Liquidity and Flows of U.S. Mutual Funds

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1. Summary

We examine the U.S. mutual fund industry with particular attention paid to fund flows, the liquidity of fund portfolios, and the interaction of those characteristics. We document the following general statistics on U.S. mutual funds:

- The amount of assets held by U.S. mutual funds (excluding money market mutual funds and exchange traded funds) is increasing rapidly. Assets grew from $4.4 trillion in 2000 to $12.7 trillion in 2014. Funds that invest primarily in U.S. equities are the largest category, but their share of the total industry assets declined from 65.2% in 2000 to 44.5% in 2014.
- Potentially less liquid mutual fund categories have grown substantially over the same period. For example, foreign bond and foreign equity funds have grown from around 11.0% of the total industry assets in 2000 to 17.4% in 2014.
- Alternative strategy funds are growing faster than any other category. Such funds held total assets of $365 million in 2005. In 2014, alternative strategy funds held total assets of $334 billion. The mean alternative strategy fund had an inflow of 2.4% of assets per month from 2005 through 2014.
- Alternative strategy funds have a broad range of holdings, which makes them difficult to define. In 2014, the average alternative strategy fund invested 30.5% of its assets in common stock. However, at that same time, at least 25% of alternative strategy funds held no common stock and at least 25% of alternative strategy funds held more than 58.7% of their assets in common stock.
- The cash and cash equivalent holdings of mutual funds vary significantly. In 2014, the median fund held 1.8% of its portfolio in cash, but about 25% of funds held 0.2% or less of their portfolio in cash and about 25% of funds held 4.4% or more of their portfolio in cash.
- The variation in cash holdings within each investment category is larger than the variation between investment categories. In 2014, the average mixed strategy fund held 5.9% of its portfolio in cash, compared to 2.8% for the average U.S. government bond fund. But at that

[1] This memorandum was prepared for Mark Flannery, Director and Chief Economist of the Division of Economic and Risk Analysis (DERA). The U.S. Securities and Exchange Commission, as a matter of policy, disclaims responsibility for any private publication or statement of any of its employees. The views expressed herein are those of the authors and do not necessarily reflect the views of the Commission or of the authors' colleagues upon the staff of the Commission.

same time, at least 10% of funds in both categories had a net negative cash position, and at least 10% of funds in both categories held greater than 13% of their portfolio cash.

- The volatility of net asset flows exhibits considerable variation between investment categories. In particular, alternative strategy funds face more volatile flows compared to more traditional funds. During the period 1999 through 2014, the average standard deviation of monthly flows for alternative strategy funds was 13.6%, compared to only 5.8% for U.S. equity funds.
- During the period 1999 through 2013, the equity portfolio of the median U.S. equity fund is about as liquid as the median stock with a market capitalization of greater than $10 billion. However, portfolio liquidity levels vary significantly between funds and over time. Among U.S. equity funds, those that invest in large cap equities and those with greater assets hold more liquid equity portfolios. Equity portfolio liquidity decreased for U.S. equity funds during the financial crisis, particularly among those funds that already had relatively low equity portfolio liquidity.

We also document the following empirical results:

- Changes in market liquidity do not, on average, result in an equivalent change in the liquidity of a fund's portfolio. The liquidity of the equity portfolio of the average U.S. equity fund increases by only 0.82% when market liquidity increases by 1.0%. Funds with more assets and greater equity portfolio liquidity have a greater increase in equity portfolio liquidity after an increase in market liquidity.
- The liquidity of the equity portfolio of U.S. equity funds is greater when flow volatility is greater. A one standard deviation increase in flow volatility decreases the impact of selling $10 million of the asset-weighted average equity portfolio holding by 4.6 basis points. Funds with more assets and lower equity portfolio liquidity have a greater increase in equity portfolio liquidity after an increase in flow volatility.
- The municipal bond holdings of U.S. municipal bond funds are a lower percentage of the fund portfolio and cash is a greater percentage of the fund portfolio when flow volatility is greater. A one standard deviation increase in flow volatility decreases the percentage of a fund's portfolio held in municipal bonds by 0.09% and increases the percentage of a fund's portfolio held in cash by 0.08%. To the extent the relative proportions of cash and municipal bonds measure fund liquidity, U.S. municipal bond funds increase their liquidity after an increase in flow volatility.
- The percentage of a fund's portfolio held in cash and cash equivalents is greater when flow volatility is greater. For the average fund across all investment categories, a one standard deviation increase in flow volatility increases the percentage of the fund portfolio held in cash by 0.07%. Funds that hold less cash have a greater increase in cash holdings after an increase in flow volatility.
- For the average U.S. equity fund, equity portfolio liquidity decreases after a fund experiences outflows. A 10% outflow increases the impact of selling $10 million of the asset-weighted average equity portfolio holding by 11 basis points. Funds with fewer assets and lower equity portfolio liquidity have a greater decrease in liquidity after outflows.
- Among U.S. municipal bond funds, the proportion of municipal bonds in the fund portfolio increases after a fund experiences outflows. A 1% outflow results in a 0.05% increase in the percentage of the fund held in municipal bonds and a 0.05% decrease in the percentage of

the fund held in cash. To the extent the relative proportions of cash and municipal bonds measure fund liquidity, U.S. municipal bond funds have lower liquidity after outflows.

2. Introduction

Liquidity risk management is a concern for mutual funds for several reasons. First, a salient feature of mutual funds is that by statute they may not suspend the right of redemption or postpone the date of payment of redemption proceeds for more than seven days following investors' request to redeem, except under limited circumstances. This feature, as well as the widespread practice by funds to make redemption payments within shorter time frames, has created concern among policymakers and academics that large capital withdrawals from investors may force funds to unwind potentially large fractions of their portfolio at "fire sale" prices (Shleifer and Vishny, 1992; Coval and Stafford, 2007). The possibility of such asset fire sales, while present even in liquid portfolios, is greater for funds that hold less liquid positions. The recent financial crisis illustrated this point when some funds were forced to sell mortgage-backed securities at steep discounts.

Second, the possibility of asset fire sales is exacerbated by how a fund's net asset value (NAV) is determined for redeeming investors. By regulation, all investors who redeem from a mutual fund during the day transact at the fund's end-of-day NAV. The activities associated with meeting those redemptions, e.g., selling positions and portfolio rebalancing, often occur on subsequent days. As a result, the costs of providing liquidity to investors are partially or entirely borne by the non-redeeming investors. The potential for a first-mover advantage can create a spiral where each redemption increases the incentive for other investors to redeem to avoid the increasing costs paid by non-redeeming investors. When funds hold more illiquid securities and thereby encounter higher trading costs, investors have an even greater incentive to redeem before other investors (Chen, Jiang and Goldstein, 2010 and Goldstein, Jiang, Ng, 2015).

Third, recent developments in the mutual fund industry have increased awareness of the importance of liquidity risk management. One development was that during the financial crisis of 2007-2011, several large mutual funds based in Europe suspended redemption due to liquidity concerns while U.S. mutual funds saw large aggregate outflows. Another development is the significant growth in emerging market, fixed income, and alternative strategy mutual funds documented in this paper. Those funds generally invest in less liquid assets when compared to traditional funds and may be potentially more susceptible to the problems identified above, making them of particular interest to policymakers and market participants.

3. Brief overview of U.S. mutual fund industry

3.1. Data and methods

We study the composition of the U.S. mutual fund industry using the CRSP Survivor-Bias-Free Mutual Fund database. We exclude all ETFs, money market funds, and variable annuities in this section and all subsequent sections. We exclude ETFs because their structure and method of redemption are significantly different from traditional open-end funds. For instance, only authorized participants are allowed to redeem from ETFs; redemptions from ETFs are often performed in-kind rather than in-cash; and the majority of ETFs are passively managed portfolios designed to track a benchmark. The topics of fund flows and liquidity are applicable to ETFs, but the significant differences between ETFs and traditional open-end funds would require a different empirical analysis for ETFs than conducted in this paper.

All share classes of a fund are collapsed into a single fund.[2] We group funds into different broad investment categories using CRSP objective codes (see Appendix A for details). A small number of funds are missing a CRSP objective code for their entire fund history and are excluded from the analysis. Within our investment categories, we study three specific subclasses (emerging market debt, emerging market equity, and high yield bonds) identified using CRSP and Lipper objective codes (see Appendix B for details). We isolate these subclasses because some market participants have expressed particular concerns about their liquidity.[3]

3.2. The size and growth of the mutual fund industry

Table 1, Panel A presents the total assets and number of mutual funds by investment category at the end of 2014. As of that time, the industry holds $12.7 trillion in assets across 7,378 unique funds. U.S. equity funds alone hold about $5.6 trillion or 44.5% of total industry assets. Foreign equity, mixed strategy, and general bond funds each hold at least 10% of total industry assets. Those three investment categories combined hold about 42.4% of total industry assets or about the same amount as U.S. equity funds alone. None of the remaining investment categories hold more than 4.5% of total assets. Of particular note, alternative strategy funds hold only $334 billion, or 2.6% of total assets, but they are growing quickly (see below).

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[2] Since we combine all share classes into a single fund observation, institutional and retail share classes of the same fund are intermixed.

[3] For example, see "Liquidity fears loom over fund industry", Steve Johnson, Financial Times, Feb. 1 2015 http://www.ft.com/cms/s/0/2e6d526e-a581-11e4-ad35-00144feab7de.html#axzz3e12EQVyo

Table 1: An overview of the mutual fund industry at the end of 2014

This table presents summary statistics on the mutual fund industry as of the end of 2014. We exclude money market mutual funds, variable annuities, and ETFs. Assets are reported in millions of dollars. P25 and P75 are the 25th and 75th percentiles of the distribution. In Panel A, funds are grouped into broad investment categories following Appendix A. In Panel B, we present results for three selected subclasses within those broad categories that we identify following Appendix B.

Panel A: Investment Category

	Total Assets	Number of Funds	Median Assets	P25 Assets	P75 Assets	% of Total Assets
All	12,678,624	7,378	222	46	985	100.0%
Alternative Strategy	333,922	569	55	17	284	2.6%
Foreign Bonds	259,364	191	159	29	599	2.0%
Foreign Equity	1,956,005	1,257	183	33	775	15.4%
General Bonds	1,690,291	693	362	90	1580	13.3%
Mixed Strategy	1,737,201	811	204	39	952	13.7%
Mortgage-Backed Securities	229,546	102	676	166	1656	1.8%
US Corporate Bonds	98,592	79	322	69	893	0.8%
US Equity	5,642,977	2,932	258	51	1136	44.5%
US Government Bonds	165,527	167	273	83	755	1.3%
US Municipal Bonds	565,201	577	251	97	832	4.5%

Panel B: Subclasses

	Total Assets	Number of Funds	Median Assets	P25 Assets	P75 Assets	% of Total Assets
Emerging Market Debt	48,206	77	141	23	586	0.4%
Emerging Market Equity	285,609	228	136	27	875	2.3%
High Yield Bonds	59,006	61	322	67	844	0.5%

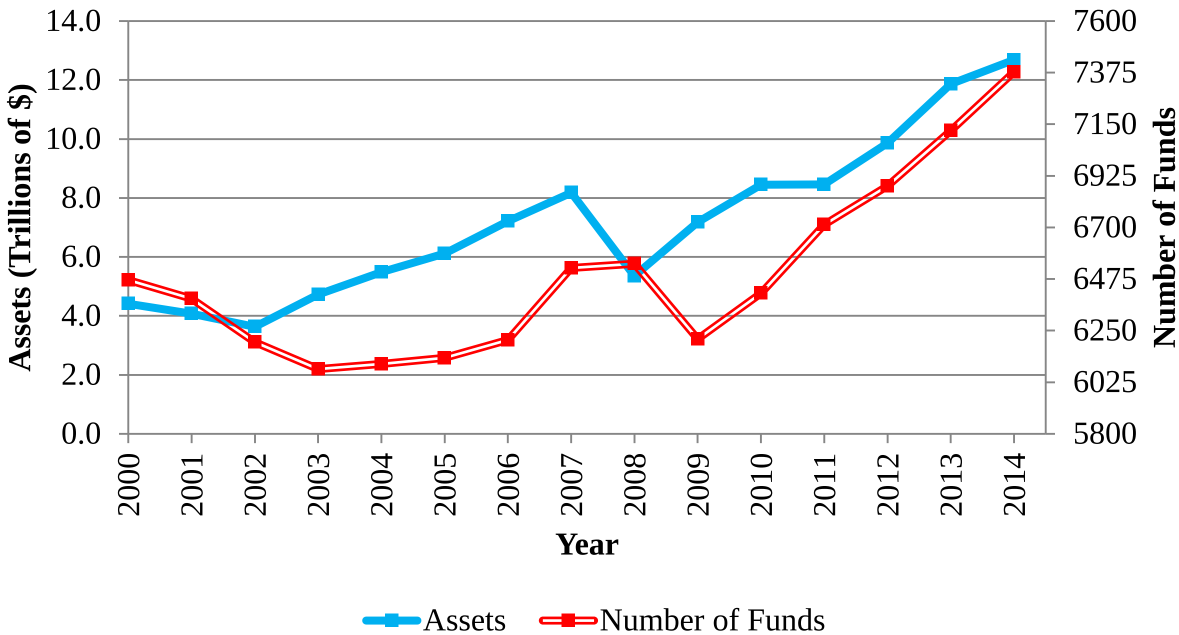
There is significant variation in the size of individual funds. The median fund holds $222 million, but 25% of funds hold less than $46 million and 25% of funds hold more than $985 million. The variation in size also occurs between investment categories. On the one hand, the median alternative strategy fund holds only $55 million, with 25% of such funds holding less than $17 million. On the other hand, the median mortgage-backed security fund holds $676 million, with 25% of such funds holding more than $1.7 billion. As a result, despite there being about 5.6 times as many alternative strategy funds as mortgage-backed security funds, alternative strategy funds hold only $104 billion more in assets.

Table 1, Panel B presents the same results for certain subclasses of funds. Emerging market debt funds hold only $48 billion across 77 unique funds. Emerging market equity funds hold $285 billion across 228 unique funds. High yield bond funds hold only $59 billion across 61 unique funds. However, while high yield bond funds are few in number, a quarter of them hold more than $844 million in assets.

While these point-in-time results are instructive for understanding the current composition of the industry, they do not indicate some significant time trends. Figure 1 shows total industry assets and number of funds from 2000 through 2014. At the end of 2000, mutual funds hold about $4.4 trillion across 6,470 unique funds. As indicated in Table 1, those values increase to $12.7 trillion and 7,378 by the end of 2014. Some portion of that change in total industry assets is due to market performance and some is related to investor flows. For example, total assets decrease from $8.2 trillion at the end of 2007 to $5.4 trillion at the end of 2008. The poor market performance during 2008 alone would have decreased total industry assets, but there was also a net outflow of about $225 billion from mutual funds at the same time.[4]

Figure 1: Growth of mutual funds

This figure shows the total assets and the number of mutual funds at the end of each year from 2000 through 2014. The figure does not include money market mutual funds, variable annuities, or ETFs.



The growth rate of assets varies significantly between investment categories. Table 2 presents total assets at the end of 2000 and the end of 2014 by investment category. We do not present results for alternative strategy funds in the table because no funds are categorized as alternative strategy in 2000, but their assets are included in the total industry assets at the end of 2014. U.S. equity funds hold $5.6 trillion at the end of 2014, compared to $2.9 trillion at the end of 2000. However, despite that growth, that category's assets as a percentage of total industry assets decreased from 65.2% to 44.5%. In a similar fashion, U.S. corporate bond, U.S. government bond, and U.S. municipal bond funds increased their total assets from 2000 to 2014 but had their assets as percentage of the industry decrease. Foreign equity, general bond, and mixed strategy funds each hold less than $500 billion at the end of 2000, but more than $1.6 trillion each at the end of 2014. Mortgage-backed security and foreign bond funds had high asset growth rates, 11.2% and 20.4% per year, but each of those investment categories holds only about 2% of total industry assets at the end of 2014.

[4] Data on net fund flow in 2008 is from Chapter 2 of the 2015 ICI Factbook. http://www.icifactbook.org/fb_ch2.html

Table 2: Growth in assets held in the mutual fund industry by investment category

This table presents the growth in assets of the mutual fund industry from 2000 and 2014. We exclude money market mutual funds, variable annuities, and ETFs. Funds are grouped into classes following Appendix A. The All row includes alternative strategy funds, but alternative strategy funds are excluded from separate presentation in the table because no funds are classified as alternative strategy in 2000. Assets are reported in millions of dollars. Assets are presented as a total value and as a percentage of the industry. The assets growth rate is the annualized geometric average growth of the total value. The assets % growth is the annualized geometric average growth of the percentage of the industry.

	2000		2014			
	Class Assets	Class Assets (%)	Class Assets	Class Assets (%)	Assets Growth Rate	Assets % Growth
All	4,409,289		12,678,624		7.8%	
Foreign Bonds	19,170	0.4%	259,364	2.0%	20.4%	12.2%
Foreign Equity	465,336	10.6%	1,956,005	15.4%	10.8%	2.7%
General Bonds	240,067	5.4%	1,690,291	13.3%	15.0%	6.7%
Mixed Strategy	324,303	7.4%	1,737,201	13.7%	12.7%	4.5%
Mortgage-Backed Securities	51,865	1.2%	229,546	1.8%	11.2%	2.9%
US Corporate Bonds	65,678	1.5%	98,592	0.8%	2.9%	-4.4%
US Equity	2,874,681	65.2%	5,642,977	44.5%	4.9%	-2.7%
US Government Bonds	90,610	2.1%	165,527	1.3%	4.4%	-3.4%
US Municipal Bonds	277,579	6.3%	565,201	4.5%	5.2%	-2.4%

We next focus on the alternative strategy funds. Figure 2 and Figure 3 present total assets and the number of funds for alternative strategy funds. Alternative strategy funds first appear in the sample at the end of 2005, so we present results from 2005 through 2014. At the end of 2005, seventeen alternative strategy funds hold total assets of $365 million. By the end of 2011, 296 alternative strategy funds hold total assets of $85 billion. Since that time, alternative strategy funds have continued to grow at a fast rate. From the end of 2011 to the end of 2014, total assets for alternative strategy funds grew by 58% per year and the number of alternative strategy funds grew by 24% per year. At the end of 2014, alternative strategy funds hold total assets of $334 billion across 569 funds. Alternative strategy funds remain a small portion of the mutual fund industry, but have grown from nonexistent to 2.6% of total assets and 7.7% of total funds in about 10 years.

Figure 2: Growth of assets held by alternative strategy mutual funds

This figure shows the total assets held by mutual funds that are classified as alternative strategy funds at the end of each year from 2005 through 2014. Assets are reported in both billions of dollars and as a percentage of total industry assets.

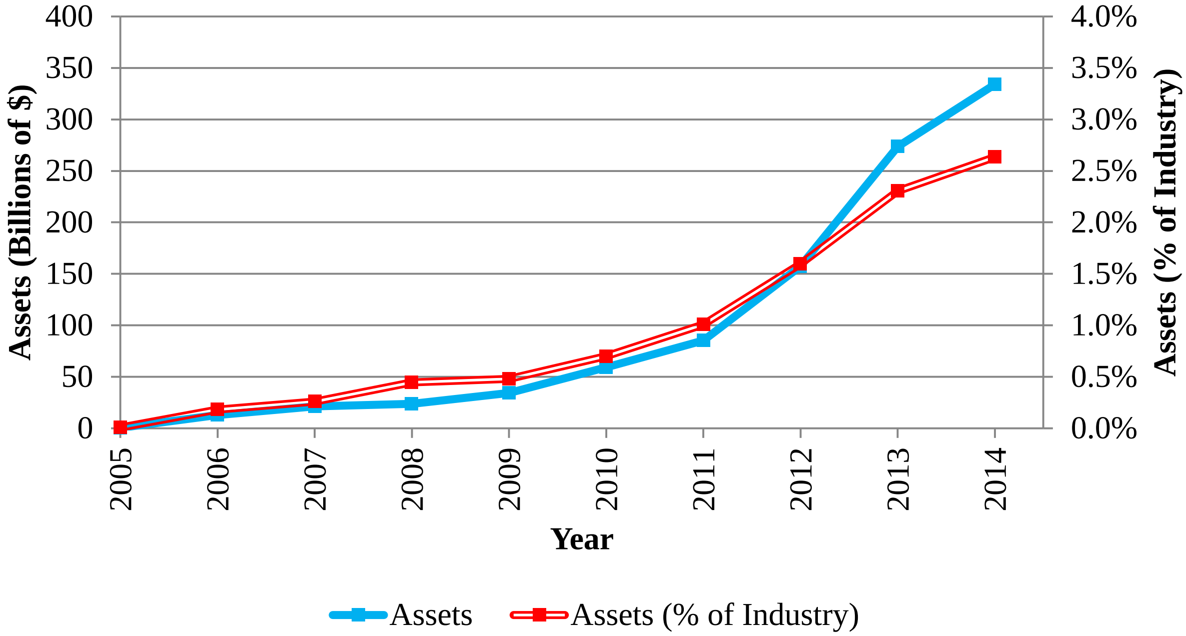
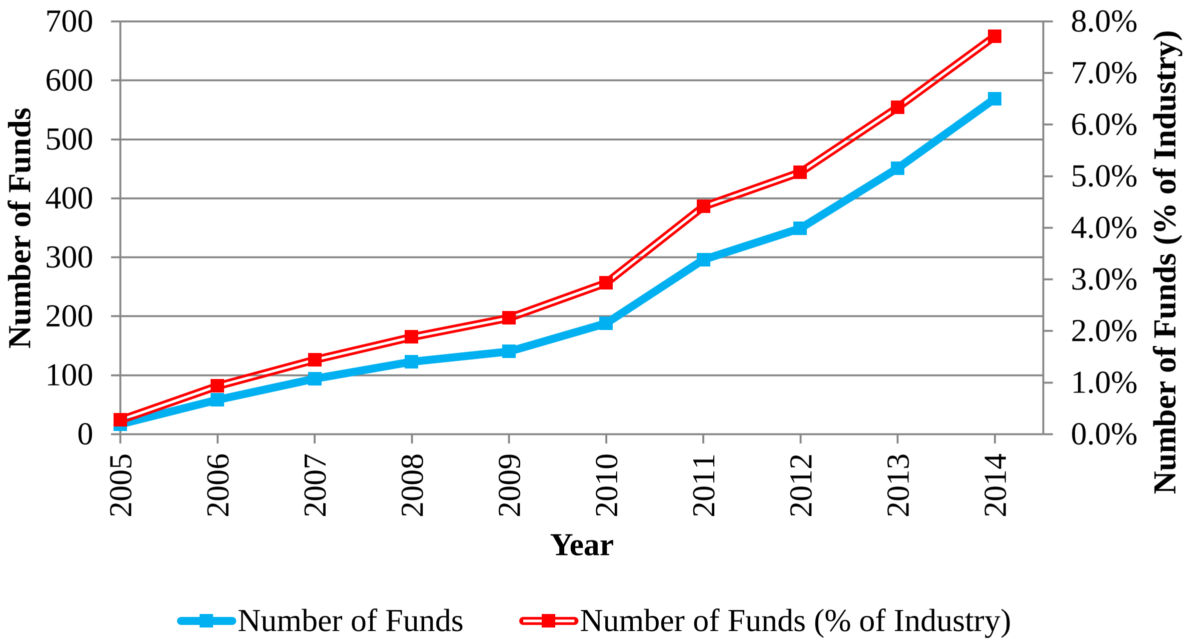


Figure 3: Growth in the number of alternative strategy mutual funds

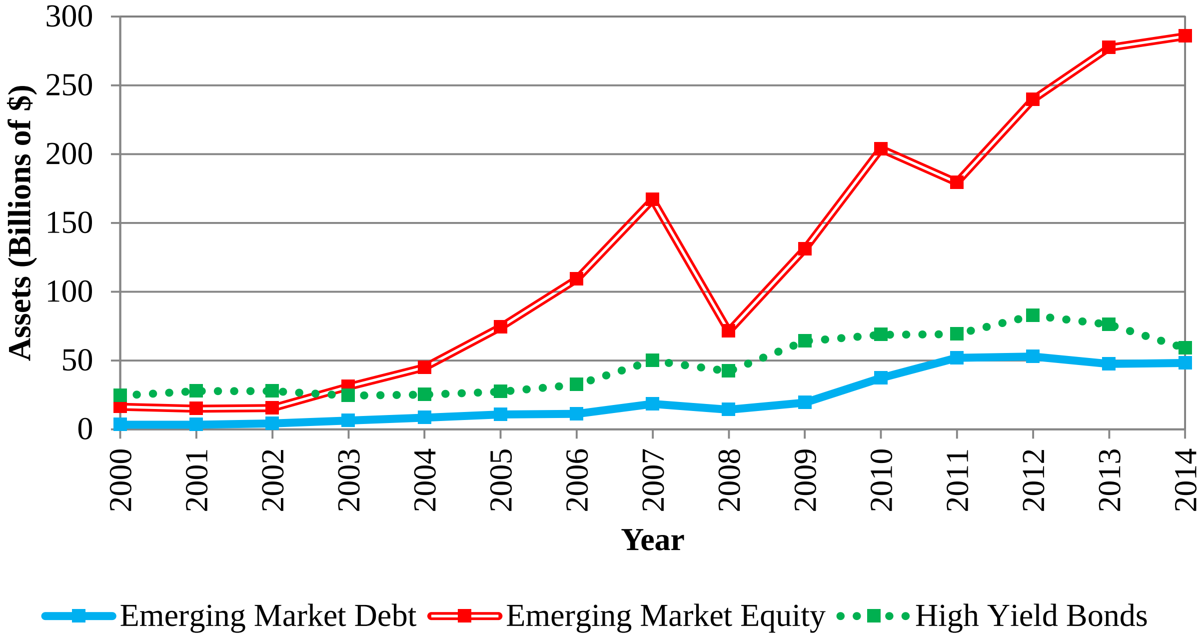
This figure shows the number of mutual funds that are classified as alternative strategy funds at the end of each year from 2005 through 2014. Both the number of funds and the number of funds as a percentage of total funds in the industry are reported.



The subclasses also experience significant growth. Figure 4 shows the total assets for each subclass at the end of each year from 2000 through 2014. At the end of 2000, the subclasses hold a combined $44 billion in assets. At the end of 2014, the subclasses hold a combined $392 billion in assets. But despite that nearly nine fold increase in total assets, the subclasses remain a small portion of total industry assets (3.2%) because of their small initial size. The growth rate of assets varies, but is high, across the subclasses. Emerging market equity and emerging market debt funds grow by 22.7% and 20.8% per year, while high yield bond funds grow by 6.5% per year.

Figure 4: Growth in assets held by emerging market and high yield mutual funds

This figure shows the total assets held by mutual funds that are classified as emerging market or high yield funds at the end of each year from 2000 through 2014.



3.3. The portfolio composition of the mutual funds

Our broad investment categories provide a reasonable indication of the asset class in which a fund primarily invests, but most funds do not invest in a single asset class. For example, U.S. government bond funds may invest primarily in U.S. government bonds, but many also invest in corporate, municipal, and asset-backed bonds. CRSP provides the percentage of each fund's portfolio invested in different broad asset classes. In subsequent tables, we present results for all funds with available data on asset class holdings at the end of 2014.[5]

Table 3 shows the average percentage of a fund's portfolio that is invested in different asset classes by investment category. In many instances, a fund's holding are reflective of their investment category. For example, the average U.S. equity fund invests 85.3% of its assets in common stocks. However, in other

[5] An insignificant number of funds (< 1%) are missing data on asset class holdings at the end of 2014.

instances, funds hold a significant percentage of their portfolio in assets that do not reflect their investment category. For example, the average U.S. corporate bond fund invests only 65.5% of its assets in corporate bonds. About 22% of the average U.S. corporate bond fund's assets are invested in government bonds and mortgage-backed securities. In comparison, the average US municipal bond fund invests 97.9% of its assets in municipal bonds.

While revealing in some respects, the results in Table 3 mask significant variation within some groups. In particular, Table 3 does a poor job describing alternative strategy funds. While the average alternative strategy fund invests 30.5% of its assets in common stock and 22.9% of its assets in cash and cash equivalents (henceforth, "cash"), those averages do not describe actual alternative strategy funds well.[6] Table 4 shows the variation in asset class holdings for alternative strategy funds. On the one hand, at least 25% of alternative strategy funds hold no common stock, and at least 10% of alternatives strategy funds report holding no cash or a negative value for cash.[7] On the other hand, at least 25% of alternative strategy funds hold more than 58.7% of assets in common stock, and at least 10% of alternative strategy funds hold at least 67.8% of assets in cash.[8] Many other alternative strategy funds hold substantial amounts of corporate bonds, government bonds, and securities classified as "other."[9]

Across all investment categories, there is significant variation in cash holdings. Table 5 shows the average fund holds 4.1% of its assets in cash, but about 25% of funds hold 0.2% or less of assets in cash. While some investment categories do tend to have higher cash holdings than others, the variation within each investment category is larger than the variation between investment categories. The average mixed strategy fund holds 5.9% of its assets in cash, compared to 2.8% for the average government bond fund. However, at least 10% of funds in both categories have net negative cash positions, and another 10% of funds in both categories hold more than 13% of assets in cash. Even among municipal bond funds, where cash holding variation is lowest, at least 10% of funds hold no cash or have a net negative cash position and at least 10% of funds hold 5.2% of assets or more in cash.

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[6] CRSP defines cash equivalents as assets which "have a low-risk, low-return profile" and "include U.S. government Treasury bills, bank certificates of deposit, bankers' acceptances, corporate commercial paper and other money market instruments."

[7] Negative cash means that the fund has a net short position in assets classified as cash and cash equivalents. It does not necessarily imply the fund holds no cash or cash equivalents.

[8] Cash and cash equivalent holdings of levels similar to 68% are most likely an indication of heavy derivative usage.

[9] Securities that can be classified as "other" include collective investments (e.g., closed-end funds), commodities, real properties, and derivatives.

Table 3: Average percentage of portfolio invested in different asset classes by investment category and subclass

This table presents the average percentage of a fund's portfolio invested in different asset classes for all funds reporting at the end of 2014. We exclude money market mutual funds, variable annuities, and ETFs. In Panel A, funds are grouped into broad investment categories following Appendix A. In Panel B, we present results for three selected subclasses within those broad categories that we identify following Appendix B.

Panel A: Investment category

	n	Common Stock	Preferred Stock	Other Stock	Corp. Bonds	Muni Bonds	Gov. Bonds	Conv. Bonds	ABS	MBS	Other FI	Other	Cash
All	5,728	55.3%	0.4%	2.4%	9.9%	9.6%	8.0%	0.5%	1.6%	2.7%	1.4%	4.0%	4.1%
Alternative Strategy	277	30.5%	0.4%	1.0%	9.5%	0.3%	11.1%	1.2%	2.7%	1.7%	2.6%	16.1%	22.9%
Foreign Bonds	133	0.3%	0.1%	0.0%	29.6%	0.9%	58.0%	0.3%	1.7%	1.4%	1.3%	1.3%	5.1%
Foreign Equity	933	82.6%	1.0%	7.9%	0.6%	0.0%	0.8%	0.1%	0.1%	-0.1%	0.1%	4.3%	2.6%
General Bonds	561	0.5%	0.8%	0.4%	52.9%	1.9%	16.1%	0.4%	8.1%	10.4%	3.7%	1.8%	2.9%
Mixed Strategy	611	45.3%	0.7%	2.3%	14.0%	1.2%	13.6%	2.8%	1.9%	4.0%	2.0%	6.3%	5.9%
Mortgage-Backed Securities	87	0.1%	0.0%	0.0%	23.4%	0.4%	2.8%	0.0%	9.6%	37.2%	29.0%	-1.1%	-1.6%
US Corporate Bonds	67	0.5%	0.4%	0.2%	65.5%	2.3%	14.6%	0.3%	4.4%	7.2%	1.7%	0.3%	2.5%
US Equity	2,379	85.3%	0.2%	2.0%	1.8%	0.1%	2.3%	0.1%	0.3%	0.4%	0.3%	4.2%	3.1%
US Government Bonds	144	0.4%	0.0%	0.0%	4.4%	0.4%	70.1%	0.0%	6.4%	14.9%	2.6%	-2.0%	2.8%
US Municipal Bonds	536	0.0%	0.0%	0.0%	0.2%	97.9%	0.1%	0.0%	0.0%	0.0%	0.1%	-0.2%	1.9%

Panel B: Investment subclass

	n	Common Stock	Preferred Stock	Other Stock	Corp. Bonds	Muni Bonds	Gov. Bonds	Conv. Bonds	ABS	MBS	Other FI	Other	Cash
Emerging Market Debt	44	0.3%	0.1%	0.0%	41.3%	0.6%	49.6%	0.3%	0.2%	0.0%	1.1%	-0.9%	7.6%
Emerging Market Equity	153	75.8%	2.2%	14.3%	1.0%	0.1%	1.8%	0.1%	0.1%	0.0%	0.1%	1.7%	2.8%
High Yield Bonds	51	0.3%	0.4%	0.3%	67.3%	1.8%	14.0%	0.4%	4.4%	6.0%	2.2%	0.5%	2.4%

Table 4: Variation in holdings for alternative strategy funds

This table presents summary statistics on the broad holdings of alternative strategy mutual funds reporting at the end of 2014. Alternative strategy funds are identified following Appendix A. We exclude money market mutual funds, variable annuities, and ETFs. P10, P25, P75and P90 are the 10th, 25th, 75th, and 90th percentiles of the distribution.

	Mean	Median	SD	P10	P25	P75	P90
Common Stock	30.5%	20.8%	34.5%	0.0%	0.0%	58.7%	87.8%
Preferred Stock	0.4%	0.0%	1.4%	0.0%	0.0%	0.1%	0.9%
Other Stock	1.0%	0.0%	2.8%	0.0%	0.0%	0.7%	2.9%
Corp. Bonds	9.5%	0.0%	16.5%	0.0%	0.0%	13.5%	35.2%
Muni Bonds	0.3%	0.0%	1.2%	0.0%	0.0%	0.0%	0.8%
Gov. Bonds	11.1%	0.0%	21.6%	0.0%	0.0%	11.7%	39.5%
Conv. Bonds	1.2%	0.0%	5.4%	0.0%	0.0%	0.0%	2.0%
ABS	2.7%	0.0%	7.3%	0.0%	0.0%	0.4%	9.9%
MBS	1.7%	0.0%	6.9%	0.0%	0.0%	0.0%	4.2%
Other FI	2.6%	0.0%	6.5%	0.0%	0.0%	1.7%	9.2%
Other	16.1%	3.2%	33.6%	-3.0%	0.0%	22.6%	63.0%
Cash	22.9%	15.5%	32.2%	0.0%	2.8%	35.5%	67.8%

Table 5: Variation in cash and cash equivalent holdings

This table presents summary statistics on the cash and cash equivalent holdings of all funds reporting at the end of 2014. We exclude money market mutual funds, variable annuities, and ETFs. P10, P25, P75and P90 are the 10th, 25th, 75th, and 90th percentiles of the distribution. In Panel A, funds are grouped into broad investment categories following Appendix A. In Panel B, we present results for three selected subclasses within those broad categories that we identify following Appendix B.

Panel A: Investment category

	Mean	Median	SD	P10	P25	P75	P90
All	4.1%	1.8%	12.8%	-0.2%	0.2%	4.4%	10.6%
Alternative Strategy	22.9%	15.5%	32.2%	0.0%	2.8%	35.5%	67.8%
Foreign Bonds	5.1%	3.1%	19.0%	-1.5%	0.0%	7.1%	19.2%
Foreign Equity	2.6%	1.4%	6.5%	0.0%	0.3%	3.4%	6.3%
General Bonds	2.9%	2.1%	13.4%	-4.6%	0.1%	5.0%	10.2%
Mixed Strategy	5.9%	3.2%	15.0%	-2.0%	0.4%	7.2%	17.8%
Mortgage-Backed Securities	-1.6%	1.5%	15.1%	-24.0%	-0.3%	3.7%	11.0%
US Corporate Bonds	2.5%	2.1%	12.0%	-3.2%	0.0%	5.3%	8.7%
US Equity	3.1%	1.8%	7.7%	-0.1%	0.3%	3.7%	7.4%
US Government Bonds	2.8%	0.9%	14.0%	-4.9%	0.0%	4.0%	13.2%
US Municipal Bonds	1.9%	0.9%	4.2%	0.0%	0.0%	2.3%	5.2%

Panel B: Investment subclass

	Mean	Median	SD	P10	P25	P75	P90
Emerging Market Debt	7.6%	3.7%	13.3%	0.0%	1.3%	8.5%	14.6%
Emerging Market Equity	2.8%	1.8%	5.0%	0.0%	0.5%	4.0%	6.2%
High Yield Bonds	2.4%	2.1%	13.6%	-7.0%	0.0%	5.3%	8.7%

4. Mutual fund flows

In this section, we study the monthly net flows of mutual funds. We briefly consider the size of flows, but focus on the volatility of flows. Our primary goal is to understand how volatile fund flows are and how fund characteristics, such as investment category and fund size, affect flow volatility. We extend our results by isolating unexpected fund flows and measuring the volatility of those flows. As with the total fund flows, we also consider how fund characteristics affect the volatility of unexpected flows.

4.1. Data and methods

To build the sample we use for our analysis of net fund flows, we again start with the CRSP Survivor-Bias-Free US Mutual Fund database. We still exclude variable annuities, ETFs, and money market funds; drop any funds missing a CRSP objective code; and aggregate all share classes of a fund into a single fund.[10] In this analysis, we exclude funds that have less than $20 million in assets to account for the incubation bias documented in Evans (2010). That choice also reduces the disproportionate impact (relative to their economic importance) of such funds on our results.

The CRSP database does not directly report any information on flows, so we follow Sirri and Tufano (1998) and calculate monthly implied net flows. An implied net flow captures the change in a fund's assets adjusted for a fund's return:

$$\text{Implied Net Flow}_{i,t} = \frac{\text{Assets}_{i,t} - \text{Assets}_{i,t-1} \cdot (1 + \text{Return}_{i,t})}{\text{Assets}_{i,t-1}} \qquad (1)$$

where $\text{Assets}_{i,t}$ is the total net assets (TNA) for fund *i* in the end of month *t* and $\text{Return}_{i,t}$ is the return on fund *i* during month *t.* The primary assumption underlying this method of calculating flows is that all flows occur at the end of month *t*. Clifford, Fulkerson, Jordan, and Waldman (2013) find the correlation between implied net flows from CRSP and actual net flows reported on SEC Form N-SAR to be 0.99, so the impact of that assumption appears low.[11] Following Coval and Stafford (2007), we drop any observations where the implied net flow is greater than 200% or less than −50%. Flows of that size are rare and are typically related to structural changes in the fund, e.g., mergers.

To verify the accuracy of the CRSP implied net flows, we make use of net flows reported in Morningstar.[12] We match the CRSP and Morningstar flow data using CUSIPs and tickers. If the net flows in the two databases differ by more than one percentage point, we drop that fund-month observation. Furthermore, we drop any fund-months where CRSP and Morningstar assets differ by more than $5 million or monthly returns differ by more than one percentage point. Our final sample of implied net

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[10] Since we combine all share classes into a single fund observation, flows into institutional and retail share classes of the same fund are intermixed.

[11] There is no publically available mapping between fund identifiers used in the CRSP database and those used in Form N-SAR.

[12] This verification is essential because the data is particularly error prone for large net flows. Since large net flows are a primary interest in this white paper, the accuracy of that data in particular is important.

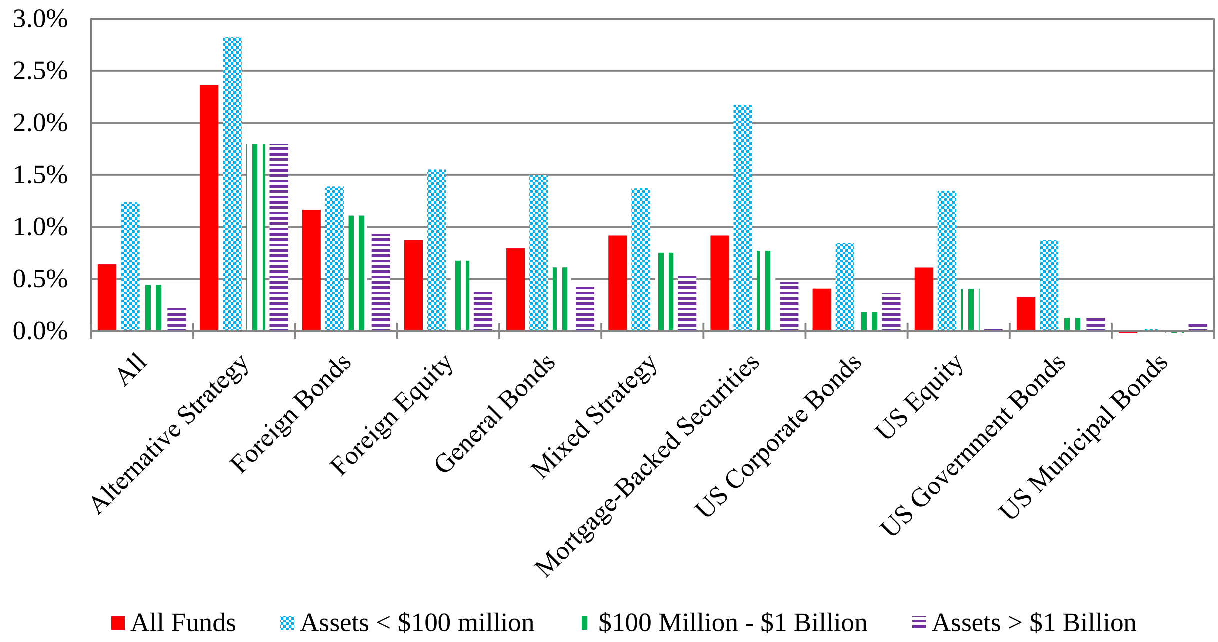
flows covers the period 1999 through 2014 and contains 844,188 fund-month observations across 8,724 unique funds. In the average month, our sample contains about 84% of total industry assets.

4.2. The size and volatility of mutual fund flows

Figure 5 shows the average monthly net flows for the full sample of funds and for different investment category and size groups. The average fund receives a monthly net inflow of about 0.6% over the sample period, but the size of that inflow varies depending on size. Funds with less than $100 million in assets in the prior month have an average net inflow of about 1.2%, compared to only 0.2% for funds with greater than $1 billion in assets. Interpretations based on percentage flows may differ from those based on dollar flows though. A 1.2% net inflow for a fund with $100 million in assets is $1.2 million, while a 0.2% net inflow for a fund with $1 billion in assets is $2.0 million. So as a percentage of fund assets, smaller funds have larger average flows, but in actual dollars, larger funds have larger average flows.

Figure 5: Average monthly net flows by investment category and assets

This figure shows the average monthly net flow for the full sample of funds and for different investment category and asset groups. The flows used are implied monthly net flows as a percentage of fund assets calculated using CRSP and verified using Morningstar. We map funds into investment category groups using CRSP objective codes following Appendix A. We present results separately for funds with less than $100 million, between $100 and $1 billion, and greater than $1 billion in assets. The sample begins in 1999, ends in 2014, and contains 844,188 fund-month observations.

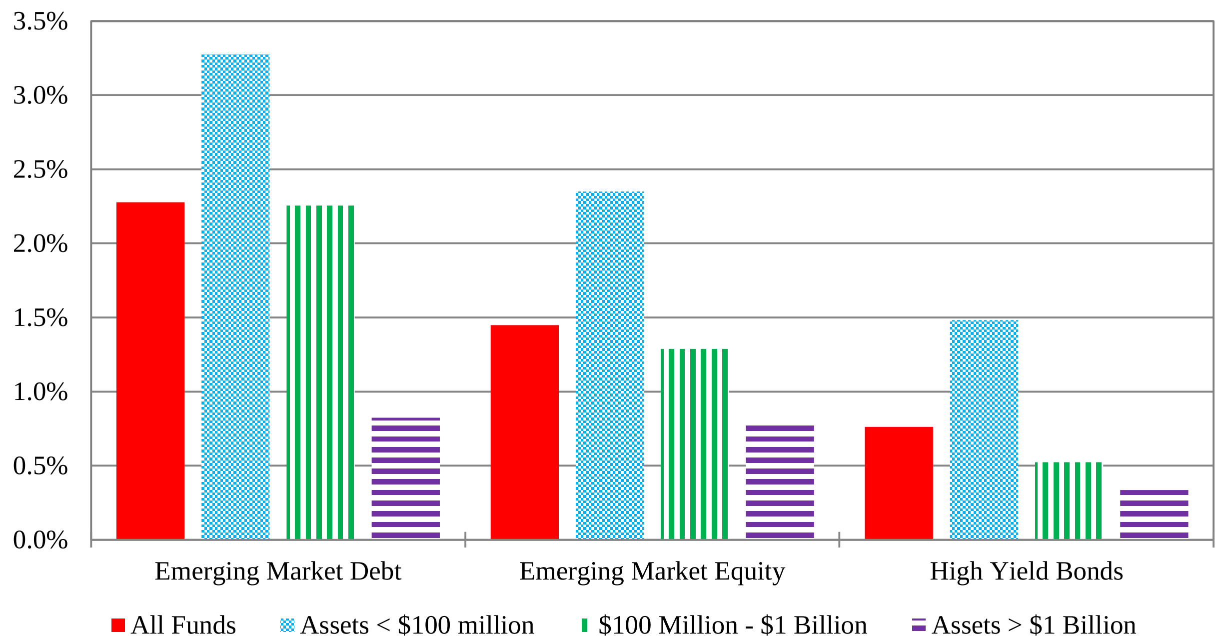


Fund flows also vary depending on investment category. The average alternative strategy fund has a monthly net inflow of 2.4%, while the average U.S. municipal bond fund has a small monthly net outflow of about zero. Within each category, fund flows as percentage of assets are generally decreasing as fund size increases. However, the relative rankings of the categories are about the same within each size group. It does not appear the full sample relative rankings of investment categories are driven by differences in average size between categories.

There is also variation in flows within our subclasses as shown in Figure 6. On the one hand, the average emerging market debt fund has a monthly net inflow of 2.3%, which is larger than the average net inflow for any investment category in Figure 5 except for alternative strategy funds. On the other hand, the average high yield bond fund has a monthly net inflow of only 0.8%, which is similar to many of the other investment categories. The average monthly net flow decreases as fund size increases in all subclasses, and the relative rankings of the subclasses are consistent across the size groups. Among funds with greater than $1 billion in assets, emerging market debt funds have a larger monthly net inflow (0.8%) than all investment categories except alternative strategy funds (1.8%) and foreign bond funds (0.9%). However, there are only two emerging market debt funds with greater than $1 billion in assets in the sample.

Figure 6: Average monthly net flows by investment subclass and assets

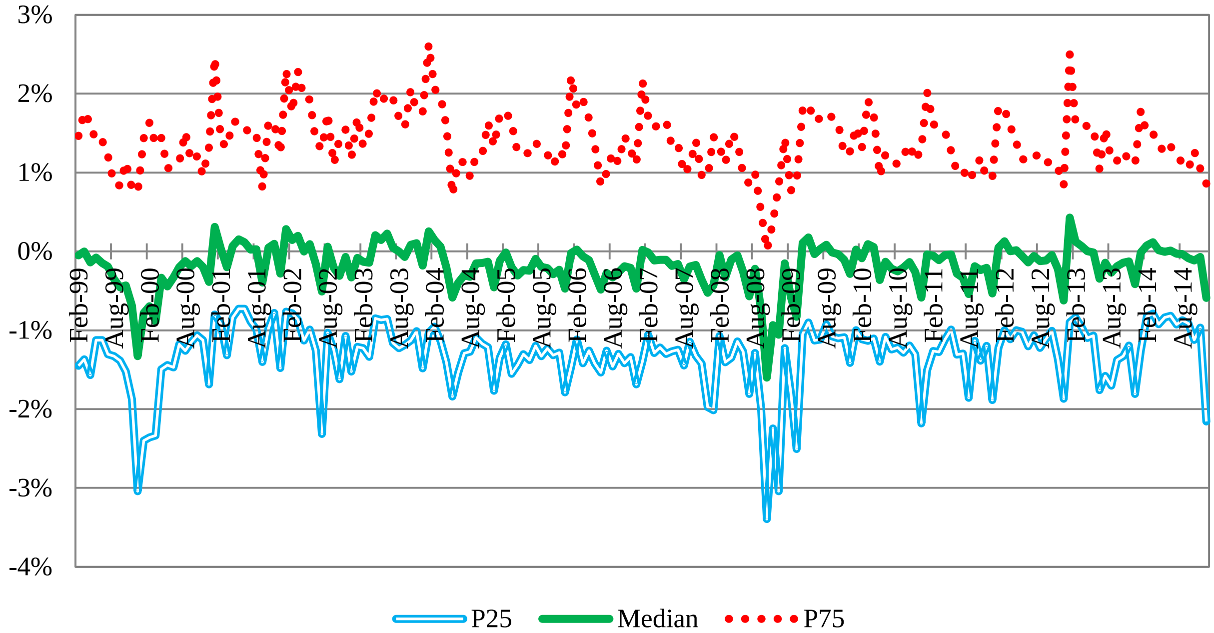
This figure shows the average monthly net flow for different investment subclass and asset groups. The flows used are implied monthly net flows as a percentage of fund assets calculated using CRSP and verified using Morningstar. We identify the subclasses using following Appendix B. We present results separately for funds with less than $100 million, between $100 and $1 billion, and greater than $1 billion in assets.



In addition to variation within investment categories and fund size groups, fund flows also vary in the time series. Figure 7 shows the median flow and the 25th and 75th percentile flow for each month of our sample. The median fund flow is typically between 0.0% and -1.0%, but falls outside that range on many occasions. There is also significant variation between funds within each month. At least 25% of funds have a net inflow of greater than 1% in most months, and at least 25% of funds have a net outflow of greater than 1% in most months. For example, January 2013 has the highest median net flow (0.43%), but 25% of funds still have a flow less than −0.9%. Likewise, October 2008 has the lowest average net flow (−1.3%), but slightly more than 25% of funds still have a positive net flow.

Figure 7: The average and interquartile range of net flows – 1999-2014

This figure presents the median and 25th and 75th percentiles of net flow for each month of our sample. The flows used are implied monthly net flows as a percentage of fund assets calculated using CRSP and verified using Morningstar. The sample begins in 1999 and ends in 2014.



To measure the volatility of fund net flows, we calculate the standard deviation of fund net flows within each fund and average across funds. This fund-level measure requires that each fund have a flow history, so we now limit our sample to funds that have at least 24 months of flows. Table 6 shows the average standard deviation of monthly net flows for all funds and for different investment categories. The average fund has a standard deviation of flows of 5.9%, so for that fund a two standard deviation event would be an 11.8% net outflow.[13] Since the standard deviation of the flow variation is 5.7%, for some funds a two standard deviation event is an outflow larger than 11.8%.

The size of a two standard deviation event for a fund is in large part a function of investment category. The average standard deviation of flows for alternative strategy funds is 13.6%, compared to only 2.7% for municipal bond funds. Therefore, for the average alternative strategy fund, a two standard deviation event is about five times larger in terms of percentage flows than for the average municipal bond fund. As with the full sample, there is significant variation in the standard deviations of flows within each investment category, so for some alternative strategy funds a two standard deviation outflow is significantly larger than that of the average alternative strategy fund.

[13] For simplicity, we assume the average net flow is zero when discussing two standard deviation events. Making that assumption does not change any of our conclusions.

Table 6: Standard deviation of monthly net flows by investment category

This table shows the average standard deviation of monthly net flows for the full sample of funds and for different investment groups. We measure the standard deviation within each fund and then average across funds. We require that a fund have at least 24 months of flows. The flows used are implied monthly net flows as a percentage of fund assets calculated using CRSP and verified using Morningstar from 1999 through 2014. We map funds into investment category groups and subclasses following Appendix A and B.

Panel A: Investment Category

	Mean	SD	n
All	5.9%	5.7%	7,821
Alternative Strategy	13.6%	10.2%	237
Foreign Bonds	8.2%	5.9%	170
Foreign Equity	6.3%	5.2%	1,094
General Bonds	6.6%	6.2%	767
Mixed Strategy	5.3%	5.1%	845
Mortgage-Backed Securities	6.3%	4.7%	109
US Corporate Bonds	4.9%	4.1%	154
US Equity	5.8%	5.5%	3,415
US Government Bonds	6.5%	5.9%	241
US Municipal Bonds	2.7%	2.6%	789

Panel B: Investment Subclass

	Mean	SD	n
Emerging Market Debt	9.4%	6.3%	52
Emerging Market Equity	6.7%	4.7%	154
High Yield Bonds	5.3%	4.6%	93

The variation in flows within a fund generally decreases as fund size increases. Table 7 shows the average standard deviation of monthly flows for different investment categories and fund size groups. Funds with less than $100 million in assets have an average standard deviation of flows of 7.5%, compared to only 2.3% for funds with greater than $1 billion in assets. However, as discussed above, the interpretation of these results is different when dollar flows are considered rather than percentages flows. A two standard deviation outflow of $46 million for a $1 billion fund is equivalent to about a six standard deviation outflow for a $100 million dollar fund.

The only category or subclass without a monotonically decreasing relation between flow volatility and fund size is emerging market debt funds. However, there are only two emerging market debt funds with greater than $1 billion in assets, so it is difficult to draw conclusions about the impact of size on flow volatility for that subclass.

Table 7: Standard deviation of monthly net flows by investment category and assets

This table shows the average standard deviation of monthly net flows for different investment groups and asset groups. We measure the standard deviation within each fund and then average across funds. We require that a fund have at least 24 months of flows. The flows used are implied monthly net flows as a percentage of fund assets calculated using CRSP and verified using Morningstar from 1999 through 2014. We map funds into investment category groups and subclasses following Appendix A and B. We present results separately for funds with less than $100 million, between $100 and $1 billion, and greater than $1 billion in assets.

Panel A: Investment Category

	Assets < $100 million			$100 Million – $1 Billion			Assets > $1 Billion		
	Mean	SD	n	Mean	SD	n	Mean	SD	n
All	7.5%	6.4%	4,521	4.1%	3.9%	2,553	2.3%	2.1%	747
Alternative Strategy	16.0%	10.4%	165	9.0%	7.7%	57	4.4%	2.9%	15
Foreign Bonds	10.0%	6.2%	104	5.3%	3.7%	61	4.6%	3.8%	5
Foreign Equity	7.9%	5.7%	661	4.5%	3.3%	333	2.4%	1.6%	100
General Bonds	8.4%	6.9%	391	5.2%	5.0%	293	3.1%	2.3%	83
Mixed Strategy	6.5%	5.6%	541	3.5%	3.1%	241	1.7%	1.5%	63
Mortgage-Backed Securities	8.8%	5.1%	44	5.5%	3.6%	46	2.6%	2.0%	19
US Corporate Bonds	6.0%	4.9%	77	4.2%	2.8%	59	2.3%	1.2%	18
US Equity	7.3%	6.1%	2,059	4.2%	3.9%	992	2.3%	2.2%	364
US Government Bonds	8.9%	7.1%	117	4.5%	3.2%	105	2.7%	1.7%	19
US Municipal Bonds	3.6%	3.0%	362	2.0%	1.9%	366	1.3%	0.9%	61

Panel B: Investment Subclass

	Assets < $100 million			$100 Million – $1 Billion			Assets > $1 Billion		
	Mean	SD	n	Mean	SD	n	Mean	SD	n
Emerging Market Debt	10.7%	6.5%	38	5.1%	4.0%	12	9.9%	3.0%	2
Emerging Market Equity	7.5%	5.1%	105	5.1%	2.7%	44	3.5%	1.8%	5
High Yield Bonds	6.6%	5.3%	53	4.0%	3.2%	30	2.4%	1.3%	10

While flow volatility allows some inference about the frequency and size of large outflows, the full distribution of flows may provide a more detailed picture. Table 8 presents various percentiles of monthly net flows for the full sample and for different investment categories. Our primary focus is fund-level outflows, so our discussion focuses on the percentiles below 50%. Across all funds, the 10th percentile of net flows is −2.9%, i.e., about 10% of monthly net flows are less than −2.9%. Similarly, the 1st percentile is −14.5%, so about 1% of monthly net flows are less than −14.5%.

Table 8: The percentiles of monthly net flows by investment category

This table shows the percentiles of the monthly net flows for the full sample of funds and for different investment categories. The flows used are implied monthly net flows as a percentage of fund assets calculated using CRSP and verified using Morningstar. The sample begins in 1999 and ends in 2014. In Panel A, funds are grouped into broad investment categories following Appendix A. In Panel B, we present results for three selected subclasses within those broad categories that we identify following Appendix B.

Panel A: Investment Category

	n	1%	5%	10%	25%	50%	75%	90%	95%	99%
All	844,188	-14.5%	-4.8%	-2.9%	-1.3%	-0.2%	1.4%	4.5%	8.4%	25.5%
Alternative Strategy	14,395	-36.8%	-18.7%	-10.7%	-3.3%	0.2%	5.0%	16.0%	28.6%	72.2%
Foreign Bonds	16,299	-19.3%	-6.5%	-3.7%	-1.3%	0.1%	2.2%	6.4%	11.3%	32.9%
Foreign Equity	110,870	-14.7%	-5.2%	-3.1%	-1.3%	0.0%	1.8%	5.4%	9.5%	26.1%
General Bonds	81,095	-15.7%	-5.9%	-3.5%	-1.4%	0.0%	1.8%	5.2%	9.2%	27.3%
Mixed Strategy	86,225	-12.3%	-3.9%	-2.4%	-1.1%	0.0%	1.6%	4.8%	8.4%	25.4%
Mortgage-Backed Securities	11,535	-13.0%	-5.3%	-3.3%	-1.6%	-0.3%	1.7%	6.1%	10.8%	29.3%
US Corporate Bonds	15,001	-12.3%	-4.5%	-2.7%	-1.2%	-0.1%	1.3%	3.6%	6.2%	18.1%
US Equity	370,784	-14.7%	-4.8%	-2.9%	-1.3%	-0.2%	1.3%	4.5%	8.4%	25.6%
US Government Bonds	27,835	-16.0%	-5.8%	-3.7%	-1.7%	-0.4%	1.3%	4.5%	8.5%	25.1%
US Municipal Bonds	110,149	-6.6%	-3.1%	-2.1%	-1.1%	-0.3%	0.6%	2.1%	3.6%	10.0%

Panel B: Investment Subclass

	n	1%	5%	10%	25%	50%	75%	90%	95%	99%
Emerging Market Debt	4,483	-19.3%	-6.5%	-3.6%	-1.1%	0.5%	3.3%	9.6%	16.3%	40.7%
Emerging Market Equity	14,870	-14.5%	-5.3%	-3.2%	-1.1%	0.4%	2.7%	6.9%	11.3%	28.4%
High Yield Bonds	8,544	-12.7%	-4.3%	-2.6%	-1.1%	0.1%	1.7%	4.5%	7.6%	20.6%

As in Table 6, the percentiles vary depending on investment category. Alternative strategy funds experience large outflows more often than any other fund category. Those funds have the largest (in absolute value) 1st, 5th, and 10th percentiles of net flows. The 10th percentile of net flows for alternative strategy funds is −10.7%, while the next largest 10th percentile is only −3.7%. U.S. municipal bond funds have the smallest (in absolute value) 1st, 5th, and 10th percentiles of net flows. The 1st percentile of net flows for U.S. municipal bond funds is −6.6%, significantly less in absolute value than the 10th percentile for alternative strategy funds.

Table 9: The percentiles of monthly net flows by investment category and assets

This table shows the percentiles of the monthly net flows for different investment categories and asset groups. The flows used are implied monthly net flows as a percentage of fund assets calculated using CRSP and verified using Morningstar. The sample begins in 1999 and ends in 2014. In Panel A, funds are grouped into broad investment categories following Appendix A. In Panel B, we present results for three selected subclasses within those broad categories that we identify following Appendix B. We present results separately for funds with less than $100 million and greater than $1 billion in assets.

Panel A: Investment Category

	Assets < $100 million							Assets > $1 Billion						
	n	1%	5%	10%	90%	95%	99%	n	1%	5%	10%	90%	95%	99%
All	259,315	-21.9%	-6.8%	-3.8%	6.7%	13.1%	42.8%	174,402	-7.7%	-3.3%	-2.2%	3.0%	4.8%	10.8%
Alternative Strategy	7,934	-40.3%	-24.0%	-15.2%	21.7%	39.0%	92.2%	1,688	-18.4%	-6.2%	-3.8%	8.8%	12.3%	22.5%
Foreign Bonds	5,130	-25.7%	-7.9%	-4.3%	8.2%	14.7%	40.9%	3,024	-14.1%	-5.0%	-2.7%	5.4%	7.7%	14.4%
Foreign Equity	32,816	-20.6%	-7.2%	-4.1%	8.1%	14.8%	42.7%	23,398	-8.4%	-3.5%	-2.2%	3.3%	5.1%	10.6%
General Bonds	21,040	-21.1%	-7.4%	-4.1%	7.4%	14.4%	45.4%	19,885	-10.3%	-4.3%	-2.7%	3.8%	5.8%	12.7%
Mixed Strategy	29,064	-19.0%	-5.9%	-3.4%	7.0%	13.4%	40.2%	16,428	-5.4%	-2.4%	-1.6%	3.0%	4.6%	9.6%
MBS	1,955	-17.4%	-7.4%	-4.0%	9.1%	18.1%	56.5%	3,519	-9.6%	-4.7%	-2.9%	5.1%	8.4%	15.9%
US Corporate Bonds	4,332	-15.3%	-5.3%	-3.2%	4.8%	9.1%	30.0%	2,834	-6.9%	-3.3%	-2.3%	3.2%	4.8%	9.4%
US Equity	114,545	-22.5%	-6.9%	-3.8%	7.0%	13.5%	44.5%	84,486	-7.0%	-3.1%	-2.1%	2.5%	4.1%	9.7%
US Government Bonds	7,338	-19.5%	-7.2%	-4.3%	6.2%	12.4%	43.1%	4,680	-12.9%	-4.4%	-2.9%	3.5%	5.9%	16.1%
US Municipal Bonds	35,161	-8.0%	-3.6%	-2.4%	2.5%	4.5%	13.0%	14,460	-5.0%	-2.6%	-1.7%	1.9%	3.2%	7.2%

Panel B: Investment Subclass

	Assets < $100 million							Assets > $1 Billion						
	n	1%	5%	10%	90%	95%	99%	n	1%	5%	10%	90%	95%	99%
Emerging Market Debt	1,359	-28.7%	-9.2%	-3.8%	13.2%	23.7%	64.7%	901	-17.5%	-6.9%	-3.7%	6.3%	9.0%	16.2%
Emerging Market Equity	3,982	-19.7%	-7.6%	-4.2%	10.2%	17.6%	44.1%	3,624	-8.3%	-3.5%	-2.1%	4.1%	6.0%	11.3%
High Yield Bonds	2,428	-14.6%	-5.0%	-2.7%	6.3%	10.3%	34.4%	1,527	-8.6%	-3.7%	-2.7%	3.7%	5.2%	10.3%

Table 9 presents percentiles of monthly net flows for different investment categories and fund size groups. The absolute size of the percentiles generally decreases as size increases. Among funds that hold less than \$100 million in assets, the 1st, 5th, and 10th percentiles are −21.9%, −6.8%, and −3.8%. Among funds that hold greater than \$1 billion in assets, the 1st, 5th, and 10th percentiles are −7.7%, −3.3%, and −2.2%. But as discussed before, the interpretation of the results is different when dollar flows are considered rather than percentages flows. A 21.9% outflow for a fund with \$100 million in assets is \$21.9 million, while a 7.7% outflow for a fund with \$1 billion in assets is \$77 million. Thus, whether large or small funds have more "extreme" outflows depends on how flows are defined.

The same relation between the percentiles and size holds within each of the investment categories. For example, about 10% of net flows to alternative strategy funds with less than \$100 million in assets are less than −15.2%, compared to −3.8% for alternative strategy funds with greater than \$1 billion in assets. However, large percentage flows occur within some investment categories even among funds with greater than \$1 billion in assets. Alternative strategy funds and foreign bond funds with greater than \$1 billion in assets have 1st percentiles of −18.4% and −14.1%, respectively. For comparison, U.S. municipal bond funds with greater than \$1 billion in assets have a 1st percentile of −5.0%. In general, the same trends across investment categories seen in Table 8 exist among funds after controlling for size.

4.3. The volatility of unexpected fund flows

When studying fund flows, it is important to consider that funds have the ability to anticipate some flows and might only be concerned about unexpected flows. We decompose actual flows into expected and unexpected flows:

$$\text{Actual Flow}_{i,t} = \text{Expected Flow}_{i,t} + \text{Unexpected Flow}_{i,t} \tag{2}$$

where $\text{Actual Flow}_{i,t}$ is the net flow for fund *i* in month *t* and the expected flow is calculated using the forecasting model proposed by Coval and Stafford (2007):

$$\text{Expected Flow}_{i,t} = \alpha + \sum_{n=1}^{N} \beta_n \text{ Actual Flow}_{i,t-n} + \sum_{m=1}^{M} \gamma_m \text{ Return}_{i,t-m} + \varepsilon_{i,t} \tag{3}$$

where the $\text{Expected Flow}_{i,t}$ is a function of a fund's prior monthly flows ($\text{Actual Flow}_{i,t-n}$) and prior monthly returns ($\text{Return}_{i,t-m}$).[14] The unexpected flow is simply the residual in equation (3). We set N and M equal to 12, so twelve months of prior flows and returns are used to estimate the expected flow. Since we cannot directly observe the parameters β and γ, we estimate them through a Fama-MacBeth regression of $\text{Actual Flow}_{i,t}$ on past flows and returns.[15] As in Coval and Stafford (2007), we find

[14] We considered alternative specification of this model that include other variables (e.g., fund size and turnover) and found results to be similar to those presented.

[15] Coval and Stafford (2007) estimate the model using both a Fama-MacBeth regression and a pooled OLS regression. Regardless of which method we use, our conclusions are the same. Further, we estimated the model separately for each investment category and size group and find that our conclusions are the same.

expected flows increase when past flows and returns increase, but for brevity, we do not tabulate the full results of that regression.

Our estimates of unexpected fund flows are imperfect. On the one hand, the size of the unexpected flows is biased downwards because we have performed an in-sample prediction, i.e., the data used to estimate the unexpected flows model is the same data for which we calculate unexpected flows. But on the other hand, the size is biased upwards since each individual fund should be able to forecast their flows better than the simple model we use. We use only information about past performance and flows and apply the same parameters to every fund.[16] It is very unlikely that funds forecast their own flows with the model we use. Fund managers have significantly more quantitative and qualitative information available and could make fund specific adjustments to any parameters in their model. We cannot test which of these biases is larger, so whether estimates are biased upward or downward overall is unclear. However, the large amount of information available to funds that is missing from the model leads us to believe we underestimate predictability.

Our primary interest is the volatility of unexpected net flows within each fund. We calculate the standard deviation of the unexpected net flows within each fund and average across funds in Table 10. As in Table 6, we present results for the full sample and for different investment categories. The unexpected flows are generally less volatile than the total flows. The average fund has a standard deviation of unexpected monthly flows of 4.1%, compared to an average standard deviation of total monthly flows of 5.9%. The variation in unexpected flows is also lower than the variation of total flows within each category. Alternative strategy funds have an average standard deviation of total flows of 13.6%, but an average standard deviation of unexpected flows of 10.0%. A two standard deviation event for the average alternative strategy fund is a 27.2% outflow, but an unexpected two standard deviation event is only 20.0%. For other fund styles, such as U.S. municipal bond funds, the gap between the volatility of the unexpected flows and the volatility of the total flows is smaller, but a notable difference still remains.

[16] We estimated the model separately for each fund and found that the unexpected flows using that approach were significantly smaller than those estimated using the full sample model. However, due to concerns about overfitting (i.e., creating a model that describes random error or noise instead of the underlying relationship), we do not present those results in this paper.

Table 10: Standard deviation of monthly unexpected net flows by investment category

This table shows the average standard deviation of monthly unexpected net flows for the full sample of funds and for different investment groups. We measure the standard deviation within each fund and then average across funds. Unexpected flows are calculated following equations (2) and (3) using implied monthly net flows as a percentage of fund assets calculated from CRSP and verified in Morningstar. We require that a fund have at least 36 months of flows. That requirement ensures that each individual fund has an unexpected flow history of at 24 months, since the first twelve months of any fund's flow history will not have the lagged data necessary to calculate an expected flow. We map funds into investment category groups and subclasses following Appendix A and B.

Panel A: Investment Category

	Mean	SD	n
All	4.1%	3.8%	6,483
Alternative Strategy	10.0%	9.1%	151
Foreign Bonds	5.8%	4.0%	121
Foreign Equity	4.5%	3.2%	886
General Bonds	4.8%	3.9%	644
Mixed Strategy	3.3%	3.5%	706
Mortgage-Backed Securities	4.3%	2.9%	89
US Corporate Bonds	4.0%	3.0%	121
US Equity	4.1%	3.4%	2,824
US Government Bonds	4.7%	3.7%	204
US Municipal Bonds	2.0%	1.8%	737

Panel B: Investment Subclass

	Mean	SD	n
Emerging Market Debt	7.6%	5.9%	29
Emerging Market Equity	5.0%	2.5%	116
High Yield Bonds	4.2%	3.0%	74

In Table 11, we present results for different investment category and fund size groups. The gap between the volatility of total and unexpected net flows decreases as size increases. The average fund with less than $100 million in assets has a standard deviation of unexpected monthly flows of 5.1%, compared to an average standard deviation of total monthly flows of 7.5%. However, among funds with greater than $1 billion in assets, the volatility of unexpected flows is greater than the volatility of the total flows. The average standard deviation of unexpected monthly flows is 2.5% while the average standard deviation of total monthly flows is 2.3%.[17]

[17] If we estimate the parameters of the expected flow model on a fund-by-fund basis, then the volatility of unexpected flows is less than the volatility of total flows for funds with greater than $1 billion in AUM. However, as discussed before, we do not present those results due to concerns about overfitting.

Table 11: Standard deviation of monthly unexpected net flows by investment category and assets

This table shows the average standard deviation of monthly unexpected net flows for different investment groups and asset groups. We measure the standard deviation within each fund and then average across funds. Unexpected flows are calculated following equations (2) and (3) using implied monthly net flows as a percentage of fund assets calculated from CRSP and verified in Morningstar We require that a fund have at least 36 months of flows. That requirement ensures that each individual fund has an unexpected flow history of at 24 months, since the first twelve months of any fund's flow history will not have the lagged data necessary to calculate an expected flow. We map funds into investment category groups and subclasses following Appendix A and B. We present results separately for funds with less than $100 million, between $100 and $1 billion, and greater than $1 billion in assets.

Panel A: Investment Category

	Assets < $100 million			$100 Million - $1 Billion			Assets >= $1 Billion		
	Mean	SD	n	Mean	SD	n	Mean	SD	n
All	5.1%	4.6%	2,571	3.6%	3.0%	3,057	2.5%	1.7%	855
Alternative Strategy	12.9%	10.3%	74	7.6%	7.3%	66	4.4%	2.6%	11
Foreign Bonds	7.0%	4.3%	49	5.1%	3.7%	63	4.4%	3.1%	9
Foreign Equity	5.5%	3.9%	329	4.3%	2.7%	436	2.7%	1.7%	121
General Bonds	5.9%	4.4%	210	4.5%	3.6%	337	3.1%	2.4%	97
Mixed Strategy	4.3%	4.4%	296	2.7%	2.6%	333	1.6%	1.0%	77
Mortgage-Backed Securities	6.5%	3.1%	24	3.9%	2.2%	47	2.6%	2.5%	18
US Corporate Bonds	4.3%	3.0%	47	4.2%	3.1%	60	2.1%	1.4%	14
US Equity	5.2%	4.3%	1,156	3.6%	2.6%	1,234	2.5%	1.4%	434
US Government Bonds	6.2%	4.7%	72	4.1%	2.8%	115	2.4%	1.6%	17
US Municipal Bonds	2.4%	1.9%	314	1.7%	1.6%	366	1.3%	1.3%	57

Panel B: Investment Subclass

	Assets < $100 million			$100 Million - $1 Billion			Assets > $1 Billion		
	Mean	SD	n	Mean	SD	n	Mean	SD	n
Emerging Market Debt	8.8%	6.1%	15	6.4%	5.8%	13	6.5%		1
Emerging Market Equity	5.2%	2.7%	46	5.2%	2.4%	61	2.9%	0.9%	9
High Yield Bonds	4.3%	2.6%	30	4.4%	3.5%	37	2.5%	1.5%	7

5. The liquidity of U.S. equities and U.S. equity mutual fund portfolios

The U.S. equity market is often considered to be highly liquid. However, there is significant variation in the liquidity of U.S. equities. In this section, we study the liquidity of the U.S. equity market, paying attention to how liquidity varies in both the cross-section and time series. We then consider how the variation in the liquidity of the U.S. equity market translates into the liquidity of U.S. equity mutual fund portfolios using a "bottom-up" approach to measure portfolio-level liquidity. We also explore how fund size and investment style influences the liquidity of a fund's portfolio. Due to data constraints discussed later in this section, we are not able to extend this analysis to other investment categories.

5.1. Data and methods

We use the asset-weighted average liquidity of a fund's holdings to measure the liquidity of a fund's portfolio:

$$\text{Fund Liquidity}_{j,t} = \sum_{i=1}^{\text{N}} \text{Weight}_{i,j,t} \cdot \text{Liquidity}_{i,t} \tag{4}$$

where $\text{Weight}_{i,j,t}$ is the weight of asset *i* at time *t* in the portfolio of fund *j*, $\text{Liquidity}_{i,t}$ is the liquidity of asset *i* at time *t*, and fund *j* holds N assets.[18] This "bottom-up" measure requires knowledge of a fund holdings and a common measure of liquidity that can be calculated for all fund holdings. The holdings of U.S. equity mutual funds and a common liquidity measure for all U.S. equities are both readily available, so we focus our initial analysis on only U.S. equity mutual funds. In calculating this measure, we focus specifically on the liquidity of the U.S. equity portion of the portfolio. We do not make adjustments for any other holdings, including cash and cash equivalents. However, when we include cash in our measure of fund liquidity our general conclusions are unchanged, but the number of observations in our analysis is significantly decreased because the percentage of a fund that is invested in cash is not available in CRSP until 2003.[19]

To measure liquidity for an individual equity on day *t*, we follow Amihud (2002):

$$\text{Amihud Liquidity}_{i,t} = \frac{1}{\text{D}} \sum_{\text{d}=0}^{\text{D}} \frac{\left|\text{Return}_{i,t-d}\right|}{\text{Dollar Trading Volume}_{i,t-d}} \tag{5}$$

where $\text{Return}_{i,t-d}$ is the return on stock *i* on day $t - d$, and $\text{Dollar Trading Volume}_{i,d}$ is the dollar trading volume for stock *i* on day $t - d$. The ratio of the price change per dollar of trading volume is calculated each day $t - d$ and averaged over all available observations in the previous year (consisting of D trading days, about 250 in a typical year). The measure can be interpreted as the average change in the price of a stock per dollar of trading. If the impact of trading volume on price changes increases, liquidity has decreased. While there are many alternative liquidity measures available for equities, Goyenko, Holden, and Trzcinka (2009) find this measure is among the best available for capturing the price impact of trading without the use of high frequency (i.e., trade-by-trade) data. We focus on price impact, rather than transaction costs, because price impact captures the effect of a sale on both the portion of the asset sold by a fund and the remainder of the asset that may still be held by a fund.

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[18] We use the asset-weighted average as a basic measure of the liquidity of a fund's portfolio, but acknowledge it is an imperfect measure. For example, a fund may hold 90% of assets in highly liquid securities and 10% of assets in very illiquid securities. In that case, the asset weighted average may understate the liquidity of the portfolio (depending on how liquidity is defined and for what purpose it is being considered).

[19] The Amihud measure of liquidity for cash is by definition zero. This effectively changes the weights in equation (4) in the sense that they have to be calculated relative to the sum of all equity holdings and cash instead of only all equity holdings.

We modify the original Amihud (2002) liquidity measure in our analysis to control for outliers generated by the original specification. A single significant outlier at the stock level can give the appearance that an entire equity portfolio is highly illiquid. We follow a method similar to Karolyi, Lee, and van Dijk (2012) and adjust the Amihud (2002) measure as:

$$\text{Modified Amihud Liquidity}_{i,t} = -1 \cdot \frac{1}{\text{D}} \sum_{d=0}^{\text{D}} \ln\left(1 + \frac{|\text{Return}_{i,t-d}|}{\text{Dollar Volume}_{i,t-d}}\right) \cdot 10^6 \qquad (6)$$

This modified measure takes the natural log of the ratio of absolute return to dollar volume and excludes the top and bottom 0.1% of returns each day. Both of these changes decrease the impact of outliers on the measurement of stock liquidity and, in turn, fund liquidity. However, taking the natural log of the ratio means we can no longer directly interpret our results as the change in the price of a stock per dollar of trading. The modified measure also multiplies the final result by negative one, so an increase in the modified measure indicates an increase in liquidity. All the data necessary to calculate this measure for U.S. equities is available in the CRSP daily stock file.

During our sample period, funds generally report their end-of-month portfolio holdings once per quarter in the Thomson Reuters mutual fund holdings database. We estimate equation (4) for each portfolio holdings report using equation (6) as our measure of liquidity. We then use the MFLINKs database to merge those results with the CRSP mutual fund database. One concern is that short positions are not reported in our data. However, the funds we study hold few short positions. Using Lipper class codes, we limit our sample to "plain vanilla" U.S. equity funds following Appendix C in all analysis of equity portfolio liquidity.

Our final sample of fund portfolio liquidity runs from 1999 through 2013 and contains 71,257 fund-quarter observations across 2,571 unique funds.[20]

5.2. U.S. equity liquidity

Table 12, Panel A shows the modified Amihud (2002) liquidity for all ordinary U.S. equities that trade on the NYSE, NASDAQ, or AMEX from 1999 through 2013. Each observation is an equity-month estimate of liquidity calculated following equation (6). We present results separately for different market capitalization groups. In Panel B, we show the monthly turnover (share volume as a percentage of shares outstanding) for the same sample of stocks. The Amihud measure captures liquidity better than turnover, but we present turnover to help further illustrate the difference between liquid and illiquid equities.

[20] The MFLINKS file required to merge the fund portfolio liquidity data with other fund data is only updated through 2013.

Table 12: Liquidity of U.S. equities by market capitalization

This table presents measures of liquidity for the full sample of U.S. equities and for groups divided by market capitalization. We measure liquidity each month for all U.S. equities that trade on the NYSE, NASDAQ, or AMEX from 1999 through 2013. We present results separately for equities whose market capitalization in the prior month was greater than $10 billion, between $1 and $10 billion, between $100 million and $1 billion, and less than $100 million. P10 and P90 represent the 10th and 90th percentiles. Panel A shows results using the modified Amihud (2002) liquidity measure following equation (6). Panel B shows the average monthly trading volume as percentage of shares outstanding.

Panel A: Amihud Liquidity

	Mean	Median	SD	P10	P90	n
All	-0.92	-0.02	3.63	-1.87	-0.0002	763,788
> $10 Billion	-0.0001	-0.0001	0.0001	-0.0002	-0.00003	26,282
$1 Billion - $10 Billion	-0.0012	-0.0004	0.0067	-0.0020	-0.0001	164,264
$100 Million - $1 Billion	-0.08	-0.01	0.71	-0.12	-0.001	322,597
< $ 100 Million	-2.69	-0.68	5.91	-7.01	-0.064	250,645

Panel B: Turnover

	Mean	Median	SD	P10	P90	n
All	13.4%	8.8%	13.8%	1.5%	31.8%	763,788
> $10 Billion	17.4%	14.1%	12.1%	6.4%	32.8%	26,282
$1 Billion - $10 Billion	20.7%	16.6%	15.1%	5.8%	42.0%	164,264
$100 Million - $1 Billion	13.9%	9.7%	13.3%	2.2%	31.4%	322,597
< $ 100 Million	7.4%	3.6%	10.8%	0.9%	18.1%	250,645

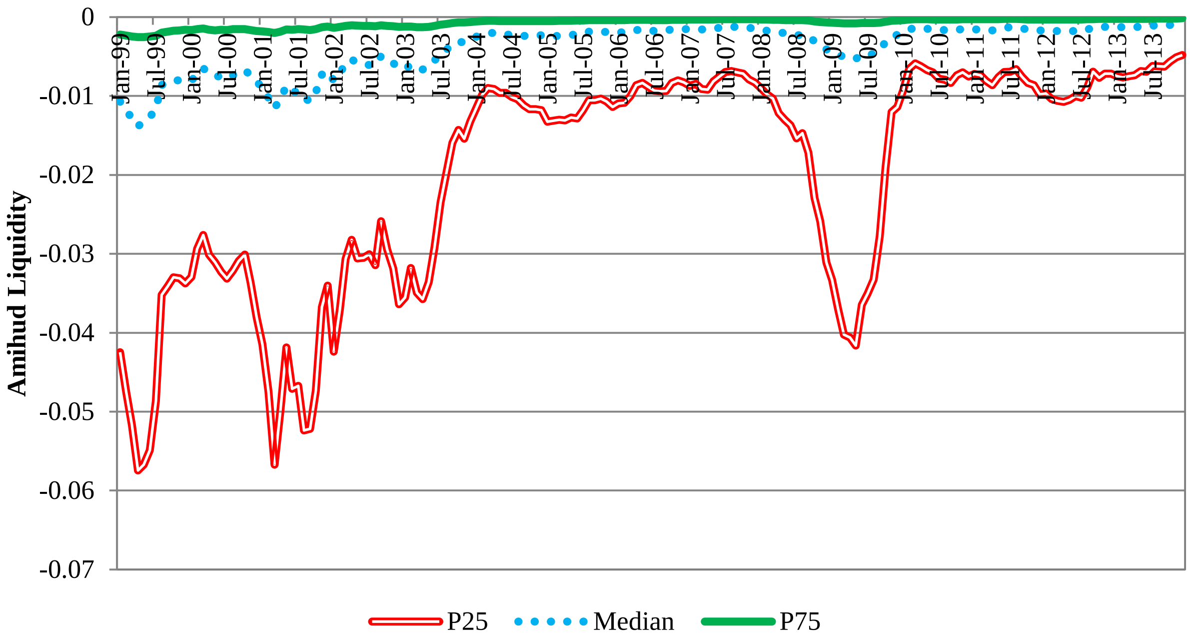
Looking first at the full sample, we find significant skewness in equity liquidity, i.e., the majority of equities are highly liquid but some are very illiquid. The median equity has a liquidity of −0.02, but the average equity has a liquidity of −0.92. The skewness is driven in large part by the relation between market cap and liquidity. Among equities with a market cap greater than $10 billion, the median liquidity is −0.0001. That value implies that the equity price moves about 23 basis points for every $10 million of trading volume. The median liquidity decreases to −0.68 among equities with a market cap less than $100 million. That value implies that the price moves about 23 basis points for every $1,470 of trading volume. The median turnover is 14.1% for equities with greater than $10 billion in market cap, compared to 3.6% for equities with less than $100 million in market cap. In dollar volume, the median equity with greater than $10 billion in market cap has greater than $1.41 billion in trades per month, compared to less than $3.6 million in trades per month for the median equity with less than $100 million in market cap.

Despite consisting of a significant fraction of equities in terms of number of securities, the less liquid portion of the U.S. equity market is a small percentage of total market cap. About 19% of the equities in the sample at the end of 2013 have a market cap less than $100 million, but those equities are only 0.2% of total market cap. The total market cap of the equities with less than $100 million in market cap is $32.6 billion, while there are 28 different individual equities with a market cap greater than $100 billion. Any U.S. equity portfolio that avoids investment in equities with less $100 million in market cap will have significantly less variance in Amihud liquidity than our initial measures indicate.

While the full sample results demonstrate well the cross-sectional variation in liquidity in the U.S. equity market, liquidity also varies in the time series. Figure 8 shows the median and 25th and 75th percentile of liquidity for all U.S. equities in our sample with greater than $100 million in market cap each month from January 1999 through December 2013. Because our liquidity measure is estimated using twelve months of data, a monthly observation should not be considered the liquidity in that month. Instead, each monthly observation represents the average liquidity during that month and the previous eleven. The months when liquidity is lowest in the figure represent when liquidity has been lowest in the past year, not necessarily the exact month when liquidity was lowest. If we instead re-measure liquidity each month using only data from that month, the overall trends hold with some time shifting.

Figure 8: Liquidity of U.S. equities – 1999-2013

This figure presents the median and 25th and 75th percentiles of U.S. equity liquidity for each month of our sample. We measure liquidity each month for all U.S. equities with a market capitalization of greater than $100 million that trade on the NYSE, NASDAQ, or AMEX. We report values for each month from 1999 through 2013. We define liquidity as the modified Amihud (2002) liquidity measure given in equation (6).



The most notable trend in the figure is the increase in the 25th percentile equity liquidity in the years before the financial crisis, the significant decrease during the financial crisis, and return to pre-crisis levels after the financial crisis. The median and 75th percentile have the same trend, but the level of the changes is significantly smaller. It is a stylized fact that liquidity decreased during the financial crisis, and the figure shows that the U.S. equity market was not immune. When liquidity is at its lowest during the crisis, the 25th percentile does not approach the low liquidity levels of equities with less than $100 million in market cap, but it does decrease by about four times its pre-crisis level. In whole, the figure makes it clear that liquidity varies not only in the cross-section, but also in the time series.

5.3. Liquidity of the equity portfolio of U.S. equity mutual funds

The portfolio liquidity of U.S. equity mutual funds reflects the overall liquidity of the U.S. equity market and the fund's holdings. Table 13 shows the "bottom-up" equity portfolio liquidity of U.S. equity mutual funds based on quarterly portfolio disclosures from 1999 through 2013. We present results separately for large (> $1 billion in assets) and small (< $100 million in assets) funds and funds that invest primarily in large cap, mid cap, or small cap stocks.[21] Our measure of fund portfolio liquidity does not reflect any non-ordinary U.S. equity assets of the funds, e.g., foreign equity, but any fund with significant investment in other asset categories is excluded in this analysis. However, to the extent a fund holds cash and cash equivalents, our measure understates the liquidity of fund assets.[22] We expect this negative bias to be small though, since U.S. equity funds typically seek to hold minimal cash to prevent return drag.[23]

Table 13: Liquidity of the equity portfolio of U.S. equity mutual funds by assets and investment style

This table presents measures of liquidity of the equity portfolios of U.S. equity mutual funds and for groups divided on assets and investment style. We measure fund liquidity as the asset-weighted modified Amihud liquidity of fund holdings following equations (4) and (6) using quarterly holding disclosures from 1999 through 2013. We present results separately for funds with less than $100 million in assets, between $100 million and $1 billion in assets, and greater than $1 billion in assets. We also present results separately for funds that Lipper objective codes identify as following a large, mid, or small cap investment style. P10 and P90 represent the 10th and 90th percentiles.

Fund Size	Fund Style	Mean	Median	SD	P10	P90	n
All	All	-0.0018	-0.0002	0.0044	-0.0047	-0.00004	71,257
	Large Cap	-0.0001	-0.0001	0.0003	-0.0002	-0.00003	22,235
	Mid Cap	-0.0015	-0.0004	0.0035	-0.0036	-0.00016	12,310
	Small Cap	-0.0056	-0.0030	0.0072	-0.0131	-0.00098	16,271
< $100 million	All	-0.0023	-0.0003	0.0053	-0.0064	-0.00004	19,455
	Large Cap	-0.0001	-0.0001	0.0005	-0.0002	-0.00003	5,510
	Mid Cap	-0.0019	-0.0005	0.0045	-0.0042	-0.00018	3,228
	Small Cap	-0.0068	-0.0039	0.0081	-0.0159	-0.00112	4,621
$100 Million - $1 Billion	All	-0.0019	-0.0003	0.0046	-0.0052	-0.00004	34,865
	Large Cap	-0.0001	-0.0001	0.0002	-0.0002	-0.00003	10,502
	Mid Cap	-0.0015	-0.0004	0.0031	-0.0036	-0.00017	6,350
	Small Cap	-0.0055	-0.0029	0.0071	-0.0128	-0.00101	9,194
> $1 Billion	All	-0.0009	-0.0002	0.0026	-0.0024	-0.00004	16,937
	Large Cap	-0.0001	-0.0001	0.0002	-0.0002	-0.00003	6,223
	Mid Cap	-0.0012	-0.0004	0.0025	-0.0032	-0.00014	2,732
	Small Cap	-0.0039	-0.0021	0.0050	-0.0091	-0.00073	2,456

[21] Not all mutual funds can be identified as primarily investing in large cap, mid cap, or small cap stocks, so the sum of the number of funds in those groups is less than the total number of funds.

[22] If we include cash holdings in our measure of fund liquidity (assigning them a liquidity measure of zero, the maximum value), our conclusions in this section are the same.

[23] Among funds with the highest 20% of equity portfolio liquidity, the average percentage of the portfolio held in cash is 2.2%, compared to 3.7% for funds with lowest 20% of equity portfolio liquidity.

Fund liquidity in our sample reflects the most liquid portion of the U.S. equity market. The median fund liquidity is −0.0002, which falls between the median liquidity of stocks with between \$1 and \$10 billion in market cap and those with greater than \$10 billion in market cap. Ten million dollars in trading volume for the underlying stocks in the median fund moves the price of those stocks about 46 basis points. Fund liquidity is highest for large cap funds and lowest for small cap funds. However, the small cap funds do not approach the illiquidity of the equities with less than \$100 million in market cap. The 10^{th} percentile of liquidity for the small cap funds is −0.0131 while the 90^{th} percentile of liquidity for stocks with less than \$100 million in market cap is −0.064. The size of the less liquid portion of the U.S. equity market creates a substantial barrier for mutual fund investment. As discussed before, the total market cap of the equities with less than \$100 million in market cap at the end of 2013 is \$32.6 billion; in contrast, the five largest U.S. equity funds each held net assets greater than \$100 billion at the end of 2013.

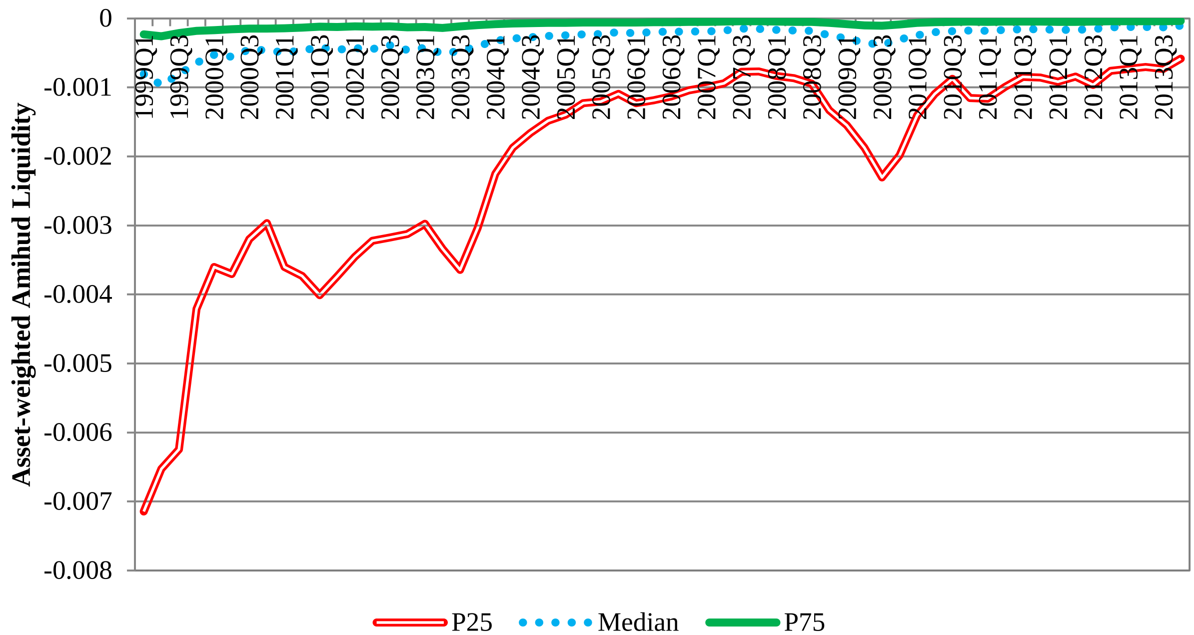
As fund size increases, the liquidity of the equity portfolio of U.S. equity funds also increases. The median fund with less than \$100 million in assets has a liquidity of −0.0003, compared to −0.0002 for funds with greater than \$1 billion in assets. The same pattern generally holds within each investment style group. Given these results, it is not surprising that the least liquid median equity portfolio (−0.0039) belongs to the funds with less than \$100 million in assets who invest in small cap stocks. However, median liquidity for those funds is still greater than the median liquidity of equities with market cap between \$100 million and \$1 billion (−0.01).

As with the underlying equities, the full sample results do not capture the time-varying nature of fund liquidity. Figure 9 presents the median and 25^{th} and 75^{th} percentile of liquidity for all U.S. equity mutual funds in our sample each quarter from 1999 through 2013. Like Figure 8, there is lag between changes in fund liquidity and changes in our figure because the underlying measure of equity liquidity is calculated over a twelve month period. However, if we re-measure fund liquidity each quarter using only data from the month the holdings were reported, the overall trend holds with some time shifting.

Fund liquidity follows the same trend as the overall U.S. equity market before, during, and after the financial crisis. Most of the changes in liquidity are driven by the 25^{th} percentile fund. The median and 75^{th} percentile funds show some change in liquidity, but the magnitude is smaller. However, from this figure alone, it is unclear whether these changes in portfolio liquidity are related to changes market liquidity or driven by fund-level trading decisions. We explore that question in Section 6.

Figure 9: Liquidity of U.S. equity mutual funds – 1999-2013

This figure presents the median and 25th and 75th percentiles of liquidity for the equity portfolio of U.S. equity mutual funds each quarter from 1999 through 2013. We measure fund liquidity as the asset-weighted modified Amihud (2002) liquidity of fund holdings following equations (4) and (6).



5.4. Measuring the liquidity of the portfolio of other investment categories

For mutual funds that invest strictly in U.S. equities, we are able to use the "bottom-up" approach to calculate portfolio liquidity as described in section 5.1. However, for mutual funds with significant investments in assets other than U.S. equities, the bottom-up approach is difficult to implement.

First, the bottom-up approach requires high quality data on fund holdings. Such data is readily available for U.S. equity mutual funds and is used extensively in academic research. In contrast, such data is difficult to locate for other types of funds. We found both the eMAXX and CRSP holdings databases were not suitable to perform our bottom-up liquidity analysis for funds that invest primarily in bonds. When we compared the eMAXX holdings reports with holdings reports filed with the SEC for several large bond funds, we found cases where the eMAXX data was incomplete or erroneous; the largest holdings reported in SEC filings were frequently missing in eMAXX. For the CRSP sample we found that a large proportion of CUSIPs are missing or appear incorrect and hence the holdings cannot be easily linked to other data sources. Furthermore, our review of SEC disclosures indicates bond funds tend to have non-negligible derivative holdings in credit default swaps, interest rate swaps, inflation rate swaps, interest rate futures, currency forwards, etc. which are either not reported in these databases or not reported in a form suitable for our analysis.

Second, the bottom-up approach requires a common measure of liquidity for all securities in a fund's portfolio. The Amihud liquidity measure works well for U.S. equity funds because it only requires data on daily prices and trading volume, which is readily available for nearly all U.S. equities, and U.S. equity funds hold few assets other than U.S. equities. In comparison, liquidity measures for fixed-income securities are typically more complex and tailored to the data available for each class. Further, if the liquidity measure we use varies between fixed-income classes, then it is not possible to calculate average portfolio liquidity for funds that invest in multiple fixed-income classes. In addition, the infrequent trading of many fixed-income securities can introduce both stale and inaccurate measures of liquidity into the calculation of a fund's bottom-up liquidity.

As a result of these difficulties, the bottom-up liquidity results in this white paper use only U.S. equity funds.

6. How do changes in market liquidity affect the liquidity of fund holdings?

As noted before, it is often unclear whether a change in the liquidity of a fund's portfolio is driven by a change in market liquidity or by fund-level activity. In this section, we divide the change in a fund's portfolio liquidity into two components, trading and market. The trading component captures the changes in fund portfolio liquidity caused by fund-level activity. The market component captures the changes in fund portfolio liquidity caused by changes in market liquidity. These two components can be separated by comparing current fund portfolio liquidity to both past fund portfolio liquidity and current fund portfolio liquidity if the fund portfolio was held constant:

$$\Delta \mathrm{Liq}_{j,t} = \mathrm{Liq}_{j,t} - \mathrm{Liq}_{j,t-1} = \left(\mathrm{Liq}_{j,t} - \mathrm{Liq\_C}_{j,t}\right) + \left(\mathrm{Liq\_C}_{j,t} - \mathrm{Liq}_{j,t-1}\right) \quad (7)$$

$$\Delta \mathrm{LiqTrade}_{j,t} = \left(\mathrm{Liq}_{j,t} - \mathrm{Liq\_C}_{j,t}\right) \quad (8)$$

$$\Delta \mathrm{LiqMarket}_{j,t} = \left(\mathrm{Liq\_C}_{j,t} - \mathrm{Liq}_{j,t-1}\right) \quad (9)$$

where $\mathrm{Liq}_{j,t}$ is the liquidity of fund *j*'s portfolio at the end of quarter t and $\mathrm{Liq\_C}_{j,t}$ is the liquidity of fund *j*'s portfolio at the end of quarter *t* assuming the fund held the same portfolio at the end of quarter t as it did at the end of quarter $t-1$. The change in fund liquidity due to fund-level activity ($\Delta\mathrm{LiqTrade}_{j,t}$) is the difference between the fund portfolio liquidity at the end of quarter *t* ($\mathrm{Liq}_{j,t}$) and fund portfolio liquidity at the end of quarter t assuming the fund held the same portfolio at the end of quarter t as it did at the end of quarter $t-1$ ($\mathrm{Liq\_C}_{j,t}$). The change in fund portfolio liquidity due to changes in market liquidity ($\Delta\mathrm{LiqMarket}_{j,t}$) is the difference between fund portfolio liquidity at the end of quarter *t* assuming the fund held the same portfolio at the end of quarter t as it did at the end of quarter $t-1$ ($\mathrm{Liq\_C}_{j,t}$) and fund portfolio liquidity at the end of quarter $t-1$ ($\mathrm{Liq}_{j,t-1}$). We follow equations (4) and (6) and use the asset-weighted average of the modified Amihud liquidity of the individual fund holdings to calculate fund liquidity at the end of quarter *t* and *t* – 1. To calculate $\mathrm{Liq\_C}_{j,t}$, we modify equation (4) as:

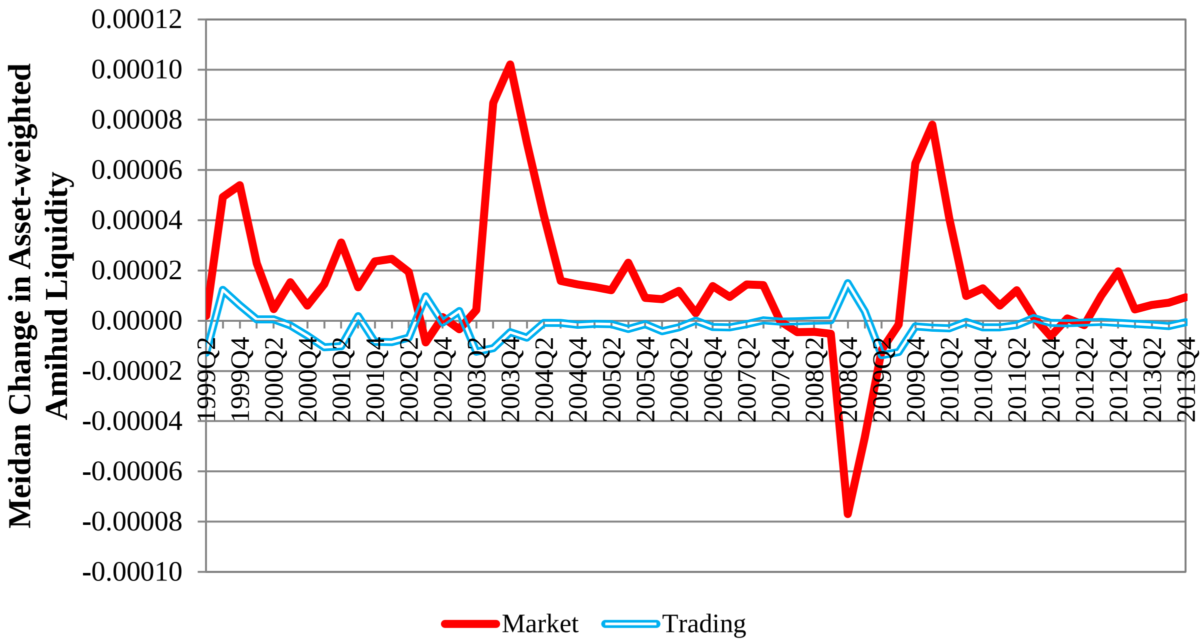
$$\mathrm{Liq\_C}_{j,t} = \sum_{i=1}^{N} w_{j,i,t-1}\mathrm{Liq}_{i,t} \quad (10)$$

where $\mathrm{Liq}_{i,t}$ is the liquidity of asset *i* at the end of quarter *t*, $w_{j,i,t-1}$ is the portfolio weight of asset *i* in fund *j*'s portfolio at the end of quarter *t* – 1, and N is total number of possible assets.

We first illustrate the relation between changes in market liquidity and changes in trading liquidity in Figure 10. The figure presents the median change in market liquidity and median change in trading liquidity across the equity portfolios of U.S. equity funds in our sample each quarter from 1999 through 2013. The most notable features of the figure are the difference in size between the two changes and their relative movements. The median changes in market liquidity are significantly greater in absolute value than the median changes in trading liquidity. The largest median absolute change in trading liquidity is only 15% the size of the largest median absolute change in market liquidity. The changes in market liquidity and trading liquidity also appear to move in opposite directions. The correlation between the median changes is −0.28.

Figure 10: Changes in market liquidity and trading liquidity

This figure presents the median change in market liquidity and trading liquidity for the equity portfolios of U.S. equity mutual funds each quarter of our sample from 1999 through 2013. We measure fund liquidity as the asset-weighted modified Amihud (2002) liquidity of fund holdings and then deconstruct the changes into market and trading components following equations (8) and (9).



We next extend the illustrative results above into a model to better capture the relation between changes in market liquidity and trading liquidity. We model changes in trading liquidity as a function of changes in market liquidity:

$$\Delta \text{LiqTrade}_{j,t} = \alpha + \beta * \Delta \text{LiqMarket}_{j,t} + \sum_{k=1}^{N} \delta_i \, C_{k,j,t-1} + \varepsilon_{j,t} \quad (11)$$

The coefficient β can be interpreted as the percent change in trading liquidity for a percent increase in market liquidity. The sum of β and 1% gives the total percentage change in the liquidity of the equity portfolio per percent increase in market liquidity.[24] We include controls ($\mathrm{C}_{k,j,t-1}$) for assets, age, turnover ratio, and expense ratio as of the end of quarter t – 1. In some models, we split $\Delta\mathrm{LiqMarket}_{j,t}$ depending on whether its value is positive or negative to test if changes in trading liquidity react differently to increases and decreases in market liquidity. $\Delta\mathrm{LiqMarket\_Pos}_{j,t}$ is equal to $\Delta\mathrm{LiqMarket}_{j,t}$ if $\Delta\mathrm{LiqMarket}_{j,t}$ is positive, else zero. $\Delta\mathrm{LiqMarket\_Neg}_{j,t}$ is equal to $\Delta\mathrm{LiqMarket}_{j,t}$ if $\Delta\mathrm{LiqMarket}_{j,t}$ is negative, else zero. We exclude funds that are less than two years old, hold less than 20 positions, or have less than $20 million in assets. We also exclude index funds since they have more limited control over buying and selling choices than active funds. We estimate the above model using OLS and cluster the standard errors by fund and quarter. While the relation between trading liquidity and market liquidity could be endogeneous, we assume that most individual U.S. equity funds have little ability to significantly influence the long-run liquidity of the equities they hold because of the small size of their positions relative to market capitalization.

We present the results from estimating the model in Table 14. When we include no control in column (1), we find a negative relation between changes in market liquidity and changes in trading liquidity. If market liquidity increases by 1.0%, then trading liquidity decreases by about 0.18%. The net result is an increase in the liquidity of the equity portfolio of about 0.82% (=1.00% + –0.18*1%) per 1% increase in market liquidity. When we include all the control variables in column (2), we find similar results. Next, we consider in column (3) whether the absolute size of the changes in trading liquidity vary depending on whether market liquidity has increased or decreased. If market liquidity decreases by 1%, then trading liquidity increases by a statistically insignificant 0.07% (t-stat = -0.89); however, if market liquidity increases by 1%, then trading liquidity decreases by 0.18%. The net result is a decrease in the liquidity of the equity portfolio of about 0.93% (=−1.00% + −0.07*−1%) per 1% decrease in market liquidity and an increase in the liquidity of the equity portfolio of about 0.82% (=1.00% + –0.18*1%) per 1% increase in market liquidity. The difference in effect is marginally statistically significant (t-stat = 1.64), but economically large.

[24] If we include cash in our measures of liquidity (assigning cash a liquidity of zero, the maximum value), our general conclusions about the relation between market liquidity and trading liquidity are unchanged.

Table 14: How do changes in market liquidity affect changes in trading liquidity?

This table presents results from estimating equation (11):

$$\Delta LiqTrade_{j,t} = \alpha + \beta * \Delta LiqMarket_{j,t} + \sum_{k=1}^{N} \delta_i C_{k,j,t-1} + \varepsilon_{j,t}$$

where $\Delta LiqTrade_{j,t}$ is the difference between $Liq_{j,t}$ and $Liq\_C_{j,t}$ and $\Delta LiqMarket_{j,t}$ is the difference between $Liq\_C_{j,t}$ and $Liq_{j,t-1}$. $Liq_{j,t}$ is the asset-weighted average modified fund liquidity for fund j at the end of quarter t. $Liq\_C_{j,t}$ is the asset weighted average of modified fund liquidity for fund j at the end of quarter t assuming they held the same portfolio as of the end of quarter t – 1. ΔLiqMarket_Pos is equal to $\Delta LiqMarket$ if $\Delta LiqMarket$ is positive, else zero. ΔLiqMarket_Neg is equal to $\Delta LiqMarket$ if $\Delta LiqMarket$ is negative, else zero. We include controls for assets (TNA), age, turnover ratio, and expense ratio as of the end of quarter t – 1. In columns (4) and (5), we interact $\Delta LiqMarket$ with fund TNA and fund liquidity (measured following equations (4) and (6)) as of the end of quarter t – 1. In those instances, TNA and liquidity are z-scored (demeaned and divided by their standard deviation). We estimate the model from 1999 through 2013 for active U.S. equity funds excluding any funds that are less than two years old, hold less than 20 equity positions, or have less than $20 million in assets at the end of quarter t − 1. t-stats derived from standard errors clustered on both fund and quarter are presented below the coefficients in brackets.

	(1)	(2)	(3)	(4)	(5)
ΔLiqMarket	-0.177	-0.167		-0.156	-0.206
	[-9.11]	[-8.76]		[-8.41]	[-7.39]
ΔLiqMarket_Pos			-0.178		
			[-8.96]		
ΔLiqMarket_Neg			-0.071		
			[-0.89]		
ΔLiqMarket * TNA_{t-1}				0.042	
				[3.06]	
ΔLiqMarket * $Liquidity_{t-1}$					-0.017
					[-1.64]
Controls variables	No	Yes	Yes	Yes	Yes
Observations	35,140	35,140	35,140	35,140	35,140

We next consider how fund assets affect the relation between changes in market liquidity and trading liquidity. In column (4), we interact the change in market liquidity with the fund assets as of the end of quarter $t - 1$. We z-score fund assets (demean and divide by the standard deviation), so that the coefficient on the interaction term can be interpreted as the impact of a one standard deviation increase in assets. As fund assets increase, the impact of changes in market liquidity on changes in trading liquidity decreases. For a fund with an average amount of assets, if market liquidity increases by 1.0%, then trading liquidity decreases by about 0.16% =(−0.156*1% + 0.42*1%*0). However, for a fund with assets one standard deviation greater than the mean, if market liquidity increases by 1.0%, then trading liquidity decreases by about 0.11% =(−0.156*1% + 0.042*1%*1). The net result is an increase in the liquidity of the equity portfolio of about 0.84% (=1.00% + –0.16*1%) per 1% increase in market liquidity for funds with an average amount of assets and an increase of about 0.89% (=1.00% + –0.11*1%) for funds with assets one standard deviation greater than the mean.

We then consider how fund equity portfolio liquidity affects the relation between changes in market liquidity and trading liquidity. In column (5), we interact the change in market liquidity with the fund equity portfolio liquidity as of the end of quarter $t-1$. We z-score fund equity portfolio liquidity (demean and divide by the standard deviation), so that the coefficient on the interaction term can be interpreted as the impact of a one standard deviation increase in equity portfolio liquidity. As equity portfolio liquidity decreases, the impact of changes in market liquidity on changes in trading liquidity increases. For a fund with an average equity portfolio liquidity, if market liquidity increases by 1.0%, then trading liquidity decreases by about 0.206% =(−0.206*1% + 0.017*1%*0). However, for a fund with equity portfolio liquidity one standard deviation below than the mean, if market liquidity increases by 1.0%, then trading liquidity decreases by about 0.223% =(−0.206*1% + 0.017*1%*−1). The net result is an increase in the liquidity of the equity portfolio of about 0.794% (=1.00% + –0.206*1%) per 1% increase in market liquidity for funds with an average equity portfolio liquidity and an increase of about 0.777% (=1.00% + –0.223*1%) for funds with equity portfolio liquidity one standard deviation below than the mean.

In conclusion, we find that, on average, changes in market liquidity do not result in an equivalent change in the liquidity of the equity portfolio of U.S. equity funds. When market liquidity increases, equity portfolio liquidity also increases, but at a slower rate. However, when market liquidity decreases, equity portfolio liquidity decreases at about the same rate. Funds with fewer assets and lower equity portfolio liquidity have smaller increases in equity portfolio liquidity when market liquidity increases.

7. How does flow volatility affect the liquidity of fund holdings?

7.1. U.S. equity mutual funds

In Section 4, we explored the volatility of mutual fund net flows, and in Section 5, we explored the liquidity of the equity holdings of U.S. equity mutual funds. In this section, we consider how those fund characteristics interact. We explore the relation using the following model:

$$\text{Fund Liq}_{i,t} = \alpha + \beta_1 * \text{Fund Liq}_{i,t-12} + \beta_2 \text{ Flow Vol}_{i,[t,t-11]} + \sum_{j=1}^{N} \delta_j \text{ C}_{i,j,t-12} + \text{FE} + \varepsilon_{i,t} \qquad (12)$$

where $\text{Fund Liq}_{\text{i,t}}$ is the equity portfolio liquidity of fund *i* in at the end of month *t* and $\text{Flow Vol}_{i,[t,t-11]}$ standard deviation of monthly net flows for fund *i* measured from month *t* through month *t* − 11. We z-score flow volatility (demean and divided by the standard deviation) so that we can interpret β_2 as the impact on fund equity portfolio liquidity from a one standard deviation increase in flow volatility. We include controls ($\text{C}_{i,j,t-12}$) for assets, age, turnover ratio, and expense as of the end of month *t* − 12. We also include Lipper class and year-month fixed effects and interactions of those fixed effects. We estimate the model from 1999 through 2013 for U.S. equity funds excluding any funds that are less than two years old, hold less than 20 equity positions, or have less than $20 million in assets as of the end of month t − 12. We also exclude index funds since they have more limited control over their buying and selling choices than active funds.

We present our estimation of the model in Table 15. In column (1), we do not include control variables or any fixed effects and find no statistically significant relation between flow volatility and the liquidity of a fund's equity portfolio (t-stat = 1.00). However, when we include the controls variables in column (2), we find a statistically significant, positive relation between flow volatility and fund equity portfolio liquidity. A one standard deviation increase in flow volatility increases fund equity portfolio liquidity by 0.00002. Put differently, a one standard deviation increase in flow volatility decreases the impact of selling $10 million of the asset-weighted average equity portfolio holding by 4.6 basis points.

Table 15: Does fund liquidity vary depending on flow volatility? Evidence from U.S. equity funds

This table presents results from estimating equation (12):

$$Fund\ Liq_{i,t} = \alpha + \beta_1 * Fund\ Liq_{i,t-12} + \beta_2\ Flow\ Vol_{i,[t,t-11]} + \sum_{j=1}^{N} \delta_j\ C_{i,j,t-12} + FE + \varepsilon_{i,t}$$

where $Fund\ Liquidity_{i,t}$ is the equity portfolio liquidity of fund i in at the end of month t and $Flow\ Vol_{i,[t,t-11]}$ is the standard deviation of monthly net flows for fund i measured from month t through month t − 11. Fund equity portfolio liquidity is measured following equations (4) and (6). We include controls for assets (TNA), age, turnover ratio, and expense as of the end of month t − 12. We also include Lipper class and year-month fixed effects and interactions of those fixed effects. In columns (3) and (4), we interact flow volatility with fund TNA and fund liquidity as of the end of month t − 12. In those instances, those particular measures of TNA and liquidity are z-scored (demeaned and divided by their standard deviation). We also z-score flow volatility in all models. We estimate the model from 1999 through 2013 for active U.S. equity funds excluding any funds that are less than two years old, hold less than 20 equity positions, or have less than $20 million in assets as of the end of month t − 12. t-stats derived from standard errors clustered on both fund and year-month are presented below the coefficients in brackets.

	(1)	(2)	(3)	(4)
Flow Volatility	0.00001	0.00002	0.00003	0.00002
	[1.00]	[1.75]	[2.41]	[1.81]
Flow Volatility * TNA_{t-12}			0.00003	
			[2.70]	
Flow Volatility * $Liquidity_{t-12}$				-0.00006
				[-1.67]
Lipper class fixed effects	Yes	Yes	Yes	Yes
Year-month fixed effects	Yes	Yes	Yes	Yes
Control variables	No	Yes	Yes	Yes
Observations	23,202	23,202	23,202	23,202

We next consider how fund assets affect the relation between flow volatility and fund equity portfolio liquidity. In column (3), we interact flow volatility with the fund assets as of the end of month t – 12. We z-score fund assets (demean and divide by the standard deviation), so that the coefficient on the interaction term can be interpreted as the impact of a one standard deviation increase in assets. As fund assets increase, the impact of flow volatility on fund equity portfolio liquidity increases. For a fund with an average amount of assets, if flow volatility increases one standard deviation, then fund equity portfolio liquidity increases by .00003 =(0.00003*1+0.00003*1*0). However, for a fund with assets one standard deviation greater than the mean, if flow volatility increases one standard deviation, then fund equity portfolio liquidity increases by 0.00006 =(0.00003*1+0.00003*1*1). A 0.00003 increase in equity portfolio liquidity is equivalent to a 6.9 basis points decrease in the cost of selling $10 million of the asset-weighted average equity portfolio holding.

We then consider how a fund's initial equity portfolio liquidity affects the relation between flow volatility and fund equity portfolio liquidity. In column (4), we interact flow volatility with the fund equity portfolio liquidity as of the end of month $t-12$. We z-score initial equity portfolio liquidity (demean and divide by the standard deviation), so that the coefficient on the interaction term can be interpreted as the impact of a one standard deviation increase in initial equity portfolio liquidity. As initial fund equity portfolio liquidity decreases, the impact of flow volatility on fund equity portfolio liquidity increases. For a fund with an average initial equity portfolio liquidity, if flow volatility increases one standard deviation, then fund equity portfolio liquidity increases by 0.00002 =(0.00002*1 + 0.00002*1*0). However, for a fund with initial equity portfolio liquidity one standard deviation below than the mean, if flow volatility increases one standard deviation, then fund equity portfolio liquidity increases by 0.00008 =(0.00002*1 + −0.00006*1*−1). A 0.0006 increase in equity portfolio liquidity is equivalent to a 13.8 basis points decrease in the cost of selling $10 million of the asset-weighted average equity portfolio holding.

In summation, we find that liquidity of the equity portfolio of U.S. equity funds is greater when flow volatility is greater. A one standard deviation increase in flow volatility decreases the impact of selling $10 million of the asset-weighted average equity portfolio holding by 4.6 basis points. Further, funds with more assets and lower equity portfolio liquidity have a greater increase in equity portfolio liquidity after an increase in flow volatility.

7.2. U.S. municipal bond mutual funds

The results in the previous section suggest a relation between equity portfolio liquidity and flow volatility for U.S. equity funds. As discussed in section 5.4, we cannot directly extend that analysis to other fund categories because a bottom-up approach measuring fund portfolio liquidity is difficult to implement for other investment categories since, among other reasons, funds in other investment categories have non-trivial investments in multiple asset classes. However, one exception is the U.S. municipal bond fund category, since these funds tend to hold significant positions only in municipal bonds and cash and cash equivalents. Therefore, an alternative proxy for portfolio liquidity in municipal bond funds is the relative amount of municipal bonds they hold in their portfolio. Assuming that as the percentage of a fund's portfolio invested in municipal bonds increases the liquidity of that portfolio decreases, we investigate the relationship between flow volatility and portfolio liquidity using a model similar to that used for U.S. equity funds:

$$\text{Muni}_{i,t} = \alpha + \beta_1 * \text{Muni}_{i,t-12} + \beta_2 \text{ Flow Vol}_{i,[t,t-11]} + \sum_{j=1}^{N} \delta_j \text{ C}_{i,j,t-12} + \text{FE} + \varepsilon_{i,t} \quad (13)$$

$\text{Muni}_{i,t}$ is the percentage of the portfolio of fund *i* held in municipal bonds at the end of month *t* and $\text{Flow Vol}_{i,[t,t-11]}$ is the standard deviation of monthly net flows for fund *i* measured from month *t* through month $t - 11$. We z-score flow volatility (demean and divided by the standard deviation) so that we can interpret β_2 as the change in the percentage of the fund portfolio held in municipal bonds from a one standard deviation change in flow volatility. To the extent the percentage of the fund portfolio held in municipal bonds measures fund liquidity, a negative value for β_2 indicates that fund liquidity increases when flow volatility increases. We include controls ($C_{i,j,t-12}$) for assets, age, turnover ratio, and expense as of the end of month $t - 12$. We also include year-month fixed effects. Municipal bond holding percentages are not available in CRSP until 2010, so we can only estimate our model from 2010 through 2014. We exclude any funds that are less than two years old or have less than $20 million in assets as of the end of month t − 12. We also exclude index funds since they have more limited control over buying and selling choices than active funds.

We present our estimation of the model in Table 16. In column (1), we do not include any control variables and find a statistically significant, negative relation between flow volatility and the percentage of fund's portfolio held in municipal bonds. A one standard deviation increase in flow volatility decreases the percentage of fund's portfolio held in municipal bonds by 0.15%. When we include all the controls variables in column (2), we find a similar, albeit weaker relation. A one standard deviation increase in flow volatility decreases the percentage of fund's portfolio held in municipal bonds by 0.09%. Note that if we reconfigure that model to use cash holdings instead of municipal bond holdings, we find the increase in cash holdings from a one standard deviation increase in flow volatility (0.08%) is nearly identical to the decrease in municipal bond holdings from a one standard deviation increase in flow volatility (0.09%).

We next consider how fund assets affect the relation between flow volatility and the percentage of fund's portfolio held in municipal bonds. In column (3), we interact flow volatility with the fund assets as of the end of month $t – 12$. We z-score fund assets (demean and divide by the standard deviation), so that the coefficient on the interaction term can be interpreted as the impact of a one standard deviation increase in assets. We find fund size has no impact on the relation between flow volatility and the percentage of fund's portfolio held in municipal bonds. The *t*-stat on the interaction variable is only −0.11.

We then consider how a fund's initial municipal bond holding percentage affects the relation between flow volatility and a fund's municipal bond holding percentage. In column (4), we interact flow volatility with the fund's municipal bond holding percentage as of the end of month $t – 12$. We z-score the initial municipal bond holding percentage (demean and divide by the standard deviation), so that the coefficient on the interaction term can be interpreted as the impact of a one standard deviation increase in initial municipal bond holding percentage. As initial municipal bond holding percentage increases, the impact of flow volatility on municipal bond holding percentage decreases. For a fund with an average initial municipal bond holding percentage, if flow volatility increases one standard deviation, then the municipal bond holding percentage decreases by 0.09% =(−0.09%*1 + 0.116%*1*0). However, for a fund with an initial municipal bond holding percentage one standard deviation greater than the mean, if flow volatility increases one standard deviation, then the municipal bond holding percentage increases by a statistically insignificant 0.03% =(−0.09%*1 + 0.116%*1*1).

Table 16: Does fund liquidity vary depending on flow volatility? Evidence from U.S. municipal bond funds

This table presents results from estimating equation (13):

$$Muni_{i,t} = \alpha + \beta_1 * Muni_{i,t-12} + \beta_2\ Flow\ Vol_{i,[t,t-11]} + \sum_{j=1}^{N} \delta_j\ C_{i,j,t-12} + FE + \varepsilon_{i,t}$$

where $Muni_{i,t}$ is the percentage of the portfolio of fund i held in municipal bonds at the end of month t and $Flow\ Vol_{i,[t,t-11]}$ is the standard deviation of monthly net flows for fund i measured from month t through month t − 11. We include controls for assets (TNA), age, turnover ratio, and expense as of the end of month t − 12. We also include year-month fixed effects fixed effects. In models (3) and (4), we interact flow volatility with fund TNA and municipal bond holding percentage as of the end of month t − 12. In those instances, those particular measures of TNA and municipal bond holding percentage are z-scored (demeaned and divided by their standard deviation). In columns (5) and (6), we exclude any fund with a municipal bond holding percentage as of the end of month t − 12 greater than 99.5%. We z-score flow volatility in all models. We estimate the model from 2010 through 2014 for all active U.S. municipal bond funds excluding any funds that are less than two years old or have less than $20 million in assets as of the end of month t − 12. t-stats derived from standard errors clustered on both fund and year-month are presented below the coefficients in brackets.

	(1)	(2)	(3)	(4)	(5)	(6)
Flow Volatility	-0.146	-0.085	-0.085	-0.090	-0.201	-0.185
	[-3.21]	[-2.31]	[-2.33]	[-2.53]	[-4.24]	[-3.74]
Flow Volatility * TNA_{t-12}			-0.004			
			[-0.11]			
Flow Volatility * $Muni_{t-12}$				0.116		0.053
				[2.49]		[0.94]
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Control variables	No	Yes	Yes	Yes	Yes	Yes
Exclude if $Muni_{t-12}$ > 99.5%	No	No	No	No	Yes	Yes
Observations	3,153	3,153	3,153	3,153	2,344	2,344

It is important to note that the results discussed above are sensitive to funds that hold very little cash. Assuming no leverage, a fund that is invested 100% in municipal bonds cannot increase its holdings of municipal bonds when flow volatility decreases. Columns (5) and (6) exclude any funds that hold greater than 99.5% of their portfolio in municipal bonds as of the end of month t − 12. With such funds excluded, the base impact of a one standard deviation increase in flow volatility on fund municipal bond holding percentage increases from 0.09% in column (2) to 0.20% in column (5). The impact of initial municipal bond holding percentage on the impact of flow volatility on municipal bond holding percentage decreases from 0.12% in column (4) to a statistically insignificant 0.05% in column (6).

Considered as whole, we find that U.S. municipal bond funds hold a lower percentage of the fund portfolio in municipal bonds and a greater percentage of the fund portfolio in cash when flow volatility is greater. To the extent that the relative proportions of each represents fund liquidity, U.S. municipal bond funds increase their liquidity when flow volatility increases. Funds with a lower percentage of municipal bonds in their portfolio have a greater decrease in municipal bond holdings after an increase in flow volatility.

8. How does flow volatility affect the cash holdings of funds?

In the previous section, we looked at the relation between fund liquidity and flow volatility. However, for reasons discussed above, the tests only examined U.S. equity funds and municipal bond funds. We now explore the relation between flow volatility and cash holdings for all investment categories. The percentage of a fund's portfolio held in cash and cash equivalents is available in the CRSP database for all funds regardless of investment category beginning in 2003. We test the relation using a model similar to those described in the prior section:

$$\mathrm{Cash}_{i,t} = \alpha + \beta_1 * \mathrm{Cash}_{i,t-12} + \beta_2\ \mathrm{Flow\ Vol}_{i,[t,t-11]} + \sum_{j=1}^{N} \delta_j\ \mathrm{C}_{i,j,t-12} + \mathrm{FE} + \varepsilon_{i,t} \quad (14)$$

where $\mathrm{Cash}_{i,t}$ is the percentage of the portfolio of fund *i* held in cash at the end of month *t* and $\mathrm{Flow\ Vol}_{i,[t,t-11]}$ is the standard deviation of monthly net flows for fund *i* measured from month *t* through month *t* − 11. We include controls ($\mathrm{C}_{i,j,t-12}$) for assets, age, turnover ratio, and expense as of the end of month *t* − 12. We z-score flow volatility (demean and divide by the standard deviation) so that we can interpret β_2 as the change in percentage cash holdings from a one standard deviation increase in flow volatility. We include controls for assets, age, turnover ratio, and expense as of the end of month *t* – 12 and include Lipper class and year-month fixed effects and interactions of those fixed effects. We exclude any funds that are less than two years old or have less than $20 million in assets as of the end of month *t* − 12. We also exclude index funds since they have more limited control over buying and selling choices than active funds.

We present our estimation of the model in Table 17. In column (1), we present results without the control variables and find that cash holdings increase when flow volatility increases. A one standard deviation increase in flow volatility increases fund cash holdings by 0.09%. When we include the control variables in column (2), we find a similar result. A one standard deviation increase in flow volatility increases fund cash holdings by 0.07%.

We next consider how a fund assets affect the relation between flow volatility and cash holdings. In column (3), we interact flow volatility with the fund assets as of the end of month *t* – 12. We z-score fund assets (demean and divide by the standard deviation) so that the coefficient on the interaction term can be interpreted as the impact of a one standard deviation increase in assets. We find fund size has no statistically significant impact on the relation between flow volatility and cash holdings. The *t*-stat on the interaction variable is only −0.98.

We then consider how initial cash holdings affect the relation between flow volatility and cash holdings. In column (4), we interact flow volatility with the fund's cash holding percentage as of the end of month *t* – 12. As initial cash holdings increase, the impact of flow volatility on cash holdings decreases. For a fund with 1% of their portfolio held in cash, if flow volatility increases one standard deviation, then cash holdings increase by 0.12% =(0.159%*1 + −0.035%*1*1%). However, for a fund with 4% of their portfolio held in cash, if flow volatility increases one standard deviation, then cash holdings increase by a statistically insignificant 0.02% =(0.159%*1 + −0.035%*1*4%).

In conclusion, we find that the percentage of a fund's portfolio held in cash and cash equivalents is greater when flow volatility is greater. A one standard deviation increase in flow volatility increases the percentage of a fund's portfolio held in cash by 0.07%. Funds that hold less cash have a greater increase in cash holdings after an increase in flow volatility.

Table 17: How does flow volatility affect the cash holdings of funds?

This table presents results from estimating equation (14):

$$Cash_{i,t} = \alpha + \beta_1 * Cash_{i,t-12} + \beta_2\, Flow\ Vol_{i,[t,t-11]} + \sum_{j=1}^{N} \delta_j\, C_{i,j,t-12} + FE + \varepsilon_{i,t}$$

where $Cash_{i,t}$ is the percentage of the portfolio of fund i held in cash at the end of month t and $Flow\ Vol_{i,[t,t-11]}$ is the standard deviation of monthly net flows for fund i measured from month t through month t − 11. We include controls for assets (TNA), age, turnover ratio, and expense as of the end of month t − 12. We also include Lipper class and year-month fixed effects and interactions of those fixed effects. In columns (3) and (4), we interact flow volatility with fund TNA and cash holding percentage as of the end of month t − 12. In those instances, those particular measures of TNA and cash holding percentage are z-scored (demeaned and divided by their standard deviation). We z-score flow volatility in all models. We estimate the model from 2003 through 2014 for all active funds excluding any funds that are less than two years old or have less than $20 million in assets as of the end of month t − 12. t-stats derived from standard errors clustered on both fund and year-month are presented below the coefficients in brackets.

	(1)	(2)	(3)	(4)
Flow Volatility	0.086	0.067	0.063	0.159
	[5.42]	[4.15]	[3.91]	[7.11]
Flow Volatility * TNA_{t-12}			-0.014	
			[-0.98]	
Flow Volatility * $Cash_{t-12}$				-0.035
				[-5.72]
Year-month fixed effects	Yes	Yes	Yes	Yes
Control variables	No	Yes	Yes	Yes
Observations	55,286	55,286	55,286	55,286

9. How do large outflows affect fund liquidity?

9.1. U.S. equity mutual funds

It is well-documented that fund flows can impact the price of assets held by a fund (see for example Coval and Stafford, 2007), but fund flows could also impact other aspects of the fund portfolio. In this section, we model equity portfolio liquidity of U.S. equity mutual funds as a function of fund flows:

$$\text{Liq}_{i,t} = \alpha + \beta_1 * \text{Liq}_{i,t-1} + \beta_2 \text{ Inflow}_{i,t} + \beta_3 \text{ Outflow}_{i,t} + \sum_{j=1}^{N} \delta_j \text{ C}_{i,j,t-1} + \text{FE} + \varepsilon_{i,t} \qquad (15)$$

where $\text{Liq}_{i,t}$ is the equity portfolio liquidity of fund *i* at the end of quarter *t*, which we measure using the "bottom-up" approach.[25] We separate fund flows into $\text{Outflow}_{i,t}$ and $\text{Inflow}_{i,t}$ to study the impact of inflows and outflows separately. $\text{Outflow}_{i,t-1}$ is equal to the maximum of the net flow for fund *i* during quarter *t* multiplied by minus one and zero:

$$\text{Outflow}_{i,t-1} = \text{Max}(-\text{Net flow}_{i,t-1}, 0) \qquad (16)$$

$\text{Inflow}_{i,t-1}$ is equal to maximum of the net flow for fund *i* during quarter *t* and zero:

$$\text{Inflow}_{i,t-1} = \text{Max}(\text{Net flow}_{i,t-1}, 0) \qquad (17)$$

A fund will always have a positive value for either $\text{Inflow}_{i,t}$ or $\text{Outflow}_{i,t}$ and a value of zero for the other, unless the net flow is exactly zero. We focus on $\text{Outflow}_{i,t}$ when discussing our results since our primary question is how outflows affect fund liquidity.

In some specifications, we examine "large" and "small" net flows separately. We set our threshold for separating large and small net outflows as the median $\text{Outflow}_{i,t}$ (excluding zeros), and we set our threshold for separating large and small net inflows as the median $\text{Inflow}_{i,t}$ (excluding zeros). Both median values are about 3.5%.[26] $\text{Large Outflow}_{i,t}$ is equal to the greater of $\text{Outflow}_{i,t}$ less the median $\text{Outflow}_{i,t}$ and zero; $\text{Small Outflow}_{i,t}$ is equal to the lesser of $\text{Outflow}_{i,t}$ and the median $\text{Outflow}_{i,t}$:

$$\text{Large Outflow}_{i,t} = \text{Max}(\text{Outflow}_{i,t} - \text{Median}(\text{Outflow}_{i,t}),0) \qquad (18)$$

$$\text{Small Outflow}_{i,t} = \text{Min}(\text{Outflow}_{i,t}, \text{Median}(\text{Outflow}_{i,t})) \qquad (19)$$

$\text{Large Inflow}_{i,t}$ is equal to the greater of $\text{Inflow}_{i,t}$ less the median $\text{Inflow}_{i,t}$ and zero. $\text{Small Inflow}_{i,t}$ is equal to the lesser of $\text{Inflow}_{i,t}$ and the median $\text{Inflow}_{i,t}$:

$$\text{Large Inflow}_{i,t} = \text{Max}(\text{Inflow}_{i,t} - \text{Median}(\text{Inflow}_{i,t}),0) \qquad (20)$$

$$\text{Small Inflow}_{i,t} = \text{Min}(\text{Inflow}_{i,t}, \text{Median}(\text{Inflow}_{i,t})) \qquad (21)$$

[25] If we include cash in our measure of liquidity (assigning cash a liquidity of zero, the maximum value), our results are similar, but statistically weaker.

[26] If we set the "large" inflow and outflow thresholds using the mean instead of the median, our results are similar.

This specification allows us to capture non-linearity in the impact of flows on liquidity.[27] The coefficient on $\mathrm{Large\ Outflow}_{i,t}$ captures the impact of each percent of outflow above the median. The coefficient on $\mathrm{Small\ Outflow}_{i,t}$ captures the impact of each percent of outflow up to median.[28]

We include controls ($\mathrm{C}_{i,j,t-1}$) for assets, age, turnover ratio, and expense ratio as of the end of quarter t – 1. We also include Lipper class and year-quarter fixed effects and interactions of those fixed effects. We exclude any funds that are less than two years old, hold less than 20 equity positions, or have less than $20 million in assets at the end of quarter $t - 1$. We also exclude index funds since they have more limited control over buying and selling choices than active funds. We estimate the model from 1999 through 2013 since we have both fund flows and fund equity portfolio liquidity data during that period.

We present results from our model in Table 18. Looking first at column (1), which excludes the control variables, we find that fund flows do impact equity portfolio liquidity. For every 10% of outflow, the liquidity of the equity portfolio decreases by 0.000047 =(0.00047*0.10). That decrease in liquidity is equivalent to increasing the impact of selling $10 million of the asset-weighted average equity portfolio holding by 11 basis points. Looking next at column (2), in which we include the control variables, we find similar results. For every 10% of outflow, the liquidity of the equity portfolio decreases by 0.000037 =(0.00037*0.10). That decrease in liquidity is equivalent to increasing the impact of selling $10 million of the asset-weighted average equity portfolio holding by 9 basis points. Extending those initial results, we find that the impact of outflows on equity portfolio liquidity is driven by large outflows in column (3). Only the impact of above median outflows on liquidity is statistically significant. The total decrease in liquidity from an outflow of 10% is .000035 =(0.00042*0.035 + −0.00077*0.065), which is about the same as the impact found in column (2).

We next consider how fund assets affect the relation between fund flows and fund equity portfolio liquidity. In column (4), we interact inflow and outflow with the fund assets as of the end of quarter t – 1. We z-score fund assets (demean and divide by the standard deviation), so that the coefficient on the interaction term can be interpreted as the impact of a one standard deviation increase in assets. As fund assets decrease, the impact of outflows on fund equity portfolio liquidity increases. For a fund with an average amount of assets, if an outflow of 10% occurs, then fund equity portfolio liquidity decreases by .000033 =(−0.00033*.1+0.00038*.1*0). That decrease in liquidity is equivalent to increasing the impact of selling $10 million of the asset-weighted average equity portfolio holding by 7.6 basis points. However, for a fund with assets one standard deviation below the mean, if an outflow of 10% occurs, then fund equity portfolio liquidity decreases by 0.00007 =(−0.00033*.1+0.00038*.1*−1). That decrease in liquidity is equivalent to increasing the impact of selling $10 million of the asset-weighted average equity portfolio holding by 16.3 basis points.

[27] Our conclusions are unchanged if we instead define $\mathrm{Large\ Outflow}_{i,t}$ equal to $\mathrm{Outflow}_{i,t}$ if $\mathrm{Outflow}_{i,t}$ was greater than the median, else zero, and $\mathrm{Small\ Outflow}_{i,t}$ equal to $\mathrm{Outflow}_{i,t}$ if $\mathrm{Outflow}_{i,t}$ was less than or equal to the median, else zero.

[28] We found that the impact of each percent of outflow up to the median was the same regardless of whether the total outflow was greater than or less than the median.

Table 18: How do outflows affect fund liquidity? Evidence from U.S. equity funds

This table presents results from estimating equation (15):

$$Liq_{i,t} = \alpha + \beta_1 * Liq_{i,t-1} + \beta_2\ Inflow_{i,t} + \beta_3\ Outflow_{i,t} + \sum_{j=1}^{N} \delta_j\ C_{i,j,t-1} + FE + \varepsilon_{i,t}$$

where $Liq_{i,t}$ is the asset-weighted modified Amihud liquidity of fund i at the end of quarter t. All flow variables are measured for fund i during quarter t. Outflow is equal to the maximum of the net flow multiplied by minus one or zero. Inflow is equal to maximum of the net flow or zero. Outflow > Median is equal to the greater of $Outflow_{i,t}$ less the median $Outflow_{i,t}$ (excluding zeros) and zero. Outflow =< Median is equal to the lesser of $Outflow_{i,t}$ and the median $Outflow_{i,t}$ (excluding zeros). Inflow > Median is equal to the greater of $Inflow_{i,t}$ less the median $Inflow_{i,t}$ (excluding zeros) and zero. Inflow =< Median is equal to the lesser of $Inflow_{i,t}$ and the median $Inflow_{i,t}$ (excluding zeros). We include controls for assets (TNA), age, turnover ratio, and expense ratio as of the end of quarter t – 1. We also include Lipper class and year-quarter fixed effects and interactions of those fixed effects. In column (4), we interact the flow variables with fund TNA at the end of quarter t − 1. In that instance, that particular measure of TNA is z-scored (demeaned and divided by their standard deviation). We estimate the model from 1999 through 2013 for active U.S. equity funds excluding any funds that are less than two years old, hold less than 20 equity positions, or have less than $20 million in assets at the end of quarter t − 1. t-stats derived from standard errors clustered on both fund and year-quarter are presented below the coefficients in brackets.

	(1)	(2)	(3)	(4)
Outflow	-0.00047	-0.00037		-0.00033
	[-2.18]	[-1.70]		[-1.57]
Inflow	0.00041	0.00047		0.00051
	[2.80]	[3.25]		[3.84]
Outflow > Median			-0.00077	
			[-2.17]	
Outflow =< Median			0.00043	
			[0.78]	
Inflow > Median			0.00046	
			[1.75]	
Inflow =< Median			0.00085	
			[1.48]	
Outflow * TNA_{t-1}				0.00038
				[1.91]
Inflow * TNA_{t-1}				0.00022
				[1.40]
Lipper class FE	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes
Control variables	No	Yes	Yes	Yes
Observations	32,219	32,219	32,219	32,219

We then consider how initial equity portfolio liquidity affects the relation between net fund flows and equity portfolio liquidity. Each quarter we sort funds into quintiles based on their equity portfolio liquidity at the beginning of the quarter. In Table 19, we estimate the large and small outflow model separately for each quintile of initial equity portfolio liquidity. We find outflows only impact equity portfolio liquidity for the funds with low initial equity portfolio liquidity. Among the funds with the lowest initial equity portfolio liquidity, the total decrease in liquidity from an outflow of 10% is .000019 =(−0.00243*0.065 + 0.00397*0.035). That decrease in liquidity is equivalent to increasing the impact of selling $10 million of the asset-weighted average equity portfolio holding by 4.4 basis points. Each percent of outflow beyond 10% will further increase that impact by 5.6 basis points. The *t*-stat associated with the large outflow term among the funds with the lowest equity portfolio liquidity is −1.39.

Table 19: How is the impact of outflows on fund liquidity affected by fund liquidity? Evidence from U.S. equity funds

This table presents results from estimating equation (15):

$$Liq_{i,t} = \alpha + \beta_1 * Liq_{i,t-1} + \beta_2\, Inflow_{i,t} + \beta_3\, Outflow_{i,t} + \sum_{j=1}^{N} \delta_j\, C_{i,j,t-1} + FE + \varepsilon_{i,t}$$

where $Liq_{i,t}$ is the asset-weighted modified Amihud liquidity of fund i at the end of quarter t. All flow variables are measured for fund i during quarter t, and defined as in Table 18. We include controls for assets (TNA), age, turnover ratio, and expense ratio as of the end of quarter t – 1. We also include Lipper class and year-quarter fixed effects and interactions of those fixed effects. We sort the sample into quintiles each quarter based on $Liq_{i,t-1}$ and run separate regressions for each resulting group. Column (1) tests the funds with the lowest liquidity, and column (5) tests the funds with the highest liquidity. We estimate the model from 1999 through 2013 for active U.S. equity funds excluding any funds that are less than two years old, hold less than 20 equity positions, or have less than $20 million in assets at the end of quarter t – 1. t-stats derived from standard errors clustered on both fund and year-quarter are presented below the coefficients in brackets.

	(1)	(2)	(3)	(4)	(5)
Liquidity Rank	Low	2	3	4	High
Outflow > Median	-0.00243	-0.00022	-0.00001	-0.00001	0.00004
	[-1.39]	[-0.48]	[-0.07]	[-0.05]	[0.72]
Outflow =< Median	0.00397	-0.00052	0.00011	-0.00047	-0.00021
	[1.26]	[-0.59]	[0.46]	[-0.95]	[-0.96]
Inflow > Median	0.00104	0.00040	-0.00007	0.00007	0.00020
	[0.98]	[1.27]	[-0.29]	[0.95]	[1.13]
Inflow =< Median	0.00518	0.00092	-0.00002	-0.00005	-0.00062
	[1.86]	[1.13]	[-0.05]	[-0.19]	[-1.03]
Lipper class FE	Yes	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes	Yes
Fund controls	Yes	Yes	Yes	Yes	Yes
Observations	6,467	6,445	6,441	6,445	6,421

In summation, we find that equity portfolio liquidity decreases for U.S. equity funds that experience outflows. A 10% outflow increases the impact of selling $10 million of the asset-weighted average equity portfolio holding by 11 basis points. Funds with fewer assets and lower equity portfolio liquidity have a greater decrease in liquidity after outflows.

9.2. Municipal bond funds

We cannot generally replicate the tests in Section 9.1 using funds other than U.S. equity funds because of the previously discussed constraints of the bottom-up liquidity approach. However, as with the flow volatility tests, we can perform a similar analysis for U.S. municipal bond funds. Since U.S. municipal bond funds typically hold only cash and U.S. municipal bonds, which are unequivocally less liquid than cash, any change in their relative weights in the fund portfolio after a large redemption is an indication of a change in fund liquidity. For the purposes of this test, we assume that if the percentage of the portfolio invested in municipal bonds increases after a large redemption, then fund liquidity has likely decreased.

We model the percentage of a fund's portfolio held in municipal bonds as a function of fund flows:

$$\mathrm{Muni}_{i,t} = \alpha + \beta_1 * \mathrm{Muni}_{i,t-1} + \beta_2\ \mathrm{Inflow}_{i,t} + \beta_3\ \mathrm{Outflow}_{i,t} + \sum_{j=1}^{N} \delta_j\ \mathrm{C}_{i,j,t-1} + \mathrm{FE} + \varepsilon_{i,t} \qquad (22)$$

where $\mathrm{Muni}_{i,t}$ is the percentage of fund *i* invested in municipal bonds at the end of quarter t. We define $\mathrm{Outflow}_{i,t}$ and $\mathrm{Inflow}_{i,t}$ following equations (16) and (17), and set the "large" and "small" inflow and outflow thresholds at the median values in this sample (about 2.25% for both inflows and outflows).[29] To the extent the percentage of the fund portfolio held in municipal bonds measures fund liquidity, a positive value for β_3 indicates that fund liquidity decreases when funds experience outflows. We include controls ($\mathrm{C}_{i,j,t-1}$) for assets, age, turnover ratio, and expense ratio at the end of quarter t − 1. We also include year-quarter fixed effects. We exclude any funds that are less than two years old or have less than $20 million in assets as of the end of quarter t − 1. We also exclude index funds since they have more limited control over buying and selling choices than active funds. We estimate the model from 2010 through 2014 since we have both fund flows and municipal bond holdings data during that period. Unlike the model for U.S. equity funds used in Section 9.1, this model allows no inference about which non-cash assets funds sell to meet redemptions. Rather, it gives an indication of the relative proportion of cash and non-cash assets funds used to meet redemptions.

We present results from our model in Table 20. Looking first at column (1), we find that a 1% outflow for a municipal bond fund results in a 0.04% increase in the percentage of the fund held in municipal bonds. When we include the controls variables in column (2), we find similar results. Note that if we reconfigure that model to use cash holdings instead of municipal bond holdings, we find the decrease in cash holdings from a 1% outflow (0.048%) is nearly identical to the increase in municipal bond holdings from a 1% outflow (0.046%). Looking next at column (3), we find that the percentage of the fund held in municipal bonds responds differently to large and small outflows. For each percent of outflow up to the median, the percentage of the fund held in municipal bonds increases by 0.10%. For each percent of outflow greater than the median, the percentage of the fund held in municipal bonds increases by only 0.02%.

[29] If we set the "large" inflow and outflow thresholds using the mean instead of the median, our results are similar.

Table 20: How do outflows affect fund liquidity? Evidence from U.S. municipal bond funds

This table presents results from estimating equation (22):

$$Muni_{i,t} = \alpha + \beta_1 * Muni_{i,t-1} + \beta_2\ Inflow_{i,t} + \beta_3\ Outflow_{i,t} + \sum_{j=1}^{N} \delta_j\ C_{i,j,t-1} + FE + \varepsilon_{i,t}$$

where $Muni_{i,t}$ is the percentage of fund i invested in municipal bonds at the end of quarter t. All flow variables are measured for fund i during quarter t, and all flow variables are defined as in Table 18. We include controls for assets (TNA), age, turnover ratio, and expense ratio as of the end of quarter $t-1$. We also include year-quarter fixed effects. In columns (4) and (5), we interact flow volatility with fund municipal bond holding percentage and TNA at the end of quarter $t-1$. In those instances, those particular measures of TNA and municipal bond holding percentage are z-scored (demeaned and divided by their standard deviation). We estimate the model from 2010 through 2014 using all active U.S. municipal bond funds excluding any funds that are less than two years old or have less than \$20 million in assets at the end of quarter $t-1$. t-stats derived from standard errors clustered on both fund and year-quarter are presented below the coefficients in brackets.

	(1)	(2)	(3)	(4)	(5)
Outflow	0.035	0.046		0.045	0.045
	[2.48]	[3.21]		[3.19]	[3.19]
Inflow	-0.047	-0.037		-0.037	-0.034
	[-2.64]	[-2.06]		[-2.06]	[-2.11]
Outflow > Median			0.024		
			[1.33]		
Outflow =< Median			0.095		
			[2.64]		
Inflow > Median			-0.037		
			[-1.40]		
Inflow =< Median			-0.012		
			[-0.34]		
Outflow * TNA_{t-1}				-0.012	
				[-1.37]	
Inflow * TNA_{t-1}				-0.011	
				[-0.97]	
Outflow * $Muni_{t-1}$					-0.019
					[-1.25]
Inflow * $Muni_{t-1}$					0.041
					[2.35]
Year-quarter FE	Yes	Yes	Yes	Yes	Yes
Control variables	No	Yes	No	Yes	Yes
Observations	4,483	4,483	4,483	4,483	4,483

We next consider how fund assets affect the relation between outflows and the percentage of fund's portfolio held in municipal bonds. In column (4), we interact outflows with the fund assets as of the end of month $t - 3$. We z-score fund assets (demean and divide by the standard deviation), so that the coefficient on the interaction term can be interpreted as the impact of a one standard deviation increase in assets. We find some statistically weak evidence that the impact of outflows on the percentage of fund's portfolio held in municipal bonds increases as fund assets decrease. For a fund with average assets, each percent of outflow increases the percentage of the fund portfolio held in municipal bonds by 0.045% = (0.045%*1% + −0.012%*1%*0). However, for a fund with assets one standard deviation below the mean, each percent of outflow increases the percentage of the fund portfolio held in municipal bonds by 0.057% = (0.045%*1% + −0.012%*1%*−1). The *t*-stat associated with the interaction term is 1.37.

We then consider how a fund's initial municipal bond holding percentage affects the relation between outflows and a fund's municipal bond holding percentage. In column (5), we interact outflow with the fund's initial municipal bond holding percentage as of the end of month $t - 3$. We z-score initial municipal bond holding percentage (demean and divide by the standard deviation), so that the coefficient on the interaction term can be interpreted as the impact of a one standard deviation increase in initial municipal bond holding percentage. We find some statistically weak evidence that the impact of outflows on the percentage of fund's portfolio held in municipal bonds decreases as the initial percentage of fund's portfolio held in municipal bonds increases. For a fund with an average municipal holdings percentage, each percent of outflow increases the percentage of the fund portfolio held in municipal bonds by 0.045% = (0.045%*1% + −0.019%*1%*0). However, for a municipal holdings percentage one standard deviation below the mean, each percent of outflow increases the percentage of the fund portfolio held in municipal bonds by 0.064% = (0.045%*1% + −0.019%*1%*−1). The *t*-stat associated with the interaction term is −1.25. Unlike the tests in Section 7.2, we do not find that excluding funds with initial municipal bond holdings near 100% affects our results in this section.

Considered as a whole, the proportion of municipal bonds in the fund portfolio increases after a fund experiences outflows. To the extent that the proportion of municipal bonds in the portfolio represents fund liquidity, outflows decrease the liquidity of U.S. municipal bond funds. Funds with fewer assets and funds with lower municipal bond holdings have a greater increase in municipal bond holdings after outflows.

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Appendix A – CRSP objective code to investment category mapping

Investment category	CRSP objective codes
Alternative Strategy	EDYH, EDYS, O, OC
Foreign Bonds	IF
Foreign Equity	EFRC, EFRQ, EFRM, EFRE, EFRI, EFRJ, EFRL, EFRP, EFRX, EFR, EFSG, EFSH, EFSF, EFSN, EFSR, EFST, EFSU, EFSG, EFSC, EFSS, EFSI, EFSM, EFSA, EFS, EFCL, EFCM, EFCS, EFCI, EFYG, EFYT, EF
General Bonds	I
Mixed Strategy	M, MT
Mortgage-Backed Securities	OM
US Corporate Bonds	ICQH, ICQM, ICQY, ICDS, ICDI, IC
US Equity	EDSG, EDSH, EDSF, EDSN, EDSR, EDST, EDSU, EDSG, EDSC, EDSS, EDSI, EDSM, EDSA, EDCL, EDCM, EDCS, EDCI, EDYG, EDYB, EDYI
US Government Bonds	IGT, IGDS, IGDI, IGD, IG
US Municipal Bonds	IUS, IUI, IUH, IU

Appendix B – Objective code to investment subclass mapping

Investment subclass	Objective codes
High Yield Bonds	CRSP objective codes - ICQY and IUH
Emerging Market Equity	CRSP objective code - EFRM
Emerging Market Debt	Lipper objective code - EMD

Appendix C – Lipper class codes for "plain vanilla" U.S. equity funds

Lipper Cass	Brief Description
EIEI	Equity Income
LCCE	Large-Cap Core
LCGE	Large-Cap Growth
LCVE	Large-Cap Value
MCCE	Mid-Cap Core
MCGE	Mid-Cap Growth
MCVE	Mid-Cap Value
MLCE	Multi-Cap Core
MLGE	Multi-Cap Growth
MLVE	Multi-Cap Value
SCCE	Small-Cap Core
SCGE	Small-Cap Growth
SCVE	Small-Cap Value