Mutual Fund Liquidity Creation*

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Abstract

We develop a novel measure of the dollar value of liquidity created by open-end mutual funds. Our measure compares the costs investors would have incurred had they traded on their own in response to liquidity shocks with the actual costs incurred by open-end mutual funds when trading to satisfy investor redemptions. Applying this measure to municipal bond mutual funds, we show that during the 2008–2017 period the average fund provides liquidity services worth 1.80 cents per dollar of gross redemptions or 50 basis points of fund assets per year. The aggregate value of liquidity services provided during this period was $14–22 billion. We decompose liquidity creation into three components: 1) flow netting, 2) liquidity management, and 3) trade execution, and explore the cross-sectional and time-series variation in liquidity creation.

Keywords: liquidity creation, mutual funds, municipal bonds

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Similarly to banks, fixed-income open-end mutual funds engage in liquidity transformation by offering investors daily liquidity while investing in illiquid assets such as corporate and municipal bonds and syndicated loans. It is their liquidity transformation that makes open-end mutual funds subject to runs (Chen, Goldstein, and Jiang, 2010, Goldstein, Jiang, and Ng, 2017, Zeng, 2017). Investors have an incentive to run because the price at which they withdraw, the end-of-day net asset value (NAV), does not account for the cost of providing liquidity, which is born by the remaining investors. While the risks posed by mutual fund liquidity transformation have received significant attention, there is still no good quantitative measure of the value of liquidity services created by open-end mutual funds. In this paper, we develop such a measure and use it to explore the cross-sectional and time-series variation in mutual fund liquidity creation.

Our value of liquidity creation, VLC, measure compares the value of liquidity services provided to fund investors with the trading costs incurred by mutual funds to provide these services. The starting point for our measure is the value of monthly gross redemptions from each fund. We think of gross redemptions as capturing the value of liquidity shocks suffered by the households investing in mutual funds. Because investors redeem at NAV that does not incorporate transaction costs, the value of the liquidity services provided to them is captured by the transaction costs—commissions, markups, and price impact—that investors would have incurred if they had traded on their own.

The cost of providing liquidity to the investors is captured by the transaction costs funds incur when trading in response to redemptions. These costs depend on the fund's ability to net daily redemptions and subscriptions, its ability to net fund flows over time so as to avoid trading in response to redemptions, and its ability to get superior trade execution than retail investors.

Municipal bond mutual funds provide the perfect laboratory to implement this methodology for two key reasons. First, households and mutual funds are the two largest investor groups in the municipal bond markets, holding 48% and 23% of the market.[1] Because investors trade municipal bonds both directly as well as through mutual funds, we can measure the transaction costs associated with both strategies. Second, because virtually all trades in municipal bonds are reported to the Municipal Securities Rulemaking Board (MSRB), and because most municipal bonds trade infrequently, we are able to identify the precise timing and terms of more than 85% of all municipal bond sales by mutual funds. Comparing the timing of sales with daily fund flows allows us in turn to identify sales that are likely to be flow-induced and to measure the transaction costs associated with these sales.

We find that municipal bond funds create significant amounts of liquidity for their investors, both in dollar terms and relative to fund assets. In the aggregate, over the 2008–2017 period, municipal bond funds create $1.4–2.2 billion of liquidity services per year.[2] The annual flow of

[1] 2020 data from the Financial Accounts of the United States.

[2] Our estimates use daily fund flows, which are not available for all funds. The lower bound is based on funds for which we can actually calculate VLC. The upper bound is our best extrapolation to funds that are missing some of

liquidity services amounts to about 50 basis points of fund assets. The value of liquidity creation is thus comparable to annual management fees of 44 basis points.

Our main analysis explores the cross-sectional and time-series variation in the VLC/Redemptions ratio, i.e. in the efficiency with which funds generate liquidity. The average fund generates 180 basis points of liquidity per dollar of redemptions, but there is significant variation across funds. The standard deviation in the fund-month data is 71 basis points.

To understand the drivers of liquidity creation and of its variation across funds, we decompose liquidity creation into three key components: *Flow netting*, *Liquidity management*, and *Trade execution*. The *Flow netting* component captures the contemporaneous netting of redemptions and subscriptions that reduces the ratio of net outflows to gross redemptions, thereby allowing funds to trade less. By using *Liquidity management* tools such as cash buffers, lines of credit, and interfund lending program, funds may trade less than dollar-for-dollar in response to net outflows. *Trade execution* captures variation in search costs and bargaining power that allow funds to trade at lower cost than retail investors. *Flow netting*, *Liquidity management*, and *Trade execution* are roughly equally important in explaining the magnitude of the VLC/Redemptions ratio, accounting for 69, 52, and 58 basis points respectively.

In the cross section, the strongest determinants of liquidity creation are the characteristics of the portfolio bonds held by the fund, in particular their credit rating and maturity. A one standard deviation increase in the remaining maturity of the portfolio bonds is associated with about 25 basis points higher VLC/Redemptions ratio. Controlling for the average remaining maturity, short-term funds have 10 basis points lower VLC/Redemptions ratio. A one standard deviation increase in the weighted average credit rating of the portfolio bonds, indicating worse credit ratings, is associated with almost 13 basis points higher VLC/Redemptions ratio. These results reflect the fact that lower rated bonds and bonds with longer maturity have larger markups; as a result, by helping investors avoid trading these bonds directly, funds that hold these bonds generate more liquidity.

A number of fund characteristics have offsetting effects on different components of VLC, underscoring the value of decomposing and analyzing the drivers of liquidity creation. Cash buffers, for examples, are associated with more *Flow netting* and *Liquidity management* but worse *Trade execution*, with the overall effect on liquidity creation being essentially zero. Share class HHI is negatively correlated with *Flow netting* and positively correlated with *Trade execution*. These results highlight the fact that our cross-sectional regressions capture equilibrium correlations between fund characteristics and liquidity creation and that these correlations can be due to both selection and treatment effects. For example, the negative correlation between cash buffers and *Trade execution* is likely due to a selection effect. Funds that are skilled at trading may hold smaller cash buffers because they worry less about the transaction costs of trading in response to redemptions. Similarly, funds that are skilled at trading may not put as much effort into setting up separate share classes

the data necessary to calculate VLC. Section 6 provides more details.

to cater to different investor clienteles.

Larger funds and funds that belong to larger families are more efficient at creating liquidity. A one standard deviation increase in fund (family) size is associated with 3.6 (3.6) basis points higher VLC/Redemptions ratio. This effect is driven by better *Flow netting*. There is no evidence that larger funds and families are on average better at *Liquidity management* or *Trade execution*.

In the time series, we document a strong downward trend in the VLC/Redemptions ratio. Over the 2008–2017 period, VLC/Redemptions ratio declines by about 125 basis points from around 250 basis points in late 2008 to 125 basis points in late 2017. This decline is driven by the decline in markups on retail-size trades. We also show that while funds become less efficient at liquidity creation, i.e., the VLC/Redemptions ratio declines, during periods of market turmoil, aggregate liquidity creation increases significantly thanks to large redemptions.

We also show that aggregate net outflows have heterogeneous effects on mutual fund liquidity creation. Aggregate net outflows increase the value of cash buffers for *Liquidity management*. But they erode the advantage large funds and funds with more diversified shareholder base enjoy in *Flow netting*. Aggregate net outflows also give larger fund families an advantage in *Trade execution*.

Our paper contributes to the literature on liquidity creation by financial intermediaries. While there is a long literature modeling (Diamond and Dybvig, 1983; Gorton and Pennacchi, 1990; Diamond and Rajan, 2001; Kashyap, Rajan, and Stein, 2002) and measuring (Berger and Bouwman, 2009; Jiang, Levine, and Lin, 2019) liquidity creation by banks, the literature on liquidity creation by other types of financial intermediaries such as open-end mutual funds is more recent and less developed. Our paper is among the first to measure liquidity creation by mutual funds. Before us, Shawky and Tian (2011) measure liquidity creation by small-cap stock funds as the difference in the liquidity of the stocks bought and sold by these funds. Looking at funds of hedge funds, Agarwal, Aragon, and Shi (2019) measure liquidity transformation as the difference between the redemption restrictions of the underlying hedge funds and the redemption restrictions of the fund of funds. These measures are similar in spirit to the bank liquidity creation measure of Berger and Bouwman (2009), which is the difference in liquidity between a bank's assets and liabilities. Most closely related to our measure is the Liquidity Provision Index (LPI) of Ma, Xiao, and Zeng (2021). The LPI is the difference between a fund's expected payment to redemptions and the liquidation value of the fund's portfolio, calculated using average haircuts for repurchase agreements backed by different asset classes. In contrast to LPI, our VLC measure directly compares the transactions costs incurred by mutual funds on flow-induced sales with the counterfactual transactions costs that investors would have incurred if they had traded on their own.

Our results highlight the value of and provide important new insights into active liquidity management by open-end mutual funds (Goncalves-Pinto and Schmidt, 2013; Chernenko and Sunderam, 2016, 2020; Agarwal and Zhao, 2019; Choi et al., 2020). Our estimates attribute 52 basis points or almost 30% of the VLC/Redemptions ratio to the *Liquidity management* component. We contribute to the literature on mutual fund liquidity management in three ways. First, we show that liquidity management is constrained by the autocorrelation of fund flows. If flows are not highly persistent, then funds can draw down liquidity buffers to meet redemptions today and rebuild cash buffers using future inflows. If flows are highly persistent, on the other hand, then using cash buffers only delays bond sales, which has a more limited effect on the value of liquidity created by the fund. Second, we provide novel evidence that cash buffers mitigate strategic complementarities in redemptions. While existing literature focuses on how cash buffers affect the slope of the performance-flow relationship (Goldstein, Jiang, and Ng, 2017), we show that cash buffers are associated with greater *Flow netting*. Third, we show that cash buffers are a significantly more valuable liquidity management tool during periods of aggregate net outflows. A one standard deviation increase in aggregate net outflows is associated with about 60% increase in the effect of cash buffers on the *Liquidity management* component. These results are in contrast to Jiang, Li, and Wang (2021) who claim that in response to increases in aggregate uncertainty, corporate bond funds tend to proportionally scale their portfolios instead of using their cash buffers. Our unique trade level data give us more power to detect changes in high frequency usage of cash buffers, which may not be detectable in monthly and quarterly portfolio holdings data.

Finally, our results suggest that the financial stability risks posed by mutual funds (Falato et al., 2021; Jiang et al., 2021; Li, O'Hara, and Zhou, 2021), must be compared with the value mutual fund liquidity creation. Over the 2008–2017 period, municipal bond funds generated $14–22 billion worth of liquidity services. Furthermore, the dollar value of mutual fund liquidity creation jumps during periods of uncertainty and large outflows, highlighting the valuable service provided by these funds.

The paper proceeds as follows. Sections 1 and 2 describe the methodology and data used to construct VLC. Section 3 reports our estimates of VLC. Section 4 analyses the cross-sectional variation in liquidity creation. Section 5 shows that liquidity creation has declined over time and analyses the time-series variation in liquidity creation. Section 6 extrapolates our estimates of liquidity creation to the population of municipal bond funds and estimates aggregate VLC. Section 7 concludes.

1 Methodology

We measure the dollar value of liquidity created, VLC, by fund f during month t as the difference between a) the dollar value of markups fund investors would have paid if they had sold individual municipal bonds with aggregate proceeds equal to the fund's gross redemptions during the month and b) the dollar value of markups on the fund's actual flow-induced sales during the month.

The markup on a given sale is the difference between the price received by a customer when selling to a dealer and the weighted-average price paid by the customers who ultimately purchase the bond from either the original dealer or from another dealer(s) through a series of interdealer trades. To measure the markup on a given municipal bond sale, we follow Li and Schürhoff (2019) and identify the chain of trades starting with the initial sale by a customer and ending with the ultimate purchases of the bond by other customers.

1.1 Counterfactual markups incurred by retail investors

The counterfactual in the VLC calculation is the markup fund investors would have paid if they had directly traded municipal bonds instead of redeeming their shares in a mutual fund. The aggregate value of such sales equals gross redemptions from the fund. We think of gross redemptions as capturing liquidity shocks suffered by investors, and we assume that these shocks, and hence the value of bond sales, would have been the same if households had invested in municipal bonds directly. This assumption is not completely accurate as redemptions are also affected by strategic complementarities that would not be present, or would be much weaker, if investors traded municipal bonds on their own. Nevertheless, without good estimates of the share of redemptions that are due to liquidity shocks versus strategic complementarities, this assumption provides a useful starting point for estimating the value of mutual fund liquidity creation.

The markup on these counterfactual sales depends on a) which bonds investors would have sold and b) the timing of investor sales. Because we do not have daily gross redemptions data, we approximate the timing of investor sales using monthly redemptions and daily net flows. In our benchmark calculation, redemptions from fund f on day d, expressed as a positive number, are calculated as

$$Max(0, -Net\ Flow_{f,d}) + \frac{1}{\#Days}\left(Redemptions_{f,m} - \sum_{d} Max(0, -Net\ Flow_{f,d})\right) \tag{1}$$

The first term is the negative of flows on days when a fund experiences net outflows and is zero otherwise. The second term is the difference between gross monthly redemptions and the absolute value of the sum of daily flows on days with net outflows. Thus we spread evenly across all trading days within the month the part of gross monthly redemptions that cannot be accounted for by days with net outflows. This assumption is unlikely to have much effect on our results because for the median fund-month observation, the first component, days with net outflows, accounts for 69% of gross monthly redemptions. To the extent that we mismeasure gross daily redemptions, this matters for the calculation of VLC only if markups vary significantly during a month, which generally does not appear to be the case.

The calculation of VLC is potentially more sensitive to the assumption about which bonds investors would have traded and in what amount. A natural assumption is that if investors held municipal bonds directly instead of through a mutual fund, they would have held the same bonds as the fund itself, and would have traded these bonds according to their portfolio weights.[3] Thus, for each bond held by the fund at the end of month $m-1$, we calculate the average markup realized on retail-size trades on each trading day d during month m.

Because most municipal bonds trade infrequently, when a bond does not have trades with valid markup on day d, we use the following algorithm. We first check if the bond has any trades with markups during that week or month. If so, we use the average markup during the week or month. If the bond does not have any trades with a markup during the month, we use the average markup on trades of similar bonds. We define similar bonds as bonds with the same credit rating and similar maturity. Credit rating and maturity are among the most important cross-sectional determinants of markups. Because there are few speculative grade bonds and because markups do not vary much with ratings for speculative grade bonds, we treat all speculative grade bonds as having the same credit rating. Unrated bonds are treated as a separate category. We assign bonds into the following maturity buckets: (0, 1), [1, 2.5), [2.5, 5), [5, 10), [10, 20), and at least 20 years to maturity. If there are no trades in similar bonds on day d, we use the average markup during that week or month. Appendix Table B1 shows that for about three-quarters of observations, the hypothetical markup on trades of less than $100,000 in par value is calculated using same-day trades on similar bonds. For another 15%, the hypothetical markup is calculated using same-month trades in the bond itself.

For our benchmark calculation, we use all trades smaller than $100,000 in par value. For robustness in Table 3, we calculate VLC under alternative assumptions about the size of retail trades. We assume that fund investors would have traded in the following amounts: ($0, $10,000), [$10,000, $25,000), [$25,000, $50,000), and [$50,000, $100,000).

1.2 Actual markups incurred by funds

The second term in the definition of VLC is the dollar value of markups incurred by mutual funds when trading to satisfy investor redemption requests. We follow the methodology in Chernenko and Doan (2020) to identify bond sales by municipal bond mutual funds. Chernenko and Doan (2020) take advantage of the infrequent trading in the municipal bond market along with the comprehensive disclosure of all municipal bond trades through Municipal Securities Rulemaking Board's (MSRB) Electronic Municipal Market Access (EMMA) system. Chernenko and Doan (2020) first infer sales of bonds from changes in portfolio holdings between successive months or quarters. They then match inferred sales to the reported trades in MSRB data. Overall, the algorithm is able to match 85% of all municipal bond sales to MSRB data.

The calculation of VLC uses the dollar markup on only flow-induced sales, but classifying in-

[3] A given investor would have probably traded a single bond. Some of a fund's investors would have held and sold more liquid bonds, while others would have held and sold less liquid bonds in the fund's portfolio. Our calculation effectively aggregates across the fund's investors.

dividual trades as flow-induced is not straightforward. Sales on days with net outflows are likely to be flow-induced. But what about funds that draw down cash buffers to meet redemptions and sell a few days later when there are no redemptions but when inflows are still not sufficient to rebuild cash buffers? Rather than trying to classify individual trades as flow-induced, we estimate aggregate value of flow-induced sales as the minimum of all sales and gross monthly outflows from the fund. Gross monthly outflows are the absolute value of the sum of net flows on days with net outflows. Thus we assume that if a fund sold more than this, the extra sales are voluntary and not flow-induced. This approach accounts for liquidity management and allows funds to postpone selling bonds until later in the month. This approach may miss cases where a fund has redemptions late in the month but sells bonds during the following month. In the Appendix Table B3 we find very similar results using quarterly data, where small delays between redemptions and sales should be less of an issue. Thus to calculate the markup on flow-induced sales, we first calculate the dollar value of markups on all sales. We then multiply the dollar value of markups by the ratio of gross outflows to the aggregate value of all sales, if this ratio is less than one.

For bond sales without valid markups, we extrapolate from the markups on other trades by the same fund. We assume the markups on these sales are equal to the 25th percentile of the fund-specific markup distributions, since as documented in Chernenko and Doan (2020), unmatched sales tend to be larger trades on more liquid bonds, implying lower dealer markups. As a robustness check, we extrapolate by grossing up the dollar value of markups on sales with valid markup data by the fraction of sales with valid markup data. In other words, we assume that for a fund-month, markups on the other sales are similar to markups that we are able to identify. All of our results affected very little by this alternative markup extrapolation.

1.3 Decomposition of VLC

To better understand the cross-sectional and time-series variation in liquidity creation, we decompose VLC into three components:

$$
\begin{aligned}
\frac{VLC}{Redemptions} &= \frac{\$\ Markup_c - \$\ Markup_a}{Redemptions} \\
&= \%Markup_c - \frac{Sales}{Redemptions} \times \%Markup_a \\
&= \underbrace{\left(1 - \frac{Outflows}{Redemptions}\right) \times \%Markup_c}_{\text{Flow netting}} + \underbrace{\left(\frac{Outflows - Sales}{Redemptions}\right) \times \%Markup_c}_{\text{Liquidity management}} \\
&+ \underbrace{\frac{Sales}{Redemptions} \Delta\%Markup_{c,a}}_{\text{Trade execution}}
\end{aligned} \tag{2}
$$

where $ $Markup_c$ is the dollar markup on the counterfactual sales and $ $Markup_a$ is the dollar markup on the actual flow-induced sales. The first component, *Flow netting*, captures the value created by fund's ability to net daily subscriptions and redemptions against each other. The *Outflows* term in the *Flow netting* component is the absolute value of the sum of daily net flows over days with negative net flows. The second component is *Liquidity management*. It captures the value created through the fund's use of cash buffers, interfund lending, and lines of credit to avoid trading in response to outflows. This component is determined by the difference between *Outflows* and *Sales*. Note that the first and second components are evaluated at the counterfactual markup on retail-size trades that fund investors would have engaged in if they had directly traded municipal bonds. The last component, *Trade execution*, captures how much more fund investors would have paid in markups if they had traded at the same *Sales/Redemptions* ratio as the fund but paid typical retail-size trade markups instead of the actual markups incurred by the fund.

1.4 Discussion of VLC

Our measure of liquidity creation is different from other measures proposed in the banking literature. Berger and Bouwman (2009) and Jiang, Levine, and Lin (2019) measure bank liquidity transformation as the difference between liquid liabilities and liquid assets. In a similar vein, Agarwal, Aragon, and Shi (2019) measure liquidity transformation by funds of hedge funds as the difference between redemptions restrictions of funds of hedge funds and the underlying funds. Although intuitive and simple to construct, these measures do not capture the actual value of liquidity services created. In contrast, VLC measures the monetary value to retail investors of being able to withdraw from an open-end mutual fund instead of directly trading the underlying securities. VLC is also different from the LPI measure of Ma, Xiao, and Zeng (2021). First, in constructing VLC we use gross redemptions rather than net outflows as a measure of liquidity shocks experienced by fund investors. This is important because, as we show, 69 basis points or more than one-third of fund liquidity creation, VLC/Redemptions ratio, is due to flow netting. Second, VLC uses actual transaction costs along with estimates of hypothetical transactions costs on retail-size trades. LPI in contrast uses average haircuts for different asset classes and does not account for variation in transaction costs within an asset class. We show that at least in the context of municipal bonds, transaction costs vary significantly across bonds, and so does fund liquidity creation. In fact, portfolio characteristics such as credit rating and remaining maturity are the most important cross-sectional determinants of liquidity creation.

It is worth noting that by calculating the dollar value of markups on sales induced by redemptions, VLC accounts for the cost of providing liquidity to the redeeming investors. Thus although these investors redeem at the end-of-day NAV that does not account for the transaction costs, VLC takes these costs into considerations.

Finally, VLC assumes that if investors had traded on their own instead of through mutual funds they would have held the same bonds as mutual funds. In practice, in the counterfactual equilibrium, investors would have probably held more liquid bonds. If so, their trading costs would be lower than assumed by our counterfactual. On the other hand, investors would not have been able to earn the illiquidity premium.

2 Data

Our main data source is Morningstar Direct, which provides data on the portfolio holdings, daily net flows, monthly redemptions, returns, and total net assets (TNA) of open-end mutual funds. Our sample consists of open-end municipal bond mutual funds that are at least two years old and have TNA of at least $10 million. Young and very small funds are excluded to prevent incubation bias from influencing the results (Evans, 2010). We also require the ratio of the portfolio's value to fund TNA to be in the $[0.5, 2]$ interval to exclude potential data errors.

The final sample consists of fund-month observations on 696 unique funds between August 2008 and December 2017. The starting point is determined by the availability of daily net flows in Morningstar, which we use to calculate counterfactual markups of sales by retail investors in response to outflows. The ending point is determined by the availability of MSRB transaction data with anonymized dealer identifiers.

Holding-implied sales are matched to MSRB transaction data following the algorithm in Chernenko and Doan (2020). Bond characteristics are from Mergent Municipal Bond Securities Database (MBSD). We include all MBSD bonds in both the matching algorithm and in the calculation portfolio-level characteristics, except cash-like bonds such as variable rate demand notes (VRDNs).

2.1 Summary statistics

Table 1 describes our final sample of fund-month observations during the 2008–2017 period. The median fund has TNA of $225 million, and belongs to a fund family with aggregate municipal bond fund TNA of approximately $9 billion. The median gross redemptions per month is equivalent to 1.60% of fund TNA. As a comparison, the median monthly net flows and outflows[4] are -0.06% and 0.94% of fund TNA respectively. This suggests that a significant portion of fund redemptions are netted by subscriptions, both daily and monthly. Meanwhile, the mean (median) total monthly sale amount is 0.93% (0.46%) of the previous-month fund size.

Most funds have only a few share classes. For the median fund, the HHI of assets across share classes is 0.68. From daily flows data, we calculate the three-month rolling autocorrelation in fund

[4] We first measure daily outflows as the negative of Morningstar-reported daily net flows if negative and zero otherwise. Then, we aggregate all daily outflows during a month to calculate monthly outflows.

Table 1
Summary Statistics

The sample consists of open-end municipal bond mutual funds over the August 2008–December 2017 period. The unit of observation is a fund-month. *Redemptions* are the fund's monthly gross redemptions reported on the SEC Form N-SAR. *Outflows* are the absolute value of the sum of all daily net flows on days with negative net flows. *Sales* are the dollar value of all flow-induced sales during the month: the minimum of a) all holdings-implied sales that can be matched to MSRB trade data and b) gross monthly outflows, the absolute sum of net flows on days with net outflows. Credit ratings are encoded so that AAA = 0, AA+ = 1, ..., BB+ = 10, ..., C = 20.

				Percentile		
	N	Mean	SD	25th	50th	75th
Redemptions/TNA (%)	45,089	2.39	3.94	1.05	1.60	2.63
Net flows/TNA (%)	45,089	0.10	3.48	-0.87	-0.06	0.86
Outflows/TNA (%)	45,089	1.55	3.51	0.54	0.94	1.69
Sales/TNA (%)	45,089	0.93	1.66	0.00	0.46	1.17
Share class HHI	45,089	0.69	0.25	0.48	0.68	0.96
Flow autocorrelation	45,089	0.02	0.16	-0.07	0.01	0.11
Cash/TNA (%)	45,089	2.72	3.97	0.26	1.49	3.40
To-be-redeemed bond share	45,089	0.01	0.01	0.00	0.00	0.01
Line of credit	45,089	0.31	0.46	0.00	0.00	1.00
Interfund lending	45,089	0.41	0.49	0.00	0.00	1.00
Short-term fund	45,089	0.11	0.31	0.00	0.00	0.00
Single-state fund	45,089	0.63	0.48	0.00	1.00	1.00
Porfolio HHI	45,089	0.01	0.01	0.01	0.01	0.02
Average rating	45,089	4.17	1.71	3.08	3.83	4.75
Unrated bond share	45,089	0.09	0.11	0.02	0.05	0.11
GO bond share	45,089	0.18	0.14	0.08	0.16	0.24
Insured bond share	45,089	0.27	0.19	0.12	0.23	0.39
Exotic bond share	45,089	0.03	0.07	0.00	0.01	0.03
Average bond age (years)	45,089	4.85	1.39	3.95	4.74	5.65
Average maturity (years)	45,089	14.96	5.37	10.15	15.98	19.13
Portfolio value/TNA	45,089	1.00	0.03	0.99	1.00	1.00
Fund TNA ($m)	45,089	657.34	1,259.55	97.38	225.39	637.21
Family TNA ($m)	45,089	11,303.67	12,525.56	1,641.87	9,048.87	15,946.55

flows. Despite its high variation, daily flow autocorrelation is close to zero for a large number of funds, indicating their flows are not persistently predictable. Cash buffers of municipal bond funds are fairly small with the median fund holding 1.49% of its net assets in cash and equivalents. About 31% (41%) of fund-month observations utilize a line of credit or participate in an interfund lending program. Another way funds can manage liquidity is to invest in bonds to be matured or redeemed shortly. In our sample, such bonds account for 0.6% of portfolio value on average.

Short-term funds account for 11% of the sample. Almost two thirds of of mutual funds in our sample are single-state funds. Funds are on average diversified with portfolio HHI of 117 (out of 10,000). Portfolio characteristics are averages of bond characteristics, with market values of positions as weights. The median portfolio consists of bonds with average rating of 3.83[5], 4.74 years since issuance, and 15.98 years until maturity. Only 5% of portfolio value are unrated bonds. General obligation (GO) bonds, insured bonds, and exotic bonds account for 16%, 23%, and 1% of net portfolio value respectively.

[5] Credit ratings are encoded so that AAA = 0, AA+ = 1, ..., BB+ = 10, ..., C = 20.

3 Value of Liquidity Creation

Panel A of Table 2 reports our benchmark estimates of mutual fund liquidity creation. The unit of observation is a fund-month. The average fund generates 180 basis points worth of liquidity services per dollar of gross redemptions. There is large variation across funds and over time, however, in VLC/Redemption: the standard deviation is 71 basis points. We explore cross-sectional variation in VLC in Table 4 and time-series variation in Tables 5, 6 and 7.

Table 2
Value of Liquidity Creation

This table reports our baseline estimates of the value of liquidity creation. *VLC* is the difference between a) the dollar value of markups fund investors would have realized if they had directly sold municipal bonds with aggregate proceeds equal to the fund's gross redemptions and b) the the dollar value of markups on the fund's actual flow-induced sales. The sample consists of open-end municipal bond mutual funds over the August 2008–December 2017 period. The unit of observation is a fund-month. *VLC* is decomposed, according to equation 2, into three components: 1) flow netting, 2) liquidity management, and 3) trade execution. *Redemptions* are the fund's monthly gross redemptions reported on the SEC Form N-SAR. *Outflows* are the absolute value of the sum of all daily net flows on days with negative net flows. *Sales* are the dollar value of all flow-induced sales during the month: the minimum of a) all holdings-implied sales that can be matched to MSRB trade data and b) gross monthly outflows, the absolute sum of net flows on days with net outflows. *VLC*, fund fees and expenses, and returns, are annualized.

Panel A: Summary statistics

				Percentile		
	N	Mean	SD	25th	50th	75th
VLC/Redemptions (bps)	45,089	179.57	71.01	129.72	177.04	227.78
Components:						
Flow netting (bps)	45,089	69.04	63.40	16.86	55.07	104.92
Liquidity management (bps)	45,089	52.09	71.60	0.00	8.03	92.01
Trade execution (bps)	45,089	58.05	68.98	0.00	33.07	99.37
Drivers:						
Outflows/Redemptions	45,089	0.64	0.29	0.42	0.68	0.90
Sales/Redemptions	45,089	0.37	0.36	0.00	0.29	0.68
Markup difference (bps)	45,089	63.52	23.30	47.23	60.43	76.42
Fees and returns:						
VLC ($m)	45,089	3.46	9.94	0.28	0.81	2.68
VLC/TNA (bps)	45,089	50.32	102.15	20.28	33.31	55.41
Management fee (bps)	45,089	43.93	11.16	37.00	45.00	50.00
Total net expense (bps)	44,449	92.10	41.58	63.00	80.00	124.00
Net return (bps)	43,747	390.17	1,828.82	-268.62	411.55	1,226.16
Abnormal return (bps)	43,719	-70.16	239.36	-175.56	-59.87	40.10

Panel B: Correlations

	VLC	FN	LM	TE	OR	SR	MD
VLC/Redemptions	1.00	0.42	0.32	0.30	-0.07	-0.15	0.67
Flow netting (FN)	0.42	1.00	-0.25	-0.22	-0.86	-0.37	0.32
Liquidity management (LM)	0.32	-0.25	1.00	-0.47	0.35	-0.60	0.08
Trade execution (TE)	0.30	-0.22	-0.47	1.00	0.35	0.80	0.31
Outflows/Redemptions (OR)	-0.07	-0.86	0.35	0.35	1.00	0.45	-0.00
Sales/Redemptions (SR)	-0.15	-0.37	-0.60	0.80	0.45	1.00	0.11
Markup difference (MD)	0.67	0.32	0.08	0.31	-0.00	0.11	1.00

The three components of VLC—*Flow netting*, *Liquidity management*, and *Trade execution*—on average contribute 69, 52, and 58 basis points, or about 38%, 30%, and 32%. Table 2 also reports summary statistics for the key drivers of VLC: Outflows/Redemptions ratio, Sales/Redemptions ratio, and the difference in average markups between institutional and retail trades. The average Outflows/Redemptions ratio is 0.64. This indicates that funds are able to offset one third of gross redemptions with subscriptions. The average Sales/Redemptions ratio is 0.37.

Table 2 also reports the dollar value of VLC and the ratio of VLC/TNA. Both of these are annualized. The average fund creates about $3.46 million of liquidity services per year. While this may not seem like a large number, mutual fund liquidity creation amounts to about 50 basis points of fund TNA. This is comparable to the average fund management fee of 44 bps and to the average abnormal return of -70 basis points.[6]

Panel B of Table 2 reports the correlation between VLC, its three components—flow netting, liquidity management, and trade execution—and key drivers including Outflows/Redemptions, Sales/Redemptions, and markup difference. The correlation of VLC/Redemptions with the *Flow netting*, *Liquidity management*, and *Trade execution* is 0.42, 0.32, and 0.30.

The calculation of VLC makes assumptions about which sales are flow-induced and about the size of retail trades fund investors would have engaged in if they had directly traded municipal bonds. Table 3 explores the sensitivity of VLC to alternative assumptions. The different rows report the results for different assumptions about the size of retail trades that fund investors would have executed had they directly traded municipal bonds. The different columns report the results for different definitions of flow-induced sales. Our benchmark calculation defines flow-induced sales as the minimum of a) all holdings-implied sales that can be matched to MSRB trade and b) monthly *Outflows*, the absolute value of the sum of net flows on days with net outflows. As a robustness, we compare total sales with cumulative outflows over month t and months $t-1$ and $t-2$. We also use gross *Redemptions* instead of *Outflows* to cap total sales.

Not surprisingly, estimated VLC is larger when smaller retail trades and stricter criteria for flow-induced sales are used. Since smaller trades incur larger percentage markups, assuming that fund investors would have traded smaller amounts had they directly traded municipal bonds results in larger estimates of mutual fund liquidity creation. Using a stricter criterion for flow-induced sales means that a smaller fraction of fund sales is used in the VLC calculation. This results in lower dollar value of markups incurred by funds to satisfy redemption requests.

Across the full range of alternative assumptions, estimated VLC/Redemptions varies from 140 to 203 basis points. The VLC/TNA ratio varies from 41 to 57 basis points.

[6] It is worth noting that while all investors incur management fees and operating expenses, liquidity creation accrues only to investors who suffer liquidity shocks and withdraw from the fund.

Table 3
VLC under Alternative Assumptions

This table reports the average values of *VLC/Redemptions* and *VLC/TNA* under different assumptions about (i) the size of the hypothetical retail trades and (ii) the definition of flow-induced sales. Baseline results cap total monthly sales by month t *Outflows* and assume trades with par value of less than \$100k as counterfactual retail trades. Alternative definitions of flow-induced sales cap total sales by either cumulative *Outflows* or *Redemptions* over months $[t-s, t]$. Counterfactual retail trades are alternatively assumed to be trades with par values: (\$0, \$10k), [\$10k, \$25k), [\$25k, 50k), [\$50k, \$100k), or [\$0, \$100k).

Panel A: VLC/Redemption (bps)

	Sales capped by *Outflows*			Sales capped by *Redemptions*		
Retail trade size	[t, t]	[t-1, t]	[t-2, t]	[t, t]	[t-1, t]	[t-2, t]
(\$0; \$10k)	203.31	190.05	181.78	197.98	183.61	175.08
[\$10k; \$25k)	186.02	172.75	164.49	180.68	166.32	157.82
[\$25k; \$50k)	177.73	164.45	156.18	172.39	158.01	149.50
[\$50k; \$100k)	167.87	154.61	146.33	162.53	148.15	139.63
(\$0; \$100k)	179.57	166.30	158.04	174.24	159.88	151.37

Panel B: VLC/TNA (bps)

	Sales capped by *Outflows*			Sales capped by *Redemptions*		
Retail trade size	[t, t]	[t-1, t]	[t-2, t]	[t, t]	[t-1, t]	[t-2, t]
(\$0; \$10k)	57.38	54.39	52.69	56.04	52.91	51.23
[\$10k; \$25k)	52.49	49.50	47.80	51.14	48.02	46.34
[\$25k; \$50k)	49.81	46.82	45.12	48.47	45.34	43.66
[\$50k; \$100k)	46.73	43.74	42.04	45.38	42.26	40.58
(\$0; \$100k)	50.32	47.33	45.62	48.97	45.85	44.16

4 Which Funds Create More Liquidity?

To understand which funds create more liquidity, Table 4 estimates regressions of the VLC/Redemptions ratio and its components on various fund characteristics that capture the fund's investor base, liquidity management tools, and portfolio holdings:

$$VLC_{f,t} = \alpha_t + \beta \cdot \textit{Fund characteristics}_{f,t-1} + \varepsilon_{f,t}, \qquad (3)$$

where f indexes funds and t indexes time in months. The results of these regressions trace out empirical correlations that may reflect both treatment and selection effects. For example, funds that are skilled at trade execution may choose to hold smaller cash buffers. Regression 3 includes month-date fixed effects to control for any time trends in liquidity creation and in fund characteristics; regression 3 therefore uses cross-sectional variation at a given point in time to estimate the relationship between liquidity creation and fund characteristics. In column 1, the dependent variable is the VLC/Redemptions ratio. In columns 2–4, the dependent variables are the three components of VLC/Redemptions ratio: flow netting, liquidity management, and trade execution.[7] Finally, to gain further insights into the drivers of cross-sectional variation in liquidity creation, columns 5–7

[7] The coefficients on a given explanatory variable across columns 2–4 do not necessarily add up to the coefficient in column 1 because VLC/Redemptions and its components are winsorized at the 1st and 99th percentiles.

report the results for the ratios of outflows and sales to redemptions, and for the markup difference, the difference in markups between retail- and institutional-size trades of bonds in the fund's portfolio. All continuous explanatory variables, except for *Outflows/Redemptions*, are standardized so that their coefficients represent the effect of a one standard deviation change.

The first two explanatory variables—share class HHI and flow autocorrelation—capture the characteristics of the fund's shareholder base and the nature of flows in and out of the fund. Funds that offer multiple share classes, and have lower share class HHI, are likely to have more diversified shareholder base that is subject to less correlated liquidity shocks. As a result, these funds should create more liquidity through *Flow netting*. We indeed find a very strong association between share class HHI and *Flow netting*: a one standard deviation increase in share class HHI is associated with 11.0 basis points less *Flow netting*. Interestingly, we also find that share class HHI is positively correlated with *Trade execution*, resulting in the net effect on VLC being small and only marginally statistically significant. It may be that funds that are skilled at trade execution find it less valuable to have a diversified shareholder base. To avoid costly trading, funds that are less skilled at trade execution create multiple share classes, which are meant to appeal to different investor clienteles that are subject to imperfectly correlated liquidity shocks. In contrast to share class HHI which has the strongest effect on flow netting, the main effect of flow autocorrelation is to impede a fund's ability to manage liquidity by drawing down cash buffers in response to outflows and building cash buffers back up using subsequent inflows. A one standard deviation increase in the autocorrelation of daily flows of about 0.16 is associated with 2.3 basis points smaller *Liquidity management*.

The next set of variables—cash ratio, share of bonds that are about to mature or be redeemed, lines of credit, and interfund lending programs—captures liquidity management tools at fund's disposal. Larger cash buffers are associated not only with greater *Liquidity management* but also with greater *Flow netting*. In fact, a one standard deviation increase in the cash ratio is associated with 5.6 basis points greater *Flow netting* and 3.3 basis points greater *Liquidity management*. Cash buffers may improve flow netting by reducing strategic complementarities between investors' withdrawal decisions (Chen, Goldstein, and Jiang, 2010; Goldstein, Jiang, and Ng, 2017). At the same time, cash buffers are associated with worse *Trade execution*, which offsets almost all of the positive effects of cash buffers on *Flow netting* and *Liquidity management*. The negative correlation between cash buffers and trade execution is likely to be due to a selection effect: funds that are skilled at trade execution choose to hold smaller cash buffers. Similarly to cash buffers, to-be-redeemed bond share, portfolio share of bonds within three months of maturity or early redemption, is correlated positively with *Liquidity management* and negatively with *Trade execution*. Interestingly, the to-be-redeemed bond share coefficient is very similar to the cash ratio coefficient in the liquidity management regression in column 3, but the cash ratio coefficient is almost three times larger than the to-be-redeemed bond share coefficient in the trade execution regression in column 4. This may be due to funds having greater control over the cash ratio. The to-be-redeemed bond share can be affected by issuers' decision to refund bonds early. In contrast to cash buffers, to-be-redeemed bond

Table 4
Which Funds Create More Liquidity?

This table reports the results of regressions of liquidity creation and its components on fund characteristics:

$$VLC_{f,t} = \alpha_t + \beta \cdot \textit{Fund characteristics}_{f,t-1} + \varepsilon_{f,t},$$

where f indexes funds and t indexes time in months. All continuous explanatory variables, except for *Outflows/Redemptions* are standardized so that their coefficients represent the effect of a one standard deviation change in the explanatory variables. Standard errors are adjusted for clustering by family and month-date. $*$, $**$, and $***$ indicate statistical significance at 10%, 5%, and 1%. $N = 45{,}089$.

		Components			Drivers		
	VLC/ Redemptions (1)	Flow netting (2)	Liquidity management (3)	Trade execution (4)	Outflows/ Redemptions (5)	Sales/ Redemptions (6)	Markup difference (7)
Share class $\text{HHI}_{f,t-1}$	−1.580*	−10.962***	1.737	7.483***	0.056***	0.005	−0.226
	(0.860)	(1.486)	(1.685)	(1.429)	(0.007)	(0.008)	(0.216)
Flow $\text{autocorrelation}_{f,t-3,t-1}$	−0.139	1.631**	−2.256***	0.459	−0.006*	0.005	0.164
	(0.368)	(0.651)	(0.831)	(0.657)	(0.003)	(0.003)	(0.108)
$\text{Cash/TNA}_{f,t-1}$	1.057*	5.555***	3.299***	−7.739***	−0.030***	−0.030***	0.671***
	(0.587)	(1.200)	(1.186)	(1.417)	(0.005)	(0.007)	(0.228)
To-be-redeemed bond $\text{share}_{f,t-1}$	1.028**	0.443	3.483***	−2.838***	−0.003	−0.021***	−0.349***
	(0.398)	(0.634)	(0.801)	(0.814)	(0.003)	(0.004)	(0.119)
Line of $\text{credit}_{f,t}$	−3.003**	−2.288	−3.577	2.997	0.003	0.020	0.062
	(1.450)	(2.744)	(2.879)	(2.586)	(0.011)	(0.013)	(0.390)
Interfund $\text{lending}_{f,t}$	−3.821*	−0.563	−4.920	1.904	−0.007	0.019	−0.515
	(2.056)	(4.288)	(4.286)	(3.825)	(0.020)	(0.018)	(0.471)
Short-term fund_f	−10.164***	−12.924**	7.407*	−4.994	0.030	−0.063**	0.768
	(3.757)	(5.280)	(4.062)	(4.508)	(0.028)	(0.026)	(0.966)
Single-state fund_f	1.211	−3.977	10.990***	−5.383*	0.022	−0.053***	−2.850***
	(1.516)	(3.052)	(2.530)	(2.746)	(0.015)	(0.014)	(0.512)
Portfolio $\text{HHI}_{f,t-1}$	1.336**	−4.595***	3.155*	2.448	0.025***	−0.005	0.105
	(0.648)	(1.546)	(1.681)	(2.028)	(0.009)	(0.009)	(0.333)
Average $\text{rating}_{f,t-1}$	12.903***	7.984***	1.085	3.563***	−0.010	−0.001	7.264***
	(1.159)	(1.928)	(1.960)	(1.172)	(0.009)	(0.008)	(0.481)
Unrated bond $\text{share}_{f,t-1}$	−0.437	5.745***	2.376*	−8.664***	−0.023***	−0.020***	2.177***
	(1.057)	(1.934)	(1.274)	(1.493)	(0.008)	(0.006)	(0.402)
GO bond $\text{share}_{f,t-1}$	−1.574*	−1.056	0.587	−1.123	−0.004	−0.002	0.663***
	(0.804)	(1.034)	(1.712)	(1.242)	(0.007)	(0.010)	(0.190)
Insured bond $\text{share}_{f,t-1}$	0.253	2.299	5.926***	−8.162***	−0.013*	−0.026***	−1.626***
	(1.214)	(2.164)	(2.078)	(1.740)	(0.007)	(0.009)	(0.319)
Exotic bond $\text{share}_{f,t-1}$	−12.402***	−7.311***	−3.557***	−1.490	0.007	0.008	−3.701***
	(0.678)	(1.206)	(1.314)	(1.199)	(0.006)	(0.007)	(0.242)
$\text{Ln(Bond age)}_{f,t-1}$	1.411*	−10.499***	11.248***	0.775	0.052***	−0.040***	0.540**
	(0.766)	(1.704)	(1.380)	(1.665)	(0.008)	(0.006)	(0.236)
$\text{Ln(Maturity)}_{f,t-1}$	25.418***	6.004***	6.628***	12.554***	0.028**	0.020*	4.650***
	(1.077)	(1.802)	(2.175)	(1.913)	(0.011)	(0.010)	(0.464)
Portfolio $\text{value/TNA}_{f,t-1}$	−0.799	−0.158	−4.554***	3.959***	0.001	0.022***	0.237
	(0.621)	(0.557)	(1.669)	(1.293)	(0.003)	(0.008)	(0.188)
$\text{Ln(Fund TNA)}_{f,t-1}$	3.556***	16.715***	−15.573***	2.573	−0.099***	0.050***	−0.662*
	(1.099)	(2.341)	(1.691)	(2.242)	(0.012)	(0.008)	(0.340)
$\text{Ln(Family TNA)}_{f,t-1}$	3.638***	3.903*	1.919	−2.191	−0.026**	−0.004	0.161
	(1.041)	(2.294)	(2.212)	(2.589)	(0.011)	(0.012)	(0.283)
$\text{Outflows/Redemptions}_{f,t}$						0.659***	
						(0.027)	
Adjusted R^2	0.67	0.44	0.20	0.17	0.42	0.30	0.68
Month-date FEs	✓	✓	✓	✓	✓	✓	✓

share is not correlated with *Flow netting*. The difference in the effects of cash buffers and to-be-redeemed bonds on *Flow netting* is potentially due to cash buffers being more salient to investors. While funds themselves and services like Morningstar report holdings of cash and equivalents, reporting of the share of bonds that are about to be paid off is much less salient. Finally, we do not find any evidence that lines of credit or interfund lending programs are associated with better *Liquidity management*. This may be because funds rarely utilize lines of credit or interfund lending programs. And to the extent that they do, funds may repay such borrowings quickly without waiting for inflows that would allow funds to avoid selling portfolio securities.

The next two variables—dummies for short-term and single-state funds—may proxy for both portfolio characteristics, and thus costs of trading, and for the fund's investor base. We find that short-term funds have 12.9 basis points smaller *Flow netting*. This may be due to investors in short-term funds being exposed to more correlated liquidity shocks or due to stronger strategic complementarities in their redemption decisions. At the same time, short-term funds have 7.4 basis points larger *Liquidity management*, marginally statistically significant at 10%.[8] Single-state funds have 11.0 basis points larger *Liquidity management*, but 5.4 basis points worse *Trade execution*. Overall single-state funds generate similar value of liquidity as national funds.

We next turn to the characteristics of bonds in the funds' portfolios. Bond characteristics are likely to have the strongest effect on trade execution since institutional investors like mutual funds are likely to have a differential advantage over retail investors in trading certain types of bonds. Bond characteristics may also affect the strategic complementarities in investor withdrawal decisions, which would affect a fund's flow netting. And by making it more or less costly to trade the underlying bonds, bond characteristics may also affect liquidity management. Long-maturity and lower rated bond shares are associated with better *Trade execution*, perhaps because institutional investors have a comparative advantage over retail investors in trading these types of bonds. Insured bond share, on the other hand, is negatively correlated with *Trade execution*, consistent with the idea that bond insurance narrows the differential in trading costs. Interestingly, unrated bond share is also negatively correlated with *Trade execution*, suggesting that mutual funds have smaller advantage in trading these bonds.

We find that *Flow netting* is negatively correlated with portfolio HHI and exotic bond share and is positively correlated with the average rating, unrated bond share, and maturity. Portfolio HHI and exotic bond share, which is the portfolio share of bonds that are not fixed rate, may negatively affect flow netting through greater strategic complementarities in investor withdrawal decisions. Knowing that the fund has a concentrated portfolio or holds a lot of exotic bonds that are likely to be costly to trade, investors may choose to withdraw early if they expect other investors to withdraw. It is also possible that investors who invest in funds that hold highly rated and shorter

[8] Note that the effect on liquidity management is after controlling for the near-maturity bond share that is strongly correlated with short-term funds.

maturity bonds are more sensitive to small changes in risk, including to the risk that other investors may withdraw, imposing their liquidation costs on the remaining investors.

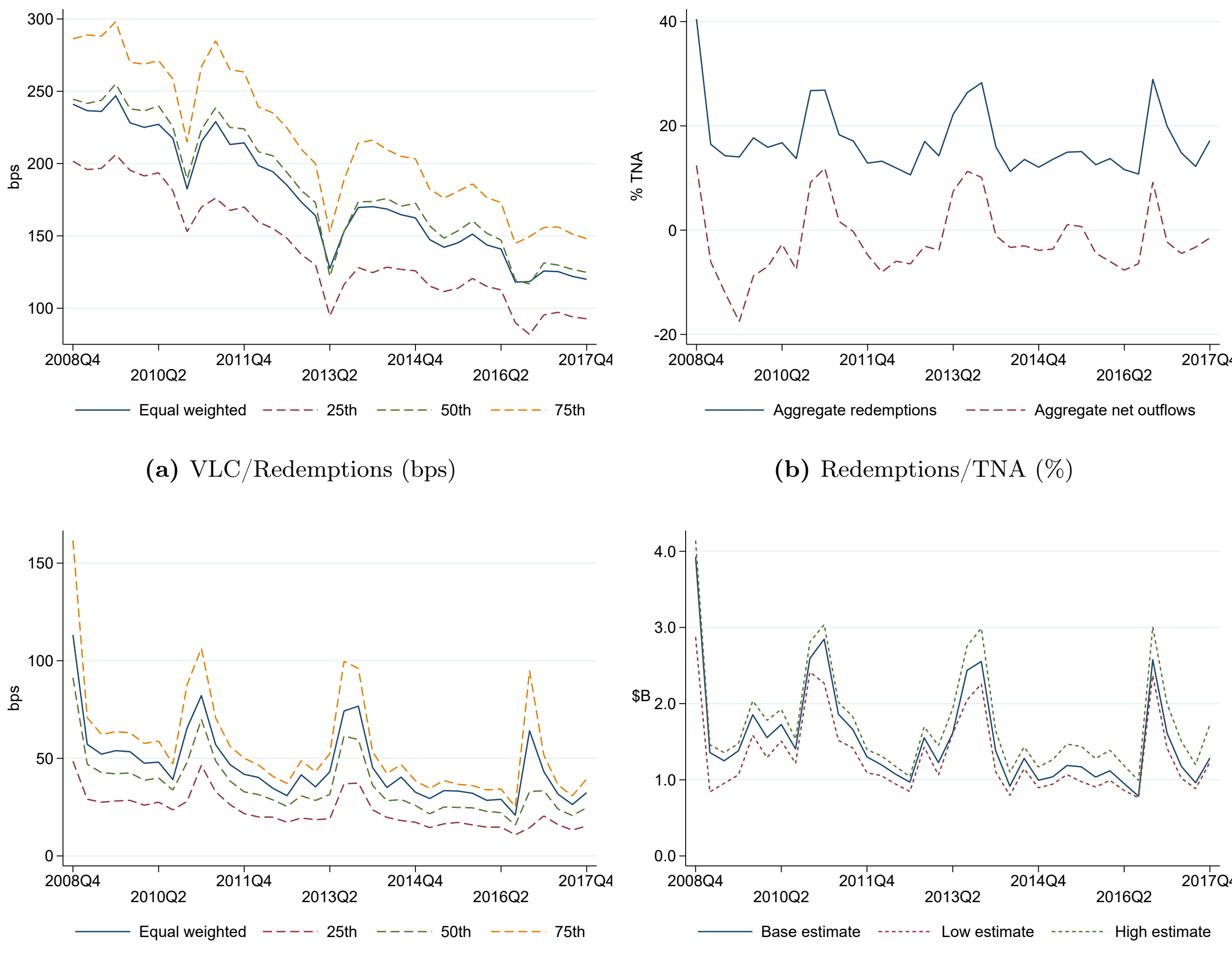
In column 3, we find that *Liquidity management* is positively correlated with bond age, maturity, and insured bond share and is negatively correlated with the exotic bond share. It is possible that during our sample period, older bonds and insured bonds are more likely to be refunded early. As a result, funds holding such bonds can avoid costly sales in response to redemption requests. While maturity is also positively correlated with *Liquidity management*, the effect of maturity works mostly through the *Markup difference* (column 7); maturity is essentially uncorrelated with the *Sales/Redemptions* ratio (column 6). The negative correlation between the exotic bond share and *Liquidity management* is also driven by the smaller *Markup difference*.

Finally, we control for the fund leverage (the ratio of portfolio value to TNA), the log TNA of the fund itself and of all municipal bond funds in the fund's family. Leverage is negatively correlated with *Liquidity management* and positively correlated with *Trade execution*. According to the results in column 1, a one standard deviation increase in fund size is associated with 3.6 basis points larger VLC/Redemptions ratio. The effect of fund size on liquidity creation is driven by flow netting and is partially offset by liquidity management. A one standard deviation increase in fund size is associated with 16.7 basis points larger *Flow netting*, but with 15.6 basis points smaller *Liquidity management*. Although we use share class HHI as a proxy for the concentration of fund's shareholder base, fund size is likely to contain incremental information. The negative effect on *Liquidity management* appears to be due to larger funds holding larger positions. Since transaction costs in the municipal bond market decline with trade size, large funds find trading in response to redemptions to be relatively cheaper and therefore have larger *Sales/Redemptions* ratios (column 6). At the same time, large and small funds report similar *Trade execution* (column 4), which is the product of the *Sales/Redemptions* ratio and the difference between the counterfactual markups that would have been incurred by retail investors and actual markups incurred by the fund. Finally, we find some suggestive evidence that larger fund families have somewhat larger *Flow netting*.

Overall, we find that fund and portfolio characteristics often times have different effects on the three components of liquidity creation. For example, while short-term funds generate less liquidity through flow netting, they trade less in response to outflows and therefore generate more liquidity through liquidity management. The strongest effects on the overall liquidity creation are due to the types of bonds funds invest in. Long-term funds that invest in lower rated bonds and do not invest in exotic bonds generate significantly more liquidity per dollar of redemptions. Larger funds and funds that are part of larger fund families also generate more liquidity, primarily thanks to greater flow netting.

5 Time Series of Liquidity Creation

We now turn to the time series variation in mutual fund liquidity creation. We start by plotting in Figure 1 various measures of liquidity creation over the 2008Q4–2017Q4 period. Subfigure (a) plots the mean as well as the 25th, 50th, and 75th percentiles of the VLC/Redemptions ratio. The ratio trends down from around 250 basis points in late 2008 to around 125 basis points in late 2017. The two sharp downward spikes in the VLC/Redemptions ratio occur in October–November 2010 and in May–June 2013. The former spike corresponds to investor concerns about the financial health of many local governments; the latter to the 2013 market tantrum.



(a) VLC/Redemptions (bps)

(b) Redemptions/TNA (%)

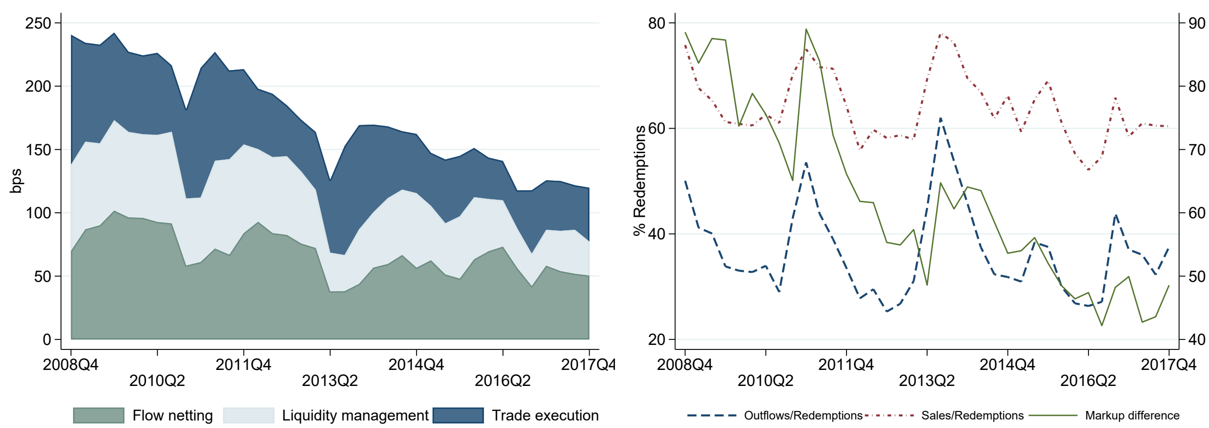
(c) VLC/TNA (bps)

(d) Aggregate VLC ($ billion)

Figure 1. Time series of liquidity creation. This figure plots the time series of annualized quarterly values of liquidity created by open-end municipal bond mutual funds. *VLC* is the difference between a) the dollar value of markups fund investors would have realized if they had directly sold municipal bonds with aggregate proceeds equal to the fund's gross redemptions and b) the the dollar value of markups on the fund's actual flow-induced sales. The sample period is August 2008–December 2017. High and low VLC estimates are calculated from Table 3.

Subfigure (b) plots aggregate gross redemptions and net outflows, defined as the negative of net fund flows. Annualized gross redemptions average around 17.5% of TNA, but are high during the 2008 financial crisis, late 2010, the 2013 market tantrum, and in November–December 2016, following the 2016 presidential election. Subfigures (c) and (d) show that despite the declines in the efficiency with which funds generate liquidity, the VLC/Redemptions ratio, increases in aggregate redemptions are associated with more liquidity created in dollar terms and relative to fund TNA.

Figure 2 shows that while all three components of liquidity creation decline over time, they behave differently during periods of market turmoil. Not surprisingly aggregate outflows are associated with less *Flow netting* and *Liquidity management*. Even if funds use their cash buffers to meet the first wave of redemptions, unless they start to receive net inflows, funds will have to sell in response to subsequent outflows. Declines in *Flow netting* and *Liquidity management* are somewhat offset by increases in *Trade execution*: funds' advantage over retail investors in the cost of trading gets stronger during periods of market turmoil. Subfigure (b) provides additional evidence by showing spikes in the *Outflows/Redemptions* and *Sales/Redemptions* ratios.



(a) Components

(b) Drivers

Figure 2. VLC components over time. This figure plots the time series of quarterly value of liquidity creation components. *VLC* is decomposed, according to equation 2, into three components: 1) flow netting, 2) liquidity management, and 3) trade execution. The sample period is August 2008–December 2017.

Table 5 provides more formal statistical evidence on the time trend in liquidity creation. We report the results of regressions of liquidity creation on a time trend and fund characteristics. Standard errors are adjusted for clustering by fund family and month-date. Column 1 and 2 shows that the VLC/TNA and VLC/Redemptions ratios decline by about 0.4 and 1.1 basis points per month. Over the whole sample period, VLC/Redemptions declines by more than 120 basis points. Columns 3–5 show that flow netting, liquidity management, and trade execution contribute about 0.4, 0.2, and 0.5 basis points per month. In columns 6 and 7, the dependent variables are the ratios

Table 5
Time Trend in Mutual Fund Liquidity Creation

This table reports the results of regressions of a fund's liquidity creation and its components on time variable:

$$VLC_{f,t} = \alpha + \beta \cdot \mathit{Time}_t + \gamma' \mathbf{X}_{f,t-1} + \varepsilon_{f,t},$$

where f indexes funds and t indexes time in months. All continuous explanatory variables, except for *Outflows/Redemptions* are standardized so that their coefficients represent the effect of a one standard deviation change in the explanatory variables. Same fund-level controls as in Table 4 are included in all regressions but not reported for brevity. Standard errors are adjusted for clustering by family and month-date. $*$, $**$, and $***$ indicate statistical significance at 10%, 5%, and 1%. $N = 45,089$.

			Components			Drivers		
	VLC/ TNA (1)	VLC/ Redemptions (2)	Flow netting (3)	Liquidity management (4)	Trade execution (5)	Outflows/ Redemptions (6)	Sales/ Redemptions (7)	Markup difference (8)
Time trend	−0.432***	−1.086***	−0.387***	−0.222***	−0.479***	−0.000	−0.000**	−0.414***
	(0.108)	(0.061)	(0.071)	(0.046)	(0.056)	(0.000)	(0.000)	(0.021)
Adjusted R^2	0.05	0.60	0.38	0.18	0.13	0.37	0.28	0.59
Controls	✓	✓	✓	✓	✓	✓	✓	✓

of *Outflows* and *Sales* to *Redemptions*. There is no meaningful time trend in these ratios; although the coefficient in column 7 is statistically significant, its magnitude is very small. Column 8 shows that the markup difference between retail- and institutional-size trades in portfolio bonds declines by about 0.4 basis points per month. The decline in the markup difference is then the main driver of the decline in mutual fund liquidity creation.[9]

5.1 Liquidity creation and market conditions

Figures 1 and 2 suggest that the dollar value of liquidity creation and VLC/TNA spike during periods of market turmoil and of aggregate outflows from municipal bond mutual funds while funds' ability to create liquidity per dollar of redemptions, VLC/Redemptions, declines. We next look more closely at how liquidity creation varies with market conditions. Table 6 reports the results of regressions of liquidity creation on aggregate monthly net outflows from municipal bond mutual funds and the monthly average of the CBOE Volatility Index (VIX). Aggregate net outflows are the negative of the sum of net flows across all open-end municipal bond funds. Aggregate net outflows during the month are scaled by lagged aggregate TNA. All continuous explanatory variables are standardized so that the coefficients can be interpreted as capturing the effect of a one standard deviation change in the explanatory variables.

Columns 1 and 2 of Table 6 show that aggregate net outflows are associated with opposite effects on the VLC/TNA and VLC/Redemptions ratios. While aggregate outflows are associated with less liquidity created per dollar of redemptions (column 2), aggregate outflows are associated with more liquidity created per dollar of TNA (column 1). The effects are large. A one standard deviation increase in aggregate net outflows is associated with 5.0 basis points lower VLC/Redemptions ratio and with 18.6 basis points higher VLC/TNA ratio.

The negative effect of aggregate net outflows flows on VLC/Redemptions is driven by the *Flow netting* and *Liquidity management* components and is partially offset by stronger *Trade executions*. A one standard deviation increase in aggregate net outflows is associated with 12.2 basis points smaller *Flow netting*, 3.2 basis points smaller *Liquidity management*, and 10.4 basis points larger *Trade execution*. The latter effect captures the fact that funds have an even greater advantage over retail investors during stressed market conditions.

To summarize, the results in Table 6 indicate that while the efficiency with which funds are able to generate liquidity decreases during periods of aggregate outflows, the overall value of liquidity created increases sharply because of large investor redemptions. Researchers and policymakers need to be careful when evaluating the overall effects of large outflows from municipal bond funds during

[9] The decline in the markup difference itself is driven by the decline in the markup on retail-size trades. This is likely thanks to increased transparency in the municipal bond market, in part due to the dissemination of price information through EMMA (Cuny, 2018) and through ETF holdings (Doan, 2021).

Table 6
Liquidity Creation and Market Conditions

This table reports the results of regressions of a fund's liquidity creation on market conditions:

$$VLC_{f,t} = \alpha + \delta \cdot Time_t + \beta \cdot Market\ conditions_t + \eta' \mathbf{X}_{f,t} + \varepsilon_{f,t},$$

where f indexes funds and t indexes time in months. All continuous explanatory variables, except for *Outflows/Redemptions* are standardized so that their coefficients represent the effect of a one standard deviation change in the explanatory variables. Same fund-level controls as in Table 4 are included in all regressions but not reported for brevity. Standard errors are adjusted for clustering by family and month-date. $*$, $**$, and $***$ indicate statistical significance at 10%, 5%, and 1%. $N = 45,089$.

			Components			Drivers		
	VLC/ TNA (1)	VLC/ Redemptions (2)	Flow netting (3)	Liquidity management (4)	Trade execution (5)	Outflows/ Redemptions (6)	Sales/ Redemptions (7)	Markup difference (8)
Time trend	−0.146	−0.989***	−0.334***	−0.226***	−0.430***	−0.000*	−0.000	−0.397***
	(0.125)	(0.084)	(0.070)	(0.053)	(0.059)	(0.000)	(0.000)	(0.031)
Aggregate net outflows$_t$	18.560***	−5.006**	−12.156***	−3.212***	10.376***	0.054***	0.033***	1.346
	(3.318)	(2.195)	(1.499)	(0.997)	(1.569)	(0.005)	(0.005)	(0.833)
VIX$_t$	17.269*	4.516	1.276	−0.578	3.844**	−0.001	0.010**	1.058
	(8.797)	(3.681)	(2.032)	(1.060)	(1.934)	(0.006)	(0.005)	(0.930)
Adjusted R^2	0.11	0.60	0.42	0.19	0.15	0.41	0.29	0.59
Controls	✓	✓	✓	✓	✓	✓	✓	✓

periods of market turmoil. While large outflows may force funds to sell bonds at fire-sale prices, mutual funds still create a lot of liquidity for their investors. The question is what share of aggregate outflows can be attributed to strategic complementarities among investors and what share can be attributed to the underlying liquidity shocks that would have caused investors to sell bonds if they were to hold municipal bonds directly.

5.2 Liquidity creation, market conditions, and fund characteristics

In this section, we investigate how the effect of market conditions, aggregate net outflows in particular, on mutual fund liquidity creation varies in the cross section of funds. Are certain funds better able to continue to generate liquidity during periods of aggregate net outflows? We might expect the cash-to-assets ratio, for example, to have a stronger effect on liquidity creation during stressed market conditions than during normal times. Table 7 reports the results of regressions of mutual fund liquidity creation on the interaction between aggregate net outflows from municipal bond funds and fund characteristics. All continuous explanatory variables, except for *Outflows/Redemptions* in column 6, are standardized to have zero mean and standard deviation equal to one so that the coefficients can be interpreted as the effect of a one standard deviation change in the explanatory variables. While our emphasis is on understanding how much liquidity funds create per dollar of redemptions, i.e., the VLC/Redemptions ratio, for consistency with the rest of our time series analyses, we also report the results for the VLC/TNA ratio.

Aggregate net outflows are associated with significantly less flow netting, in particular by large funds, funds with less concentrated shareholder base (lower share class HHI), funds with larger cash buffers, and funds that hold lower rated and longer maturity bonds. While larger funds tend to have greater *Flow netting*, their advantage in netting flows is weakened during periods of aggregate net outflows. The interaction between aggregate net outflows and fund size is -2.878, or almost one fifth of the direct effect of fund size of 16.350. Aggregate net ouflows also weaken the ability of funds with diversified shareholder base to net flows. The interaction of aggregate net outflows and share class HHI is 2.100, about one fifth of the magnitude of the coefficient on share class HHI itself of -10.896. When investors in the aggregate choose to withdraw from municipal bond funds, having lower share class HHI makes less difference to net outflows. While cash is positively correlated with *Flow netting*, the effect of cash gets weaker with aggregate net outflows. It appears that during stressed market conditions, cash buffers are just not large enough to mitigate strategic complementarities in investor redemption decisions. Strategic complementarities are likely to be stronger for funds holding lower rated and longer maturity bonds. These bonds are exposed to more credit and interest rate risk and are costlier to trade. Aggregate net outflows weaken the ability of funds holding these bonds to net flows.

While aggregate net outflows have no direct effect on *Liquidity management*, they improve *Liquidity management* of large funds and those with large cash buffers and decrease *Liquidity man-*

Table 7
Interaction between Market Conditions and Fund Characteristics

This table reports the results of regressions of mutual fund liquidity creation on the interaction between market conditions and fund characteristics:

$$VLC_{f,t} = \alpha + \delta \cdot t + \beta \cdot \textit{Market conditions}_t + \gamma \cdot \textit{Market conditions}_t \times X_{f,t} + \eta' \mathbf{X}_{f,t} + \varepsilon_{f,t},$$

where f indexes funds and t indexes time in months. All continuous explanatory variables, except for *Outflows/Redemptions* are standardized so that their coefficients represent the effect of a one standard deviation change in the explanatory variables. Standard errors are adjusted for clustering by family and month-date. $*$, $**$, and $***$ indicate statistical significance at 10%, 5%, and 1%. $N = 45,089$.

			Components			Drivers		
	VLC/ TNA	VLC/ Redemptions	Flow netting	Liquidity management	Trade execution	Outflows/ Redemptions	Sales/ Redemptions	Markup difference
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Time trend	−0.161	−0.981***	−0.340***	−0.225***	−0.417***	−0.000	−0.000	−0.391***
	(0.109)	(0.086)	(0.071)	(0.052)	(0.059)	(0.000)	(0.000)	(0.031)
Aggregate net outflows$_t$	19.413***	−3.761*	−13.523***	−0.759	10.670***	0.061***	0.026***	1.312*
	(4.876)	(2.159)	(1.614)	(1.787)	(1.883)	(0.006)	(0.009)	(0.741)
VIX$_t$	16.644**	4.721	0.963	−0.625	4.419**	0.002	0.013**	1.329
	(8.054)	(3.537)	(1.919)	(1.107)	(1.881)	(0.005)	(0.005)	(0.981)
Agg. net outflows$_t\times$ Share class HHI$_{f,t-1}$	−1.550	0.096	2.100***	−1.714***	−0.233	−0.010***	0.005	0.086
	(1.550)	(0.444)	(0.550)	(0.624)	(0.675)	(0.003)	(0.003)	(0.100)
Agg. net outflows$_t\times$ Flow autocorrelation$_{f,t-3,t-1}$	−0.654	1.073	−0.158	−0.048	1.266**	0.003	0.003	0.484**
	(2.623)	(0.648)	(0.600)	(0.764)	(0.622)	(0.002)	(0.003)	(0.230)
Agg. net outflows$_t\times$ Cash/TNA$_{f,t-1}$	3.013	1.062**	−1.960***	2.081***	0.904	0.007***	−0.009**	0.107
	(2.215)	(0.518)	(0.479)	(0.771)	(0.713)	(0.002)	(0.004)	(0.146)
Agg. net outflows$_t\times$ To-be-redeemed bond share$_{f,t-1}$	−0.705	−0.305	−0.050	0.069	−0.370	0.000	−0.001	0.118
	(0.816)	(0.443)	(0.422)	(0.636)	(0.552)	(0.002)	(0.003)	(0.138)
Agg. net outflows$_t\times$ Line of credit$_{f,t}$	0.122	0.538	2.065*	−0.198	−1.418	−0.006	−0.003	−0.268
	(2.421)	(0.938)	(1.185)	(1.441)	(1.517)	(0.005)	(0.006)	(0.172)
Agg. net outflows$_t\times$ Interfund lending$_{f,t}$	−4.115	0.657	1.652	−0.553	−0.448	−0.008	0.001	0.197
	(6.245)	(0.903)	(1.435)	(1.524)	(1.458)	(0.006)	(0.007)	(0.169)
Agg. net outflows$_t\times$ Short-term fund$_f$	−2.643	−2.163*	1.967	1.771	−6.010***	−0.008	−0.015	−0.398
	(6.515)	(1.110)	(1.630)	(1.687)	(1.855)	(0.009)	(0.010)	(0.561)
Agg. net outflows$_t\times$ Single-state fund$_f$	1.663	−2.054***	−0.389	−3.209**	1.444	0.001	0.014**	0.240
	(2.648)	(0.520)	(1.093)	(1.243)	(1.450)	(0.005)	(0.006)	(0.199)
Agg. net outflows$_t\times$ Portfolio HHI$_{f,t-1}$	−3.143	1.287**	2.551***	1.927	−3.032***	−0.015***	−0.013**	−0.234
	(4.082)	(0.556)	(0.912)	(1.499)	(1.099)	(0.004)	(0.005)	(0.144)
Agg. net outflows$_t\times$ Average rating$_{f,t-1}$	−0.419	−0.720	−2.186**	0.956	0.561	0.004	−0.003	0.678**

(Continued)

Table 7—*continued*

			Components			Drivers		
	VLC/ TNA (1)	VLC/ Redemptions (2)	Flow netting (3)	Liquidity management (4)	Trade execution (5)	Outflows/ Redemptions (6)	Sales/ Redemptions (7)	Markup difference (8)
	(2.164)	(1.166)	(0.968)	(1.056)	(1.113)	(0.004)	(0.004)	(0.333)
Agg. net outflows$_t \times$ Unrated bond share$_{f,t-1}$	3.449*	−0.802	−1.017	0.601	−0.367	−0.001	−0.005	−0.584
	(1.992)	(1.569)	(1.025)	(0.887)	(0.904)	(0.004)	(0.003)	(0.415)
Agg. net outflows$_t \times$ GO bond share$_{f,t-1}$	−2.109	0.010	0.075	0.898*	−1.024*	0.002	−0.002	0.301**
	(1.700)	(0.452)	(0.382)	(0.539)	(0.574)	(0.002)	(0.003)	(0.144)
Agg. net outflows$_t \times$ Insured bond share$_{f,t-1}$	−0.221	−0.450	−0.008	−0.487	−0.034	−0.006	−0.004	−0.353
	(1.648)	(1.397)	(0.913)	(0.863)	(1.038)	(0.004)	(0.004)	(0.423)
Agg. net outflows$_t \times$ Exotic bond share$_{f,t-1}$	−1.074	0.580	1.629***	−0.050	−0.994	−0.002	−0.001	−0.170
	(1.728)	(0.384)	(0.380)	(0.671)	(0.604)	(0.003)	(0.003)	(0.131)
Agg. net outflows$_t \times$ Ln(Bond age)$_{f,t-1}$	0.694	2.101***	1.667**	0.357	0.125	−0.003	−0.001	0.404**
	(2.089)	(0.557)	(0.712)	(0.857)	(0.631)	(0.003)	(0.003)	(0.182)
Agg. net outflows$_t \times$ Ln(Maturity)$_{f,t-1}$	3.446	−3.381***	−3.069***	0.371	−0.778	0.008**	−0.005	−0.399
	(3.267)	(0.746)	(0.876)	(0.851)	(1.148)	(0.004)	(0.005)	(0.522)
Agg. net outflows$_t \times$ Portfolio value/TNA$_{f,t-1}$	−0.738	−0.511*	0.290	−1.961***	1.197*	−0.001	0.010***	0.113
	(0.751)	(0.283)	(0.272)	(0.672)	(0.609)	(0.001)	(0.003)	(0.161)
Agg. net outflows$_t \times$ Ln(Fund TNA)$_{f,t-1}$	0.271	0.780	−2.878***	2.570***	1.169	0.009**	−0.007**	−0.111
	(1.922)	(0.729)	(0.767)	(0.844)	(0.975)	(0.003)	(0.003)	(0.183)
Agg. net outflows$_t \times$ Ln(Family TNA)$_{f,t-1}$	1.190	0.337	−1.462*	−1.357	3.110***	0.007***	0.006	0.204**
	(1.623)	(0.430)	(0.754)	(0.895)	(1.009)	(0.003)	(0.004)	(0.093)
Share class HHI$_{f,t-1}$	−5.015***	−1.371*	−10.896***	1.774	7.590***	0.056***	0.005	−0.136
	(1.264)	(0.822)	(1.473)	(1.673)	(1.434)	(0.007)	(0.008)	(0.229)
Flow autocorrelation$_{f,t-3,t-1}$	−1.270	0.744	2.396***	−2.371***	0.683	−0.008**	0.007**	0.542***
	(3.808)	(0.552)	(0.691)	(0.779)	(0.628)	(0.003)	(0.003)	(0.202)
Cash/TNA$_{f,t-1}$	4.426***	1.173**	5.669***	3.603***	−8.036***	−0.031***	−0.031***	0.568**
	(1.122)	(0.585)	(1.139)	(1.180)	(1.414)	(0.005)	(0.007)	(0.234)
To-be-redeemed bond share$_{f,t-1}$	0.069	1.226**	0.582	4.414***	−3.707***	−0.003	−0.026***	−0.674***
	(0.576)	(0.502)	(0.705)	(0.923)	(0.945)	(0.003)	(0.005)	(0.177)
Line of credit$_{f,t}$	2.195	−3.475**	−2.082	−4.104	2.855	0.002	0.022*	0.046
	(2.209)	(1.518)	(2.785)	(2.859)	(2.618)	(0.011)	(0.013)	(0.451)
Interfund lending$_{f,t}$	−1.222	−3.775*	−0.496	−5.225	2.178	−0.006	0.022	−0.281
	(4.577)	(1.957)	(4.176)	(4.212)	(3.685)	(0.019)	(0.018)	(0.431)
Short-term fund$_f$	6.811	−9.557***	−12.508**	7.403*	−4.795	0.028	−0.063**	0.805
	(4.519)	(3.544)	(5.177)	(4.012)	(4.437)	(0.028)	(0.026)	(0.828)

(Continued)

Table 7—*continued*

			Components			Drivers		
	VLC/ TNA	VLC/ Redemptions	Flow netting	Liquidity management	Trade execution	Outflows/ Redemptions	Sales/ Redemptions	Markup difference
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Single-state fund$_f$	−9.620***	0.786	−3.696	11.281***	−6.376**	0.020	−0.056***	−3.390***
	(2.091)	(1.581)	(3.021)	(2.554)	(2.678)	(0.015)	(0.014)	(0.527)
Portfolio HHI$_{f,t-1}$	−0.817	1.346	−6.334***	3.298	3.936*	0.035***	−0.002	0.276
	(2.699)	(0.923)	(1.719)	(2.003)	(2.127)	(0.010)	(0.011)	(0.386)
Average rating$_{f,t-1}$	6.812***	14.775***	8.733***	2.437	3.322**	−0.010	−0.006	7.118***
	(1.794)	(2.003)	(1.995)	(2.001)	(1.304)	(0.008)	(0.008)	(0.535)
Unrated bond share$_{f,t-1}$	2.103	−2.570	5.214**	0.869	−8.751***	−0.024***	−0.016**	2.575***
	(1.640)	(2.294)	(2.025)	(1.524)	(1.640)	(0.008)	(0.007)	(0.580)
GO bond share$_{f,t-1}$	−0.913	−1.380	−0.880	0.940	−1.456	−0.004	−0.004	0.506**
	(1.068)	(0.887)	(1.038)	(1.779)	(1.276)	(0.007)	(0.010)	(0.202)
Insured bond share$_{f,t-1}$	−1.957	−0.274	2.276	5.052**	−7.796***	−0.014**	−0.022**	−1.267***
	(1.628)	(1.375)	(2.203)	(2.108)	(1.744)	(0.007)	(0.009)	(0.326)
Exotic bond share$_{f,t-1}$	−3.302***	−12.439***	−7.387***	−3.725***	−1.276	0.007	0.009	−3.531***
	(0.985)	(0.671)	(1.169)	(1.219)	(1.134)	(0.006)	(0.007)	(0.276)
Ln(Bond age)$_{f,t-1}$	−2.312	2.166***	−10.637***	11.488***	1.436	0.055***	−0.039***	0.912***
	(1.664)	(0.743)	(1.665)	(1.418)	(1.706)	(0.007)	(0.006)	(0.261)
Ln(Maturity)$_{f,t-1}$	3.766*	25.590***	6.224***	6.812***	12.324***	0.027**	0.018*	4.585***
	(1.989)	(1.061)	(1.812)	(2.152)	(1.924)	(0.011)	(0.010)	(0.438)
Portfolio value/TNA$_{f,t-1}$	0.260	−1.286**	−0.151	−6.183***	5.121***	0.000	0.030***	0.452*
	(1.219)	(0.560)	(0.731)	(1.431)	(1.370)	(0.003)	(0.007)	(0.270)
Ln(Fund TNA)$_{f,t-1}$	−3.155**	2.724**	16.350***	−16.148***	2.659	−0.098***	0.052***	−0.843**
	(1.340)	(1.198)	(2.321)	(1.809)	(2.276)	(0.012)	(0.008)	(0.347)
Ln(Family TNA)$_{f,t-1}$	1.416	3.544***	3.855*	2.225	−2.534	−0.026**	−0.006	0.038
	(1.777)	(1.060)	(2.286)	(2.278)	(2.595)	(0.011)	(0.012)	(0.276)
Outflows/Redemptions$_{f,t}$							0.667***	
							(0.026)	
Constant	62.851***	235.344***	91.728***	59.935***	82.978***	0.651***	−0.017	86.807***
	(5.015)	(5.912)	(6.212)	(4.634)	(6.114)	(0.026)	(0.019)	(2.139)
Adjusted R^2	0.12	0.61	0.44	0.19	0.16	0.42	0.29	0.59

agement of funds employing leverage. The interaction between aggregate net outflows and fund size is 2.570, or about 16% of the magnitude of the direct effect of fund size of -16.148. The interaction between aggregate net outflows and the cash-to-assets ratio is 2.081 or almost 60% of the coefficient on cash itself. Thus cash buffers are particularly valuable for liquidity management during stressed market conditions. Leverage, or the portfolio value/TNA ratio, on the other hand, impairs *Liquidity management*. The coefficient on the interaction of aggregate net outflows and leverage is -1.961, or about one third of the direct effect of -6.183. We do not find any evidence that aggregate net outflows affect the relationship between a fund's flow autocorrelation and its *Liquidity management*.

Aggregate net outflows improve *Trade execution* of funds that belong to large families and worsen *Trade execution* of short-term funds and funds with concentrated portfolios. Significant positive interaction between aggregate net outflows and family size is interesting considering that we find no direct effect of family size. The negative interaction between aggregate net outflows and portfolio HHI suggests that the flexibility in terms of which bonds to trade is valuable in bad times but not necessarily in good times.

Overall the results in Table 7 indicate that aggregate net outflows have heterogeneous effects on mutual funds liquidity creation. Aggregate net outflows erode the advantage large funds and funds with diversified shareholder base generally enjoy in *Flow netting*. Aggregate net outflows also strengthen the importance of fund size, cash buffers, and leverage for *Liquidity management*. Finally, aggregate net outflows give larger fund families an advantage in *Trade execution*.

6 Aggregate VLC

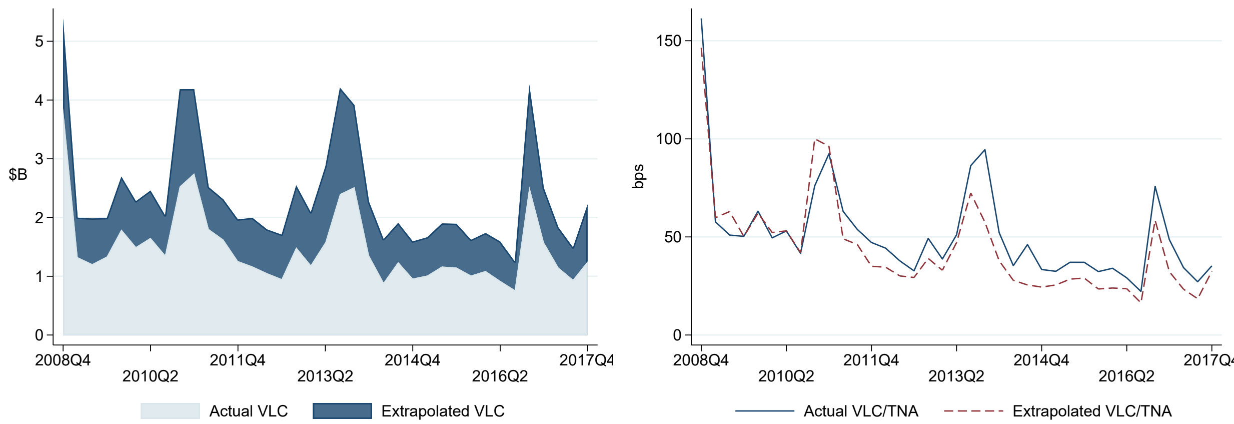
Our estimates of aggregate VLC reported in Figure 1 are biased downwards because our measure of liquidity creation relies on the availability of daily flows in Morningstar and monthly redemptions in N-SAR.[10] Appendix Figure B1 shows that the share of open-end municipal bond funds for which we cannot calculate VLC increases from 17% in 2008Q4 to 37% in 2017Q4. Because funds with missing VLC tend to be larger, they account for almost 50% of aggregate TNA of municipal bond funds.[11] Although it may be tempting to simply double our estimates of aggregate VLC to account for funds with missing VLC, doing so assumes that missing funds are similar to our sample funds.

Even though we do not observe actual VLC for funds without daily flows, we can estimate their VLC/Redemptions ratio using their characteristics and the cross-sectional estimates in Table 4. We first have to make one modification to the specifications in Table 4 however. Because we do not observe daily flows, we re-estimate our cross-sectional regressions without flow autocorrelation.

[10] Missing daily flows data account for 70–80% of all observations with missing VLC.

[11] Some large funds families, such as Fidelity, T Rowe Price, Vanguard, and Putnam, do not have daily flows reported in Morningstar for either all or almost all of their open-end municipal bond funds.

Multiplying the estimated VLC/Redemptions ratio by the fund's monthly redemptions reported on form N-SAR, we estimate the fund's dollar VLC. For a small number of funds without N-SAR redemptions, we estimate monthly redemptions using the average Redemptions/TNA ratio of all muni funds in the same month.



(a) Aggregate VLC ($ billion) **(b)** VLC/TNA (bps)

Figure 3. Time series of extrapolated liquidity creation. This figure plots the time series of annualized quarterly values of actual versus extrapolated liquidity created by open-end municipal bond mutual funds. For funds without VLC, VLC/redemptions ratio is extrapolated from monthly cross sectional regressions from Table 4. Liquidity creation, in dollar amount, is calculated from extrapolated VLC/Redemptions ratio and either fund-specific N-SAR monthly redemption, or monthly average redemption-to-TNA ratio, if the former is missing. The sample period is August 2008–December 2017.

Figure 3 plots the time series of annualized quarterly VLC by all open-ended municipal bond mutual funds. When we include funds with extrapolated VLC, aggregate VLC increases by about 60%. Aggregate VLC over the whole 10-year sample period is $22 billion, compared to our baseline estimate of $14 billion.

7 Conclusion

By investing in illiquid assets while offering daily redemption at the end-of-day net asset value, open-end mutual funds engage in liquidity transformation similarly to commercial banks. The literature lacks however good quantitative measures of mutual fund liquidity creation. In this paper, we introduce a novel measure that captures the dollar value of liquidity services created by open-end mutual funds. Our measure compares the markups incurred by funds when trading to satisfy investor redemptions with the hypothetical markups investors would have incurred if they had invested and traded directly.

Applying this measure to municipal bond funds, we find that over the 2008–2017 period, funds created $1.4 billion in liquidity services per year, or $2.2 billion if extrapolating to all active open-end muni funds. On average, funds create 180 basis points of liquidity services per dollar of gross redemptions. About 69 basis points of liquidity creation is due to flow netting, 52 basis points is due to liquidity management, and 58 basis points is due to trade execution. We study the cross-sectional and time-series determinants of mutual fund liquidity creation, shedding new light on how funds manage and create liquidity.

Large outflows from open-end mutual funds during the early stages of the COVID-19 pandemic have once again called attention to the financial fragility of open-end mutual funds. While there has understandably been much interest in studying the financial fragility of mutual funds, our paper quantifies the bright side—the large dollar value of liquidity services provided by mutual funds. It also shows that even at times of market distress, mutual funds continue to create liquidity for their investors.

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Appendix A: Variable Definitions

Table A1
Variable Definitions

Variable	**Definition**
VLC	Value of liquidity created by a fund, defined as the difference between a) the hypothetical dollar markup fund investors would have incurred if they had sold individual municipal bonds and b) the total dollar markup on the fund's actual flow-induced sales. For each bond held by the fund on the last reporting date, we measure the markups realized on retail-size trades (with par values of less than \$100,000) on each trading day during month t. We calculate the average percentage markup across all bonds traded on each day and multiply with daily redemption from equation 1. Aggregating all daily markups within a month yields VLC in dollar amount.
Flow netting	Value of liquidity creation, in basis points, attributed to the netting of daily redemptions and subscriptions: $\left(1 - \frac{Outflows}{Redemptions}\right) \times \%Markup_c$, where $\%Markup_c$ is the markup on the counterfactual retail-size trades that fund investors would have engaged in if they had invested directly in the municipal bonds held by the fund.
Liquidity management	Value of liquidity creation, in basis points, attributed to fund liquidity management allowing funds to meet outflows without engaging in flow-induced sales: $\frac{Outflows-Sales}{Redemptions} \times \%Markup_c$, where $\%Markup_c$ is the markup on the counterfactual retail-size trades that fund investors would have engaged in if they had invested directly in the municipal bonds held by the fund.
Trade execution	Value of liquidity creation, in basis points, attributed to fund's superior trade execution: $\frac{Sales}{Redemptions}\Delta\%Markup_{c,a}$, where $\Delta\%Markup_{c,a}$ is the difference in markups between the counterfactual retail-size trades that fund investors would have engaged in if they invested directly in the municipal bonds held by the fund and the markup on the fund's actual flow-induced sales.
Redemptions	Gross redemptions during the month, as reported on the SEC Form N-SAR and extracted from Morningstar Direct. Redemptions are scaled by lagged TNA and expressed in percentage points.
Outflows	The absolute sum of daily flows on days with negative net daily flows during the month. Outflows are scaled by lagged TNA and expressed in percentage points.
Sales	Dollar value of flow-induced sales is the minimum of a) all holdings-implied sales matched to MSRB trade data and b) monthly *Outflows*.
Markup difference	Value-weighted difference in markups between retail- and institutional-size trades of bonds in a fund's portfolio. Retail-size trades are all trades with par values of less than \$100,000. Institutional-size trades are all trades with par value of at least \$100,000.
Fund characteristics	
Share class HHI	Concentration of fund TNA across share classes. Monthly share class-level TNA is from Morningstar.
Flow autocorrelation	First-order autocorrelation of daily flows, estimated over months $t-3$ to $t-1$, requiring at least 20 observations.

Continued

Table A1—*continued*

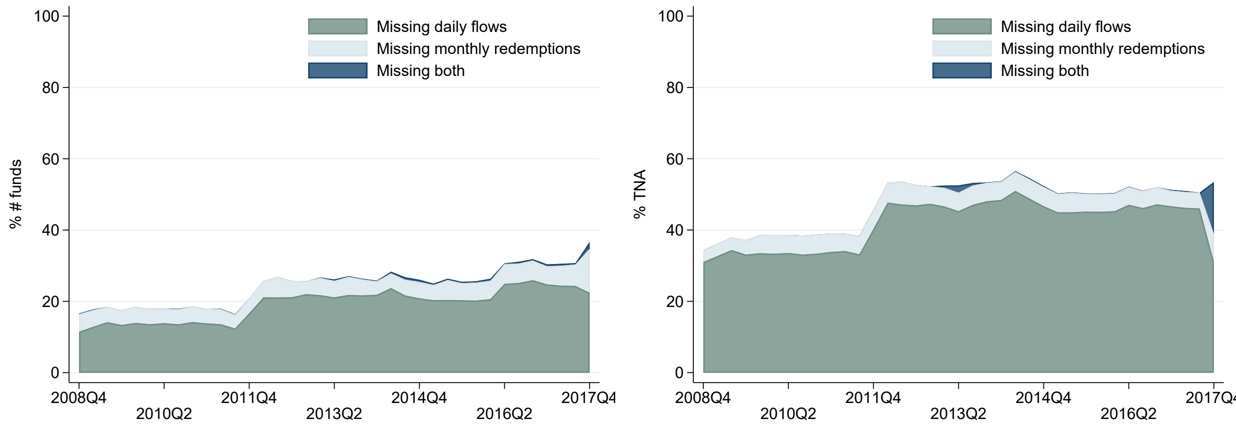
Variable	Definition
Cash/TNA	The ratio of cash & cash equivalents to fund's TNA as of the last reporting date before the bond sale. Cash equivalents include money market mutual funds, repo, commercial paper, T-Bills, agency and municipal debt securities with original maturity of less than one year, and variable rate demand notes (VRDNs). Cash ratio is winsorized at the 99th percentile.
To-be-redeemed bond share	Aggregate value of municipal bonds, scaled by fund TNA, that are within three months before their maturity or any redemption date as of the last portfolio holding reporting date. Maturity dates and redemption schedules are from Mergent. Cash & cash equivalents are excluded.
Line of credit	Binary variable equal to one if the fund had bank loans or overdrafts greater than 1% of TNA at any point during the overlapping semi-annual reporting period from Form N-SAR.
Interfund lending	Binary variable equal to one for funds that participate in interfund lending programs. We use the timing of the SEC exemptive relief orders allowing fund sponsors to set up interfund lending programs: https://www.sec.gov/rules/icreleases.shtml#interfundlending. We assume that all funds sharing the Central Index Key (CIK) numbers associated with the interfund lending application on the SEC From 40-APP participate in the program once it is approved by the SEC.
Portfolio value	Aggregate value of all holdings as of the last portfolio holding reporting date. Expressed in $ millions.
Fund TNA	Total Net Assets as of the last reporting date before the bond sale. Expressed in $ millions.
Family TNA	Aggregate TNA of all open-end municipal bond funds within a family, defined using N-SAR variable *i019c*. Expressed in $ millions.
Fund age	Number of years since the inception of the fund's oldest share class.
Portfolio characteristics	
Short-term fund	Binary variable equal to one if the fund's *Morningstar Category* includes the word "Short".
Single-state fund	Binary variable equal to one if the fund's *Morningstar Category* indicates that the fund invests in securities of a single state.
Portfolio HHI	Herfindahl-Hirschman Index of portfolio concentration: $$\sum_s \left(\frac{V_{f,s,t}}{\sum_s V_{f,s,t}}\right)^2$$ where $V_{f,s,t}$ is the market value of fund f's holdings of security s and time t, and where summation is over all long positions except for holdings of cash and equivalents, open-end mutual funds, and ETFs.
Average rating	Weighted average rating of a fund's all positions as of the last reporting date. A bond's rating is the median of Moody's, S&P, and Fitch ratings when all are available, or lower rating otherwise. Ratings are from Mergent. Ratings are coded such that AAA = 0, AA+ = 1, AA = 2, etc.
Unrated share	Unrated bonds' portfolio share as of the last reporting date.
GO bond share	General obligation bonds' portfolio share as of the last reporting date.

Continued

Table A1—*continued*

Variable	Definition
Insured bond share	Insured bonds' portfolio share as of the last reporting date. Insured bonds are those with nonmissing *bond_insurance_code* in Mergent.
Exotic bond share	Non-fixed-rate bonds' portfolio share as of the last reporting date.
Bond age	Weighted average of the time, in years, since the bond's offering date, of a fund's all positions as of the last reporting date.
Maturity	Weighted average remaining maturity, in years, of a fund's all positions as of the last reporting date.
Market conditions	
Aggregate net outflows	The sum of the negative of net monthly fund flows across all open-end municipal bond funds, scaled by lagged aggregate TNA. Municipal bond funds are funds whose Morningstar category includes the words *muni* or *municipal*.
VIX	Monthly average of CBOE Volatility Index.

Appendix B: Additional Results



(a) Number of funds

(b) TNA

Figure B1. Share of funds without VLC. This figure plots the time series of the fraction of open-end municipal bond mutual funds without calculated VLC, attributed to the following sources: missing Morningstar daily flows data, or missing N-SAR monthly redemptions data, or both. The sample period is August 2008–December 2017.

Table B1
How are Counterfactual Markups Calculated?

This table shows that for 75–91% of fund-date-bond observations, markups are estimated using average markups on similar bonds trading on the same day. For each observation, the counterfactual markup is first calculated from the average markup on trades of that bond taking place within the same day/week/month. If still missing, the counterfactual markup is calculated as the average markup on trades of similar bonds, where similar bonds are defined based on bond rating and maturity. $N = 206,080,965$.

		Trade size				
Source	Horizon	(0, 10K)	(0, 25K)	(0, 50K)	(0, 100K)	≥ 100K
Bond	day	0.00	0.01	0.02	0.03	0.01
Bond	week	0.01	0.04	0.06	0.07	0.04
Bond	month	0.03	0.10	0.13	0.15	0.10
Similar bonds	day	0.91	0.85	0.79	0.75	0.84
Similar bonds	week	0.04	0.00	0.00	0.00	0.01
Similar bonds	month	0.00	0.00	0.00	0.00	0.00

Table B2
Characteristics of Funds with and without VLC

This table reports the characteristics of funds with and without VLC calculated from the data. Δ is the difference in means between funds with and without VLC. *VLC/Redemptions* and annualized *VLC/TNA* are extrapolated for funds with missing *VLC* following the procedure in section 6. t-statistics for the difference in means are adjusted for clustering by family and month-date. The sample period is August 2008–December 2017.

	With VLC			Without VLC				
	N	Mean	Median	N	Mean	Median	Δ	t-stat
VLC/Redemptions (bps)	45,089	179.57	177.04	14,901	166.19	166.24	13.39	2.39
VLC/TNA (bps)	45,089	48.80	33.31	14,901	37.60	27.31	11.20	2.83
Monthly redemptions/TNA (%)	45,089	2.24	1.57	11,718	2.05	1.46	0.20	0.96
Monthly flows/TNA (%)	45,089	0.09	-0.06	14,899	0.19	0.09	-0.10	-0.82
Monthly flows/redemptions	44,758	0.47	-0.05	11,081	0.38	0.08	0.09	0.74
Sales/TNA (%)	45,089	0.93	0.46	14,901	2.00	0.60	-1.07	-3.60
Share class HHI	45,089	0.69	0.68	14,901	0.70	0.71	-0.01	-0.28
Flow autocorrelation	45,089	0.02	0.01	3,253	0.02	0.01	0.00	0.30
Cash/TNA (%)	45,089	2.73	1.49	14,901	4.59	3.19	-1.86	-2.45
To-be-redeemed bond share	45,089	0.01	0.00	14,901	0.01	0.00	-0.00	-2.26
Line of credit	45,089	0.31	0.00	14,901	0.10	0.00	0.21	4.11
Interfund lending	45,089	0.41	0.00	14,901	0.60	1.00	-0.19	-1.44
Short-term fund	45,089	0.11	0.00	14,901	0.17	0.00	-0.06	-1.82
Single-state fund	45,089	0.63	1.00	14,901	0.59	1.00	0.05	0.92
Porfolio HHI	45,089	0.01	0.01	14,901	0.01	0.01	0.00	3.44
Average rating	45,089	4.17	3.83	14,901	3.99	3.79	0.18	0.82
Unrated bond share	45,089	0.09	0.05	14,901	0.06	0.04	0.02	1.90
GO bond share	45,089	0.18	0.16	14,901	0.19	0.17	-0.00	-0.18
Insured bond share	45,089	0.27	0.23	14,901	0.25	0.22	0.02	1.18
Exotic bond share	45,089	0.03	0.01	14,901	0.05	0.03	-0.02	-1.79
Average bond age (years)	45,089	4.85	4.74	14,901	4.76	4.71	0.10	0.56
Average maturity (years)	45,089	14.96	15.98	14,901	14.58	15.32	0.38	0.45
Portfolio value/TNA	45,089	1.00	1.00	14,901	1.00	1.00	-0.00	-0.16
Fund TNA ($m)	45,089	657.34	225.39	14,901	1,889.09	603.03	-1,231.75	-1.94
Family TNA ($m)	45,089	11,303.67	9,048.87	14,901	30,989.92	17,749.70	-19,686.25	-2.14

Table B3
Quarterly Cross Sectional Variation in Liquidity Creation

This table reports the results of regressions of liquidity creation and its components on fund characteristics:

$$VLC_{f,t} = \alpha_t + \beta \cdot \textit{Fund characteristics}_{f,t-1} + \varepsilon_{f,t},$$

where f indexes funds and t indexes time in quarters. All continuous explanatory variables, except for *Outflows/Redemptions* are standardized so that their coefficients represent the effect of a one standard deviation change in the explanatory variables. Standard errors are adjusted for clustering by family and quarter-date. $*$, $**$, and $***$ indicate statistical significance at 10%, 5%, and 1%. $N = 15,722$.

		Components			Drivers		
	VLC/ Redemptions (1)	Flow netting (2)	Liquidity management (3)	Trade execution (4)	Outflows/ Redemptions (5)	Sales/ Redemptions (6)	Markup difference (7)
Share class $\text{HHI}_{f,t-1}$	−1.473**	−10.341***	1.689	7.026***	0.053***	0.002	−0.255
	(0.629)	(1.247)	(1.166)	(1.168)	(0.006)	(0.005)	(0.179)
Flow $\text{autocorrelation}_{f,t-3,t-1}$	0.116	1.455**	−1.674**	0.359	−0.006*	0.003	0.276**
	(0.329)	(0.685)	(0.655)	(0.733)	(0.003)	(0.003)	(0.123)
$\text{Cash/TNA}_{f,t-1}$	1.183*	4.991***	2.843**	−6.599***	−0.026***	−0.025***	0.690***
	(0.616)	(1.007)	(1.094)	(1.198)	(0.005)	(0.006)	(0.219)
To-be-redeemed bond $\text{share}_{f,t-1}$	0.673	0.113	3.780***	−3.141***	−0.001	−0.022***	−0.376***
	(0.473)	(0.523)	(0.727)	(0.655)	(0.003)	(0.004)	(0.110)
Line of $\text{credit}_{f,t}$	−2.588**	−2.638	−3.524	3.646*	0.006	0.020**	0.187
	(0.981)	(1.675)	(2.239)	(2.095)	(0.008)	(0.009)	(0.369)
Interfund $\text{lending}_{f,t}$	−3.862***	−0.042	−4.726**	1.119	−0.008	0.018*	−0.509
	(1.134)	(2.122)	(2.315)	(2.263)	(0.011)	(0.010)	(0.395)
Short-term fund_{f}	−11.531***	−12.364***	7.428*	−6.900*	0.026	−0.066***	0.526
	(2.413)	(4.154)	(4.020)	(3.773)	(0.024)	(0.022)	(0.749)
Single-state fund_{f}	1.548	−4.082	11.375***	−5.286*	0.024	−0.054***	−2.661***
	(1.490)	(3.003)	(2.890)	(3.069)	(0.016)	(0.015)	(0.452)
Portfolio $\text{HHI}_{f,t-1}$	1.531**	−4.449**	3.323**	2.380	0.024**	−0.007	0.070
	(0.696)	(1.800)	(1.569)	(1.899)	(0.009)	(0.007)	(0.262)
Average $\text{rating}_{f,t-1}$	13.271***	7.687***	1.811	3.575**	−0.010	−0.003	7.282***
	(1.195)	(1.677)	(1.605)	(1.448)	(0.008)	(0.007)	(0.522)
Unrated bond $\text{share}_{f,t-1}$	−1.120	5.049***	2.064	−8.313***	−0.019***	−0.017***	1.879***
	(1.420)	(1.529)	(1.306)	(1.342)	(0.007)	(0.006)	(0.603)
GO bond $\text{share}_{f,t-1}$	−1.630**	−1.067	0.768	−1.344	−0.003	−0.003	0.709***
	(0.781)	(1.087)	(1.568)	(1.200)	(0.006)	(0.008)	(0.247)
Insured bond $\text{share}_{f,t-1}$	0.268	2.177	5.476***	−7.537***	−0.011	−0.023***	−1.665***
	(0.862)	(1.602)	(1.765)	(1.533)	(0.007)	(0.008)	(0.344)
Exotic bond $\text{share}_{f,t-1}$	−12.143***	−6.938***	−3.426***	−1.754*	0.006	0.006	−3.698***
	(0.731)	(0.951)	(1.214)	(0.955)	(0.005)	(0.007)	(0.255)
$\text{Ln(Bond age)}_{f,t-1}$	1.930**	−9.716***	11.185***	0.520	0.048***	−0.042***	0.611**
	(0.775)	(1.407)	(1.370)	(1.286)	(0.006)	(0.006)	(0.231)
$\text{Ln(Maturity)}_{f,t-1}$	24.547***	5.682***	6.546***	12.107***	0.029***	0.018**	4.567***
	(1.114)	(1.495)	(1.584)	(1.682)	(0.008)	(0.008)	(0.529)
Portfolio $\text{value/TNA}_{f,t-1}$	−0.530	−0.291	−3.322**	3.114***	0.001	0.017**	0.077
	(0.566)	(0.397)	(1.495)	(0.974)	(0.002)	(0.007)	(0.145)
$\text{Ln(Fund TNA)}_{f,t-1}$	4.031***	16.163***	−15.141***	3.199*	−0.094***	0.052***	−0.558*
	(1.036)	(1.910)	(1.691)	(1.805)	(0.009)	(0.008)	(0.300)
$\text{Ln(Family TNA)}_{f,t-1}$	3.495***	4.309***	1.307	−2.160	−0.027***	−0.002	0.182
	(0.838)	(1.501)	(1.575)	(1.666)	(0.007)	(0.009)	(0.258)
$\text{Outflows/Redemptions}_{f,t}$						0.707***	
						(0.022)	
Adjusted R^2	0.74	0.48	0.29	0.23	0.47	0.40	0.77
Month-date FEs	✓	✓	✓	✓	✓	✓	✓