Do Floating NAVs Affect Money Fund Management?*

Su Li† Wei Liu† David Musto†

November 20, 2019

Abstract:

In 2016, institutional prime funds floated their Net Asset Values (NAVs), whereas retail funds retained stable NAVs. We use this contrast to test whether flotation affects portfolio management, and find that it does not. The reform had an effect around the transition to flotation, with duration, illiquidity, credit risk, yields and NAVs all lower among institutional funds, but this passed. Both institutional and retail funds shrank through the transition, to which they adjusted largely through shrinking their transactions, rather than by investing in fewer securities, or with fewer issuers.

JEL Classification: G10, G18, G23, G28

Keywords: money market funds, money market regulation, financial stability, floating Net Asset Value

---

* This paper is part of the Division of Economic and Risk Analysis' Working Paper Series. Papers in this series investigate a broad range of issues relevant to the Commission's mission and are preliminary materials disseminated to stimulate discussion and critical comment. Inclusion of a paper in this series does not indicate a Commission determination to take any particular action. References to this paper, and all papers in the DERA Working Paper Series, should indicate that the paper is a "DERA Working Paper."

† Su is with the U.S. Securities and Exchange Commission (lisu@sec.gov). Wei is with the U.S. Securities and Exchange Commission (liuw@sec.gov). David is with the Wharton School, University of Pennsylvania (musto@wharton.upenn.edu) and the U.S. Securities and Exchange Commission (mustod@sec.gov). Securities and Exchange Commission disclaims responsibility for any private publication or statement of any SEC employee or Commissioner. This article expresses the author's views and does not necessarily reflect those of the Commission, the Commissioners, or members of the staff. We thank the staff in DERA, especially Dan Hiltgen, and the staff in the Division of Investment Management, especially Sharon Pichler for providing helpful comments, and also seminar participants at the 2019 Chicago Financial Institutions Conference, the Norwegian School of Economics, the Office of Financial Research, the Wharton School, and Brandeis. We also thank Philipp Eschenbach and Gabriel Pohl-Zaretsky for their excellent research assistance. All errors are our own.

I. Introduction

This paper addresses the effect of NAV flotation on the management of prime money funds, and it does so by contrasting the management of retail and institutional funds across the date when only institutional funds had to start floating their NAVs. This flotation is a major development in the money-fund industry, one that contributed to a trillion-dollar reallocation, but we find that it ultimately has little or no direct effect on the funds' risk choices, along all the major dimensions. The flotation does affect the funds through the asset shrinkage it contributed to, and we find that funds adapt to this shrinkage mostly by shrinking the size of their transactions rather than by reducing their diversification across issuers or maturity dates.

Before going further it is worth defining some terms as we use them here. A *money fund*, or just *fund*, is a money market mutual fund governed by Rule 2a-7 of the Investment Company Act of 1940, and a *prime* money fund is one whose investible universe includes the whole range of money market instruments with minimal credit risk, whereas a *government* money fund is limited to some combination of Treasury securities, Agency securities and repos of such securities. The *NAV* of a fund is its Net Asset Value, the share price at which its investors transact, and a *floating* NAV is one that is marked to market, whereas a *stable* NAV is kept precisely at $1, if possible, with valuations that disregard, within a tolerance dictated by Rule 2a-7, market fluctuations. A *retail* prime money fund is one that has declared itself to be such, and has thereby committed itself to excluding non-natural persons as investors. An *institutional* fund has not made this commitment. The word "retail" is a defined term in Rule 2a-7 but the word "institutional" is not; we use it here out of convenience, and also for consistency with common usage. Before "retail" became a defined term in April 2016, it was generally and informally applied at the shareclass, rather than fund, level: a fund could have some shareclasses regarded as retail, and some as institutional, and the fund might use these terms or it might not.

The collapse of Lehman in 2008 started a run on the institutional shareclasses of prime money funds, which lost over $300 Billion of investment in the ensuing week (Schmidt et al, 2016). The run continued until the US Treasury initiated its Temporary Guarantee Program that insured existing shareholdings in participating funds against loss, and that ultimately consumed $2 Trillion of the Treasury's balance sheet until it was taken off a year later. The near-disastrous run, the resulting disruptions and the giant government liability led to Money Fund Reform (see, e.g., Lewis, 2016), which culminated in the October 14th, 2016 implementation of operational changes which differ across fund categories. Among these changes is the mandate that institutional, but not retail, prime funds float their NAVs.

Floating a fund's NAV combats the incentive to run it. If a fund stabilizes its NAV at $1, then if investors think the market value is below $1, and if they think others will leave, they will want to leave too, especially if they own a lot of shares, since they would expect every departure at $1 to dilute the shares of those who stay.[1] This helps explain the turmoil after Lehman, when uncertainty about a fund's holdings, combined with the size of institutional investments and exacerbated by the Reserve Fund 'breaking the buck,' made institutional prime funds especially vulnerable. If instead the leavers would get only the estimated market value of their shares, this causality would be weaker, and a run therefore less likely.[2] So in the interests of financial stability, institutional prime funds were required to start floating their NAVs.

The potential impact of this requirement on portfolio management is high, for two reasons. First, *not* marking shares to market has been fundamental to money funds since their beginning, as it is instrumental to their emulation of bank deposits. Money funds are not banks, and do not have the safeguards such as FDIC insurance that banks enjoy, but they can replicate a large part of

[1] See Schmidt et al (2016) for a detailed analysis of this point, with application to the flows after Lehman.
[2] The causality is not completely defeated, however, as the analysis of ultra-short bond funds in Schmidt et al (2016) and of corporate bond funds in Goldstein et al (2015), indicates.

the banking experience when investors can buy shares for $1 each, receive interest as more shares valued at $1 each, and then redeem at $1 each. Before Lehman, fund families consistently behaved as if the stable NAV were crucial, by among other things absorbing expensive credit losses that threatened it (Securities and Exchange Commission, 2009).

The other reason the potential impact of the requirement is high is that so much money flowed out of funds that were due to start floating.[3] This is apparent in Figure 1, which tracks the assets of different money-fund categories across the onset of the reform, and shows about a trillion dollars flowing out of institutional prime shareclasses in the months before flotation, and about the same flowing *in* to institutional *government* shareclasses, which would *not* float[4]. This is consistent with a strong aversion to flotation, though the simultaneous but milder shrinkage of retail shareclasses, which were not due to float but like the institutional shareclasses were due to start allowing for redemption gates and fees, indicates that flotation is likely not the only cause of these flows.

This paper assesses the impact of the reform with a difference-in-difference methodology that follows a balanced panel across the onset of reform. We identify all prime funds that operated throughout the three-year period from the year before the reform to the year after, i.e. 2015 through 2017, split this panel by the funds' status at the end into the institutional group and the retail group, and track the difference between the groups over the period. We focus on the change from the beginning of the period to the end, rather than from just before the reform to just after, since the portfolio decisions right around the reform may reflect more the flows and uncertainty of those days than the general effect of floating vs stable NAVs. We use this methodology to assess two varieties of impact: the direct impact of the reform, i.e. the impact on portfolio decisions that have

[3] See, e.g., Rennison (2016), Teitelbaum and Monga (2016) and Kelly (2016).
[4] Hiltgen (2017) finds no evidence that investors reallocated significantly from money market funds to private liquidity funds and their parallel accounts before the compliance date.

implications for NAVs, and the indirect impact, i.e. the impact of the asset shrinkage, induced by the reform, on transactions.

We assess the impacts through the funds' monthly portfolio disclosures, form N-MFP and its successors. These filings show the regulatory fund-level risk metrics, yields and NAVs, and they also report on each security held at month-end. Through this window onto funds' portfolio choices we observe the impact of the reform along the key dimensions of money-market risk: credit risk, interest-rate risk and liquidity risk. We also observe how the reform affects the realized volatility of NAVs.

Our main finding is that the reform had little or no direct effect on fund management. By the end of 2017, the difference between the floating and stable funds was approximately where it was at the beginning of 2015, when they were all stable. There is no significant effect on interest-rate risk, liquidity risk and credit risk, and on the level and realized volatility of NAVs. We do find a transitory dip in risk taken by the institutional funds, but only in the months right around the 10/16 onset. So along all the dimensions of risk associated with fixed-income investment, and despite all the evidence from history and flows about the importance of stable NAVs, marking NAVs to market has no long-term effect on prime fund management.

The indirect effect of the reform, through the asset shrinkage it caused, is mostly on transaction size. About three quarters of funds' adaptation to the shrinkage is through the principal amount of their individual transactions. The remaining quarter splits between shrinking the number of transactions per issuer and shrinking the number of issuers, more the former than the latter. Since fewer transactions per issuer means less diversification across maturity dates, and fewer issuers means less diversification across credit risks, this indirect effect through shrinkage is to some extent a cost imposed by the reform on funds and their shareholders.

The paper is in seven sections. Section II describes the data; Section III provides background and summary statistics, and identifies the panel for the tests; Section IV discusses the connection between money-fund management and NAVs; Section V uses the panel to test for the direct effect of the reform on portfolio risk choices, Section VI uses the panel to test for the indirect effect of the reform on portfolio transactions, and Section VII summarizes and concludes.

II. Database

The primary database for this paper combines the filings by money funds of the monthly forms N-MFP and its successors N-MFP1 and N-MFP2. We use the term N-MFPx to refer generally to these three forms. The first filings of N-MFP date to December, 2010, and cover portfolios held as of 11/30/2010 (from here on we will refer to the filing covering the last day of month *mm* in year 20*yy* as the *mm*/*yy* filing). The first filing of N-MFP1 is the 4/16 filing, and the first of N-MFP2 is the 10/16 filing. Our database includes all filings by prime funds, starting with 11/10 and running through 12/17.

The 4/16 filing of N-MFP1 marked the first time that funds declared whether they were retail.[5] In particular, Item A.10(a) asked whether they qualified as exempt retail funds, as defined in 270.2a-7(a)(25). This definition is now located in the code at 270.2a-7(a)(21), which reads

> *Retail money market fund* means a money market fund that has policies and procedures reasonably designed to limit all beneficial owners of the fund to natural persons.

Before N-MFP1, there was no reference required by any money-fund filing to a definition of "retail," but from 4/16 onward, a fund's shareclasses are either all retail or all not retail, which we

[5] The SEC recognized that funds might not have decided, as of April 2016, whether they are retail or institutional. See the FAQ on money market fund reform, and in particular the answer to question 24.

refer to as institutional. We refer to this sample period with the retail designation, 4/16 through 12/17, as the N-MFP1/2 sample period.

There is another important difference between N-MFP and N-MFP1, which is that N-MFP reports the amortized cost of individual securities, whereas N-MFP1 does not. There are no important differences, for our purposes here, between N-MFP1 and N-MFP2. So any analysis calling for amortized costs uses the N-MFP sample period running from 11/10 to 3/16.

The filings provide security-level, shareclass-level and fund-level data. The security-level data include security type – Certificates of Deposit (CDs), Commercial Paper (CP), etc – and identifier (generally CUSIP), issuer name, yield, principal amount purchased, market value,[6] and (in the case of N-MFP) amortized cost. The filings also report the dates used for DWAM and DWAL, where DWAL is the number of days to maturity,[7] and DWAM is the number of days to maturity *or* interest-rate reset. The shareclass-level data include the net yield, minimum initial investment and assets under management (AUM), and the fund-level data include the gross yield, NAV, WAM and WAL (i.e. weighted-average maturity and weighted-average life, respectively, which are the DWAM and DWAL of the fund's holdings, value-weighted), fund category (prime, government, etc.) and (in the case of N-MFP1/2) the retail designation. In the N-MFP1/2 period there are also weekly reports of Daily Liquid Assets and Weekly Liquid Assets, as a percentage of total assets, which we abbreviate DLA and WLA.[8] To track DLA and WLA starting 1/15, we calculate them ourselves for month-ends, using their definitions (See Appendix A for details).

[6] The market values come from pricing agents, and as for whether they are best viewed as bids or bid/ask midpoints, the two relevant sections of the code are section 270.2a-7(a)(28), which states that a security is illiquid if it "cannot be sold or disposed of in the ordinary course of business within seven calendar days at approximately the value ascribed to it by the fund," and section 270.2a-7(d)(4)(i), which states that "The money market fund may not acquire any illiquid security if, immediately after the acquisition, the money market fund would have invested more than five percent of its total assets in illiquid securities."

[7] For the purposes of calculating DWAL and DWAM, the nearest date on which the investor has the option to put the security back to the issuer at par, before the legal maturity date, would count as the maturity date.

[8] A fund's DLA is its investment in cash, direct obligations of the US government and securities with DWAL within one business day, and receivables due within one business day (270.2a-7(a)(8)), and its WLA is its DLA plus securities

There is some information on the securities' ratings, but this information is too spotty to be useful. Funds do not have to report ratings on N-MFP1/2, consistent with the removal of direct reference to ratings in rule 2a-7, but there is an option to report security ratings considered in response to Item C.10. Of the 65,655 securities reported on form NMFP1/2, 45,896, which is 70 percent, have no rating information reported.

The gross yield reported at the fund level and the net yields reported at the shareclass level imply the expense ratios of the fund's shareclasses, since the expense ratio is simply the difference between the two. The expense ratio of a fund is calculated as the AUM-weighted average of the expense ratios of its constituent shareclasses.

For the analysis of diversification across issuers of CDs and CP, we need to group securities by issuer within portfolios. Since the filings report issuer names, this would seem to be trivial. However, a couple complications arise. One is simply that issuers' names are abbreviated differently, even within funds. The other is that the same parent organization can issue through several legal entities. For example, the 12/17 filing by the Vanguard Prime Money Market Fund shows CDs issued by HSBC Bank USA NA, and CP issued by HSBC Bank PLC, and the 12/17 filing by the Fidelity Prime Money Market Portfolio shows CDs issued by Sumitomo Mitsui Trust Bank Ltd. London Branch, and by Sumitomo Mitsui Bank Corp. In the former case we would group the two as both issues from HSBC, and in the latter case we would group the two as both issues from Sumitomo Mitsui. This is not to say that there is never a meaningful difference between the legal entities referenced by the similar names, only that we abstract from any such differences in this paper.

---

with DWAL between 1 and 5 business days, receivables due between 1 and 5 business days, and securities from government instrumentalities, issued at a discount and maturing within 60 days (270.2a-7(a)(28)).

We do not analyze diversification across issuers of municipal securities, for two reasons. First, the total investment in such securities is small: as of 1/15, only 1.4% of prime fund dollars, $20 Billion out of $1.44 Trillion, were in munis.[9] Second, despite the small average investment, there are many municipal issuers which would have to be grouped, as with CDs and CP. This labor cost would be prohibitive, relative to the small benefit.

For the analysis of the transition of funds between types across the reform, we need to know which shareclasses were retail vs. institutional as of the beginning of the sample. This involves some amount of judgment, since the retail/institutional distinction was not well-defined, and funds were free to admit retail investors into shareclasses associated with institutional investors, and vice versa. There was, however, a general understanding that shareclasses were either retail or institutional, as is apparent from, for example, data from the Investment Company Institute which tracks retail and institutional money-market assets separately over the years.[10] To determine which shareclasses were retail vs institutional as of 1/15, we start with the 1/15 data from *Money Fund Intelligence* (MFI),[11] which provides fund identifiers, and merge this via the identifiers with the 1/15 filings of N-MFP. The MFI data label the shareclasses retail or institutional, and there are also some shareclasses with 1/15 filings that are not covered by MFI. If an uncovered fund is insurance-related, we take it to be a retail fund. If it is not, we make the determination via the shareclass name. If the name contains “administrative”, “agency”, “dollar”, “premier”, “agency”, “X”, “Y”, “Z”, “M”, “P” or “advisor”, then the shareclass is labeled as institutional[12]. And if the name of the shareclass contains “investor” or “participant,” or ends with

---

[9] From statistics reported by the Investment Company Institute.
[10] See, for example, Table 36 in the 2017 *Investment Company Fact Book*.
[11] MFI data are available through the SEC Library.
[12] See, for example, http://mutualfunds.com/education/what-are-share-classes/, http://www.valueline.com/Tools/Educational_Articles/Funds/Fund_Share_Classes_%E2%80%93_From_A_to_Z.aspx#.WqwBnvnwZhE , https://www.pimco.com/en-us/resources/frequently-asked-questions/ , https://www.blackrock.com/cash/literature/fact-sheet/bcf-institutional-fund-sl-agency-shares-factsheet.pdf, and https://www.blackrock.com/latamiberia/resources/share-classes-and-loads

"A", "B", "C", "R", "T" or "F", then the shareclass is labeled as retail. We also use the minimum investment threshold reported in the filing and the expense ratio derived from gross yield of the fund and net yield of the shareclass for cross-validation[13]. It is important to note that this determination of whether a fund was retail or institutional as of 1/15 does not affect the construction of our retail and institutional panels, because for that we use the funds' 12/17 explicit statements whether or not they are retail.

III. Background and Literature

III.A Money Fund Reform and Panel Construction

Before the 10/16 reform, public-facing money funds quoted stable NAVs almost without exception. Besides the period just after Lehman, there was just one obscure episode when a publicly available money fund broke the buck.[14] This track record reflects not just conservative management and tight regulation but also, on occasion, considerable sacrifice: large credit losses that would have destabilized a fund's NAV were borne instead by the fund's sponsor.[15] So money-fund shareholders were insulated from not only normal variability due to market fluctuations but also losses due to adverse developments, both of which enhanced the resemblance of their shareholdings to insured bank deposits. This long experience of safety may help explain why shareholders' reaction to the Reserve Fund breaking the buck was as severe as it was.

The reform imposed some restrictions across the board, and some on specific categories. All money funds are subject to the same 10% floor on DLA and 30% floor on WLA, and to a 120-day limit to WAL and 60-day limit to WAM. But only prime and tax-exempt funds, retail or institutional, had to implement policies providing for redemption fees of up to two percent and

[13] Minimum Investment threshold is usually high and expense ratio is usually low for an institutional shareclass.
[14] See Securities and Exchange Commission (2009) footnote 30.
[15] Relevant no-action letters from the SEC are available at https://www.sec.gov/divisions/investment/im-noaction.shtml#money. See also McCabe (2010).

redemption gates for up to ten days, in stressful circumstances. And only the institutional prime and institutional tax-exempt funds had to start floating their NAVs. Government funds could adopt gates or redemption fees or floating NAVs but they also could keep operating as there were. What is important for the purposes of this study is that the floating NAV is the one difference between the treatments of institutional prime and retail prime funds[16].

The regulatory variation across categories gave sponsors of money funds a choice. Those who wanted to keep their funds prime had to decide whether they would be retail, in which case the NAV could be stable but institutional accounts would have to leave, or institutional, so the NAV would float but everybody could stay. A sponsor could instead convert a prime fund to government, so that everybody could stay, the NAV would be stable and there would be no redemption fees or gates, but the investible universe would shrink and the yield would likely fall. Funds could also be liquidated, or merged it into other funds, or similarly be converted to feeder funds, so that their portfolios would reduce to shareholdings in master funds. Figures 2A and 2B report the fate, as of 12/17, of the 1/15 universe of prime funds, by number and by assets as of 1/15.

The figures show the large effect of reform on the count of prime funds, beyond the asset loss in Figure 2. Of the 228 prime funds operating in 1/15,[17] only 68, just 30 percent, are prime funds by the end. The most popular choice was to convert to government, and the next was to liquidate. Tracking dollars rather than funds, the change is milder: the 68 funds still prime at the end had 67 percent of the prime dollars at the beginning, while the 50 funds that liquidated had just 6 percent. The differences as of 1/15 of the funds that meet different fates by 12/17 are summarized in Table 1. Not surprisingly, those that become retail prime had more in retail

[16] For a study addressing the effect of the reform through March, 2017 on MMF portfolio holdings, see Alnahedh and Bhagat (2017).
[17] The sample of 228 funds in Figures 2A and 2B, and in Table 1, excludes the funds that were feeder funds as of 1/15.

shareclasses to begin with, and those that become institutional prime had more in institutional shareclasses, and consistent with that, charged lower expense ratios (though all expense ratios were compressed in 1/15 by the low market rates). It is perhaps a little surprising that the funds that become government, thereby retaining the ability to quote stable NAVs to institutional shareholders, had as much *retail* money as they did.

The funds that are prime as of 1/15 and are prime retail or prime institutional as of 12/17 are the funds in the difference-in-difference panel, with one class of exceptions. Three of the funds had floating NAVs before 10/16,[18] and thus are inappropriate for the study of the onset of flotation. So the final panel, listed in Appendix B, has the institutional group of 33 funds that start floating as of 10/16, and the retail group of 32 that do not. The difference between these two groups, and the change in this difference across the onset of reform, is the focus of our analysis of the effect of flotation.

We use a balanced panel, i.e. a panel with only those funds that exist through the whole sample period, to avoid contaminating the change over time with the effect of funds entering and leaving the sample. Funds within the prime category manage their portfolios in different ways, possibly because they serve different clienteles or face other different circumstances (see, e.g., Kacperczyk and Schnabl, 2013, Chernenko and Sundaram, 2014 and Gallagher et al, 2015), so if we were to track *all* funds across the reform, we would observe variation due both to the reform *and* to the changing sample composition.[19] Also, in order to target the management of the average portfolio, rather than the management of the average dollar in a portfolio, we focus on equal-

[18] The three funds are the Mutual of America Institutional Funds Money Market Fund, the Mutual of America Investment Corporation Money Market Fund, and the DFA Short Term Investment Fund. The first two are insurance-related funds that accumulate returns in the share price and declare dividends infrequently. The third invests cash collateral arising from securities loans by DFA funds.

[19] Also, prime funds that transition to government continue to call themselves prime while they let their non-government securities run off. For example, the Thrivent Money Market Fund committed as early as its 11/25/2015 prospectus to invest in government securities, but did not call itself "Government/Agency" on N-MFP until its 2/16 filing. Including such funds in the time series would give a misleading impression of prime fund management.

weighted, rather than asset-weighted, averages across the funds in the panel. The cost of the balanced-panel approach is the possibility of survivor bias. That is, these are the funds that remain prime for the three years, rather than meet one of the other fates, and funds due to remain can differ systematically from those not due to remain.

Do the funds in the panel shrink when the prime category shrinks? Since the number of prime funds also shrinks, it isn't immediate that they would. To find out, we track the median fund size of the institutional group and the retail group across the three years, and plot the result as Figure 3. The medians both shrink substantially in the months leading up to the onset. So not only did the institutional group have to content with the direct effect of flotation, both groups had to contend with asset shrinkage, which presumably reflects both the flotation of the institutional group and the risk of redemption fees and gates of both groups. We address the shrinkage after we address the direct effect of the flotation.

We can summarize the panel construction with a few bullet points.

- *Which funds are in the panel?* The panel contains all funds that are prime funds filing form N-MFPx from the beginning to the end of the sample period, excluding a) three funds that floated their NAVs before the onset of reform, and b) 25 funds that were feeder funds at the beginning of the sample period, and 1 fund that became a feeder fund by the end of the sample period. We eliminate the former funds because the goal is to understand the effect of flotation, and we eliminate the latter because feeder funds do not manage their own portfolios.
- *How are funds sorted into the retail and institutional subsamples?* They are sorted by whether they are retail funds at the end of the sample period.
- *What is the sample period?* The sample period begins with 1/15 and ends with 12/17. We begin with the beginning of 1/15 so as to begin before reform starts affecting funds through

shrinkage, and we end with the end of 12/17 to allow any transitory effect of adjusting to the reform to play out. We do not start earlier or end later because this would tend to reduce the number of funds operating throughout the sample period.

III.B Potential Effects of NAV Flotation

What effect should floating a fund's NAV have on its management? Should risk go up or down? One argument for risk going up is that the floating NAV weakens the link between portfolio risk and run risk, because redeeming when the market value is below $1/share imparts less loss on those who stay. On the other hand, the evidence from history and flows that investors tend not to like fluctuating NAVs, i.e. that they like money-fund shares to be like money, would suggest decreasing portfolio risk to decrease fluctuation. The heavy attrition from institutional prime funds might also be relevant. Since flotation appears to be one of the forces driving investors out, the self-selection of those who stayed may imply stronger appetites for NAV fluctuation, which would encourage higher portfolio risk. They may also have stronger tolerances for redemption fees and gates, which does not point so clearly to higher portfolio risk. There is also the possibility that the reform reduced the relative appeal of prime funds by reducing the expectation of future sponsor bailouts. Before the reform, fund sponsors preserved their stable NAVs when they absorbed credit losses, and this absorption meant that prime-fund investors got the *whole* credit spread (minus the expense ratio) but only *some* of the credit risk. Now that the sponsors of institutional prime funds have no stable NAV to preserve, the motive to absorb losses may be weaker, making institutional prime funds relatively less appealing *regardless* of risk appetite. So the departure from funds due to flotation may reflect a lower expectation of bailouts, rather than lower risk appetite.

IV. Portfolio risk choices and NAVs

IV.A Introduction

This section addresses the different risk choices portfolio managers make, and their implications for NAVs. We first address the mechanics of Amortized Cost Accounting, the valuation method behind stable NAVs, as this demonstrates how market fluctuations translate to NAV fluctuations. We then address the choice of interest-rate risk, credit risk and liquidity risk, and other perspectives on the connection between portfolio management and NAVs. The subsequent section runs the empirical tests on these choices.

IV.B Stable NAVs and Amortized Costs

Funds can stabilize their NAVs with Amortized Cost Accounting. By this method, a security's value travels a straight line from purchase to maturity. So, for example, if a fund buys $12MM principal amount of 30-day CP at a discount rate of 2.4%, implying a purchase price of $12MM – (2.4%)(30/360)$12MM = $12MM - $24,000, then that $24,000 discount reduces at a steady linear rate over those 30 days. That is, every day the valuation increases by exactly $800, whether or not the market discount rate for that paper stayed at 2.4%. If the fund bought an interest-bearing CD at a premium or discount to par, then the valuation of that CD would again follow a straight line from the original premium or discount to par at maturity. The fund can value its securities this way as long as the resulting portfolio valuation is sufficiently close to the portfolio's mark-to-market valuation.[20]

Another way to look at this is that floating NAVs depart from stable NAVs when market rates depart from purchase rates. If a fund buys 30-day CP at 2.4% and 10 days later, the 20-day rate for that issuer is 2.0%, then the paper's market value exceeds its amortized cost, and if this

[20]The mark-to-market NAV must be above $0.995 and below $1.005 for a stable-NAV fund to quote $1.

happens throughout the fund's portfolio then the fund's NAV will exceed 1. Similarly, if the fund pays par for a 6-month floating CD paying one-month LIBOR + 20bp, and then two months later the issuer's 4-month floating CD is quoted at one-month LIBOR + 30bp, then the security's market value will fall short of its amortized cost, dragging the fund's NAV downward.

IV.C Interest-Rate Risk and the Level and Volatility of NAVs

A fund's choice where to buy on the yield curve influences not only the volatility but also the level of its subsequent NAVs. That longer original term imparts more volatility is straightforward, as this is just standard duration risk; that it also means a generally higher NAV is a little more subtle, and depends on the slope and stability of the yield curve.

To the extent the yield curve slopes up and stays put, the market value of a security will rise above its amortized cost as it moves toward maturity, and eventually fall back to meet the amortized cost at maturity. We can see this easily if we assume the term structure of discount rates is a stable and upward-sloping straight line, so the market rate for paper with m days to maturity is $a + bm$, where a and b are fixed over time. Consequently, the market value of CP with m days to maturity is $F - F(a + bm)(\frac{m}{360})$, and the original cost of CP with initial maturity of m_0 days is $F - F(a + bm_0)(\frac{m_0}{360})$. Amortized cost accounting will value this security, on each remaining day to maturity, at its original discount rate, so when there are m days left,

- Amortized cost = $F - F(a + bm_0)(\frac{m}{360})$, but
- Market value = $F - F(a + bm)(\frac{m}{360})$, so
- Market value – Amortized cost = $F(\frac{b}{360})(m_0 m - m^2)$.

Because $m_0 > m$, and by assumption $b > 0$, this last expression must be positive, so market value is greater than amortized cost.

How much greater than amortized cost is the market value? The maximum difference is at $m = \frac{m_0}{2}$, i.e. halfway to maturity, where the value is $F(\frac{b}{360})(\frac{m_0^2}{4})$. For example, if the 360-day rate is 100bp higher than the overnight rate, so $b = (\frac{100}{360})(\frac{1}{10000})$, and the original maturity m_0 is 180, then the maximum is at 180/2 = 90 days, and the maximum difference (per dollar of face value, so we can leave F out) is $\left(\frac{100}{360}\right)\left(\frac{1}{10000}\right)\left(\frac{1}{360}\right)\left(\frac{180^2}{4}\right) = 0.000625$, i.e. 6.25bp.

That's the maximum, but how big is the difference *on average* across the m_0 days to maturity? This works out to

$$\frac{1}{m_0}\int_0^{m_0}\left(\frac{b}{360}\right)(m_0 m - m^2)dm = \left(\frac{b}{2160}\right)m_0^2.$$

With the example parameter values, this is $(\frac{100}{360})(\frac{1}{10000})(\frac{1}{2160})(180^2)$, which is 4.2bp.

Figure 4A shows the relation between the average difference and initial maturity that would result from the example slope from above, i.e. 100bp increase out to 360 days. Given these numbers, we can gauge what would happen if, for example, retail and institutional funds first both put 10% of their assets in 390-day fixed-rate paper, and then the institutional funds reduce the initial maturity of this part of their portfolios by 100 days, i.e. down to 290-day paper. This would reduce institutional funds' WAMs by (10%)(100) = 10 days, and would reduce the average difference of these securities by 19.56 – 10.82 = 8.74bp. And since these securities are 10% of the portfolio, this means a (10%)(8.74) = 0.874bp reduction in institutional NAVs, relative to retail NAVs. Because the relation is convex, maturity reductions at the long end of the term structure will have bigger effects than reductions at the short end.

This analysis assumes the yield curve is straight and stable, but that is only an approximation so realized security values will not track its predictions exactly. For illustration, Figure 4B plots the market value and amortized cost of CP from Toyota Motor Credit held for six months by the Vanguard Prime fund. The difference peaks earlier than halfway through, due to whatever happened to the market rates calculated for TMC paper by the pricing agent.

We can gauge the general relation between original maturity and NAV by using the whole sample of fixed-rate[21] CP and CDs covered by N-MFP filings. We start with all such securities covered from the first month-end after purchase to the last month-end before maturity, so this is all fixed-rate CP and CDs that 1) are purchased by any money fund in 12/10 or later, and 2) mature in 4/16 or earlier, and 3) are not sold before the last month-end before maturity. The resulting sample includes 75,753 CD holdings and 279,913 CP holdings,[22] which we sort into original-maturity buckets, so bucket n contains securities that were between n-1 and n months to maturity when they first appeared, out to the maximum of $n = 13$.[23] Finally, within each bucket and for each of the n months to maturity for the securities in that bucket, we average (Market Value)/(Amortized Cost) across the securities. The result is plotted as Figures 5A (CP) and 5B (CDs), which both show the hump shape, cresting around halfway to maturity as the securities move from right to left toward maturity.

For the average realized effect of initial maturity on NAV, as in Figure 4A, we can average each of the lines in Figures 5A and 5B across the months to maturity. The result is in Figure 5C, in which the two lines representing fixed-rate CP and CDs do indeed show the convex relation, outside of the small sample of very long-dated fixed-rate CDs. This correspondence to the functional form we derive is consistent with the short end of the yield curve sloping up and not moving much over the 2010-2016 sample period.

[21] Throughout the paper, we take those securities with DWAM=DWAL to be fixed-rate, and those with DWAM<DWAL to be floating rate.

[22] These figures exclude 4,742 CD holdings and 9,055 CP holdings which were sold before the last month-end before maturity.

[23] 270.2a-7(11)(i) limits the remaining maturity of a security that “presents minimal credit risks to the fund” to 397 days.

Putting this together, in a period when the short end of the yield curve slopes up, as it usually does, and also when the curve doesn't move too much, more interest-rate risk means both higher yields and higher NAVs, while also risking greater NAV volatility to the extent the yield curve moves.

IV.D Liquidity Risk

A money fund can take on liquidity risk separately from interest-rate risk by investing in floating-rate securities, whose interest-rate risk is measured, both in duration calculations and in the DWAM calculation, from coupon reset dates. Liquidity risk could be especially dangerous in a financial crisis, and less-liquid securities did indeed drop to large discounts from more-liquid alternatives in the 2008-9 crisis, which is often characterized as a flight to liquidity (see, e.g., Musto, Nini and Schwarz, 2018). Investors may therefore be compensated for this greater risk with higher yield when they buy longer-dated floating-rate securities: investors who require 1M LIBOR + 10bp for 4-month paper might need 1M LIBOR + 20bp for 6-month paper. If that were true, there would be an upward-sloping term structure for liquidity risk so investing in longer floating-rate securities would raise NAVs in the same way that longer fixed-rate securities raise NAVs in Figures 4A and 4B. But there's a potential countervailing force pushing the slope down: because a longer floating-rate security saves on back-office costs for both sides, compared to rolling over shorter securities with the same duration, longer securities bring cost reductions that could push their yields down.

The net effect of original maturity on the pricing of floating-rate securities can be measured with the same methodology used for Figures 5A and 5B. The sample is 6,547 CD holdings and 3,513 CP holdings,[24] and the analogous figures are 6A (CP) and 6B (CDs), which are plotted on

[24] This excludes 1,268 CD holdings and 841 CP holdings which were sold before the last month-end before maturity.

the same scale as 5A and 5B. The floating-rate securities show little of the term premia of the fixed-rate securities: market values rise only a little relative to amortized cost after purchase, implying that funds get few extra basis points for extending the maturity of floating-rate paper, and that the effect on NAVs is small. This is even more apparent in Figure 6C, which shows that, as the initial maturity of a floating-rate security increases, its effect on the NAV does not curve up as with the fixed-income securities but instead drifts down. So the prime fund transactions show little evidence of an upward-sloping term structure of illiquidity premia at the short end of the yield curve, which suggests that the transactions-cost savings is at least as important to pricing as the risk borne by the investor.

IV.E Credit Risk

A credit event, i.e. the default of Lehman, precipitated the post-Lehman run. Credit risk would have led to other funds breaking the buck, both in the post-Lehman era and over the decades before, had the funds' sponsors not bailed out the shareholders by guaranteeing the credits or by simply buying them from the funds at high-enough prices. Credit risk can move NAVs even without credit events, through a widening or narrowing of credit spreads, either market-wide or issuer-specific. So a fund's choice of credit risk can be an important source of NAV fluctuation.

V. Tests for the Effect of Reform on Prime Fund Management

V.A Introduction

In this section we test whether NAV flotation affected prime fund management. We do this for a series of portfolio metrics, where in most cases we calculate the metric for each fund in the panel, plot the average of the stable retail funds and of the floating institutional funds from 1/15 to 12/17, and test for significant change by running a regression which tests for each calendar quarter after Q1 of 2015 whether the difference between the two groups is different from the difference in Q1 of 2015. The null hypothesis for each metric is that there is no difference between the difference at the end, i.e. Q4 of 2017, and the difference at the beginning. We calculate confidence intervals for that null, and also for every other quarter. One of the tests, regarding credit spreads, uses a different methodology.

V.B Effect of Flotation on Interest-Rate Risk

Money funds summarize their interest-rate risk with WAM so we use this statistic for our test. The average WAM of the two groups of funds is plotted as Figure 7A, which shows that WAM is consistently lower for the institutional funds, and also that the difference at the end is close to the difference at the beginning. To gauge the statistical significance of the difference-in-difference, we run the following regression explaining a fund's WAM:

$$WAM_{i,q} = \alpha + b_{Ins}Ins_i + b_q Ins_i \times Date_q + Date_q + \varepsilon_{i,q},$$

where $WAM_{i,q}$ is the average WAM of fund *i* over the month-ends of quarter q; Ins_i equals 1 if fund *i* is institutional as of 12/17 and 0 otherwise; and $Date_q$ is an indicator for quarter q. With this regression model, the coefficient b_q estimates how much the WAM of institutional funds minus the WAM of retail funds in quarter q exceeds the WAM of institutional funds minus the WAM of retail funds in Q1 of 2015. We summarize the regression result with the time series of b_q and the 95% confidence interval around it in Figure 8A.

The difference-in-difference test finds no significant difference between the beginning and the end. The point estimate is almost zero, and the confidence interval includes zero. The test does pick up a significant difference around the Q4 2016 onset of reform, denoted by the thick red dashed line. In those months, the interest-rate risk of institutional funds was temporarily lower, by about a week of duration. So the funds that started floating did scale back risk relatively more for a few months, during and just after the period of rapid withdrawals and operational changes, but then returned to their prior relation to the funds that remained stable.

The time series in Figure 7A do show an absolute trend among all prime funds, retail and institutional, toward lower interest-rate risk. That this occurs in both groups implies that this was not due to flotation. This may reflect the general rise in rates, in that the rise may have reduced the managers' desire to extend maturity for higher yield.

As the previous section documents, a fund's choice of interest-rate risk influences not only its WAM but also its NAV, where this influence is not linear but instead quadratic. So how do the NAVs of the two groups compare? Figures 7B and 8B are analogous to 7A and 8A, except that they address NAV rather than WAM. The general pattern is the same: there is a statistically significant but transitory drop in the relative NAVs of the institutional funds around the onset of reform, but by the end the difference is not significant (though the point estimate differs by 1bp).

V.C Effect of Flotation on Liquidity Risk

There are several ways to gauge a fund's liquidity risk from its reported risk metrics. One is to reference WAL, since this summarizes the time to liquidation opportunity, due either to maturity or a redemption option, of the fund's holdings. But since WAL conflates liquidity risk with interest-rate risk, it may help to distinguish the two by referencing WAL-WAM, i.e. the *addition* of liquidity risk to the minimum necessary for the interest-rate risk choice. Accordingly, Figures 7C and 8C address WAL, and Figures 7D and 8D address WAL-WAM. We find that the absolute and relative values of WAL are not much different from those found for WAM: there is again the transitory dip around reform, and no significant difference at the end. The results for WAL-WAM are similar but they find no significant difference at any point.

Besides WAL and WAL-WAM, funds also summarize their liquidity position with DLA and WLA, which tell us not how long the fund has to wait for the average dollar back, but rather how much liquidity is available in a day or a week. Since these statistics are reported by funds only in the N-MFP1/2 period, 4/16 onward, we calculate them ourselves for the whole period (see Appendix A for more details). They are addressed by Figures 7E and 8E (DLA) and 7F and 8F (WLA). The figures show the same pattern yet again, though since now the metrics *increase* with liquidity, the lines moves the other way: institutional funds have significantly more liquidity around the reform, 5% more in daily assets and 10% more in weekly assets at the point estimates, but there is no significant difference by the end.

V.D Effect of Flotation on Credit Risk

Funds do not report statistics summarizing their credit risk. They do, however, report their allocations to asset classes commonly associated with more or less credit risk. We use this data to calculate for each month of each fund its allocation to securities in the investible universe of government funds, i.e. Treasury and Agency securities and repos of those securities. This allocation may reflect funds' credit-risk choice, because these asset classes are generally regarded as lower-risk. We call it the Government Allocation and we run the same exercise as with the other metrics and plot the results as Figures 7G and 8G.

The prime funds' Government Allocation is seen in Figure 7G to trend down over the three years, from around 20 percent to around 14 percent of fund assets. This is perhaps not surprising, since government funds greatly expanded over that period, and it stands to reason they might crowd out investment in their investible universe by funds that are free to invest in something else. There is not, however, any of the onset-era tilt toward safety apparent in the earlier figures, and the difference from Q1 2015 is not significant at any point.

We can evaluate credit risk from another direction by inferring it from security-specific data. We can do this by running a cross-sectional regression at the end of each month explaining the yields of the non-floating securities purchased that month. We use non-floating securities so that, to the extent possible, each security's interest-rate risk is the same as its liquidity risk, so by controlling for one we control for both. In cases where multiple funds buy the same security and do not quote the same market yield, the dependent variable is the average of the yields they quote. We explain a security's yield with two variables: days to maturity, to control for interest-rate and liquidity risk, and the fraction of the purchases of the security that were by institutional funds. So the regression model is

$$y_{it} = \alpha_t + \beta_{1t} DWAM_{it} + \beta_{2t} INSTL_{it} + \varepsilon_{it},$$

where i indexes securities purchased in month t, y_{it} is the month-end yield, $DWAM_{it}$ is the security's $DWAM$ as of the month-end, and if there were *n* purchases of that security that month by institutional funds and *m* by retail funds, then $INSTL_{it}$ is *n*/(*n*+*m*).[25]

The key assumption of the test design is that the yield not explained by the date or by maturity[26] either is explained by credit risk or is simply idiosyncratic noise. Under this assumption, β_{2t} picks up the extra credit spread of securities purchased, in month t, by institutional rather than retail funds. We run one series of regressions on all the CP purchases and another on all the CD purchases in the N-MFP1/2 sample period, i.e. the period when we have the retail designation. In order to use all purchases, these regressions use all prime funds, not just those in the panel. The β_{2t} coefficients, along with confidence intervals, are presented in Figures 9A (CP) and 9B (CD).

---

[25] This takes a value other than 0 or 1 for 23 percent of the CP and 27 percent of the CDs.
[26] The regressions assume a linear relation of yields to *DWAM* but we get very similar results with a quadratic relation.

The CP results follow the pattern of the interest-rate and liquidity results: the relative credit spread of the securities purchased by the institutional, floating group drops significantly in the months around the onset of the reform, down to -17bp as of 9/16, and then returns to its initial level. To put this in context, for that same day, September 30th, 2016, the Federal Reserve Bank of New York reports that the 30-Day AA Nonfinancial CP rate was 0.39%, and the 30-Day A2/P2 Nonfinancial CP rate was 0.74%, for a spread of 0.35%, which is just over twice 17bp, so this is half the prevailing CP credit spread.

The CD results similarly find no difference between the beginning and the end, but they also find no dip in between. The relative risk of the CDs purchased by institutional rather than retail funds in the months just after the reform is if anything slightly higher.

V.E Effect of Flotation on Fund Yields

Risks besides those enumerated here may command higher yields. So as a backstop, we run the same exercise from Figures 7A-G and 8A-G on the funds' gross 7-day yields. The results are in Figures 7H and 8H, and again we find no change from beginning to end, and a significant transitory dip, down to -10bp, in the relative yields of the institutional group. Therefore we conclude that, while there may be yet more priced risks relevant to the effect of flotation, the effect we observe in specific risks is the effect we see across the funds' whole portfolios.

V.F Effect of Flotation of NAV Volatility

Do portfolio managers respond to the flotation of NAVs in a way that affects the fluctuation of NAVs? We can gauge the effect on NAV volatility the same way we gauge the effect on other metrics, though we have to adapt to the changing frequency of observations across the three years. Funds report their NAVs monthly in form N-MFP through 3/16, and weekly in the subsequent forms. So for each fund we calculate its monthly volatility over the fifteen observations through Q1 2016, and annualize by multiplying by the square root of 12, and then we calculate its weekly volatility in each of the seven subsequent quarters, which generally have thirteen observations, and multiply those values by the square root of 52. Then we run the same exercise, only modifying it so that instead of comparing Q2 2015 through Q4 of 2017 to Q1 2015, we compare Q2 2016 through Q4 2017 to the five initial quarters combined. The results are in Figures 7I and 8I.

We do not find any statistically significant change in the relative realized volatility of the floating and non-floating funds. There is a dip but the confidence intervals all include zero. This is a result to interpret cautiously given the infrequent realization of money-market credit events. That is, the 2015-17 sample period sheds only so much light on the exposure funds choose to Lehman-like events, because there was nothing like such an event in the sample period.

V.G Summary

The balanced panel shows us whether and how prime-fund managers responded to NAV flotation by changing their risk choices. We look at the whole range of risk choices, and in case we missed something, we also look at yields, NAVs and the realized volatility of NAVs. There is, ultimately, no effect. There *was* an effect, right around the reform, but by all measures it went away. This is not to say that flotation didn't affect funds *at all*: prime funds collectively lost a trillion dollars of assets as reform set in, and funds had to adjust to this somehow. The next section asks how managers adapted to this shrinkage.

VI. Adaptation to Asset Loss

The funds in the panel generally shrank, and had to adapt to this shrinkage through combinations of smaller and fewer transactions. In this section we decompose each fund's transactions into three components that capture transaction size, diversification across maturity dates and diversification across issuers, and then analyze how funds spread the effect of shrinkage across these components.

A fund's assets are the product of three factors: the average investment size (*AIS*), its average number of investments per issuer (*AII*), and number of issuers it invests in (*NII*). We can restate this identity as

$$\ln(Assets) = \ln(AIS) + \ln(AII) + \ln(NII)$$

How do funds spread asset change across these factors? Do smaller funds simply make smaller transactions, or do they avoid putting the whole burden of shrinkage on transaction size by spreading the effect to the other factors? We address the question with regressions where the factors, or changes in the factors, are regressed on assets, or changes in assets. In these regressions, the identity is not exact because we relate a fund's assets to just its CP, CD and repo investments, so the main investment categories we omit are municipal, government and agency securities. We omit municipal securities because they account for little prime-fund investment and because grouping the investments that do occur by issuer is impractical (see the data section), and we omit government and agency securities because the economics of those transactions are likely quite different, particularly with respect to diversification concerns. Similarly, we run the regressions both with and without repos, since the collateralization, size and margining of repo transactions (see, e.g., Hu, Pan and Wang, 2015) makes the economics of those transactions less comparable to transactions in CP and CDs. The results are in Table 2, where Panel A includes repos in the factor calculations, and Panel B does not.

Most asset variation, we find, is managed through transaction size. In the regressions addressing the adaptation to asset change across the reform, the coefficient on transaction size is around three quarters with and without repos, and the remaining quarter splits more or less evenly between the number of transactions per issuer and the number of issuers. Figures 10A-C illustrate this result by plotting the datapoints and regression lines from the bottom of Panel A of Table 2. That funds would extend the effect of shrinkage beyond transaction size suggests there could be a downside to smaller transactions, i.e. that there could be economies of scale in transaction size. This is the possibility explored by Li and Musto (2019).

VII. Summary and Conclusion

This paper documents the effect on money-fund portfolio management of the NAV flotation introduced for institutional, but not retail, prime funds by the October, 2016 reform. This analysis focuses primarily on those funds that remained prime funds from January, 2015 to December, 2017. Our main finding is that there is ultimately no effect on funds' risk choices. There was an effect in the months around and just after the reform took effect, generally in the direction of less risk-taking by institutional funds, but this difference faded through 2017, leaving the relative risk-taking of institutional and retail funds about where it started, on all the dimensions we explore. These dimensions include the interest-rate, liquidity and credit risk of the portfolios, and the volatility of the funds' NAVs. The funds' gross yields follow a similar pattern, with institutional funds earning less than retail funds during the period of reduced risk-taking, but earning the same by the end.

The prime category shrank during the sample period, in particular the institutional prime category. Many funds ceased being prime funds, most often by converting to government funds or liquidating. Despite these departures, the funds that remained also shrank, and fund managers had to adapt to the shrinkage. We find that they did this largely by shrinking transaction sizes, but also by shrinking the number of issuers they invested in, and the number of securities purchased per issuer. So while we find no direct effect of NAV flotation on fund management, we do find an indirect effect, through the overall reduced attractiveness of prime funds, that reduced their diversification across maturity dates and across credit risks.

Our main result about NAV flotation is negative: flotation could have increased risk taking by reducing the risk of runs or by scaring off risk-averse investors, or it could have decreased risk taking by encouraging managers to make floating NAVs more like stable NAVs, but ultimately it just left risk-taking where it started the year before. So NAV flotation, implemented to improve financial stability, did not have an unintended consequence for portfolio management.

References

Alnahedh, Saad, and Sanjai Bhagat, 2017. "Shadow Banking Concerns: The Case of Money Market Funds," Working Paper, University of Colorado.

Chernenko, Sergey and Adi Sunderam, 2014, "Frictions in Shadow Banking: Evidence from the Lending Behavior of Money Market Mutual Funds." *Review of Financial Studies* 27(6), pp. 1717-1750.

Gallagher, Emily, Lawrence Schmidt, Allan Timmermann and Russ Wermers, 2015. "By Force of Flow: Investor Behavior and Money Market Fund Risk Allocations During the Eurozone Crisis." Working paper, Sorbonne, UCSD and U. Maryland.

Goldstein, Itay, Hao Jiang, and David T. Ng. "Investor flows and fragility in corporate bond funds." Journal of Financial Economics 126.3 (2017): 592-613.

Hiltgen, Daniel, 2017. "Private Liquidity Funds: Characteristics and Risk Indicators." Securities and Exchange Commission White Paper.

Hu, Grace Xing, Jun Pan and Jiang Wang, 2015. "Tri-Party Repo Pricing." NBER Working Paper No. 21502.

Kacperczyk, Marcin, and Philipp Schnabl, 2013. "How Safe are Money Market Funds?" *The Quarterly Journal of Economics*, 128(3), pp. 1073-1122.

Kelly, Susan, 2016. "Bracing for New Money Fund Rules," *Treasury and Risk*, June 8.

Lewis, Craig, 2016. "Money Market Funds and Regulation." *Annual Review of Financial Economics* 8, pp, 25-51.

Li, Su, Wei Liu and David K. Musto, 2019, "Scale Economies in the Money Market." *DERA Working Paper, Securities and Exchange Commission*.

McCabe, Patrick E., 2010, "The Cross Section of Money Market Fund Risks and Financial Crises," Finance and Economics Discussion Series, Division of Research & Statistics and Monetary Affairs, Federal Reserve Board.

Rennison, Joe, 2016. "US Money Market Fund Reform: An Explainer," *Financial Times*, Oct. 14.

Schmidt, Lawrence, Allan Timmermann and Russ Wermers, 2016. "Runs on Money Market Mutual Funds," *American Economic Review* 106(9), pp 2625-2657.

Securities and Exchange Commission, "Money Market Fund Reform: Proposed Rule," available at www.sec.gov/rules/proposed/ 2009/ic-28807.pdf, 30 June 2009. Release no. IC-28807.

Teitelbaum, Richard, and Vipal Monga, 2016. "CFOs Unfazed Ahead of New Rule -- WSJ," *The Wall Street Journal Online*, August 9.

Witmer, Jonathan, 2017. "Strategic Complementarities and Money Market Fund Liquidity Management." Bank of Canada Staff Working Paper 201.

Appendix A: Derivation of DLA and WLA

We derive DLA and WLA for a particular fund in a particular month as follows. In the first step, we determine whether a security held by a fund is qualified as a daily liquid asset, and hence a weekly liquid asset. If the category of the security (Item C.6 of the N-MFP1/2 form or Item 31 of the N-MFP form) is U.S. Treasury Debt, or if the security's WAL date (Item C.12 of the N-MFP1/2 form or Item 36 of the N-MFP form) is within one business day of the filing date, or if the security has a demand feature and its WAM date (Item C.11 of the N-MFP1/2 form or Item 35 of the N-MFP form) is within one business day of the filing date, then the security is a daily liquid asset, and therefore weekly liquid asset.

In the second step, we examine the remaining securities to see if they are qualified as weekly liquid assets or not. If the security is a Government Agency Debt with its WAL date within 60 business days of the filing date, or if the security's WAL date is within 5 business days of the filing date, or if the security has a demand feature and its WAM date is within 5 business days of the filing date, then the security is a weekly liquid asset.

Finally, for fund *i* in month *t*, we add up market value of all the securities held by the fund, denoted as $MV\_securities_{i,t}$, add up market value of all the daily liquid assets within the fund, denoted as $MV\_DLAs_{i,t}$, and add up market value of all the weekly liquid assets within the fund, denoted as $MV\_WLAs_{i,t}$. The $DLA_{i,t}$ and $WLA_{i,t}$ are then defined as:

$$\mathrm{DLA}_{i,t} = \frac{\mathrm{MV\_DLAs}_{i,t} + \mathrm{cash}_{i,t}}{\mathrm{total\_net\_assets}_{i,t}} \text{ and } \mathrm{WLA}_{i,t} = \frac{\mathrm{MV\_WLAs}_{i,t} + \mathrm{cash}_{i,t}}{\mathrm{total\_net\_assets}_{i,t}}$$

where $cash_{i,t}$ is the total cash held by the fund (item A.14a in form N-MFP1/2 or $max(total\_net\_assets_{i,t} - MV\_securities_{i,t}, 0)$ during the N-MFP period[27]).

[27] Funds did not report their cash holdings during this period.

Appendix B: Funds in the Balanced Panel

Table B1: List of Institutional Prime Funds.

Investment Adviser	Fund Name
BLACKROCK	PLAN MONEY MARKET FUND
BLACKROCK	BLACKROCK LIQUIDITY TEMPFUND
BLACKROCK	BLACKROCK LIQUIDITY TEMPCASH
BLACKROCK	MONEY MARKET MASTER PORTFOLIO
COLUMBIA MANAGEMENT	COLUMBIA SHORT-TERM CASH FUND
DEUTSCHE INVESTMENT MANAGEMENT	DEUTSCHE VARIABLE NAV MONEY FUND
FEDERATED INVESTMENT MGMT CO	FEDERATED MASTER TRUST
FEDERATED INVESTMENT MGMT CO	FEDERATED MONEY MARKET MANAGEMENT
FEDERATED INVESTMENT MGMT CO	FEDERATED PRIME OBLIGATIONS FUND
FIDELITY	FIDELITY MONEY MARKET CENTRAL FUND
FIDELITY	FIDELITY CASH CENTRAL FUND
FIDELITY	FIDELITY SECURITIES LENDING CASH CENTRAL FUND
FIDELITY	PRIME MONEY MARKET PORTFOLIO
GOLDMAN SACHS	FINANCIAL SQUARE PRIME OBLIGATIONS FUND
GOLDMAN SACHS	FINANCIAL SQUARE MONEY MARKET FUND
INVESCO ADVISERS	LIQUID ASSETS PORTFOLIO
INVESCO ADVISERS	STIC PRIME PORTFOLIO
J.P. MORGAN	JPMORGAN PRIME MONEY MARKET FUND
LEGG MASON	LIQUID RESERVES PORTFOLIO
MASSACHUSETTS FINANCIAL SERVICES COMPANY	MFS INSTITUTIONAL MONEY MARKET PORTFOLIO
MORGAN STANLEY	MONEY MARKET PORTFOLIO
MORGAN STANLEY	PRIME PORTFOLIO
NEW YORK LIFE INVESTMENT	MAINSTAY MONEY MARKET FUND
NORTHERN TRUST	NORTHERN INSTITUTIONAL PRIME OBLIGATIONS PORTFOLIO
SSGA	STATE STREET MONEY MARKET PORTFOLIO
TDAM	TDAM MONEY MARKET PORTFOLIO
DREYFUS	DREYFUS CASH MANAGEMENT
DREYFUS	DREYFUS INSTITUTIONAL PREFERRED MONEY MARKET FUND
VANGUARD	VANGUARD MARKET LIQUIDITY FUND
U.S. BANCORP	FIRST AMERICAN PRIME OBLIGATIONS FUND
UBS	PRIME MASTER FUND
WELLS FARGO	ADVANTAGE CASH INVESTMENT MONEY MARKET FUND
WELLS FARGO	ADVANTAGE HERITAGE MONEY MARKET FUND

Table B2: List of Retail Prime Funds.

Investment Adviser	Fund Name
AMERICAN CENTURY	PRIME MONEY MARKET FUND
BLACKROCK	BLACKROCK MONEY MARKET PORTFOLIO
BMO	BMO PRIME MONEY MARKET FUND
CHARLES SCHWAB	SCHWAB MONEY MARKET FUND
CHARLES SCHWAB	SCHWAB CASH RESERVES
CHARLES SCHWAB	SCHWAB ADVISOR CASH RESERVES
CHARLES SCHWAB	SCHWAB VALUE ADVANTAGE MONEY FUND
CHARLES SCHWAB	SCHWAB RETIREMENT ADVANTAGE MONEY FUND
CHARLES SCHWAB	SCHWAB INVESTOR MONEY FUND
DEUTSCHE INVESTMENT MANAGEMENT	DEUTSCHE MONEY MARKET PRIME SERIES
FEDERATED	FEDERATED CAPITAL RESERVES FUND
FEDERATED	FEDERATED PRIME CASH OBLIGATIONS FUND
FIDELITY	MONEY MARKET PORTFOLIO
FIDELITY	FIDELITY MONEY MARKET FUND
INVESCO	PREMIER PORTFOLIO
J.P. MORGAN	JPMORGAN LIQUID ASSETS MONEY MARKET FUND
JANUS	JANUS MONEY MARKET FUND
MEEDER	MONEY MARKET FUND
MORGAN STANLEY	ACTIVE ASSETS INSTITUTIONAL MONEY TRUST
NORTHERN TRUST	NORTHERN MONEY MARKET FUND
PRINCIPAL MANAGEMENT	MONEY MARKET FUND
PUTNAM	PUTNAM MONEY MARKET FUND
T. ROWE PRICE	T. ROWE PRICE SUMMIT CASH RESERVES FUND
DREYFUS	DREYFUS BASIC MONEY MARKET FUND, INC
DREYFUS	DREYFUS LIQUID ASSETS, INC
DREYFUS	GENERAL MONEY MARKET FUND INC
DREYFUS	CITIZENSSELECT PRIME MONEY MARKET FUND
VANGUARD	MONEY MARKET PORTFOLIO
VANGUARD	VANGUARD PRIME MONEY MARKET FUND
USAA	MONEY MARKET FUND
WADDELL & REED	WADDELL & REED ADVISORS CASH MANAGEMENT
WELLS FARGO	WELLS FARGO ADVANTAGE MONEY MARKET FUND

Figure 1: Evolution of Money Fund Assets by Category

The figure shows the total investment in each of the following money market fund categories: (1) government, (2) Institutional prime, (3) retail prime, (4) institutional tax-free and (5) retail tax-free during the period of 1/15 to 1/18. The figure is based on the data from Bloomberg.

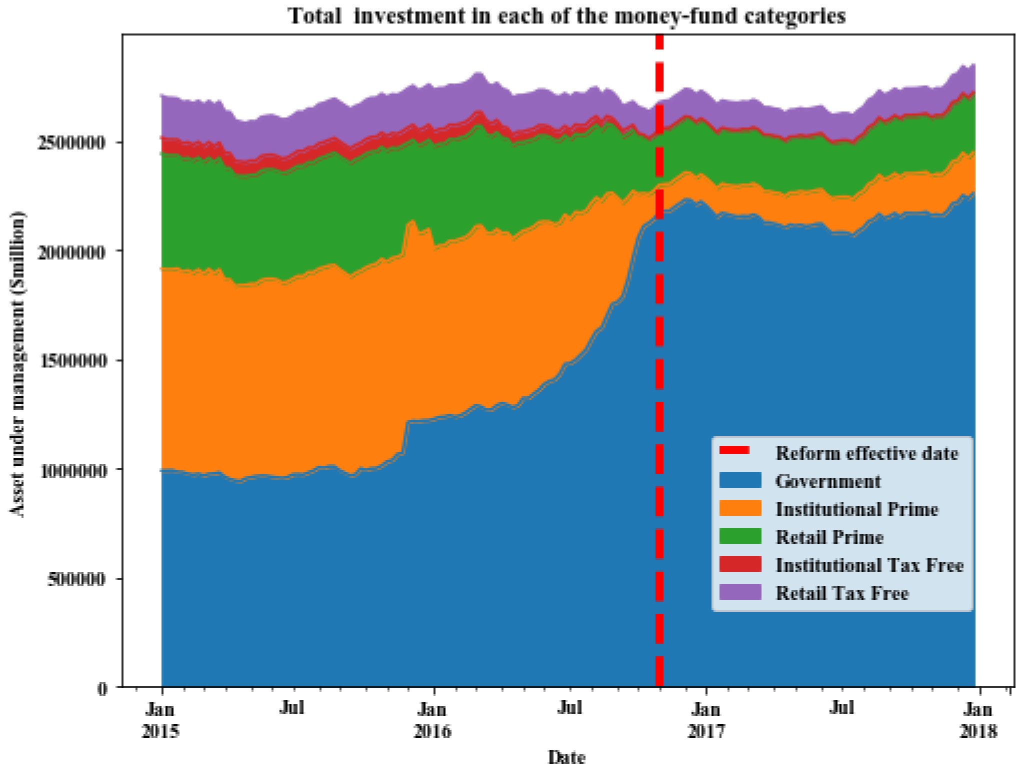
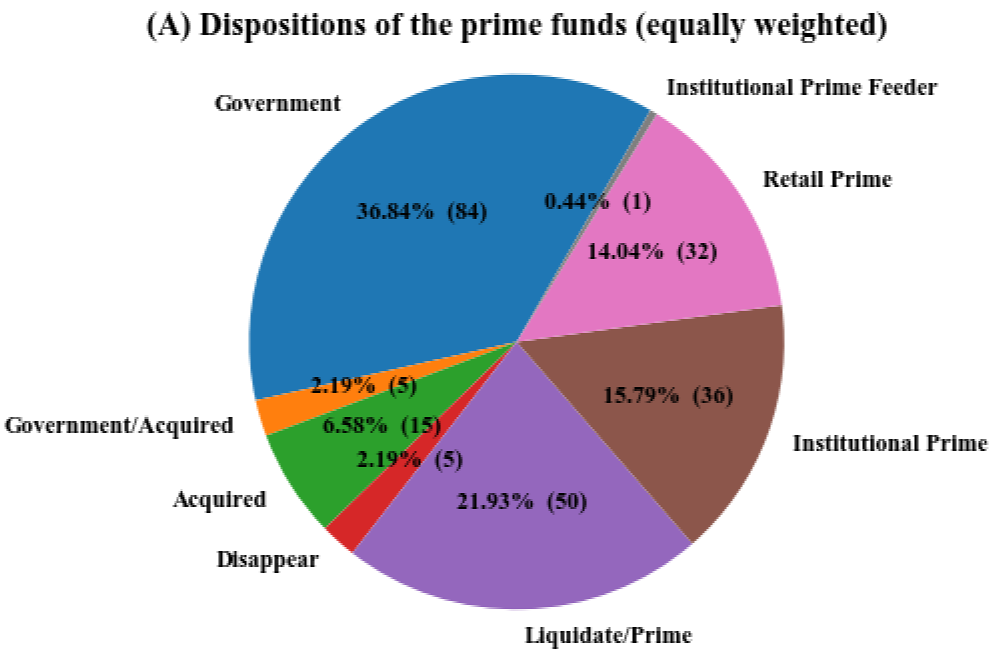


Figure 2: Disposition of Prime Funds

The following charts demonstrate the transition of prime funds across the reform. There are 228 prime funds as of 1/15. They could (1) remain to be prime funds and choose to be retail or institutional, (2) become government funds, (3) merge into another fund, (4) become government funds and later merge into another fund, (5) liquidate, (6) become feeders into other funds, or (7) stop reporting without any reasons. Panel A (equal-weighted across funds) and Panel B (asset-weighted across funds) summarize the results.



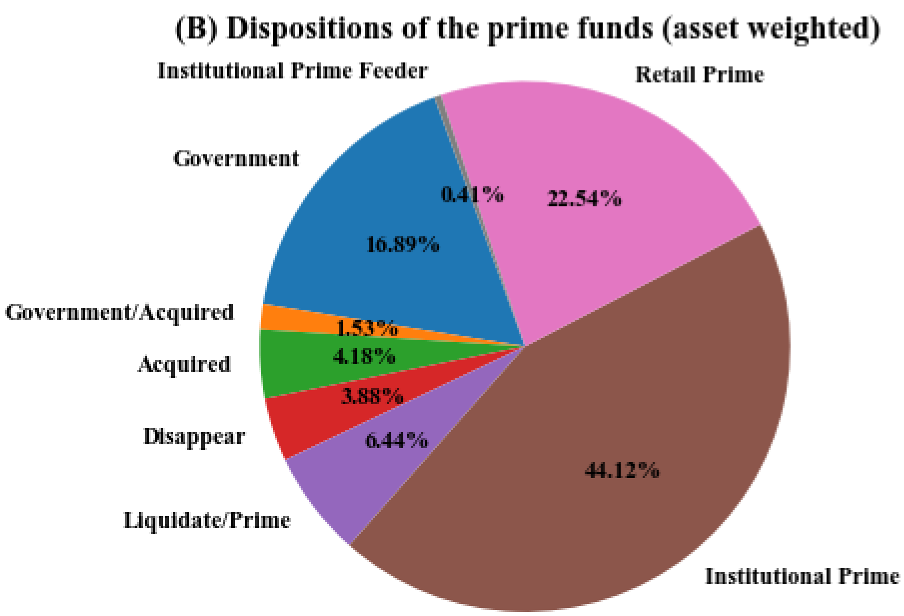


Figure 3: Evolution of Median Fund Assets: Balanced Panel

This figure plots the median AUM for the 32 funds that are prime as of 1/15 and retail prime as of 12/17, and for the 33 funds that are prime as of 1/15 and institutional prime as of 12/17, during the sample period of 1/15 to 12/17.

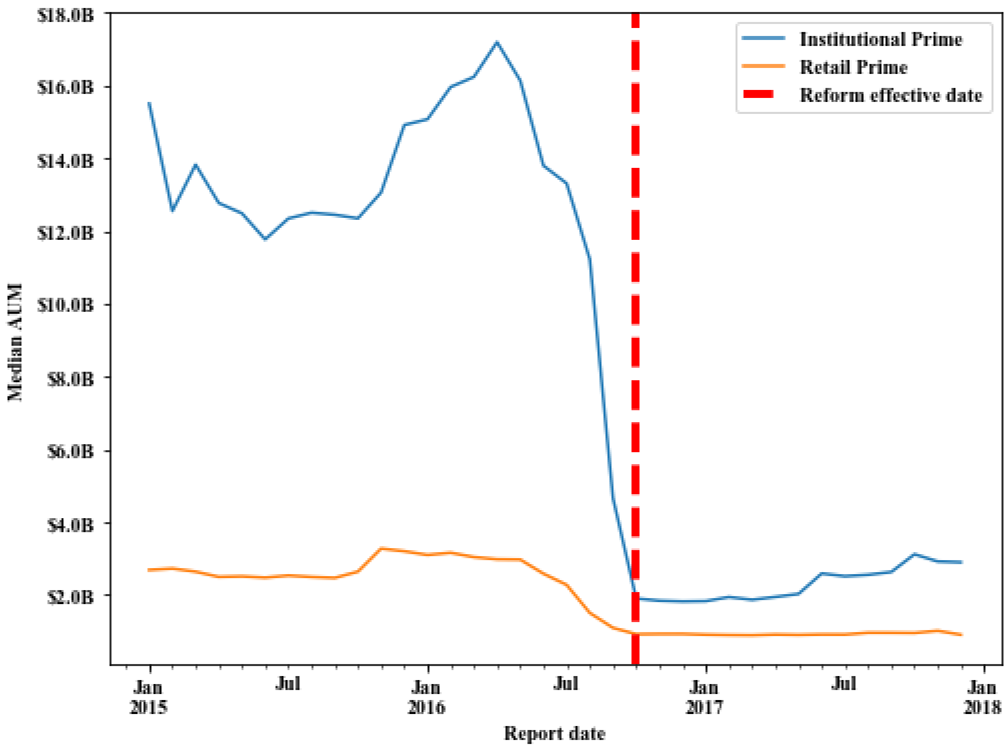
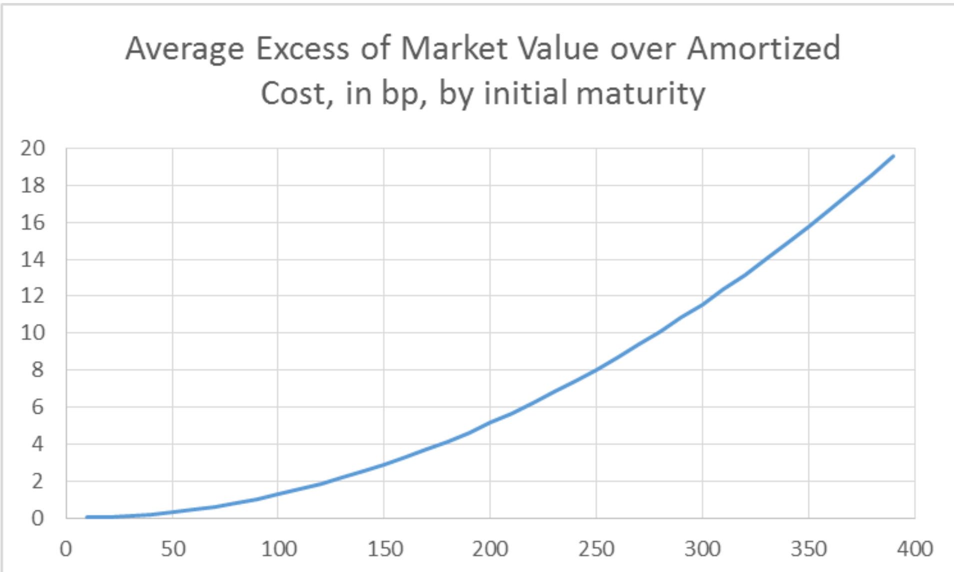


Figure 4: Excess of Market Value over Amortized Cost and Example of Market Value and Amortized Cost

Panel A of this figure plots the average of (Market Value – Amortized Cost), in basis points, for a fixed-rate security purchased with the initial maturity, in days, indicated on the horizontal axis. The calculation assumes that the term structure is a straight line that increases 100 basis points from overnight to 360 days to maturity, and also assumes that the term structure does not move over the life of the security. Panel B shows the amortized cost and market value of a CP issue of Toyota Motor Credit held by the Vanguard Prime fund, as reported in form N-MFP from 8/31 through 1/14.



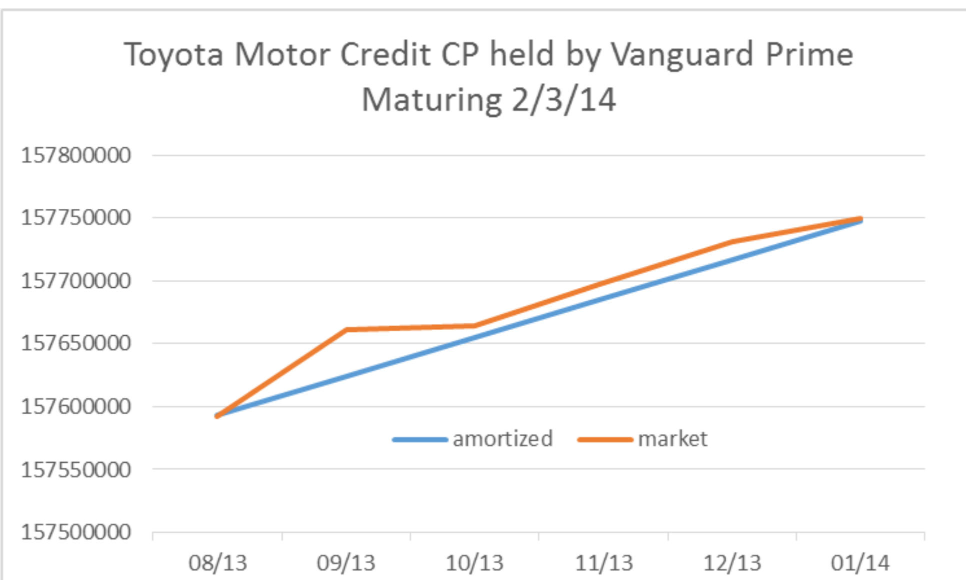


Figure 5: Valuation Relative to Amortized Cost of Fixed Rate Securities

The following charts plot the average (Market value)/(Amortized cost) against months to maturity for fixed rate CP (panel A) and CDs (panel B), and the averages of each of the lines in panel A and panel B across the months to maturity. Each security is sorted an n-month maturity bucket if the maturity date is between n-1 and n months after the date of its first appearance. We then average the (Market value)/(Amortized cost) across all the securities in the bucket, for each of the $i \leq n$ months to maturity, resulting in n averages.

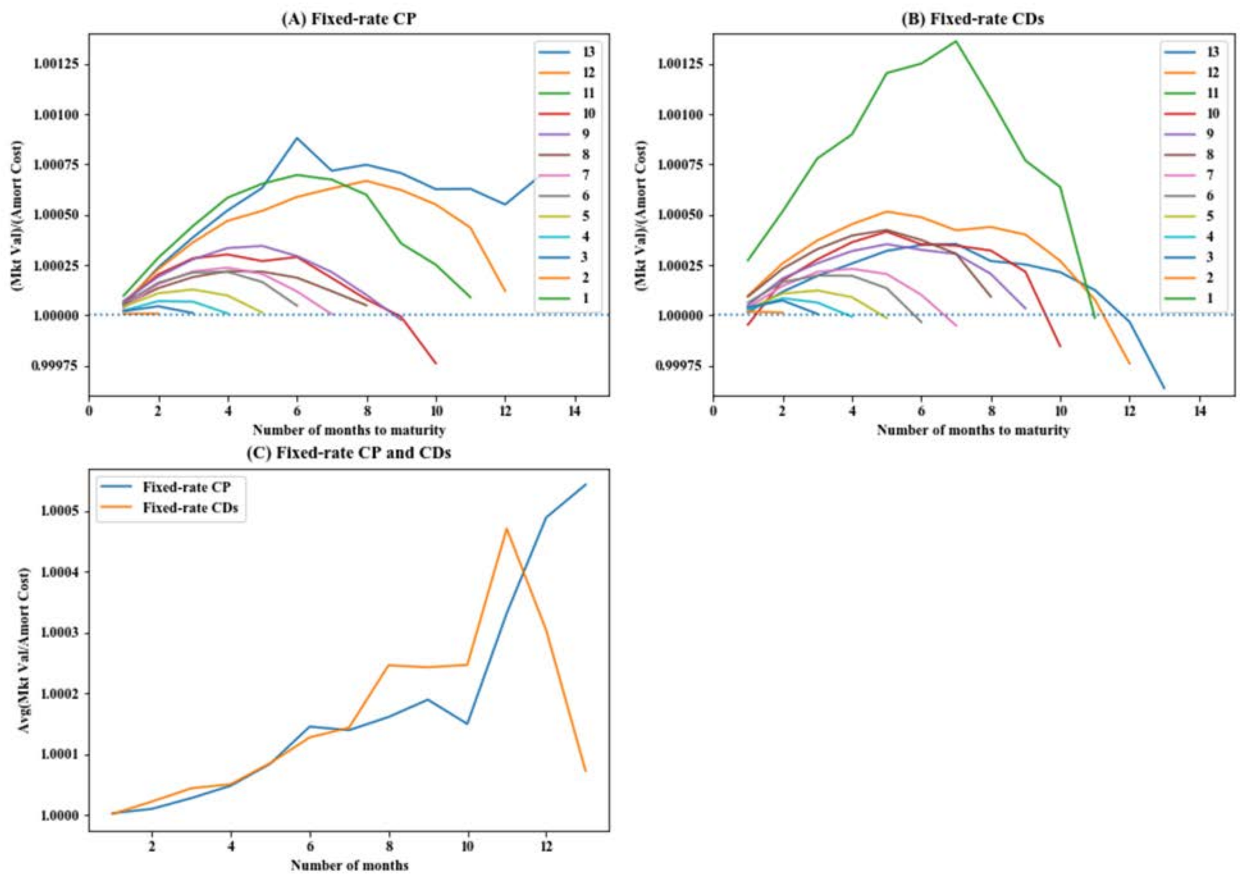


Figure 6: Valuation Relative to Amortized Cost of Floating Rate Securities

The following charts plot the average (Market value)/(Amortized cost) against months to maturity for floating rate CP (panel A) and CDs (panel B), and the averages of each of the lines in panel A and panel B across the months to maturity. Each security is sorted an n-month maturity bucket if the maturity date is between n-1 and n months after the date of its first appearance. We then average the (Market value)/(Amortized cost) across all the securities in the bucket, for each of the *i*≤*n* months to maturity, resulting in *n* averages.

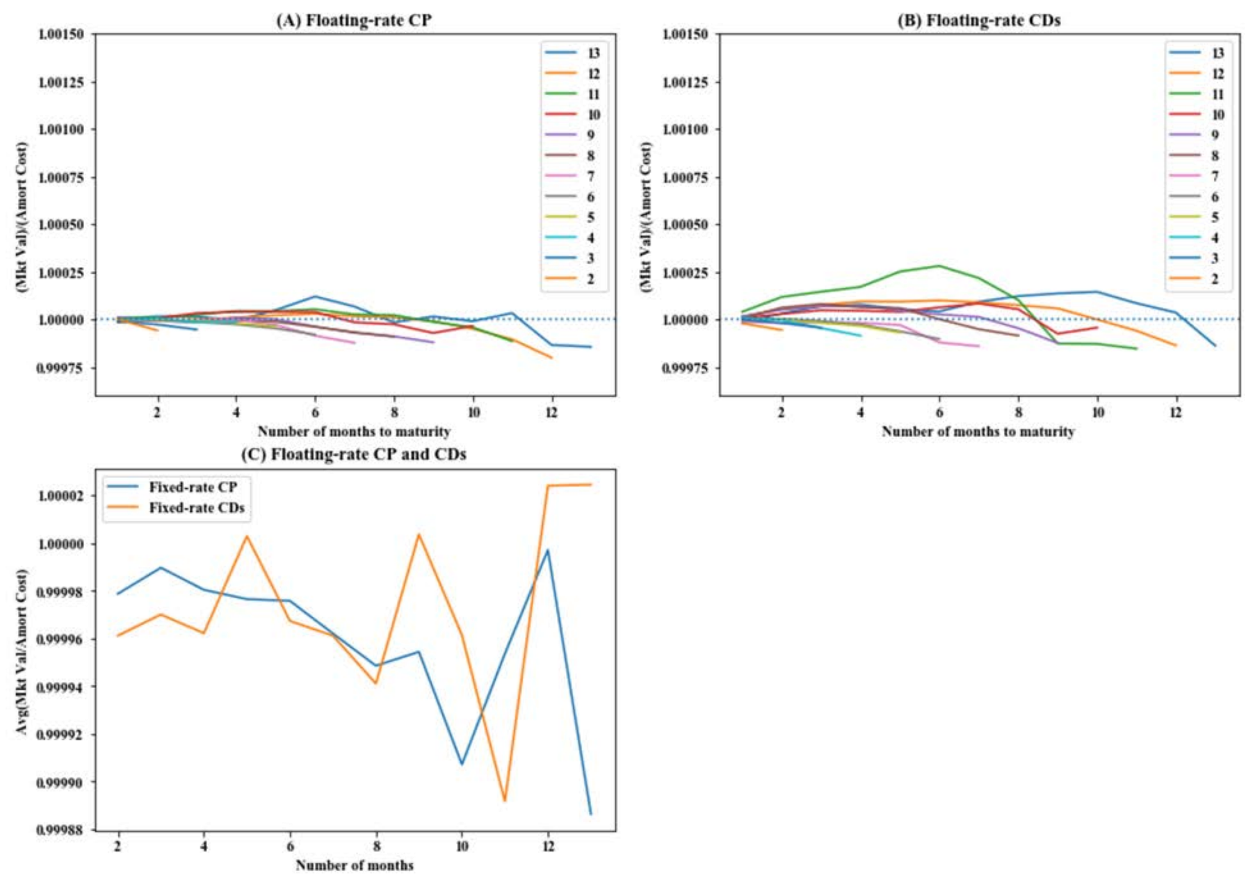


Figure 7: Evolution of Various Metrics for Balanced Panel

The following charts plot the average WAM (panel A), WAL (panel B), WAL-WAM (panel C), NAV (panel D), SevenGY (Panel E), percentage of government securities (panel F), DLA (panel G), WLA (panel H), and NAV volatility (panel I) for the 32 funds that are prime as of 1/15 and retail prime as of 12/17, and for the 33 funds that are prime as of 1/15 and institutional prime as of 12/17, during the sample period of 1/15 to 12/17. All the variables of interest are at monthly frequency, except the percentage of government securities and NAV volatility, which are at quarterly frequency.

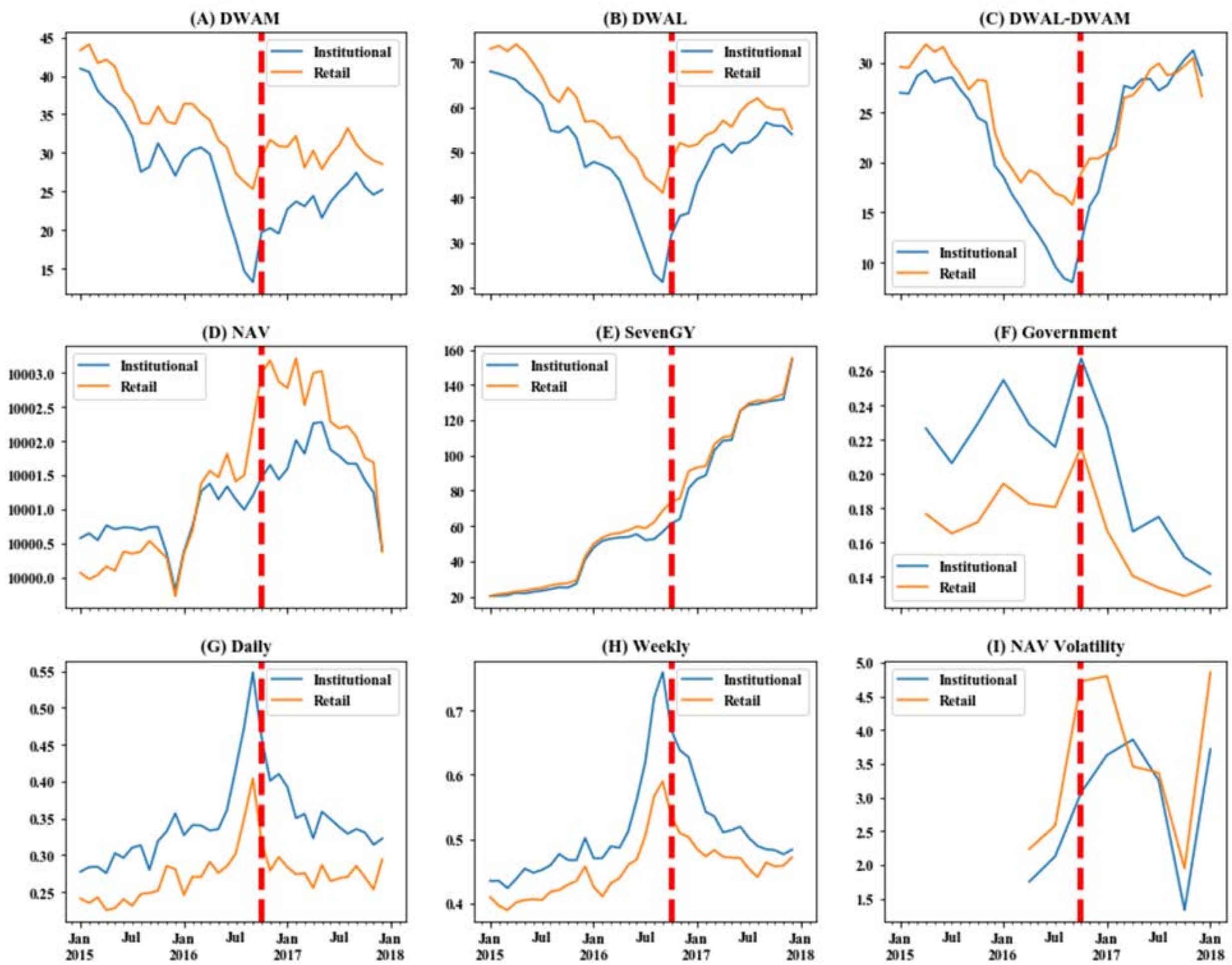


Figure 8: Summary of the Diff-in-diff regression results

The following charts plot the coefficients for the interaction term $Ins_i \times Date_q$ in the diff-in-diff regression setup, when the dependent variable is WAM (panel A), WAL (panel B), WAL-WAM (panel C), NAV (panel D), SevenGY (Panel E), percentage of government securities (panel F), DLA (panel G), WLA (panel H), and NAV volatility (panel I).

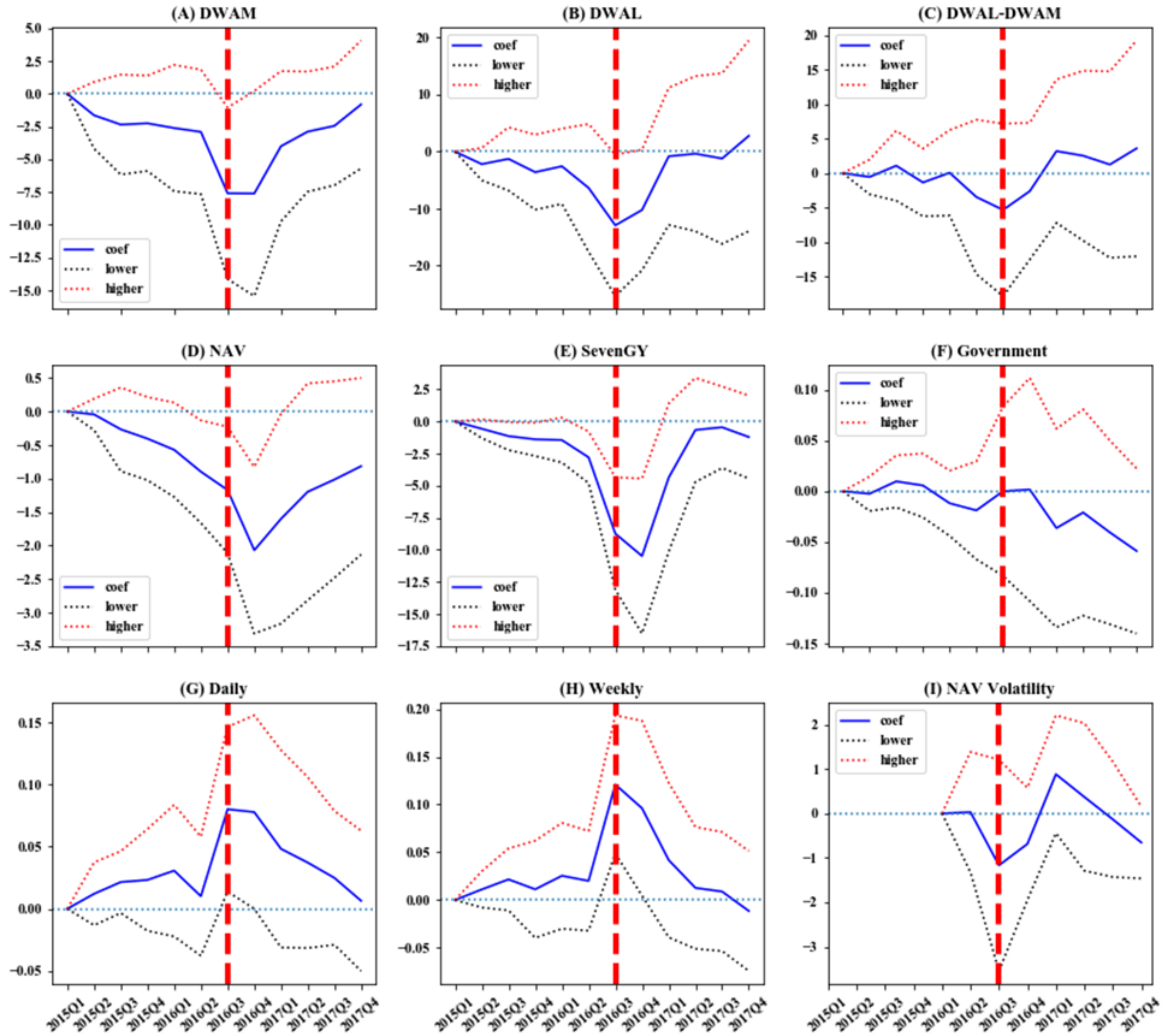


Figure 9: Evolution of Credit Risk: All Prime Funds

This figure plots the fitted values of β_{2t} from the regression $y_{it} = \alpha_t + \beta_{1t}DWAM_{it} + \beta_{2t}INSTL_{it} + \varepsilon_{it}$, along with the 95% confidence intervals, against purchase date across the sample period of 4/16 to 12/17. Panel A covers CP and Panel B covers CDs.

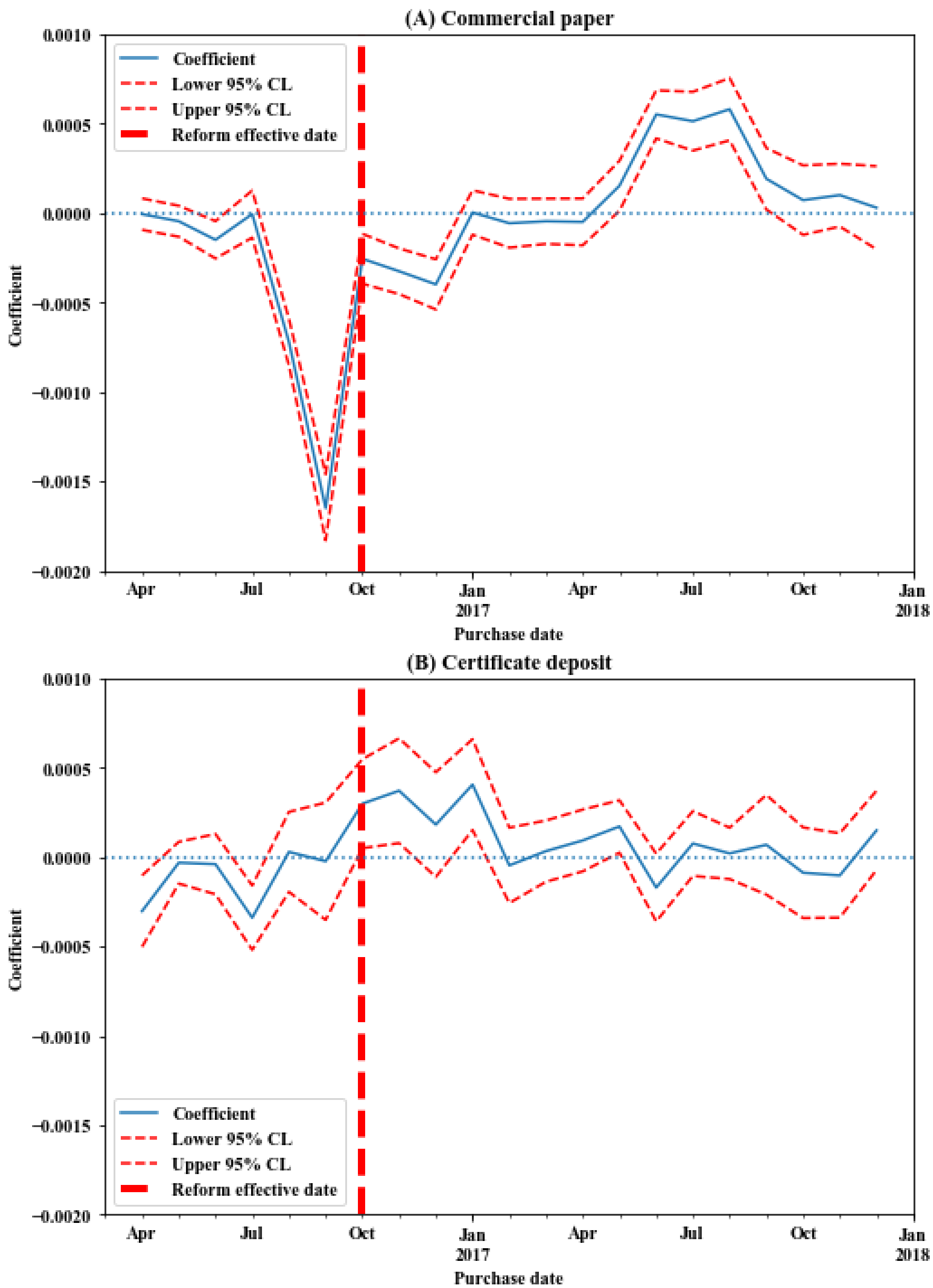


Figure 10: Adaptation of Portfolios across Reform: Balanced Panel

The following charts demonstrate the relation between the time-series change of funds' log(AUM) and the change of the log of the number of issuers, number of issues divided by number of issuers, and average issue size at the start and at the end of the balanced-panel sample period. The issues represented in the plots are only CP and CDs. Panel A plots $\log(NISSUERS_{i,12/17}/NISSUERS_{i,1/15})$ against $\log(AUM_{i,12/17}/AUM_{i,1/15})$, and Panel B and Panel C do the same, with $\log(NISSUERS_{i,12/17}/NISSUERS_{i,1/15})$ replaced by $\log(AVGISSUES_{i,12/17}/AVGISSUES_{i,1/15})$ and $\log(AVGSIZE_{i,12/17}/AVGSIZE_{i,1/15})$, respectively. Each chart includes a simple OLS regression line.

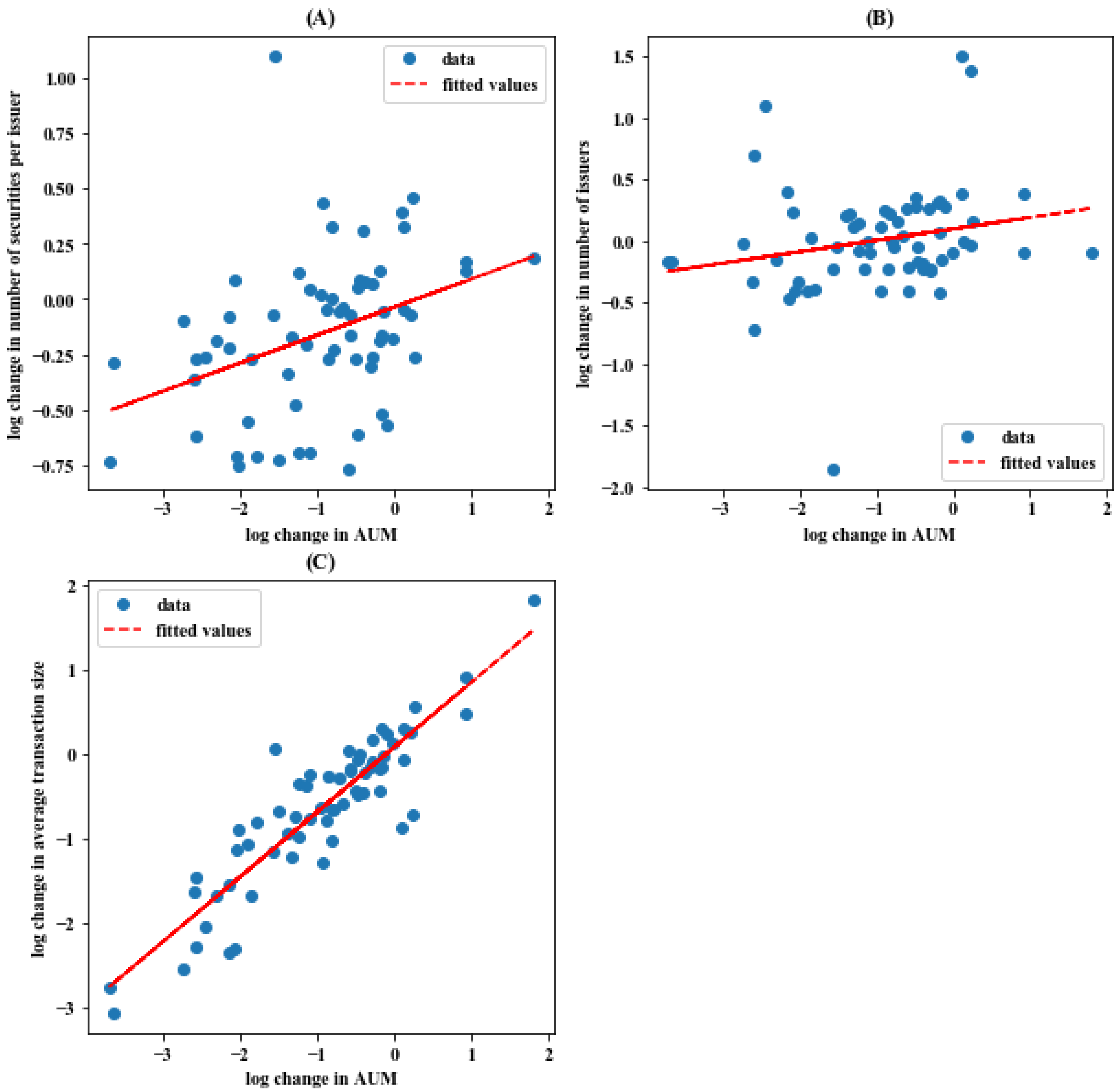


Table 1: Portfolio Statistics by Ultimate Disposition

This table reports the equal-weighted (Panel A) and asset-weighted (Panel B) average of AUM, expense ratio, WAM, WAL, gross yield, fraction in shareclasses with minimum investment of $1000 or less, and fraction of the fund in retail shareclasses for each group of funds in Figure 2A and 2B.

(A) Equally weighted

Final status	Expense	Minimum Investment	WAM	WAL	Gross Yield	Retail Percent
Acquired/Government	0.20%	58.28%	43.8	72.2	0.21%	40.58%
Acquired/Prime	0.18%	34.35%	38.3	58.1	0.20%	62.61%
Disappear	0.12%	60.00%	38.8	64.6	0.18%	21.31%
Government	0.15%	80.12%	43.5	71.7	0.17%	40.09%
Institutional Prime	0.11%	35.11%	40.3	65.6	0.20%	7.56%
Liquidate/Prime	0.10%	74.35%	30	44.7	0.18%	23.74%
Prime Feeder	0.23%	0.00%	34	59	0.28%	22.75%
Retail Prime	0.18%	44.65%	43.3	72.9	0.20%	71.49%

(B) Asset weighted

Final status	Expense	Minimum Investment	WAM	WAL	Gross Yield	Retail Percent
Acquired/Government	0.22%	11.12%	46.2	81	0.23%	48.18%
Acquired/Prime	0.18%	32.88%	41.6	70.4	0.21%	47.52%
Disappear	0.07%	63.57%	40.8	75.9	0.19%	0.99%
Government	0.15%	52.52%	45.8	82.5	0.21%	63.08%
Institutional Prime	0.11%	30.12%	41.3	73.7	0.21%	3.15%
Liquidate/Prime	0.09%	76.51%	39.9	69.5	0.20%	31.02%
Prime feeder	0.23%	0.00%	34	59	0.28%	22.75%
Retail Prime	0.18%	31.80%	47.8	86.6	0.21%	64.55%

Table 2: Relation of Assets to Portfolio Composition

The table analyzes the effects of asset shrinkage on prime money funds across the reform, with two panels that each have three groups of regressions. Group (*i*) examines the relation between the level of log(AUM) and the levels of log of number of issuers, number of issues divided by number of issuers, and average issue size as of 1/15. The dependent variables are log($NISSUERS_{i,1/15}$), log($AVGISSUES_{i, 1/15}$) and log($AVGSIZE_{i, 1/15}$). The independent variable is log($AUM_{i,1/15}$). Group (*ii*) examines the relation between the level of log(AUM) and the levels of log of number of issuers, number of issues divided by number of issuers, and average issue size as of 12/17. The dependent variables are log($NISSUERS_{i,12/17}$), log($AVGISSUES_{i, 12/17}$) and log($AVGSIZE_{i, 12/17}$). The independent variable is log($AUM_{i, 12/17}$). Group (*iii*) examines the relation between the time-series change of log(AUM) and the change of log of issuers, number of issues divided by number of issuers, and average issue size across the reform. The dependent variables are log($NISSUERS_{i,12/17}/NISSUERS_{i,1/15}$), log($AVGISSUES_{i,12/17}/AVGISSUES_{i,1/15}$) and log($AVGSIZE_{i,12/17}/AVGSIZE_{i,1/15}$). The independent variable is log($AUM_{i,12/17}/AUM_{i,1/15}$). The regressions in Panel A exclude repos, and correspond to Figures 15 and 16. The regressions in Panel B include repos. The number of observations is lower by 1 in Panel A, because one fund invested only in Repos at the end of 2017.

Panel A: Without Repos

(*i*) Level: 01/2015

	log_per_issuer	log_num_issuer	log_transaction_size
Intercept	-3.0335***	3.2298***	-0.1282
	(0.6046)	(0.4583)	(0.8682)
log_aum	0.1793***	0.0116	0.7839***
	(0.0268)	(0.0468)	(0.0469)
Observations	64	64	64

(*ii*) Level: 12/2017

	log_per_issuer	log_num_issuer	log_transaction_size
Intercept	-2.1550***	2.2524***	-0.2323
	(0.2039)	(0.6632)	(0.3203)
log_aum	0.1392***	0.0579**	0.7949***
	(0.0217)	(0.0307)	(0.0327)
Observations	64	64	64

(*iii*) Change

	log_per_issuer_ch	Δlog_num_issuer	Δlog_transaction_size
Intercept	-0.0349	0.0976	0.1934***
	(0.0566)	(0.0768)	(0.0602)
Δlog_aum	0.1265***	0.0932*	0.8472***
	(0.0395)	(0.0536)	(0.0420)
Observations	64	64	64

Note: Standard errors in parentheses.

* p<.1, ** p<.05, ***p<.01

Panel B: With Repos

(*i*) Level: 01/2015

	log_per_issuer	log_num_issuer	log_transaction_size
Intercept	-2.6837***	0.9334***	1.3211
	(0.4080)	(0.5923)	(0.8230)
log_aum	0.1598***	0.1230**	0.7307***
	(0.0251)	(0.0278)	(0.0386)
Observations	65	65	65

(*ii*) Level: 12/2017

	log_per_issuer	log_num_issuer	log_transaction_size
Intercept	-2.3843***	1.4048**	1.3211
	(0.4119)	(0.2310)	(0.8230)
log_aum	0.1524***	0.1038***	0.7307***
	(0.0192)	(0.0247)	(0.0386)
Observations	65	65	65

(*iii*) Change

	log_per_issuer_ch	Δlog_num_issuer	Δlog_transaction_size
Intercept	0.1278**	0.0590*	-0.1323**
	(0.0286)	(0.0325)	(0.0288)
Δlog_aum	0.2394***	0.403***	0.6101***
	(0.0449)	(0.0511)	(0.0796)
Observations	65	65	65

Note: Standard errors in parentheses.

* p<.1, ** p<.05, ***p<.01