reserves. However, because there is diversification across investors, the cash-assets

---

[6] Assuming that $i \le c$ rules out the uninteresting case where the carrying cost is so small that the fund holds enough cash to rule out any possibility of ever having to liquidate its securities at fire sale prices.

ratio falls with fund size: the amount of additional cash reserves the fund holds for each incremental dollar of assets falls as fund size increases. This is analogous to the way diversification across depositors allows banks to hold illiquid assets, as in Diamond and Dybvig (1983). The comparative statics also show that this diversification benefit dissipates as the correlation between individual investor flows rises. As flows become more correlated, economies of scale in liquidity management diminish.

C. Socially Optimally Cash Reserves

We next consider the problem of many funds and ask whether in the aggregate they hold the socially optimal amount of cash holdings. Suppose there are G funds, each of size M. For simplicity, assume that flows to all funds are perfectly correlated. This simplifies the algebra but does not change the intuition. Further, suppose that the liquidation cost c faced by individual funds is a function of the total asset sales by all funds: $c = c\big(G(x-r)\big)$. Consider fund j, and denote all other funds (-j). Fund j now seeks to minimize costs

$$iR + \int_R^{\infty} c\Big(x - R + (G-1)\big(x_{(-j)} - R_{(-j)}\big)\Big)(x-R)\,dF(x). \tag{2}$$

Eq. (2) is the same as Eq. (1), except now we have the costs of liquidation c depending on the reserve choices and flows faced by all G funds. Differentiating with respect to R, and imposing a symmetric equilibrium ($R = R_{(-j)}$), we have:

$$i - \int_{R^*}^{\infty}\Big[c\big(G(x-R^*)\big) + (x-R^*)c'\big(G(x-R^*)\big)\Big]dF(x) = 0. \tag{3}$$

Next, consider the problem of a social planner seeking to minimize costs across all mutual funds.[7] The planner seeks to minimize

$$G\left[iR + \int_R^{\infty} c\big(G(x-R)\big)(x-R)\,dF(x)\right]. \tag{4}$$

Crucially, from the planner's perspective, it moves all funds' cash reserves at the same time. In contrast, in the private market equilibrium, each individual fund treats other funds' reserve

[7] Note that for there to be a social loss in general equilibrium, the liquidation costs to the funds must not simply be a transfer to an outside liquidity provider. This would be the case if, as in Stein (2012), those outside liquidity providers had to forgo other positive-NPV projects in order to buy the assets being sold by mutual funds.

policies as fixed when choosing its own reserves. Essentially, in the private market equilibrium, an individual fund does not internalize the positive effect its cash holdings have on the liquidation costs faced by other funds. This can be seen in the planner's first order condition:

$$i-\int_{R^{**}}^{\infty}\left[c\left(G\left(x-R^{**}\right)\right)+G\left(x-R^{**}\right)c'\left(G\left(x-R^{**}\right)\right)dF(x)\right]=0. \qquad (5)$$

Eq. (5) is the same as the private market first order condition in Eq. (3), with one exception. In the last term, the effect of the choice of reserves on marginal costs of liquidation is multiplied by G. Essentially, the planner internalizes the fact that high reserves benefit all funds through lower liquidation costs. Proposition 3 says that this leads the planner to a higher level of reserves than the private market outcome.

Proposition 3: The socially optimal level of cash holdings R^{**} is greater than the level of cash holdings chosen in the private market equilibrium R^{*}.

A corollary that follows from this logic is that larger funds tend to internalize their price impact more than smaller funds and therefore hold more cash reserves, particularly if their assets are illiquid. The externality that makes private market cash holdings R^{*} lower than the socially optimal level of cash holdings R^{**} arises because funds take into account how cash holdings impact their own price impact but not how that price impact affects other funds. Holding fixed the size of the other funds, a larger fund cares more about its own price impact relative to the size of the externality that its price impact exerts on the other funds. Thus, private market cash holdings will be closer to the socially optimal level. Put differently, if one fund owns the whole market, there is no externality. Allowing the size of one fund to grow arbitrarily large relative to all other funds is very close to this.

Corollary: Larger funds tend to internalize their price impact more than smaller funds and therefore hold more cash reserves, particularly if their assets are illiquid.

III. Data

A. Cash holdings

We combine novel data on the cash holdings of mutual funds with several other data sets. Our primary data comes from the SEC form N-SAR. These forms are filed semi-annually by all mutual funds and, among other things, provide data on asset composition, including holdings of cash and cash substitutes. Specifically, we measure holdings of cash and cash substitutes as the sum of cash (item 74A), repurchase agreements (74B), short-term debt securities other than repurchase agreements (74C), and other investments (74I). Short-term debt securities have remaining maturities of less than a year and consist mostly of US Treasury Bills and commercial paper.

The other investments category (74I) consists mostly of investments in money market mutual funds (MMFs), loan participations, physical commodities, and other mutual funds. We examined the composition of other investments for a random sample of 320 funds for which other investments accounted for at least 10% of total net assets. We used SEC form N-CSR, which reports the schedule of investments to determine the composition of other investments. The mean and median fractions of MMFs in other investments were 75% and 100%. We therefore treat the other investments category as consisting entirely of MMFs. When this is not the case, we introduce measurement error in our dependent variable. This will inflate our standard errors and make it more difficult to find any statistically significant results.

Our dependent variable is the sum of cash and cash equivalents scaled by TNA (item 74T). We winsorize this cash ratio at the 1st and 99th percentiles.

In addition to data on asset composition, form N-SAR contains data on fund flows and investment practices. Gross and net fund flows for each month since the last semi-annual filing are reported in item 28. Item 70 reports indicators for whether the fund engages in the use of futures, options, or other derivatives, whether the fund uses leverage or engages in short sales, and whether the fund lends out its securities.[8]

[8] Almazan et al (2004) also use form N-SAR's investment practices data.

B. Link to CRSP Mutual Fund Database

For additional fund characteristics such as investment objective, fraction of institutional share classes, and holdings liquidity (see next subsection), we link N-SAR data to the CRSP Mutual Fund Database. We match funds based on name, taking advantage of the structure of fund names in CRSP. The full fund name in CRSP is generally of the form "trust name: fund name; share class." For example, "Vanguard Index Funds: Vanguard 500 Index Fund; Admiral Shares". The first piece, "Vanguard Index Funds", is the name of the legal trust that offers Vanguard 500 Index Fund as well as a number of other funds. Vanguard Index Funds is the legal entity that files on behalf of Vanguard 500 Index Fund with the SEC. The second piece, "Vanguard 500 Index Fund," is the name of the fund itself, while the final piece, "Admiral Shares" indicates different share classes, with different shares being claims on the same portfolio but having different minimum investment requirements, operating expenses, and other features and restrictions. Given the basic name structure, we can straightforwardly match the majority of funds in N-SAR to CRSP. During the 1999-2014 period when this name structure has been in place, we match more than 70% of all fund-year observations in N-SAR to CRSP. In dollar terms, we match more than 80% of all assets.

C. Asset Liquidity

We use holdings data from the CRSP Mutual Fund Database to measure the liquidity of equity mutual fund holdings. These data start in 2002Q2. Following Chen, Goldstein, and Jiang (2010), we construct the square root version of the Amihud (2002) liquidity measure for each stock. We then aggregate up to the fund-quarter level, taking the value-weighted average of individual stock liquidity. Our results are robust to using other measures of holdings liquidity, including the raw Amihud measure, average market capitalization, and turnover.

For bond funds, we use monthly holdings data from Morningstar, which covers the 2002Q2-2012Q2 period.[9] Following Bao, Pan, and Wang (2011), Friewald, Jankowitsch, and Subrahmanyam, (2012), and Dick-Nielsen, Feldhütter, and Lando (2012), we measure the liquidity of individual bond holdings using the Roll (1984) measure. To compute the Roll

[9] Although CRSP has holdings data for some bond funds going back to 2004Q2, coverage is poor until 2010Q4.

measure, we link our holdings data to TRACE for secondary market prices.[10] We exclude bonds that have less than three trades in a given day and those with prices greater than 200% and less than 0% of $1 notional. This excludes only about .05% of trading prices. Once we have the Roll measure for each bond, we aggregate up to the fund-month level, taking the value-weighted average of individual bond liquidity. Our results are robust to using other measures of holdings liquidity, including the inter-quartile daily price range measure used by Han and Zhou (2008), Pu (2009), and Schestag, Schuster, and Homburg (2014).

D. Summary statistics

Our final data set is a semi-annual fund-level panel that combines the N-SAR data with additional fund information from CRSP and data on asset liquidity from CRSP and Morningstar. Throughout the paper, we conduct our analysis at the fund-half year level.

The sample periods are determined by the availability of holdings data in CRSP and Morningstar and of bond transaction data in TRACE. For equity funds, the sample period is January 2002-June 2014. For bond funds, the sample period is January 2004-June 2012.

Table 1 reports basic summary statistics for funds in our data, splitting them into equity versus bond funds. Our sample of equity funds consists of about twenty-five thousand observations. Our sample of bond funds is only about one fifth the size of the equity fund sample. Equity and bond funds are broadly comparable in size with median and mean TNA of about $600 million and $2.3 billion.

Bond funds tend to hold significantly more cash. The median bond fund has a cash-to-assets ratio of 7.5%, while the median equity fund has a cash-to-assets ratio of 4.4%.

Bond funds have somewhat higher institutional ownership and significantly higher turnover.[11] The volatility of fund flows is comparable for bond and equity funds, averaging approximately 11%. There are fewer bond index funds (4%) than equity index funds (15%). Except for securities lending, bond funds are more likely than equity funds to engage in various sophisticated investment practices such as trading options and futures and shorting.

[10] Note that this means that we cannot measure liquidity for Treasuries, Agencies, and private label ABS and MBS because these are not TRACE-eligible securities during our sample period.

[11] Higher turnover of bond funds is in part due to bond maturities being treated as sales and in part due to trading in the to-be-announced market for agency MBS.

IV. Results

We now present our main results. We start by showing that cash holdings play an economically significant role in how mutual funds manage their liquidity to meet inflows and outflows. We then study the determinants of cash holdings, showing that, consistent with the simple model in Section II, cash holdings are strongly related to asset liquidity and the volatility of fund flows. It is worth noting that, throughout the analysis, we are essentially documenting endogenous relationships. Fund characteristics, investor behavior, and cash holdings are all jointly determined, and our results trace out the endogenous relationship between them.[12]

A. Liquidity Management through Cash Holdings

We begin by showing that cash holdings play an important role in the way mutual funds manage inflows and outflows. In Table 2, we estimate regressions of the change in a fund's cash holdings over the last six months on the net flows it received during each of those six months:

$$\Delta Cash_{i,t-6\to t} = \alpha + \beta_0 Flows_{i,t} + \ldots + \beta_5 Flows_{i,t-5} + \varepsilon_{i,t}. \tag{6}$$

Panel A reports the results for equity funds. In the first three columns, the dependent variable is the change in cash holdings over the last six months as a fraction of net assets six months ago: $\Delta Cash_{i,t-6\to t} / Assets_{i,t-6}$. In the first column, the coefficient $\beta_0 = 0.157$ ($t = 8.81$) is large and highly statistically significant. Since flows are scaled by the same denominator (assets six months ago) as the dependent variable, the coefficients can be interpreted as dollars. Thus, $\beta_0 = 0.16$ indicates that a dollar of outflows during month t decreases cash holdings by 16 cents. Similarly, a dollar of inflows increases cash holdings by 16 cents.[13] The other 84 cents are met by transacting in the fund's holdings of equities.

The coefficient β_0 shows that an economically significant portion of flows is accommodated through cash holdings. Even though equities are quite liquid, and a month is a relatively long period, over 15% of flows at a monthly horizon are accommodated through

[12] In most cases, the endogeneity bias should lead to coefficients that are smaller in magnitude. For instance, Chen, Goldstein, and Jiang (2010) argue that higher cash holdings should endogenously lower the volatility of fund flows because investors are less worried about fire sales. This should weaken the relationship between cash and fund flow volatility relative to the case where fund flow volatility is exogenous.

[13] In untabulated results, when we run regressions separating inflows and outflows, we find that funds respond symmetrically to them.

changes in cash holdings. Presumably, at higher frequencies (e.g., daily or weekly), cash plays an even more important role. The remaining coefficients show that the effect of fund flows on cash holdings persists over time. The regression coefficient on flows five months ago is $\beta_5 = 0.056$. A dollar of flows five months ago changes the fund's cash holdings today by almost six cents.

The second column of Table 2 adds time (half-year) fixed effects. The results are unaffected, so we are not just picking up a correlation between aggregate flows and aggregate cash holdings. In the cross section, funds that have inflows build up their cash positions by more than funds that have outflows. The third column adds Lipper objective code cross time fixed effects. The results are again unaffected, indicating that the results are not driven by relationships between flows and cash holdings in particular fund objectives.

In the last three columns of Table 2, the dependent variable is the change in the fund's cash-to-assets ratio:

$$\Delta\left(\frac{Cash}{Assets}\right)_{i,t} = \left(\frac{Cash}{Assets}\right)_{i,t} - \left(\frac{Cash}{Assets}\right)_{i,t-6}.$$

These regressions show that funds are not simply responding to flows by scaling their portfolios up and down. The overall composition of the portfolio is changing, becoming more cash-heavy when the fund receives inflows and less cash-heavy when the fund suffers outflows.

In the fourth column, the coefficient $\beta_0 = 0.066$ ($t = 4.75$) is statistically and economically significant. Flows equal to 100% of assets increase the fund's cash-to-assets ratio by 6.6% (percentage points). For reference, the standard deviation of flows is 11%. The fifth and sixth columns show that these results are robust to including time and objective-time fixed effects.

Panel B of Table 2 reports analogous results for bond funds. The coefficients are again large and statistically significant, and the economic magnitudes are larger. Specifically, in the first column, the coefficient $\beta_0 = 0.295$ ($t = 10.31$) indicates that one dollar of outflows in month t decreases cash holdings by 30 cents. The effect of fund flows persists longer, with a dollar of flows five months ago changing cash holdings today by 12 cents. Similarly, in the fourth column, the coefficient $\beta_0 = 0.117$ ($t = 3.78$) indicates that flows equal to 100% of assets increase the fund's cash-to-assets ratio by 11.7% (percentage points). The larger magnitudes we find for bond funds are consistent with bonds being less liquid than equities. Because funds face a larger price impact trading in bonds, they accommodate a large share of fund flows through changes in cash.

B. *Effects of Asset Liquidity*

To further flesh out the idea that asset illiquidity affects a fund's propensity to use cash to manage inflows and outflows, Table 3 estimates specifications of the form

$$\begin{aligned}\Delta Cash_{i,t-6\to t} = \alpha + \beta_1 Flows_{i,t-2\to t} \times Illiq_{i,t-6} + \beta_2 Flows_{i,t-5\to t-3} \times Illiq_{i,t-6} \\ + \beta_3 Flows_{i,t-2\to t} + \beta_4 Flows_{i,t-5\to t-3} + \beta_5 Illiq_{i,t-6} + \varepsilon_{i,t}.\end{aligned} \tag{7}$$

For compactness, we aggregate flows into quarters, i.e., those from month t-5 to t-3 and month t-2 to t.[14] We interact each of these quarterly flows with lagged values of holdings illiquidity. This specification is effectively asking: given the illiquidity of the holdings that a fund started out with two quarters ago, how did it respond to fund flows during the last two quarters?

For the equity funds studied in Panel A, illiquidity is measured as the square root version of the Amihud (2002) measure. In the first three columns, the dependent variable is the change in cash holdings over the last six months as a fraction of assets six months ago: $\Delta Cash_{i,t-6\to t} / Assets_{i,t-6}$. We standardize the illiquidity variables so that their coefficients can be interpreted as the effect of a one-standard deviation change in asset illiquidity. Thus, the first column of Table 3 Panel A shows that for the average equity fund, one dollar of flows over months t-2 to t changes cash holdings by β_3 = 15 cents. For a fund with assets one standard deviation more illiquid than the average fund, the same dollar of flows changes cash holdings by $\beta_1 + \beta_3$ = 24 cents, a 59% larger effect. Asset illiquidity also increases the persistence of the effect. One dollar of flows over months t-5 to t-3 affects cash balances by β_4 = 7 cents for the average fund but by $\beta_2 + \beta_4$ = 11 cents for a fund with assets one standard deviation more illiquid than average.

The second and third columns of Table 3 Panel A show that these results are robust to controlling for time and objective-time fixed effects. The coefficients are virtually unchanged. In the last three columns of Table 3 Panel A, the dependent variable is the change in the fund's cash-to-assets ratio. Once again, fund flows over the last three months have a larger effect on funds with more illiquid assets.

---

[14] We obtain similar results if we do not aggregate flows this way and study monthly flows instead.

Panel B of Table 3 reports analogous analyses for bond funds. We once again find that fund flows have a large effect on cash for funds with more illiquid assets. For example, the results in column 1 indicate that for a fund with assets one standard deviation more illiquid than the average, a dollar of flows during months *t-2* to *t* changes cash holdings by $\beta_1 + \beta_3 = 32$ cents. For the average fund, the same dollar of flows changes cash holdings by β_3= 24 cents.[15]

C. Effects of Aggregate Market Liquidity

We next turn to time variation in how funds manage their liquidity. The basic idea is that when markets for the underlying securities are more liquid, funds should have a lower propensity to accommodate flows using cash. Intuitively, this seems likely to be particularly true for managing outflows. When markets are liquid, cash can be conserved and outflows can be met by transacting in the underlying securities. Thus, in Table 4, we run specifications of the form

$$\begin{aligned}\Delta Cash_{i,t-6\to t} = \alpha &+ \beta_1\left(Flows_{i,t-2\to t}\right)^{-} \times AggLiq_{i,t-2\to t} + \beta_2\left(Flows_{i,t-5\to t-3}\right)^{-} \times AggLiq_{i,t-5\to t-3} \\ &+\beta_3\left(Flows_{i,t-2\to t}\right)^{+} \times AggLiq_{i,t-2\to t} + \beta_4\left(Flows_{i,t-5\to t-3}\right)^{+} \times AggLiq_{i,t-5\to t-3} \\ &+\beta_5\left(Flows_{i,t-2\to t}\right)^{-} + \beta_6\left(Flows_{i,t-5\to t-3}\right)^{-} \\ &+\beta_7\left(Flows_{i,t-2\to t}\right)^{+} + \beta_8\left(Flows_{i,t-5\to t-3}\right)^{+} + \beta_9 AggLiq_{i,t-2\to t} + \beta_{10} AggLiq_{i,t-5\to t-3} + \varepsilon_{i,t}.\end{aligned} \tag{8}$$

For the equity funds studied in Panel A, our measure of aggregate market liquidity is the Pastor and Stambaugh (2003) measure.[16] In the first three columns, the dependent variable is the change in cash holdings over the last six months as a fraction of assets six months ago: $\Delta Cash_{i,t-6\to t} / Assets_{i,t-6}$. We standardize the variables so that the coefficients can be interpreted as the effect of a one-standard deviation change in asset illiquidity.

Thus, the first column of Table 4 Panel A shows that for the average half-year, one dollar of outflows over months *t*-2 to *t* changes cash balances by $\beta_5 = 9$ cents. When aggregate market

[15] The cross-sectional variation in the propensity to use cash to accommodate fund flows appears to be weaker for bond funds than for equity funds. One reason for this might be that our measure of bond liquidity is noisier than our measure of equity liquidity. If that is the case, then the coefficients on illiquidity and its interactions will be (more) biased towards zero in the analysis of bond funds than in the analysis of equity funds.

[16] We use the Pastor-Stambaugh measure rather than averaging the Amihud measure across stocks because changes in market capitalization mechanically induce changes in the Amihud measure. This means that time variation in the average Amihud measure does not necessarily reflect time variation in aggregate stock market liquidity.

liquidity is one standard deviation above its average, the same dollar of outflows changes cash balances by $\beta_1 + \beta_5 = 7$ cents, or 21% less.

The second and third columns of Table 4 Panel A show broadly similar results when time and objective-time fixed effects are included. In the last three columns of Table 3 Panel A, the dependent variable is the change in the fund's cash-to-assets ratio. Here again, we see suggestive evidence that cash-to-assets ratios are less sensitive to outflows when aggregate market liquidity is high.

In Panel B, we turn to bond funds. There is less agreement in the literature over the appropriate way to measure the liquidity of the aggregate bond market. We use the volatility of the Barclays U.S. Aggregate Index, multiplied by -1. Bao, Pan, and Wang (2011) show that aggregate bond market volatility is strongly related to the average cross sectional illiquidity of bonds at a point in time.

In the first three columns of Panel B, we find that higher aggregate market liquidity during months *t-5* to *t-3* decreases the sensitivity of cash holdings to fund flows during those months. However, there is not a statistically significant effect of aggregate market liquidity during the most recent quarter.

D. Determinants of Cash Holdings

Having shown that cash holdings play an important role in how mutual funds manage inflows and outflows, we next turn to the stock of cash holdings. In Table 5, we run regressions of the form:

$$\frac{Cash_{i,t}}{Assets_{i,t}} = \alpha + \beta_1 Illiq_{i,t} + \beta_2 Scale_{i,t} + \beta_3 InvestorBehavior_{i,t} + \beta_4 TradingPractices_{i,t} + \varepsilon_{i,t}. \quad (9)$$

Here $Illiq_{i,t}$ refers to our measures of the illiquidity of fund assets, and the remaining regressors are variables capturing economies of scale, investor behavior, and trading practices of the fund. Our measures of economies of scale are the (log) size of the fund and the (log) size of the fund family. Our proxies for investor behavior are the volatility of fund flows and the fraction of the fund's assets that are in institutional share classes. Measures of trading practices include the turnover of the fund's assets and indicators for whether the fund engages in the use of futures and options, whether the fund engages in short sales, and whether the fund lends out its securities. We also include an indicator for index funds.

Panel A of Table 5 reports the results for equity funds. All specifications include objective-time fixed effects, and standard errors are adjusted for clustering at the fund family level. The results indicate that funds that engage in more liquidity transformation hold more cash. Focusing on the last column, where we control for all explanatory variables simultaneously, a one-standard deviation increase in asset illiquidity increases cash holdings by 3.6 percentage points as a fraction of assets, relative to an average of 7.8%. Similarly, the volatility of fund flows comes in positive and significant. A one-standard deviation increase in flow volatility (of around 22%) is associated with 0.53 percentage points higher cash-assets ratio. Finally, funds that impose redemption fees on short-term investors and that have illiquid assets hold significantly less cash. For these funds, the effect of a one-standard deviation increase in asset illiquidity is 1.5 percentage points as compared to 3.6 percentage points for funds without redemption fees. Again, this is consistent with the idea that cash holdings play an important role in liquidity transformation. Funds with redemption restrictions provide less liquidity to their end investors and thus need to hold less cash.

Trading practices are another significant determinant of cash holdings. A one-standard deviation increase in asset turnover (of 110%) is associated with a 30 basis point increase in the cash-to-assets ratio. Funds that lend out their securities hold much more cash (6.5 percentage points) because they receive cash collateral when they lend out their securities. Similarly, funds that trade options and futures and that are engaged in short sales tend to hold more cash because they may need to pledge collateral themselves. Index funds hold significantly less cash. This is consistent with the tracking error (carrying cost i in the model of Section II) being more important for these funds.

Finally, our results provide little evidence of economies of scale in liquidity management. To the extent that there are any economies of scale, they show up at the fund family level rather than the fund level. A one-log point increase in fund family total assets decreases the cash-assets ratio by 65 basis points.[17] Why is there little evidence of economies of scale in the liquidity management of mutual funds? One reason, as suggested by the model, is that highly correlated investor flows diminish the scope for scale economies. In particular, effective liquidity provision by mutual funds depends in part on gross inflows and outflows from different investors netting out. This is analogous to banks, where withdrawals from some depositors are met in part using incoming deposit from other depositors. This diversification across liquidity shocks to depositors allows banks to hold illiquid assets while providing depositors with demandable claims (Diamond and Dybvig, 1983). As shown in section II, this diversification benefit increases with the number of investors in the fund, but increases more slowly when investor flows are more correlated.

In the context of mutual funds, past returns are natural public signals that result in correlated flows and thus diminish economies of scale. It is well known that net investor flows respond to past returns (e.g., Chevalier and Ellison, 1997; Sirri and Tufano, 1998). In particular, following poor fund returns, each individual investor is more likely to redeem shares from the fund. This reduces the fund's ability to diversify across investor flows and means that the fund is more likely to suffer net outflows. In untabulated results, we find strong evidence of this mechanism at work. The ratio of net flows faced to gross flows faced by a fund is strongly correlated with past returns.

In Panel B of Table 5, we find similar effects for bond mutual funds. Once again, the amount of liquidity transformation the fund engages in plays a key role. A one-standard deviation increase in asset illiquidity increases cash holdings by 2.9 percentage points as a fraction of assets, relative to an average of 11.6%. Similarly, institutional funds, whose investors may be quicker to redeem their shares in bad times, hold 3.9 percentage points more cash. As with equity funds, bond funds that have higher turnover and those that engage in securities lending hold substantially more cash, while index funds hold less cash.

[17] For fund family to come in negatively, we need to control for securities lending. Larger families are significantly more likely to have securities lending programs in place, and these are associated with higher cash-assets ratios. However, large families without securities lending programs tend to hold significantly less cash.

E. Evolution of Cash Holdings

We next study the time series pattern of how mutual fund cash holdings have evolved over time. A first point to note is that the cash holdings of mutual funds are large and have grown rapidly over recent years. Figure 1 shows the time series of holdings of both cash and cash substitutes. Holdings of cash and cash substitutes rise from $178 billion in 1997 to $744 billion in 2014. This is large as a fraction of total asset manager cash holdings, estimated by Pozsar (2013) to be approximately $2 trillion. It is also large in comparison to corporate cash holdings, which have received substantial attention from both the academics and the press and stand at approximately $2 trillion.

The large cash holdings of mutual funds make clear that in the aggregate liquidity provision by asset managers relies heavily on liquidity provision by the banking and shadow banking systems. In order to provide their investors with liquid claims, asset managers must themselves hold large quantities of cash and cash substitutes. Moreover, these cash holdings largely come from the financial sector, not the government. In our data, over 80% of cash holdings are bank deposits and money market mutual fund shares, not Treasury securities. This presumably reflects an unwillingness on the part of fund managers to pay the high liquidity premia associated with Treasuries when the banking and shadow banking systems can provide cheaper cash substitutes (e.g., Greenwood, Hanson, and Stein, 2015; Nagel, 2014; Sunderam, 2015).

The large increase in mutual fund cash holdings depicted in Figure 1 is a function of two factors. First, total mutual fund assets have risen substantially from $2.4 trillion to $12.6 trillion. Second, as shown in Figure 2, average cash-assets ratios have actually risen over this time period, growing from 7% in 1997 to 9.5% in 2014. This rise is particularly prominent when we look at holdings of cash and cash substitutes. Over time, mutual funds have substituted away from pure cash holdings.

Figures 3 and 4 decompose the rise in cash and cash substitutes as a function of assets. Specifically, we run regressions like (9) over the first year of the sample. We then take the fitted values from these regressions over the sample and separate them into parts attributable to asset illiquidity, economies of scale, investor behavior, and trading practices of the fund.[18] Finally, we construct the changes in these parts of the fitted value relative to the beginning of the sample. Essentially, this procedure attributes changes in average cash-assets ratios over time to changes in asset illiquidity, economies of scale, investor behavior, and trading practices based on a regression like (9) restricted to the first year of the sample.

Figure 3 presents the results for equity funds. It shows that economies of scale and asset illiquidity have played a modest role in reducing cash-assets ratios. Funds and fund families have grown over time, and the stocks held by equity mutual funds have become somewhat more liquid. However, investor behavior and investment practices have acted as countervailing forces, raising cash-assets ratios. In particular, the fraction of assets in institutional funds has grown over time. In addition, investment practices, especially securities lending, played an important role in driving up cash-assets ratios, particularly before the financial crisis.

Figure 4 presents the results for bond funds. It shows that asset illiquidity played an important role in driving up cash-assets ratios, particularly in the aftermath of the financial crisis. Since the financial crisis, investment practices have actually helped to reduce cash-asset ratios. This reflects the fact that fewer bond mutual funds engage in securities lending and shorting since the crisis.

Overall, these results suggest that as the asset management sector grows, it is unlikely to reap significant benefits from economies of scale in liquidity management and is instead likely to continue to grow as a significant demander of liquidity in the form of cash and cash substitutes.

F. Internalizing Price Impact: Fund-level results

Finally, we look for evidence that mutual fund holdings of cash are lower than the social optimum, as suggested by the model. In this section, we look at fund-level evidence. The logic of the model suggests that larger funds should internalize more of their price impact, suggesting

[18] In particular, the part attributable to each category is based on the estimated coefficients for covariates in that category times the mean values of covariates in the category at a point in time. For instance, the part attributable to asset illiquidity is the estimated coefficient on asset illiquidity times the mean value of asset illiquidity in each time period. The economies of scale category includes fund size and fund family size. The investor behavior category includes the volatility of fund flows, the fraction of the fund's assets that are in institutional share classes, and the index fund indicator. The trading practices category includes turnover and indicators for the fund's investment practices.

they should have higher cash-assets ratios. However, larger funds may also capture greater economies of scale in liquidity provision, which would drive them towards lower cash-assets ratios. Thus, a sharper test for price impact externalities examines the interaction of size and asset illiquidity: larger funds with more illiquid assets should particularly hold more cash.

A related intuition is that funds with more concentrated holdings should internalize more of the price impact of their trading and therefore hold more cash. As a simple example, consider two funds. Fund A holds a single asset, while fund B is diversified across many assets, including the asset held by fund A. Consider what happens when both funds are hit with a liquidity shock and have to liquidate some of their holdings of the common asset to meet redemptions. Both funds might have to sell at a discount to fair value, the liquidation cost c in the model of Section II. In addition to bearing this direct cost, however, fund A suffers indirectly because the value of his whole portfolio declines as a result of price pressure on its single asset holding. The value of fund B's remaining portfolio on the other hand is not affected.

Table 6 examines these two predictions. We estimate regressions similar to those in Eq. (9) but add controls for the Herfindahl index (HHI) of holdings as a measure of holdings concentration and for the interaction between asset illiquidity and fund size. The interaction of illiquidity and fund size is statistically significant for bond but not for equity funds. Holdings concentration, on the other hand, is statistically and economically significant for both types of funds. The standard deviation of holdings HHI is 1.86 for equity funds and 3.13 for bond funds. A one-standard deviation increase in holdings HHI therefore increases the cash-assets ratio by 47 basis points for equity funds and 132 basis points for bond funds.

Overall, these results are consistent with the predictions of the model and suggest that in a counterfactual world in which all mutual fund assets were held by a single fund, cash holdings would be substantially higher in order to mitigate price impact.

G. Internalizing Price Impact: Family-level results

We can also look at the fund family level for evidence that cash holdings are lower than the social optimum. Specifically, fund families may at least partially internalize price impact across different funds with the family. Thus, if a fund holds assets that other funds in the fund family hold, then it may be more likely to internalize the price impact of its trading on those funds than on funds outside the fund family. This suggests that funds should hold more cash when they are in investment objectives that make up a larger fraction of the fund family's total assets. This effect should again be stronger for larger funds, for two reasons. First, larger funds might hold more securities and thus have greater overlap with other funds in the same family and objective. Second, by their sheer size, larger funds might have to dump more assets on the market resulting in larger price impact than smaller funds (for the same percentage of asset fund flows and asset sales).

In Table 7, we examine this prediction. We run panel regressions similar to those in Eq. (9) but add family objective share – the fraction of the fund family's total assets in the same objective as the fund – and its interaction with fund size. The first four columns show the results for equity mutual funds. The interaction between family objective share and fund size comes in positive and significant. Large funds in objective classes that are important to the fund family tend to hold significantly more cash than small funds with illiquid assets. The last four columns show the results for bond funds. Here the coefficient on the interaction of family objective share and fund size is not statistically significant.

Overall, the evidence in Sections IV.F and IV.G is consistent with the idea that mutual fund cash holdings are lower than the social optimum. These results are consistent with theory, which suggests that funds do not fully internalize the price impact of their trading on one another. Thus, from the perspective of a planner trying to minimize price impact externalities across funds, our evidence suggests that, despite their relatively high levels of cash holdings, funds do not hold enough cash overall.

V. Conclusion

We study the cash management strategies of equity and bond mutual funds to shed light on liquidity transformation by asset managers. Our analysis highlights three key features of this liquidity transformation. First, mutual funds accommodate a substantial fraction of fund flows through changes in cash holdings as opposed to trading in portfolio securities. For equity funds, a \$1 of fund outflows in month t decreases cash holdings by 15 cents. For bond funds, the same \$1 of outflows decreases cash holdings by 30 cents.

Second, the fact that mutual funds accommodate fund flows through changes in cash holdings indicates that liquidity transformation in asset management is highly dependent on liquidity provision by the traditional banking and shadow banking sectors. In order to provide liquidity to end investors, mutual funds must hold substantial amounts of cash, bank deposits, and money market mutual fund shares.

Third, despite their size, cash holdings of mutual funds are not large enough to completely mitigate price impact externalities created by the liquidity transformation that mutual funds engage in. Our evidence shows that, consistent with theory, funds do not fully internalize the effects that providing investors with daily liquidity have on the prices of the underlying securities. This suggests that the aggregate level of cash holdings in the mutual fund sector is below the socially optimal level.

Appendix

Proof of Proposition 1

Differentiating the fund's objective function with respect to *R* yields the first order condition

$$-i + c\int_R^\infty dF(x) = -i + c\left(1 - F(R)\right) = 0.$$

Rearranging yields $F\left(R^*\right) = 1 - i/c$. Because *x* is normally distributed with standard deviation $\sqrt{\sigma^2 M\left(1+(M-1)\rho\right)}$, we have

$$\frac{x}{\sqrt{\sigma^2 M\left(1+(M-1)\rho\right)}} \sim N(0,1),$$

which is standard normal.

Proof of Proposition 2

We have

$$r^* = k\sqrt{\sigma^2\left(1+(M-1)\rho\right)/M}\ ,$$

where $k = \Phi^{-1}\left(1 - i/c\right)$. Differentiating with respect to *c*, we have

$$\frac{\partial r^*}{\partial c} = \frac{\partial k}{\partial c}\sqrt{\sigma^2\left(1+(M-1)\rho\right)/M} > 0$$

$$\frac{\partial r^*}{\partial \sigma} = k\sqrt{\left(1+(M-1)\rho\right)/M} > 0$$

$$\frac{\partial r^*}{\partial M} = \frac{k}{2M}\left(M\sigma^2 + M(M-1)\sigma^2\rho\right)^{-1/2}\sigma^2\left(\rho - 1\right) < 0$$

$$\frac{\partial^2 r^*}{\partial M^2} = \frac{k}{2M}\left(M\sigma^2 + M(M-1)\sigma^2\rho\right)^{-1/2}\sigma^2 > 0.$$

Proof of Proposition 3

The private market equilibrium is characterized by the first order condition

$$i-\int_{R^*}^{\infty}\left[c\left(G\left(x-R^*\right)\right)+\left(x-R^*\right)c'\left(G\left(x-R^*\right)\right)\right]=0.$$

The social planner's solution is characterized by the first order condition

$$i-\int_{R^{**}}^{\infty}\left[c\left(G\left(x-R^{**}\right)\right)+G\left(x-R^{**}\right)c'\left(G\left(x-R^{**}\right)\right)\right]=0.$$

Evaluating the social planner's first order condition at the private market equilibrium R^* and substituting in the private market first order condition, we have

$$\begin{aligned}&i-\int_{R^*}^{\infty}\left[c\left(G\left(x-R^*\right)\right)+G\left(x-R^*\right)c'\left(G\left(x-R^*\right)\right)\right]dF\left(x\right)\\&=-\int_{R^*}^{\infty}\left[\left(G-1\right)\left(x-R^*\right)c'\left(G\left(x-R^*\right)\right)\right]dF\left(x\right)<0.\end{aligned}$$

Thus, the planner's first order condition does not hold at the private market equilibrium R^*. Note that the planner's first order condition is increasing in R, so we must have $R^{**} > R^*$.

Table A1: Variable definitions[19]

Variable	Definition
Cash/Assets	Cash is cash (74A) + repurchase agreements (74B) + short-term debt securities other than repurchase agreements (74C) + other investments (74I). Other investments consist mostly of money market mutual funds. Cash is scaled by total net assets (74T). Cash/assets is winsorized at the 1st and 99th percentiles.
$\Delta Cash_{i,t-6\rightarrow t} / Assets_{i,t-6}$	Change in cash between two semi-annual reporting periods divided by TNA as of the previous semi-annual reporting period.
$\Delta(Cash / Assets)_{i,t-6\rightarrow t}$	Change in the cash-to-assets ratio between two semi-annual reporting periods.
Flows	Net fund flows during each of the preceding six months (28) are scaled by monthly average of TNA during the reporting period (75B). When monthly average is not available, fund flows are scaled by end of period assets (74T). Fund flows are winsorized at the 1st and 99th percentiles.
Illiq for equity funds	We first calculate Amihud (2002) liquidity measure for each stock in a fund's portfolio. We use daily data for the preceding six months. We then calculate the value-weighted average of the square root of the Amihud measure across all stocks held by a given mutual fund. Equity fund portfolio holdings are from the CRSP Mutual Fund Database.
Illiq for bond funds	Value-weighted average of the Roll (1984) measure of bond illiquidity. Bond fund portfolio holdings are from Morningstar. Bond transaction data is from TRACE. Bonds with fewer than 3 trades in a given day and those with prices greater than 200% and less than 0% of $1 notional are excluded. This excludes only about 0.05% of all transactions. Once we have the Roll measure for each bond, we aggregate up to the fund-month level, taking the value-weighted average of individual bond liquidity.
Aggregate market illiquidity	For equity funds, we use the Pastor and Stambaugh (2003) measure of market liquidity. For bond funds, we use the volatility of daily returns on Barclays U.S. Aggregate Index. We first calculate monthly time series of return volatility, and then calculate the average during months [t-5, t-3] and [t-2, t].
Index fund	Binary variable for index funds (69).
Family size	Log of aggregate TNA (74T) across all funds within the same family. Fund families are identified based on N-SAR question 19.
σ(Flows)	Volatility of monthly fund flows (28) over the preceding six months.
Institutional share	Fraction of institutional share classes, identified based on the inst_fund variable in CRSP Mutual Fund Database.

[19] Numbers in parenthesis refer to form N-SAR question numbers.

Turnover	Portfolio turnover for the current semi-annual reporting period (71D). Portfolio turnover is the minimum of purchases and sales (including all maturities), divided by the monthly average value of the portfolio. Portfolio turnover is winsorized at the 1st and 99th percentiles.
Securities lending	Binary variable equal to one for funds that engage in loaning portfolio securities (70N).
Shorting	Binary variable equal to one for funds that engage in short selling (70R).
Options & Futures	Maximum of 8 binary variables, each equal to one if a fund engages in writing or investing in 1) options on equities (70B), 2) options on debt securities (70C), 3) options on stock indices (70D), 4) interest rate futures (70E), 5) stock index futures (70F), 6) options on futures (70G), 7) options on stock index futures (70H), and 8) other commodity futures (70I).
Other practices	Maximum of 7 binary variables for engagement in the following investment practices: 1) investment in restricted securities (70J), 2) investment in shares of other investment companies (70K), 3) investments in securities of foreign issuers (70L), 4) currency exchange transactions (70M), 5) borrowing on money (70O), 6) purchases/sales by certain exempted affiliated persons (70P), 7) margin purchases (70Q).
Redemption fees	Binary variable equal to one for funds that have redemption fees. Redemption fees are from CRSP Mutual Fund Database.
Holdings HHI	Herfindahl index of portfolio shares. For equity funds, holdings HHI is calculated using fund holdings data from CRSP Mutual Fund Database. For bond funds, holdings HHI is calculated using holdings data from Morningstar and limiting the sample of securities to corporate bonds.
Family objective share	Aggregate TNA of family funds in a given objective (based on CRSP objective code) divided by family TNA.

References

Acharya, Viral, and Lasse Pedersen, 2005, Asset Pricing with Liquidity Risk, *Journal of Financial Economics* 77, 375-410.

Amihud, Yakov, 2002, Illiquidity and Stock Returns: Cross-Section and Time Series Effects, *Journal of Financial Markets* 5, 31-56.

Amihud, Yakov, and Haim Mendelson, 1986, Liquidity and Stock Returns, *Financial Analysts Journal* 42, 43-48.

Andres Almazan, Keith C. Brown, Murray Carlson, and David A. Chapman, 2004, Why Constrain Your Mutual Fund Manager? *Journal of Financial Economics* 73, 289-321.

Bao, Jack, Jun Pan, and Jiang Wang, 2011, The Illiquidity of Corporate Bonds, *Journal of Finance* 66, 911–946.

Bates, Thomas W., Kathleen M, Kahle, and Rene Stulz, 2009, Why Do U.S. Firms Hold so Much More Cash than They Used to? *Journal of Finance* 64, 1985-2021.

Chen, Qi, Itay Goldstein, and Wei Jiang, 2010, Payoff Complementarities and Financial Fragility: Evidence from Mutual Fund Outflows, *Journal of Financial Economics* 97, 239-262.

Chevalier, Judith and Glenn Ellison, 1997, Risk Taking by Mutual Funds as a Response to Incentives, *Journal of Political Economy* 105, 1167-1200.

Chordia, Tarun, Richard Roll, and Avanidhar Subrahmanyam, 2001, Market Liquidity and Trading Activity, *Journal of Finance* 56, 501-530.

Coval, Joshua, and Erik Stafford, 2007, Asset Fire Sales (and Purchases) in Equity Markets, *Journal of Financial Economics* 86, 479-512.

Diamond, Douglas, and Philip Dybvig, 1983, Bank Runs, Deposit Insurance, and Liquidity, *Journal of Political Economy* 91, 401-419.

Dick-Nielsen, Jens, Peter Feldhutter, and David Lando, 2012, Corporate Bond Liquidity Before and After the Onset of the Subprime Crisis, *Journal of Financial Economics* 103, 471-492.

Ellul, Andrew, Chotibhak Jotikasthira, and Christian Lundblad, 2011, Regulatory Pressure and Fire Sales in the Corporate Bond Market, *Journal of Financial Economics* 101, 596-620.

Feroli, Michael, Anil Kashyap, Kermit L. Schoenholtz, and Hyun Song Shin, 2014, Market Tantrums and Monetary Policy, U.S. Monetary Policy Forum Report No.8, Initiative on Global Markets, University of Chicago Booth School of Business.

Financial Stability Oversight Committee, 2014 Annual Report.

Friewald, Nils, Rainer Jankowitsch, and Marti Subrahmanyam, 2012, Liquidity, Transparency and Disclosure in the Securitized Product Market, Center for Real Estate Finance Research, New York, Vereinigte Staaten/USA, 20.11.

Geanapoklos, John, 2009, The Leverage Cycle, NBER Macroeconomics Annual 2009, vol. 24, pp 1-65 (University of Chicago Press).

Goldstein, Itay, Hao Jiang, and David Ng, 2015, Investor Flows and Fragility in Corporate Bond Funds, Unpublished working paper.

Gorton, Gary and Andrew Metrick, 2010, Regulating the Shadow Banking System, Brookings Papers on Economic Activity.

Gorton, Gary, and George Penacchi, 1990, Financial Intermediaries and Liquidity Creation, *Journal of Finance* 45, 49-72.

Greenwood, Robin, and David Thesmar, 2011, Stock Price Fragility, *Journal of Financial Economics* 102, 471-490

Greenwood, Robin, Samuel G. Hanson, and Jeremy C. Stein, 2015, A Comparative-Advantage Approach to Government Debt Maturity, *Journal of Finance*, forthcoming.

Han, Song, and Hao Zhou, 2008, Effects of Liquidity on the Nondefault Component of Corporate Yield Spreads: Evidence from Intraday Transactions Data, Finance and Economics Discussion Series 2008-40, Board of Governors of the Federal Reserve System (U.S.).

Krishnamurthy, Arvind, and Annette Vissing-Jorgensen, 2015, The Impact of Treasury Supply on Financial Sector Lending and Stability, *Journal of Financial Economics*, conditionally accepted.

Longstaff, Francis A, 2004, The Flight-to-Liquidity Premium in U.S. Treasury Bond Prices, *Journal of Business* 77, 511-526.

Merrill, Craig B., Taylor D. Nadauld, Shane M. Sherlund, and Rene Stulz, 2012, Did Capital Requirements and Fair Value Accounting Spark Fire Sales in Distressed Mortgage-Backed Securities? NBER Working Paper No. 18270.

Nagel, Stefan, 2014, The Liquidity Premium of Near-Money Assets, Unpublished working paper.

Pastor, Lubos, and Robert F. Stambaugh, 2003, Liquidity Risk and Expected Stock Returns, *Journal of Political Economy* 111, 642-685.

Pozsar, Zoltan, 2013, Institutional cash pools and the Triffin dilemma of the US banking system, *Financial Markets, Institutions & Instruments* 22, 283-318.

Roll, Richard, 1984, A Simple Implicit Measure of the Effective Bid-Ask Spread in an Efficient Market, *The Journal of Finance* 39, , 1127-1139.

Schestag, Raphael, Piliipp Schuster, and Marliese Uhrig-Homburg, 2014, Measuring Liquidity in Bond Markets, Unpublished working paper.

Shleifer, Andrei, and Robert W. Vishny, 1992, Liquidation Values and Debt Capacity: A Market Equilibrium Approach, *Journal of Finance* 47, 1343-1366.

Shleifer, Andrei, and Robert W. Vishny, 1997, The Limits of Arbitrage, *The Journal of Finance* 52, 35-55.

Sirri, Erik, and Peter Tufano, 1998, Costly Search and Mutual Fund Flows, *Journal of Finance* 53, 1589-1622.

Stein, Jeremy, 2005, Why Are Most Funds Open-End? Competition and the Limits of Arbitrage, *Quarterly Journal of Economics* 120, 247-272.

Stein, Jeremy, 2012, Monetary Policy as Financial-Stability Regulation, *Quarterly Journal of Economics* 127, 57-95.

Sunderam, Adi, 2015, Money Creation and the Shadow Banking System, *Review of Financial Studies* 28, 939-977.

Wang, Jeffrey, 2015, Asset Managers and Financial Instability: Evidence of Run Behavior and Run Incentives in Corporate Bond Funds, Harvard College Senior thesis.

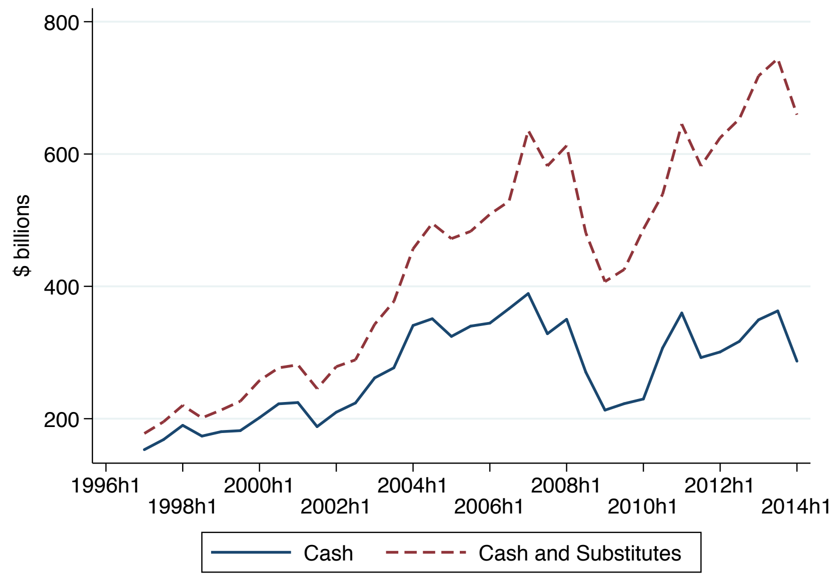

Figure 1. Total cash holdings of equity and bond mutual funds. Sample of mutual funds reporting on semiannual form N-SAR. Cash and substitutes is the sum of cash, repurchase agreements, short-term debt securities, and money market fund shares. See Appendix Table A1 for more details on measurement of cash substitutes.

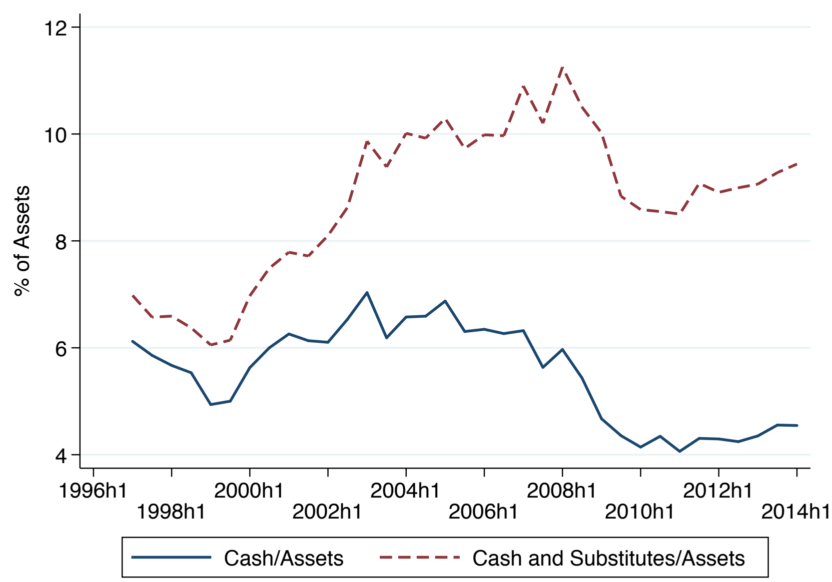

Figure 2. Cash-to-assets ratios of equity and bond mutual funds. Sample of mutual funds reporting on semiannual form N-SAR. Cash and substitutes is the sum of cash, repurchase agreements, short-term debt securities, and money market fund shares. See Appendix Table A1 for more details on measurement of cash substitutes.

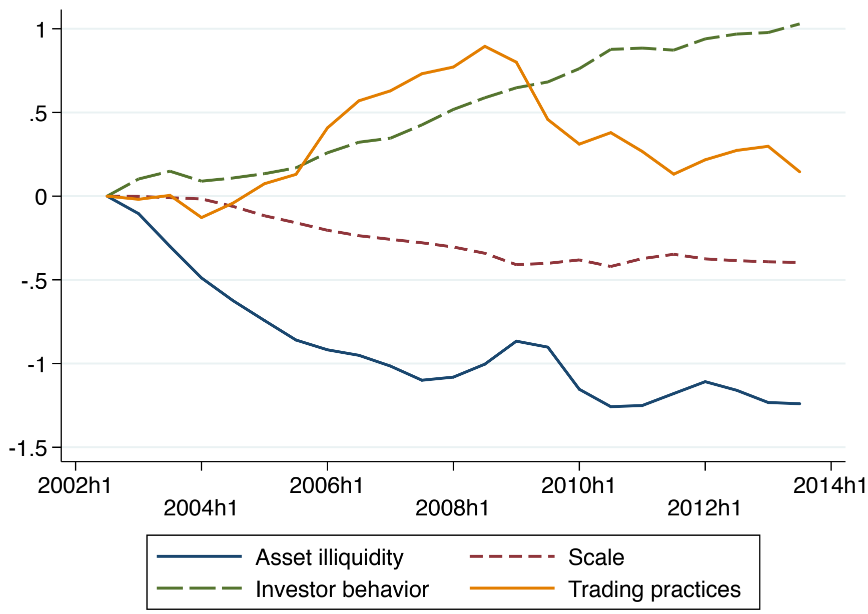

Figure 3. Decomposition of change in cash-to-assets ratios for equity mutual funds. We first run a regression explaining cash-to-assets ratios for equity funds in 2003H2 and 2004H1. We then use the estimated coefficients and the mean values of covariates in each semiannual period to construct the time series of fitted values. Finally, we construct differences relative to the beginning of the sample period and plot a one-year moving average.

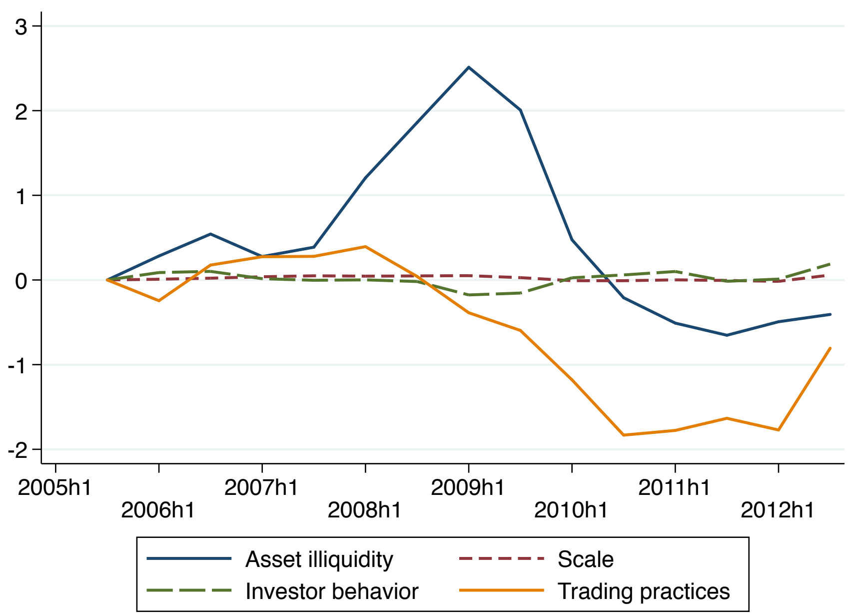

Figure 4. Decomposition of change in cash-to-assets ratios for bond mutual funds. We first run a regression explaining cash-to-assets ratios for equity funds in 2005H2 and 2006H1. We then use the estimated coefficients and the mean values of covariates in each semiannual period to construct the time series of fitted values. Finally, we construct differences relative to the beginning of the sample period and plot a one-year moving average.

Table 1. Summary statistics

This table reports summary statistics for the sample of mutual funds used in the paper. Equity funds sample is funds reporting on semi-annual form N-SAR during the 2002-2014 period, matched to CRSP Mutual Fund Database, and holding at least 25 CRSP stocks. Bond funds sample is funds reporting on semi-annual form N-SAR during the 2004-2012 period, matched to CRSP Mutual Fund Database and Morningstar, and holding at least 25 corporate bonds. TNA is total net assets; size is ln(TNA); family size is ln(total family TNA); Cash/Assets is the ratio of cash and cash substitutes to assets; $Flows_{j \to k}$ is net flows from month *j* to *k*, scaled by average monthly assets; Institutional share is the fraction of assets in institutional share classes; turnover is the minimum of purchases and sales divided by the monthly average size of the portfolio; σ(Flows) is the standard deviation of monthly net flows during the semi-annual reporting period; Sec lending/Shorting/Options & Futures/Other are indicators for funds that engage in securities lending/shorting/trading of options & futures/and other investment practices specified in question 70 of form N-SAR.

	Panel A: Equity funds						Panel B: Bond funds					
				Percentile						Percentile		
	N	Mean	SD	25th	50th	75th	N	Mean	SD	25th	50th	75th
TNA	25,263	2,259	6,524	226	570	1,592	5,444	2,410	7,953	259	600	1,761
Size	25,263	6.53	1.37	5.42	6.35	7.37	5,444	6.61	1.37	5.56	6.4	7.47
Family size	25,263	11.53	2.09	10.15	11.81	13	5,444	11.58	1.88	10.48	11.84	12.91
Cash/Assets	25,263	7.87	9.52	1.8	4.38	10.02	5,444	11.6	12.05	3.35	7.52	15.88
ΔCash/Assets	23,530	0.47	6.38	-1.63	0.06	2.05	5,057	0.78	9.22	-2.82	0.24	3.89
Δ(Cash/Assets)	20,346	-0.19	5.83	-1.79	-0.05	1.44	4,588	-0.35	8.57	-3.11	-0.11	2.79
$Flows_{t-5 \to t-3}$	25,120	2.09	11.04	-3.34	-0.03	5.45	5,408	3.79	10.74	-1.59	2.24	7.5
$Flows_{t-2 \to t}$	25,120	2.45	12.96	-3.53	-0.35	4.99	5,408	4.40	12.97	-1.78	1.98	7.61
Institutional share	25,262	36.27	40.78	0	13.59	82.82	5,444	42.47	40.94	0.15	29.97	90.72
Turnover	25,246	105	108	34	72	138	5,439	219	248	66	126	272
σ(Flows)	25,072	11.53	21.42	2.48	5.52	12.08	5,402	11.11	18.26	3.27	6.25	12.01
Index fund	25,248	0.15	0.35	0	0	0	5,444	0.04	0.19	0	0	0
Sec lending	24,887	0.53	0.5	0	1	1	5,395	0.39	0.49	0	0	1
Shorting	24,886	0.04	0.19	0	0	0	5,394	0.08	0.28	0	0	0
Options & Futures	24,887	0.25	0.43	0	0	0	5,395	0.47	1	0	0	1
Other practices	24,888	0.98	0.14	1	1	1	5,395	0.99	0.1	1	1	1

Table 2. Flow management through cash holdings

This table reports regressions of changes in cash holdings on fund flows. In the first three columns, the dependent variable is the change in cash over a six-month period scaled by assets six months ago. In the second three columns, the dependent variable is the change in the cash-to-assets ratio over a six-month period. The independent variables are monthly net fund flows, scaled by average monthly assets. The second and fifth columns include year-half (time) fixed effects. The third and sixth columns include time-objective code fixed effects. Panel A reports the results for equity funds 2003-2014. Panel B reports the results for bond funds 2004-2012. Standard errors are clustered by time.

	Panel A: Equity funds					
	$\Delta Cash_{i,t-6->t}/Assets_{t-6}$			$\Delta(Cash/Assets)_{i,t-6->t}$		
$Flows_{i,t}$	0.157	0.156	0.151	0.066	0.067	0.066
	[8.81]	[9.36]	[9.06]	[4.75]	[5.10]	[4.86]
$Flows_{i,t-1}$	0.134	0.13	0.128	0.03	0.03	0.028
	[9.47]	[8.88]	[9.16]	[2.31]	[2.45]	[2.12]
$Flows_{i,t-2}$	0.091	0.085	0.08	-0.015	-0.016	-0.019
	[5.47]	[5.49]	[5.38]	[-1.32]	[-1.43]	[-1.56]
$Flows_{i,t-3}$	0.063	0.061	0.057	-0.009	-0.01	-0.013
	[3.66]	[3.35]	[3.06]	[-0.52]	[-0.60]	[-0.75]
$Flows_{i,t-4}$	0.069	0.068	0.067	0.013	0.008	0.007
	[3.11]	[3.23]	[3.18]	[1.02]	[0.61]	[0.57]
$Flows_{i,t-5}$	0.056	0.05	0.05	-0.034	-0.037	-0.037
	[3.11]	[2.64]	[2.88]	[-2.12]	[-2.35]	[-2.44]
R^2	0.085	0.11	0.129	0.005	0.014	0.026
N	23403	23403	23403	23403	23403	23403
FE		YH	YH x Obj		YH	YH x Obj

	Panel B: Bond funds					
	$\Delta Cash_{i,t-6->t}/Assets_{t-6}$			$\Delta(Cash/Assets)_{i,t-6->t}$		
$Flows_{i,t}$	0.295	0.291	0.284	0.117	0.112	0.108
	[10.31]	[9.55]	[9.60]	[3.78]	[3.29]	[3.18]
$Flows_{i,t-1}$	0.153	0.159	0.164	0.006	0.013	0.016
	[3.17]	[3.32]	[3.31]	[0.16]	[0.39]	[0.45]
$Flows_{i,t-2}$	0.191	0.184	0.18	0.094	0.089	0.087
	[4.18]	[4.11]	[3.81]	[2.76]	[2.69]	[2.55]
$Flows_{i,t-3}$	0.065	0.065	0.055	-0.054	-0.052	-0.054
	[1.29]	[1.33]	[1.04]	[-1.40]	[-1.39]	[-1.36]
$Flows_{i,t-4}$	0.112	0.113	0.113	0.001	0.002	0.009
	[4.02]	[4.30]	[4.16]	[0.05]	[0.09]	[0.34]
$Flows_{i,t-5}$	0.124	0.117	0.123	-0.001	-0.006	-0.009
	[3.04]	[2.89]	[2.79]	[-0.03]	[-0.14]	[-0.20]
R^2	0.125	0.136	0.131	0.008	0.017	0.005
N	5024	5024	5024	5024	5024	5024
FE		YH	YH x Obj		YH	YH x Obj

Table 3. Interactions with asset illiquidity

This table reports regressions of changes in cash holdings on fund flows interacted with the fund's asset illiquidity. In the first three columns, the dependent variable is the change in cash over a six-month period, scaled by assets six months ago. In the second three columns, the dependent variable is the change in the cash-to-assets ratio over a six-month period. The independent variables are net fund flows, a measure of asset illiquidity, and their interaction. Asset illiquidity is measured as of the beginning of the six-month period and is standardized so that the coefficients on illiquidity and its interactions represent the effect of a one-standard deviation change in illiquidity. The second and fifth columns include year-half (time) fixed effects. The third and sixth columns include time-objective code fixed effects. Panel A reports the results for equity funds 2003-2014. The measure of asset illiquidity for equity funds is the square-root Amihud measure. Panel B reports the results for bond funds 2004-2012. The measure of asset illiquidity for bond funds is the Roll measure. Standard errors are clustered by time.

	Panel A: Equity funds					
	$\Delta Cash_{i,t-6\to t}/Assets_{t-6}$			$\Delta(Cash/Assets)_{i,t-6\to t}$		
$Flows_{i,t-2\to t}$ x $Illiq_{i,t-6}$	0.09	0.085	0.077	0.034	0.032	0.03
	[6.15]	[6.10]	[5.04]	[2.50]	[2.37]	[1.97]
$Flows_{i,t-5\to t-3}$ x $Illiq_{i,t-6}$	0.04	0.035	0.035	0.001	0.001	-0.002
	[3.23]	[2.71]	[2.22]	[0.06]	[0.09]	[-0.13]
$Flows_{i,t-2\to t}$	0.153	0.148	0.143	0.037	0.037	0.036
	[17.40]	[18.98]	[17.65]	[6.19]	[6.92]	[6.15]
$Flows_{i,t-5\to t-3}$	0.074	0.07	0.069	-0.009	-0.013	-0.014
	[7.72]	[7.23]	[7.11]	[-1.11]	[-1.70]	[-1.80]
$Illiq_{i,t-6}$	0.095	0.096	0.198	-0.096	-0.101	-0.168
	[0.48]	[0.47]	[1.05]	[-0.65]	[-0.66]	[-0.88]
R^2	0.093	0.117	0.135	0.003	0.012	0.025
N	23403	23403	23403	23403	23403	23403
FE		YH	YH x Obj		YH	YH x Obj

	Panel B: Bond funds					
	$\Delta Cash_{i,t-6\to t}/Assets_{t-6}$			$\Delta(Cash/Assets)_{i,t-6\to t}$		
$Flows_{i,t-2\to t}$ x $Illiq_{i,t-6}$	0.085	0.078	0.072	0.015	0.009	0.004
	[3.07]	[2.81]	[2.39]	[0.54]	[0.33]	[0.15]
$Flows_{i,t-5\to t-3}$ x $Illiq_{i,t-6}$	-0.03	-0.029	-0.026	0.009	0.009	0.015
	[-0.79]	[-0.81]	[-0.69]	[0.28]	[0.29]	[0.51]
$Flows_{i,t-2\to t}$	0.239	0.235	0.23	0.074	0.071	0.065
	[8.68]	[9.11]	[8.96]	[4.19]	[3.67]	[3.49]
$Flows_{i,t-5\to t-3}$	0.092	0.09	0.09	-0.035	-0.033	-0.031
	[3.46]	[3.43]	[3.41]	[-1.43]	[-1.32]	[-1.30]
$Illiq_{i,t-6}$	-0.147	-0.125	-0.117	-0.445	-0.422	-0.426
	[-0.41]	[-0.33]	[-0.30]	[-1.14]	[-1.03]	[-1.04]
R^2	0.11	0.12	0.119	0.005	0.015	0.012
N	3282	3282	3282	3282	3282	3282
FE		YH	YH x Obj		YH	YH x Obj

Table 4. Interactions with market liquidity

This table reports regressions of changes in cash holdings on fund flows interacted with the aggregate asset liquidity. In the first three columns, the dependent variable is the change in cash over a six-month period, scaled by assets six months ago. In the second three columns, the dependent variable is the change in the cash-to-assets ratio over a six-month period. The independent variables are positive and negative net fund flows, a measure of aggregate liquidity, and their interaction. Measures of aggregate liquidity are standardized so that the coefficients on market liquidity and its interactions represent the effect of a one-standard deviation change in liquidity. The second and fifth columns include year-half (time) fixed effects. The third and sixth columns include time-objective code fixed effects. Panel A reports the results for equity funds 2003-2014. The measure of asset illiquidity for equity funds is the Pastor-Stambaugh measure. Panel B reports the results for bond funds 2004-2012. The measure of asset illiquidity for bond funds is the volatility of the Barclays Aggregate Index return. Standard errors are clustered by time.

	Panel A: Equity funds					
	$\Delta Cash_{i,t-6->t}/Assets_{t-6}$			$\Delta(Cash/Assets)_{i,t-6->t}$		
$(Flows_{i,t-2->t})^{-}$ x $AggLiq_{t-2->t}$	-0.017	-0.014	-0.021	-0.019	-0.017	-0.023
	[-1.82]	[-1.47]	[-2.29]	[-1.93]	[-1.51]	[-1.74]
$(Flows_{i,t-5->t-3})^{-}$ x $AggLiq_{t-5->t-3}$	-0.005	-0.002	0.001	0.002	0.006	0.008
	[-0.68]	[-0.28]	[0.10]	[0.37]	[0.77]	[0.87]
$(Flows_{i,t-2->t})^{+}$ x $AggLiq_{t-2->t}$	0.005	0.001	0.003	0.003	0.001	0.002
	[0.48]	[0.14]	[0.31]	[0.33]	[0.10]	[0.25]
$(Flows_{i,t-5->t-3})^{+}$ x $AggLiq_{t-5->t-3}$	0	-0.005	-0.008	0.009	-0.001	-0.003
	[-0.02]	[-0.58]	[-0.96]	[0.89]	[-0.19]	[-0.52]
$(Flows_{i,t-2->t})^{-}$	0.089	0.088	0.104	0.027	0.029	0.042
	[9.13]	[7.96]	[8.32]	[2.05]	[2.28]	[3.05]
$(Flows_{i,t-5->t-3})^{-}$	0.102	0.103	0.094	0.019	0.021	0.012
	[10.65]	[10.46]	[8.49]	[1.61]	[1.64]	[0.82]
$(Flows_{i,t-2->t})^{+}$	0.149	0.145	0.152	0.031	0.032	0.038
	[18.19]	[15.85]	[16.49]	[4.38]	[4.40]	[5.59]
$(Flows_{i,t-5->t-3})^{+}$	0.062	0.052	0.045	-0.018	-0.026	-0.033
	[4.13]	[3.40]	[3.18]	[-1.53]	[-2.51]	[-3.95]
$AggLiq_{t-2->t}$	0.985			0.17		
	[3.37]			[0.65]		
$AggLiq_{t-5->t-3}$	0.512			0.026		
	[3.43]			[0.18]		
R^2	0.101	0.128	0.147	0.004	0.022	0.039
N	19386	19386	19386	19386	19386	19386
FE		YH	YH x Obj		YH	YH x Obj

	Panel B: Bond funds					
	$\Delta Cash_{i,t-6->t}/Assets_{t-6}$			$\Delta(Cash/Assets)_{i,t-6->t}$		
$(Flows_{i,t-2->t})^{-}$ x $AggLiq_{t-2->t}$	0.027	0.009	0.002	0.009	-0.006	-0.012
	[1.17]	[0.30]	[0.06]	[0.41]	[-0.24]	[-0.48]
$(Flows_{i,t-5->t-3})^{-}$ x $AggLiq_{t-5->t-3}$	0.049	0.055	0.042	0.054	0.062	0.053
	[1.20]	[1.39]	[1.05]	[1.51]	[1.66]	[1.37]
$(Flows_{i,t-2->t})^{+}$ x $AggLiq_{t-2->t}$	-0.014	-0.011	-0.01	-0.02	-0.016	-0.015
	[-0.66]	[-0.56]	[-0.46]	[-1.31]	[-0.93]	[-0.87]
$(Flows_{i,t-5->t-3})^{+}$ x $AggLiq_{t-5->t-3}$	-0.059	-0.06	-0.063	-0.017	-0.021	-0.025
	[-1.97]	[-1.99]	[-2.11]	[-0.93]	[-1.23]	[-1.49]
$(Flows_{i,t-2->t})^{-}$	0.183	0.189	0.189	0.069	0.076	0.079
	[4.93]	[4.39]	[4.57]	[2.11]	[2.02]	[2.20]
$(Flows_{i,t-5->t-3})^{-}$	0.126	0.115	0.118	0.045	0.032	0.032
	[2.89]	[2.41]	[2.39]	[1.10]	[0.70]	[0.67]
$(Flows_{i,t-2->t})^{+}$	0.229	0.224	0.229	0.082	0.079	0.082
	[8.62]	[8.51]	[8.72]	[5.41]	[4.92]	[5.09]
$(Flows_{i,t-5->t-3})^{+}$	0.086	0.091	0.088	-0.038	-0.026	-0.027
	[2.99]	[3.01]	[2.91]	[-1.72]	[-1.13]	[-1.14]
$AggLiq_{t-2->t}$	-0.267			-0.122		
	[-0.91]			[-0.55]		
$AggLiq_{t-5->t-3}$	0.113			-0.072		
	[0.44]			[-0.34]		
R^2	0.122	0.128	0.135	0.009	0.007	0.013
N	4562	4562	4562	4562	4562	4562
FE		YH	YH x Obj		YH	YH x Obj

Table 5. Level of cash holdings

This table reports regressions of cash-to-assets ratio on fund characteristics. All specifications include time-objective code fixed effects. Panel A reports the results for equity funds 2003-2014. For equity funds, *Illiq* is the square-root Amihud measure. Panel B reports the results for bond funds 2004-2012. For bond funds, *Illiq* is the Roll measure. *Size* is ln(TNA); *Family size* is ln(total family TNA); *Institutional* is the fraction of assets in institutional share classes; *Turnover* is trading volume as a fraction of the portfolio; *σ(Flows)* is the standard deviation of monthly net flows; *Sec lending* is an indicator for whether the fund engages in securities lending; *Shorting* is an indicator for whether the fund engages in short sales; *Options & Futures* is an indicator for whether the fund engages in the use of options or futures; *Other practices* is an indicator for whether the fund uses other investment practices specified on form N-SAR; *Redemption* is an indicator for whether the fund has redemption restrictions. Standard errors are clustered by fund family.

	Panel A: Equity funds				
$Illiq_{i,t}$	2.643	2.521	2.68	2.674	3.596
	[6.23]	[4.52]	[5.08]	[4.79]	[6.21]
$Index_{i,t}$	-1.286	-1.204	-2.213	-2.213	-2.942
	[-2.92]	[-1.11]	[-1.94]	[-1.94]	[-2.79]
$Size_{i,t}$		-0.164	-0.078	-0.078	-0.12
		[-1.28]	[-0.62]	[-0.61]	[-0.76]
$Family\ size_{i,t}$		-0.088	-0.074	-0.074	-0.651
		[-0.66]	[-0.57]	[-0.57]	[-4.98]
$\sigma(Flows)_{i,t}$			0.024	0.024	0.024
			[3.17]	[3.43]	[3.82]
$Institutional_{i,t}$			0.017	0.017	0.007
			[1.78]	[1.78]	[0.94]
$Illiq \times \sigma(Flows)_{i,t}$				0.001	-0.003
				[0.04]	[-0.24]
$Turnover_{i,t}$					0.003
					[1.80]
$Sec\ lending_{i,t}$					6.461
					[10.08]
$Shorting_{i,t}$					2.063
					[1.87]
$Options\&Futures_{i,t}$					1.21
					[2.26]
$Other\ Practices_{i,t}$					1.125
					[1.79]
$Redemption_{i,t}$					-0.392
					[-0.70]
$Illiq \times Redemption_{i,t}$					-2.103
					[-3.41]
R^2	0.123	0.124	0.132	0.132	0.239
N	28059	28059	28059	28059	28059
FE	YH x Obj	YH x Obj	YH x Obj	YH x Obj	YH x Obj

	Panel B: Bond funds				
Illiq$_{i,t}$	3.815	3.774	3.349	3.518	2.914
	[5.59]	[5.58]	[4.92]	[5.03]	[3.08]
Index$_{i,t}$	-4.064	-4.162	-4.725	-4.74	-4.788
	[-2.67]	[-2.25]	[-2.77]	[-2.78]	[-2.39]
Size$_{i,t}$		0.179	0.186	0.188	0.064
		[0.40]	[0.46]	[0.46]	[0.19]
Family size$_{i,t}$		-0.056	0.082	0.083	0.06
		[-0.16]	[0.23]	[0.24]	[0.17]
σ(*Flows*)$_{i,t}$			-0.009	-0.007	-0.007
			[-0.76]	[-0.59]	[-0.72]
Institutional$_{i,t}$			0.052	0.052	0.039
			[4.19]	[4.19]	[3.85]
Illiq x σ(*Flows*)$_{i,t}$				-0.015	-0.014
				[-1.19]	[-1.10]
Turnover$_{i,t}$					0.008
					[3.15]
Sec lending$_{i,t}$					6.227
					[5.74]
Shorting$_{i,t}$					1.346
					[0.81]
Options&Futures$_{i,t}$					0.706
					[0.64]
Other Practices$_{i,t}$					2.049
					[0.87]
Redemption$_{i,t}$					-0.168
					[-0.13]
Illiq x Redemption$_{i,t}$					-1.272
					[-0.83]
R^2	0.07	0.069	0.097	0.097	0.19
N	3509	3509	3509	3509	3509
FE	YH x Obj	YH x Obj	YH x Obj	YH x Obj	YH x Obj

Table 6. Internalizing price impact at the fund level

This table reports regressions of cash-to-assets ratio on fund characteristics. All specifications include time-objective code fixed effects. Panel A reports the results for equity funds 2003-2014. For equity funds, *Illiq* is the square-root Amihud measure. Panel B reports the results for bond funds 2004-2012. For bond funds, *Illiq* is the Roll measure. *Size* is ln(TNA); *Family size* is ln(total family TNA); *Institutional* is the fraction of assets in institutional share classes; *Turnover* is trading volume as a fraction of the portfolio; *σ(Flows)* is the standard deviation of monthly net flows; *Sec lending* is an indicator for whether the fund engages in securities lending; *Shorting* is an indicator for whether the fund engages in short sales; *Options & Futures* is an indicator for whether the fund engages in the use of options or futures; *Other practices* is an indicator for whether the fund uses other investment practices specified on form N-SAR; *Redemption* is an indicator for whether the fund has redemption restrictions. *Holding* $HHI_{i,t}$ is the Herfindahl index of holdings. Standard errors are clustered by fund family.

	Equity funds			Bond funds		
Illiq x $Size_{i,t}$	0.18		0.171	1.02		1.083
	[0.69]		[0.65]	[2.75]		[2.92]
Holding $HHI_{i,t}$		0.255	0.254		0.402	0.423
		[2.22]	[2.21]		[2.53]	[2.60]
$Illiq_{i,t}$	2.429	3.548	2.479	-4.179	2.288	-5.098
	[1.53]	[6.41]	[1.56]	[-1.62]	[2.42]	[-1.97]
$Size_{i,t}$	-0.093	-0.126	-0.101	0	0.161	0.102
	[-0.60]	[-0.79]	[-0.64]	[-0.00]	[0.46]	[0.32]
$Index_{i,t}$	-0.652	-0.634	-0.634	0.141	0.083	0.171
	[-4.98]	[-4.87]	[-4.86]	[0.39]	[0.23]	[0.47]
Family $size_{i,t}$	0.024	0.024	0.024	-0.008	-0.01	-0.009
	[3.56]	[3.42]	[3.43]	[-0.94]	[-0.97]	[-0.98]
$\sigma(Flows)_{i,t}$	0.007	0.007	0.007	0.039	0.037	0.037
	[0.95]	[0.95]	[0.95]	[3.82]	[3.65]	[3.60]
$Institutional_{i,t}$	0.003	0.003	0.003	0.008	0.008	0.008
	[1.82]	[1.96]	[1.97]	[3.13]	[3.00]	[2.98]
$Turnover_{i,t}$	6.456	6.481	6.477	6.353	6.228	6.362
	[10.05]	[10.11]	[10.08]	[5.89]	[5.77]	[5.93]
Sec $lending_{i,t}$	2.044	2.073	2.058	1.324	1.199	1.135
	[1.86]	[1.89]	[1.88]	[0.79]	[0.73]	[0.69]
$Shorting_{i,t}$	1.209	1.272	1.27	0.699	0.629	0.629
	[2.26]	[2.35]	[2.34]	[0.65]	[0.58]	[0.59]
$Options\&Futures_{i,t}$	1.125	1.087	1.087	2.188	2.144	2.262
	[1.79]	[1.73]	[1.73]	[0.97]	[0.93]	[1.03]
Other $Practices_{i,t}$	-2.954	-2.837	-2.846	-4.75	-4.584	-4.546
	[-2.81]	[-2.63]	[-2.64]	[-2.43]	[-2.26]	[-2.30]
$Redemption_{i,t}$	-0.396	-0.436	-0.44	-0.156	-0.173	-0.153
	[-0.70]	[-0.78]	[-0.79]	[-0.13]	[-0.14]	[-0.13]
Illiq x	-2.082	-2.092	-2.082	-1.614	-1.116	-1.448
$Redemption_{i,t}$	[-3.40]	[-3.42]	[-3.41]	[-1.44]	[-0.72]	[-1.33]
R^2	0.239	0.24	0.24	0.198	0.199	0.208
N	28059	28059	28059	3509	3509	3509
FE	YH x Obj	YH x Obj	YH x Obj	YH x Obj	YH x Obj	YH x Obj

Table 7: Internalizing price impact at the family level

This table reports regressions of cash-to-assets ratio on fund characteristics. All specifications include time-objective code fixed effects. Panel A reports the results for equity funds 2003-2014. For equity funds, *Illiq* is the square-root Amihud measure. Panel B reports the results for bond funds 2004-2012. For bond funds, *Illiq* is the Roll measure. *Size* is ln(TNA); *Family size* is ln(total family TNA); *Institutional* is the fraction of assets in institutional share classes; *Turnover* is trading volume as a fraction of the portfolio; *σ(Flows)* is the standard deviation of monthly net flows; *Sec lending* is an indicator for whether the fund engages in securities lending; *Shorting* is an indicator for whether the fund engages in short sales; *Options & Futures* is an indicator for whether the fund engages in the use of options or futures; *Other practices* is an indicator for whether the fund uses other investment practices specified on form N-SAR; *Redemption* is an indicator for whether the fund has redemption restrictions. *Family Obj Share* is the share of family assets in the fund's objective.

	Equity funds				Bond funds			
Family Obj Share$_{i,t}$	-0.003	-0.062	-0.061	-0.081	0.01	0.01	0.032	0.006
	[-0.32]	[-2.75]	[-2.58]	[-3.41]	[0.74]	[0.13]	[0.42]	[0.09]
Family Obj Share x *Size*$_{i,t}$		0.01	0.009	0.012		0	-0.001	0.003
		[2.54]	[2.46]	[3.31]		[0.02]	[-0.10]	[0.25]
Illiq$_{i,t}$	2.674	2.633	2.712	3.555	3.801	3.762	3.336	2.723
	[4.91]	[4.74]	[5.16]	[6.43]	[5.31]	[5.42]	[4.72]	[2.79]
Index$_{i,t}$	-1.299	-1.171	-2.11	-2.812	-4.007	-4.163	-4.926	-4.951
	[-1.15]	[-1.07]	[-1.87]	[-2.71]	[-2.05]	[-2.17]	[-2.77]	[-2.37]
Size$_{i,t}$		-0.498	-0.313	-0.453		0.143	0.042	-0.268
		[-2.46]	[-1.75]	[-2.26]		[0.18]	[0.06]	[-0.42]
Family size$_{i,t}$			-0.112	-0.691			0.427	0.387
			[-0.82]	[-4.76]			[0.99]	[0.90]
σ(*Flows*)$_{i,t}$			0.024	0.024			-0.009	-0.009
			[3.17]	[3.55]			[-0.83]	[-0.99]
Institutional$_{i,t}$			0.016	0.007			0.053	0.041
			[1.75]	[0.91]			[4.22]	[3.89]
Turnover$_{i,t}$				0.003				0.008
				[1.81]				[3.05]
Sec lending$_{i,t}$				6.503				6.263
				[10.24]				[5.87]
Shorting$_{i,t}$				2.03				1.473
				[1.85]				[0.85]
Options&Futures$_{i,t}$				1.23				0.824
				[2.35]				[0.80]
Other Practices$_{i,t}$				1.145				2.519
				[1.83]				[1.11]
Redemption$_{i,t}$				-0.332				-0.245
				[-0.59]				[-0.19]
Illiq x Redemption$_{i,t}$				-2.039				-1.368
				[-3.26]				[-0.89]
R^2	0.123	0.125	0.133	0.241	0.07	0.07	0.099	0.191
N	28059	28059	28059	28059	3507	3507	3507	3507
FE	YH x Obj	YH x Obj	YH x Obj	YH x Obj	YH x Obj	YH x Obj	YH x Obj	YH x Obj