THE U.S. TREASURY FLOATING RATE NOTE PUZZLE: IS THERE A PREMIUM FOR MARK-TO-MARKET STABILITY?

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Abstract. We find that Treasury floating rate notes (FRNs) trade at a significant premium relative to the prices of Treasury bills and notes. This premium differs from previously-documented liquidity premia in Treasury security prices, is directly related to the near-constant nature of FRN prices, and is correlated with measures reflecting investor demand for safe assets. Motivated by evidence that money market funds are often the primary investors in FRNs, we use an important discontinuity in the recent regulatory reform of money market funds to identify exogenous shocks in the demand for investments with stable net asset values (NAVs). The FRN premium is related to flows into money market funds with fixed NAVs, but not to flows into similar funds with variable NAVs. These results provide strong evidence that the FRN premium represents a convenience yield for the mark-to-market stability feature of FRNs.

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1. INTRODUCTION

There is an extensive literature documenting that markets incorporate a substantial liquidity premium into the prices of Treasury securities because of their near-money characteristics. In particular, the liquidity of many Treasury securities allows them to serve in a medium-of-exchange role since they can be rapidly converted into cash even during flights-to-security in financial markets. As a result, Treasury securities include a large premium in their prices relative to those of less-liquid securities that are likewise guaranteed by the full faith and credit of the United States (Longstaff (2004) and Lewis, Longstaff, and Petrasek (2018)). Furthermore, on-the-run Treasury bills and bonds often trade at a premium to less-liquid off-the-run Treasury securities (Amihud and Mendelson (1991), Kamara (2004), and Krishnamurthy (2002)).[1]

We provide evidence that the market also incorporates a significant additional near-money premium into the prices of what may be the nearest-to-money of all Treasury securities—Treasury floating rate notes (FRNs). This premium appears to be directly related to the store-of-value or capital-preservation role that FRNs play in protecting financial institutions against mark-to-market variability in fund share values. FRNs are among the most important recent innovations in fixed income markets. Since their introduction in 2014, FRNs have become one of the most popular types of Treasury debt with nearly $940 billion issued to date. By nature of their security design, FRN prices fluctuate far less than those of other Treasury securities and are among the most stable collateral options available. Furthermore, FRNs represent informationally-insensitive debt in the sense of Dang, Gorton, and Holmström (2015) since their market values are virtually unaffected by either private or public information.

We begin by examining the relative valuation of FRNs and other types

[1]Other key examples of this literature include Duffee (1996), Krishnamurthy and Vissing-Jorgensen (2012), Fleckenstein, Longstaff, and Lustig (2014), Nagel (2016), and Musto, Nini, and Schwarz (2018).

of Treasury debt. In doing this, we use a no-arbitrage approach in which we compare the prices of FRNs to the value of a replicating portfolio of Treasury bills or notes. This allows us to identify directly whether the market embeds an additional premium or convenience yield into the prices of FRNs. A key advantage of this approach is that since the replicating portfolio has the identical cash flows, duration, and maturity date as the FRN, we are able to control for any potential credit or refinancing-rollover risk associated with Treasury financing. This aspect is particularly important in light of the central role that rollover risk plays in models of safe assets (He, Krishnamurthy, and Milbradt (2019)).

The empirical results are striking. FRN prices are significantly higher than the value of their replicating portfolios of Treasury bills or notes. This is true across the maturity spectrum as we compare FRN prices to replicating portfolios using fixed rate securities ranging from three-month on-the-run Treasury bills to the most-recently-auctioned two-year Treasury notes. On average, the premium is 5.97 basis points relative to Treasury bills, and 9.73 basis points relative to Treasury notes. These premia, however, vary significantly through time and can exceed 30 basis points (or, alternatively, more than 40 cents per $100 par amount). Furthermore, these premia are economically large, almost uniformly positive, and are orders of magnitude larger than the bid-ask spreads for these actively-traded and highly-liquid Treasury bills, notes, and FRNs. We also show that the premia in FRN prices differ fundamentally from the liquidity and safety premia in Treasury security prices previously documented in the literature.

What is the source of the large premia in FRN prices? Motivated by recent theory on the demand for safe assets because of their store-of-value or capital-preservation role, we begin by examining the nature of the demand for Treasury FRNs. We find that money market funds (MMFs), mutual funds, ETFs, and other net-asset-value-sensitive institutional investors are the primary holders of FRNs. MMFs in particular often represent the single largest class of investors in FRNs and frequently hold more than 50 percent of FRN issues. This strong preference for FRNs is intuitive in light of recent regulatory reforms in the money market industry. In these reforms, many MMFs are now subject to liquidity fees and floating net asset value (NAV) requirements that may negatively impact them through exposure to mark-to-market volatility in their security holdings. These regulatory changes have resulted in massive outflows from retail and institutional MMFs. Furthermore, institutional investors are now subject to periodic stress tests that may impose additional capital requirements based on the mark-to-market sensitivity of their holdings to interest rate shocks.

To explore the relation between the premia and the mark-to-market stability of FRN prices, we conduct a number of analyses. First, we find that the cross-section of premia is significantly and positively related to the difference in the price volatilities of FRNs and the matched-maturity Treasury bills and notes used in the replicating portfolios. Thus, the premia appear directly related to mark-to-market stability of FRN prices. Second, we show that changes in the premia are strongly related to changes in exogenous variables proxying for financial and macroeconomic uncertainty. These results support the implications of He, Krishnamurthy, and Milbradt (2019) that safe asset values increase when the risk of a flight-to-security becomes more likely. Consistent with Nagel (2016), we also find that the average premia are significantly related to the opportunity cost of holding money as measured by short-term interest rates. Third, we find that the premia are significantly related to key components of the demand for money.

To examine the causal relation between the premia and the demand for mark-to-market stability, we make use of an important exogenous regulatory shock to the ability of many MMFs to continue reporting fixed NAVs. Specifically, the SEC's Money Market Reform of 2014 creates a discontinuity between MMFs that invest 99.50 percent or more of their assets in Treasury securities, and those that do not. MMFs that meet this 99.50 percent threshold are exempt from having to report floating NAVs and/or subjecting investors to redemption fees and restrictions on withdrawals (gating). Thus, cross-sectional variation in the flows into the various types of MMFs allows us to identify the causal effects of changes in the exogenous demand for stable NAV values on the FRN premia.

The results provide strong support for the hypothesis that the FRN premia reflect the demand for the price stability that these securities provide. We find that FRN premia increase significantly with net flows into MMFs that are exempt from redemption fees and floating NAV requirements. In contrast, there is no relation between FRN premia and flows into non-exempt MMFs holding similar investment portfolios. These findings make a compelling case for interpreting the richness of FRNs as evidence of a stability premium in their prices.

Finally, we consider and rule out a number of alternative possible explanations for the FRN premia. For example, we demonstrate that the premia are not due to the pricing of the swaps used in creating the replicating portfolios. This follows since we do not observe similar premia when we apply the same methodology and swap prices to corporate and agency FRNs. We also show that the premia are unlikely to be due to differences in liquidity between FRNs and the Treasury bills and notes used in the replicating portfolios. Furthermore, the premia are not due to on-the-run effects since the premia are present even when comparing on-the-run FRNs with on-the-run Treasury bills and notes. Finally, we show that the premia cannot be attributed to differences in haircuts and financing rates in the repo markets, collateral restrictions, taxation, etc.

These results have a number of important implications. First, they suggest that economic agents place a high value on the capital-preservation or store-of-value function of FRNs. Second, our findings have implications for the management of sovereign debt. Specifically, the results suggest that the U.S. Treasury could potentially reduce its debt financing costs by issuing floating rate debt with near-constant market values that are largely unaffected by either public or private information. A simple calculation suggests that the total savings to the Treasury from the close to $940 billion of FRNs issued to date could approach a billion dollars. In theory, the potential savings from refunding all fixed rate Treasury debt with floating rate debt could be orders of magnitude larger.

2. RELATED LITERATURE

There is a rapidly growing theoretical literature focusing on the unique role that safe assets such as Treasury securities play in the financial markets. Important examples include Caballero, Farhi, and Gourinchas (2008), Caballero and Krishnamurthy (2009), Cochrane (2015), and Duffie (2015). Gorton and Ordoñez (2013) present a model in which the store-of-value role of safe assets facilitates borrowing, clearing, and settlement in financial markets since these assets represent stable high-quality collateral. He, Krishnamurthy, and Milbradt (2016, 2019) present models in which the capital-preservation aspect of safe assets plays a central role. Guiband, Nosbusch, and Vayanos (2013) present a clientele model of the optimal maturity structure of government debt. Greenwood, Hanson, and Stein (2010, 2015) study optimal government debt maturity in a model where short-term riskless debt provides monetary services to agents. Vayanos and Weill (2008) use a search-based model to study the on-the-run liquidity premium in Treasury securities. Dang, Gorton, and Holmström (2015) consider the role that the informational sensitivity of a security plays in its valuation. Our empirical results about the existence of an additional premium related to the price stability of FRNs support the implications of many of these theoretical models.

There is also an extensive empirical literature documenting that the prices of near-money assets such as Treasury securities incorporate liquidity and safety premia. Key examples include Amihud and Mendelson (1991) and Kamara (1994) who show that liquid Treasury bills trade at a premium relative to older less-liquid Treasury notes and bonds with similar maturities. Duffee (1996) documents idiosyncratic variation in the prices of Treasury bills. Longstaff (2004) and Lewis, Longstaff, and Petrasek (2018) show that Treasury securities trade at a premium relative to agency or corporate bonds that are likewise guaranteed by the full faith and credit of the United States. Krishnamurthy (2002) finds that on-the-run Treasury bonds are priced at a premium relative to less-liquid off-the-run Treasury bonds. Greenwood and Vayanos (2014) find that Treasury supply affects the expected returns of long-term Treasury securities. Krishnamurthy and Vissing-Jorgensen (2012) show that Treasury bond prices incorporate significant safety and liquidity premia. Nagel (2016) compares general collateral repo rates to Treasury bill yields and finds that Treasury bills incorporate a significant liquidity premium. Nagel (2016) also finds that this liquidity premium is related to the opportunity cost of money as reflected by short-term interest rates, and that controlling for this opportunity cost largely subsumes Treasury supply-related factors. We extend this literature by showing that in addition to the liquidity and safety premia previously documented in the literature, nearer-to-money assets such as FRNs may also incorporate an additional premium for their price-stability or capital-preservation role in financial markets.

An important recent paper by Hartley and Jermann (2018) studies the valuation of FRNs and argues that they are priced at a discount relative to three-month Treasury bills. An insightful contribution of Hartley and Jermann (2018) is the recognition that some portion of the discount they estimate may be related to the rollover risk induced by the maturity difference between the FRNs and Treasury bills used in their analysis (also see He and Xiong (2012), and He, Krishnamurthy, and Milbradt (2019)). In light of this, our paper conducts an apples-to-apples comparison of the pricing of FRNs to that of matched-maturity replicating portfolios of Treasury bills and notes. An important advantage of this no-arbitrage approach is that it allows for a clean identification of the premium while holding fixed the credit or rollover risk of Treasury financing.[2]

3. TREASURY FRNs

Like Treasury bills, notes, and bonds, FRNs are direct obligations of the Treasury and are backed by the full faith and credit of the U.S. government. The key difference is that the coupon cash flows of FRNs are indexed to the most-recent

[2]Because of the potential credit or refinancing risk of Treasury securities, FRNs are not equivalent to rolling over a series of three-month Treasury bills. See the discussion in Duffie (2015), Cochrane (2015), and Bhanot and Guo (2017). In recent empirical work on MMFs, Li, Liu and Musto (2018) observe that spreads between long- and short-dated floating-rate commercial paper are small compared to those on fixed rate commercial paper which suggests that investors may be willing to accept a smaller spread in exchange for less rollover risk.

13-week Treasury bill auction high rate plus a constant spread.[3] Thus, the coupon accrual rate on these securities varies through time with the weekly auction cycle for 13-week Treasury bills. FRNs pay quarterly coupon cash flows on the last calendar day of the corresponding month. The dollar amount of the coupon payment is the cumulative arithmetic total of the daily interest accrual over the quarter. The daily interest accrual rate is floored at zero percent. At maturity, FRNs are redeemed at their par value.

FRNs are currently issued with a maturity of two years. The first FRN was issued on January 31, 2014. Since then, the Treasury has auctioned FRNs every three months in January, April, July, and October, and reopened the FRNs in the two subsequent months after the original issue. As of March 31, 2019, the total par amount of all FRNs issued was $938 billion. Similar to Treasury notes, FRNs are auctioned using a single-price auction mechanism in which each competitive bidder specifies a discount margin, expressed in tenths of a basis point, which can be positive, zero, or negative. The Treasury awards FRNs to bidders at the price equivalent to the highest accepted discount margin at which bids were accepted.

By nature of their contract design, Treasury FRN prices vary little from their par values. To illustrate this, Table 1 presents summary statistics for the prices of the individual FRNs issued during the January 2014 to March 2018 sample period. The sources and description of the data (and for all other data used in the study) are given in the Online Appendix. As shown, the average prices of the individual FRNs are all close to their par value of $100. The average prices of the FRNs range from 99.980 to 100.202. The average price taken over all FRNs is 100.060. Furthermore, the FRN prices display relatively little variation over time. The volatility of the market price over the entire two-year life of a FRN issue is typically on the order of only two to six cents per $100 par amount.

Treasury FRNs also display far less day-to-day variability in their mark-to-market values than other Treasury securities with similar maturities. Table 2 reports the volatility of daily price changes for FRNs and for matched-maturity

[3]The Online Appendix provides additional details about Treasury FRNs.

Treasury bills and notes. As shown, the standard deviation of the daily price changes for FRNs is far less than that of Treasury bills and notes even for maturities as short as three months. The difference in volatilities is even more striking for longer maturities. The stability in the daily mark-to-market values of FRNs makes a strong case for why market participants may view them as attractive capital-preservation vehicles during turbulent periods in financial markets.

Finally, FRNs are very similar in terms of their liquidity to the matched-maturity Treasury bills and notes. Table 3 presents summary statistics for a number of liquidity measures for the FRNs and the Treasury bills and notes used in the replicating portfolios. The FRNs, Treasury bills, and Treasury notes mirror each other closely in terms of their total amounts issued, average bid-ask spreads, and bid-to-cover ratios at the initial auction of the issues.

4. IDENTIFYING THE PREMIUM

In comparing the values of FRNs with those of other Treasury securities, it is important to ensure that differences in the risk characteristics of the securities do not contaminate the results. For example, we cannot simply compare the yields of two-year FRNs with those of two-year Treasury notes since the two securities have very different durations. Similarly, we cannot directly compare the yields on two-year FRNs with those of three-month Treasury bills since the two securities differ fundamentally in their exposure to Treasury credit or rollover risk. To address this, we use a no-arbitrage replication approach to identify the premium in FRN prices. In this section, we first discuss how synthetic FRNs can be created by swapping fixed rate Treasury securities into floating. We then describe how the replication approach is used to identify the premium.

4.1 Replicating FRNs

The key to our replication approach is that there are large and actively-traded over-the-counter basis swap markets that allow participants to exchange the stream of fixed payments received from a fixed-coupon Treasury note or bond for a stream of floating payments. These floating payments can be based on a variety of floating indexes such as the 13-week Treasury bill yield.[4]

To convey the intuition, Table 4 presents a specific numerical example of how the cash flows of a FRN can be replicated using a Treasury note, swaps, and STRIPS. The first five columns show the cash flows from the individual components of the replicating strategy. Specifically, the first column shows the cash flows from a long position in a two-year Treasury note with a coupon rate of 2.00 percent. The second column shows the cash flows from a standard interest rate swap in which the investor receives the Libor rate L_t and pays the fixed swap rate of 2.332 percent. The third column shows the cash flows from a basis swap in which the investor receives the average 13-week Treasury bill rate X_t plus a fixed spread of 36.16 basis points. The net effect of using the basis swap in tandem with a standard Libor swap is to convert the fixed coupons from the Treasury note into a stream of floating coupons based on X_t. The fourth column shows the cash flows from a small portfolio of Treasury STRIPS that enables the replicating portfolio to zero out the residual fixed cash flows. The fifth column shows the total cash flows of the replicating portfolio. As illustrated, the future cash flows of the replicating portfolio match exactly those of the Treasury FRN. Table 4 also shows that the price of the replicating portfolio is 99.6151 while the price of the Treasury FRN is 100.0039. Thus, the FRN price premium is 38.88 cents, which maps into a premium of 19.51 basis points.

A similar approach allows us to replicate the cash flows of a Treasury FRN using a portfolio of Treasury bills. For example, a one-year Treasury FRN can be replicated by taking positions in 3-, 6-, 9-, and 12-month Treasury bills and again using a basis swap in tandem with a standard Libor swap to convert fixed cash flows into floating cash flows based on X_t. The Online Appendix provides full details about the methodology for replicating FRNs using either Treasury

[4]The Online Appendix provides a detailed discussion of the basis swap markets. Du, Tepper, and Verdelhan (2018) use the one-month/three-month Libor basis (tenor) swap in their analysis.

notes or Treasury bills, along with additional numerical examples.

4.2 Estimating the Premium

Once the replicating portfolio is identified, the premium or convenience yield can be readily measured by comparing the price of the FRN with the price of the synthetic FRN replicating portfolio. In doing this, we estimate the premium relative to replicating portfolios created using Treasury bills and to replicating portfolios created using matched-maturity Treasury notes.

To estimate the premium relative to Treasury bills, we focus on FRNs with maturities of one year or less and identify the Treasury bills with maturities closest to the coupon payment dates of the FRNs. In replicating the cash flows of the FRN, we always use the on-the-run or most-recently-auctioned Treasury bills with maturity dates closest to the cash flow payment dates of the FRN. The premium is then estimated by taking the difference between the price of the FRN and the price of the replicating portfolio of Treasury bills.

To estimate the premium relative to Treasury notes, we first identify Treasury notes with maturity dates that match those of the FRNs. Fortunately, this task is straightforward because the Treasury auctions two-year fixed coupon Treasury notes on virtually the same cycle as two-year FRNs. For each of the FRNs in the sample, there is a two-year fixed coupon Treasury note with an identical maturity date, and the auction date of this matched Treasury note is within a day or two of the auction date of the corresponding FRN. Once the matched-maturity two-year Treasury note is determined, the premium is identified by comparing the price of the FRN to that of the replicating portfolio.

Finally, because the FRN and replicating portfolio have identical cash flows, the durations of both are exactly the same. This means that the premia are not simply equilibrium risk premia compensating investors for differences in duration or interest rate sensitivity between floating rate and fixed rate Treasury securities. Similarly, since the FRN and the replicating portfolio have identical maturities, potential Treasury credit or rollover risk is held fixed in the analysis. Thus, the estimated premia are not equilibrium credit or rollover risk premia.[5]

5. THE PREMIA

In this section, we use the replication approach described above to estimate the premia in FRN prices. In some cases, we will express the premia as cents per $100 par amount which we denote as price premia. In general, however, we will express the premia in terms of basis points which we denote simply as premia.[6]

Table 5 reports summary statistics for the estimated premia by individual FRN issue. The first section of the table reports the results from the comparisons of FRNs to the replicating portfolio of Treasury bills.[7] The second section of the table reports the results from the comparisons of FRNs to the replicating portfolio using two-year Treasury notes. Both sets of results are based on observations for which the maturity of the FRN is greater than or equal to three months. Figure 1 plots the time series of the estimated price premia.

The results are striking. Focusing first on the valuation of FRNs relative to Treasury bills, Table 5 shows that FRN prices incorporate a substantial premium relative to the prices of Treasury bills. The average premia are all positive (with the exception of the first FRN) and highly statistically significant. The average taken over all FRNs is 5.97 basis points. The averages for some of the FRNs,

[5]In contrast, approaches that compare yields of two-year FRNs directly to three-month Treasury bill rates have the drawback of confounding near-money premia with credit premia. For discussions of the implications of rollover risk, see Hartley and Jermann (2018) and He, Krishnamurthy, and Milbradt (2019).

[6]Price premia are converted into basis point premia by calculating the change in the yield of the fixed rate Treasury security used in the replicating portfolio resulting from a change in its value by the price premium. A positive premium implies that the value of the FRN exceeds that of the replicating portfolio.

[7]The premia for the last four FRNs issued are not computed since their maturities exceed one year throughout the sample period and, therefore, cannot yet be replicated using Treasury bills.

however, are in excess of 15 basis points. These averages are an order of magnitude larger than the typical bid-ask spread for FRNs. The table also shows that more than 75 percent of the estimated premia are positive. For some of the more-recent FRNs, however, 100 percent of the estimated premia are positive.

Turning next to the valuation of FRNs relative to the matched-maturity Treasury notes, Table 5 shows that the FRNs are uniformly priced at a large premium to their Treasury note counterparts. The average premium is positive and significant for all 17 of the FRNs with average values typically in excess of 10 basis points. The average premium taken over all FRNs is 9.73 basis points. Furthermore, nearly 89 percent of the premia are positive.

While average premia on the order of six to ten basis points may seem modest, these values are actually very large in the context of Treasury markets. As shown in Table 3, these values are an order of magnitude larger than the typical bid-ask spreads for Treasury securities. Furthermore, these average values are comparable in size to a number of previously-documented liquidity effects. For example, the average value of the bond/old-bond spread studied by Krishnamurthy (2002) is 6.25 basis points. Cammack (1991) finds that the average difference between auction and secondary market yields in the Treasury bill market is four basis points. Longstaff (2004) finds that the average flight-to-liquidity premium in Treasury bond prices relative to Treasury-guaranteed Refcorp bonds is roughly ten basis points for maturities out to 10 years.

Another way of evaluating the economic importance of these results is by estimating the total value of the premium across all FRNs. To do this, we multiply the average price premium for each FRN by the total par amount issued. This simple calculation implies that the total valuation effect of the premium is $309 million relative to Treasury bills, and $992 million relative to the Treasury notes. These valuation effects are clearly very significant from an economic perspective.

To provide additional perspective, Figures 2 and 3 present three-dimensional plots of the price premia as functions of time to maturity over the sample period. As shown, the price premia are strongly related to the maturity of the FRNs and the corresponding matched-maturity Treasury bills and notes. In particular, there is a strong positive correlation between the price premium and the time to maturity of the FRN for the large majority of days in the sample period.

These premia are not the only differences between the FRNs and the replicating portfolios. In particular, the daily mark-to-market variation in the value of the replicating portfolios is significantly higher than the same measure for the FRNs. This is shown in Table 6 which reports the volatility of daily price changes for the FRNs and the FRN replicating portfolios. For example, the volatility of daily changes in the values of the replicating portfolios with maturities ranging from 21 to 24 months is 2.228 cents. In contrast, the corresponding volatility of daily price changes for the FRNs is 0.783 cents. Thus, the replicating portfolio has nearly three times the daily mark-to-market volatility of the actual FRN. An important implication of this is that investors who are sensitive to mark-to-market variability in their portfolios may not view FRNs and synthetic FRNs as perfect substitutes despite the fact that both have the exact same cash flows over time. If so, then these investors may be willing to pay an additional convenience yield for the mark-to-market stability that FRNs provide.

Finally, it is important to recognize that these premia differ from those previously documented in the literature. First, recall that the credit/default risk of the FRNs is identical to that of the matched-maturity Treasury bills and notes since all are guaranteed by the full faith and credit of the United States. Similarly, the rollover risk discussed by Hartley and Jermann (2018) and He, Krishnamurthy, and Milbradt (2019) is the same for the FRN as for the Treasury bill or note used in the replication. Thus, the premia we estimate differ from the safety premia in Treasury security prices documented by Krishnamurthy and Vissing-Jorgensen (2012) and others.

Second, as shown earlier, FRNs are very similar in their liquidity characteristics to the matched-maturity Treasury bills and notes. Thus, the premia we estimate are unlikely to be due to differences in liquidity across the securities. This argues that these premia differ from the liquidity premia in Treasury security prices identified by Amihud and Mendelson (1991), Kamara (1994), Longstaff (2004), Krishnamurthy and Vissing-Jorgensen (2012), and others.

Third, these premia are also unlikely to be related to on-the-run/off-the-run effects (Krishnamurthy (2002)). The reason is that in estimating the premium relative to Treasury bills, we use the most-recently-issued Treasury bills in the replication. Thus, we compare off-the-run FRNs to on-the-run or recently-issued Treasury bills. The positive FRN premia we find are inconsistent with the on-the-run/off-the-run effect since they go in the wrong direction. Furthermore, in comparing FRNs with two-year Treasury notes, we compare one on-the-run security with another on-the-run security. As discussed earlier, the auction dates for the FRNs and the matched-maturity two-year Treasury notes are typically within a day or so of each other. This means that both securities used in the estimation are on-the-run at the same time. Thus, the premium in FRN prices is unlikely to be the same as the familiar on-the-run/off-the-run liquidity effect.

Fourth, these premia also differ from the near-money liquidity premium in Treasury bill yields documented by Nagel (2016). In particular, Nagel (2016) finds that there is a significant spread between the three-month general collateral government repo rate and the three-month Treasury bill rate. Since fully-collateralized government repo is essentially default free, this spread represents an additional liquidity premium for the near-money properties of Treasury bills relative to contractuals such as a repo loan. To verify this point, we compute the correlations of monthly changes in the average FRN premium with changes in the Nagel (2016) liquidity premium measure. These correlations are only -0.039 and 0.092 when the FRN premium is estimated relative to Treasury bills and Treasury notes, respectively, and are not significant.

6. WHO OWNS TREASURY FRNs?

The results discussed above—and finding that these premia differ from those previously documented in the literature—immediately raise the question: what is the source of the large premia in FRN prices? Motivated by recent research on the demand for safe assets in the financial markets (Gorton and Ordoñez (2013), He, Krishnamurthy, and Milbradt (2016, 2019), Nagel (2016), and others), our first step in addressing this issue will be to identify the primary holders of FRNs.

To understand the demand for FRNs, we collect data from the Bloomberg system on the institutional ownership of FRNs via its Holders (HDS) reports. Using these reports, we compute the percentages of the total notional amounts of FRNs and matched-maturity Treasury notes held by various categories of institutions, including banks, brokers and dealers, holding companies, corporations, unincorporated businesses, insurance companies, pension funds, the U.S. government, MMFs, mutual funds, ETFs, and hedge funds.[8] We augment this CUSIP-level data with data on aggregate Treasury security holdings from Table L.210 of the Federal Reserve Board Z.1 Release. To provide perspective, we compute the average percentages of FRNs held by various categories of institutional investors for the FRNs in the market at different points in time. Table 7 provides a snapshot of these average percentages as of March 31, 2019—snapshots of the average percentages at other points in time are similar to those shown.

Table 7 shows that FRNs are held primarily by MMFs, mutual funds, ETFs, and other funds. MMFs owned nearly 40 percent of the FRNs, while the other types of funds collectively held slightly more than 50 percent. Since the total assets of MMFs are only about 20 percent as large as those of all mutual funds, MMFs clearly hold a disproportionally large share of FRNs given their size. This pattern of FRN ownership contrasts with that for both Treasury notes with maturities matched to those of the FRNs, as well as with that of Treasury securities in general. In particular, the distribution of institutional ownership for these other categories is far broader and more diverse than is the case for FRNs.

To examine the pattern of MMF ownership of FRNs in more depth, we also collect data on the monthly holdings of FRNs by MMFs at the individual CUSIP

[8]The Bloomberg system collects the holdings information from regulatory filings including Form 13F, Form N-MFP, Form 10-K, IRS Form 990, Department of Labor Form 5500, NAIC Form Schedule D, and public disclosures from pension funds, hedge funds, MMFs, and ETFs.

level throughout our sample period. This data is obtained from Form N-MFP filings with the SEC and downloaded via the SEC's EDGAR (Electronic Data Gathering, Analysis, and Retrieval) online public database.[9] Table 8 reports summary statistics for the percentages of the individual FRNs in the sample held by MMFs. As shown, MMFs were major holders of FRNs throughout the sample period. The average percentages of the individual FRNs held by MMFs range from roughly 20 percent to nearly 50 percent.

It is important to stress, however, that in addition to being major holders of FRNs, MMFs frequently become the majority holders of FRNs. As shown in Table 8, the maximum percentage of the FRN issues held by MMFs exceeds 50 percent for 10 of the 17 FRNs in the sample (and exceeds 45 percent for 15 of the 17 FRNs in the sample). Thus, MMFs often represent the largest single class of institutional FRN ownership in the financial markets.

This latter point may seem counterintuitive since total assets held by MMFs are smaller than those held by other types of institutions such as mutual funds or ETFs.[10] However, the reason why MMFs are often the largest institutional holders of FRNs is that they tend to significantly overweight FRNs in their portfolio holdings. To illustrate, we observe that as of March 31, 2018, the universe of Treasury securities with maturities eligible to be held by MMFs consisted of 37.69, 56.80, and 5.51 percent Treasury bills, Treasury notes and bonds, and FRNs, respectively.[11] In contrast, the Treasury component of the portfolios held by MMFs consisted of 73.99, 9.17, and 16.84 percent Treasury bills, Treasury notes and bonds, and FRNs, respectively. Thus, FRNs were overweighted by a

[9]MMFs are required to file monthly Form N-MFP reports with the SEC pursuant to rule 30b1-6 under the Investment Company Act of 1940 (17 CFR 270.30b1-6).

[10]For example, the total assets of MMFs, mutual funds, and ETFs as of Q4 2018 were $3,038.3 billion, $14,669.8 billion, and $3,370.7 billion, respectively (see Tables L.121, L.122, and L.124 of the Federal Reserve Statistical Release Z.1, Fourth Quarter 2018).

[11]As of March 31, 2018, the total notional amounts of Treasury bills, Treasury notes and bonds with maturities of 397 days or less, and FRNs outstanding were $2,284.4 billion, $3,442.5 billion, and $334.0 billion, respectively.

factor of 16.84/5.51 = 3.06. Figure 4 plots the time series of the relative overweights/underweights for the three categories of Treasury securities. As shown, FRNs are heavily overweighted by MMFs throughout the sample period.

7. WHY DO MMFs HOLD FRNs?

There are a number of reasons for the strong demand from MMFs for FRNs. In this section, we discuss two important reasons arising from the regulatory environment in which MMFs operate. The first stems from recent SEC money market reforms that have the effect that investors in many MMFs are no longer guaranteed to be able to redeem shares at a fixed $1.00 NAV. Thus, these MMFs have strong incentives to increase their holdings of FRNs to reduce the potential variability of their NAVs. The second relates to the fact that the 397-day limitation imposed by SEC Rule 2a-7(c)(2) on the maturity of securities that can be held by MMFs does not apply to FRNs.

7.1 The SEC Money Market Reform

In July 2014, the SEC announced the Money Market Fund Reform (MMF Reform) which introduced new rules and tightened existing requirements for MMFs. The roots of the MMF Reform trace back to the 2008 financial crisis when the Reserve Primary Fund "broke the buck." One day after Lehman Brothers filed for bankruptcy protection on September 15, 2008, the Reserve Primary Fund's NAV fell below $1.00 per share which triggered a run of redemptions from MMFs as investors feared that other MMFs might also lose their "mark-to-market" stability.[12] During the week of September 15, 2008, investors withdrew approximately $300 billion (14 percent of total assets) from prime MMFs.[13]

[12]The SEC uses the term "principal stability" to describe a MMF's ability to maintain a stable share price. See, e.g. Money Market Fund Reform; Amendments to Form PF: Final Rule, Securities and Exchange Commission, 79 Fed. Reg at 47,736 (14 August 2014), p. 7.

[13]See Investment Company Institute (ICI), Report of the Money Market Working Group, 62, 03/17/2009, at http://www.ici.org/pdf/ppr_09_mmwg.pdf.

To prevent another run on MMFs, the SEC announced amendments to Rule 2a-7 of the Investment Company Act of 1940 on July 12, 2014 to take effect on October 14, 2016 after a two-year transition period.[14] The SEC's MMF Reform essentially created three distinct categories of MMFs: retail, institutional, and government. Retail MMFs are available only to retail investors and can be further divided into prime and tax exempt MMFs. Prime MMFs invest in high-quality commercial paper, certificates of deposit, bankers' acceptances, and repurchase agreements collateralized by such securities, but can also hold short-term securities issued by the U.S. Treasury and agencies. Tax-exempt MMFs invest in municipal debt securities that pay interest that is not taxed by the federal government, and in some cases are exempt from state and municipal taxes. Institutional MMF investors include, but are not limited to, defined benefit plans, endowments and foundations, corporations, and retirement savings trusts. Institutional MMFs can also be divided into prime and tax exempt MMFs.

In contrast, MMFs designated by the SEC as government MMFs are not subject to mandatory fees, gates, and floating NAV requirements. Government MMFs are required to invest at least 99.50 percent of their total assets in cash, U.S. government securities and/or repurchase agreements that are collateralized fully by cash or government securities. A government security is defined as a security backed by the full faith and credit of the U.S. government (Rule 2a-7(a)(17); section 2(a)(16)).[15]

Under the new rules, investors in retail and institutional MMFs face a greater risk of not being able to redeem shares at a fixed NAV of $1.00 per share than before. In particular, retail and institutional MMFs are now required to charge a liquidity fee if their weekly liquidity level falls below a required threshold. For

[14]Money Market Fund Reform; Amendments to Form PF: Final Rule, Securities and Exchange Commission, 79 Fed. Reg at 47,736 (14 August 2014), Section III.N.

[15]Certain issuers of U.S. government securities, e.g., government-sponsored enterprises such as Fannie Mae, Freddie Mac, and the Federal Home Loan Banks, are sponsored or chartered by Congress, but their securities are neither issued by nor guaranteed by the U.S. Treasury.

example, these MMFs are required to impose a one-percent fee on the NAV of investor shares when weekly liquid assets fall below ten percent of total assets. The MMF's management, however, also has certain discretion to impose up to a two-percent fee when weekly liquid assets fall below 30 percent of total assets. Investors may also be unable to redeem their shares periodically since MMFs can gate withdrawals when certain liquidity triggers are reached.

Furthermore, under the new SEC MMF Reform rules, institutional MMFs are no longer allowed to report a stable $1.00 per share NAV. Instead, they become floating NAV MMFs. Specifically, institutional MMFs are required to sell and redeem shares based on the current mark-to-market value of the securities in their underlying portfolios rounded to the fourth decimal place (e.g., $1.0000), i.e., transact at a floating NAV. As a result, the NAV can fluctuate, or float. In contrast, retail MMFs are still allowed to round up their NAV to $1.00 provided that the amortized cost per share is greater than or equal to $0.9950. Floating NAV requirements create significant complications for investors who use these MMFs to manage their short-term liquidity needs since they may no longer be able to redeem their shares instantaneously. For example, the SEC recognizes that since it may take several hours to strike a market-based NAV price, floating NAV funds may no longer be able to offer trading times for same day settlement late in the day (i.e., after 4 p.m.).[16] Moreover, floating NAVs complicate accounting for short-term investments since they are marked to market with gains and losses flowing through to earnings. For instance, a floating NAV fund could strike a NAV at 9:00 a.m. for 1.0000, and they could strike again at 12:00 p.m. for 0.9999, which would be a $10,000 loss for every $100 million invested.

Finally, as a result of the reforms, all MMFs are now subject to more stringent constraints on their portfolio holdings and to enhanced stress-testing and reporting requirements. For example, SEC Rule 2a-7 requires MMFs to test their ability to maintain weekly liquid assets of at least ten percent of total assets under specific stress scenarios that include increases in the level of short-term interest

[16]See Money Market Fund Reform; Amendments to Form PF, Investment Company Act Release No. 31166 (July 23, 2014), pp. 192-193.

rates, the downgrade or default of particular portfolio security positions, and a widening of spreads in various sectors to which the MMF's portfolio is exposed, each in combination with various increases in shareholder redemptions.[17] Furthermore, Rule 2a-7 also requires retail and government MMFs to calculate the market-based value of the portfolio ("shadow price") periodically and compare it to the MMF's stable share price. If the deviation between these two values exceeds 50 basis points, the MMF's board of directors must consider what action, if any, should be taken by the board, including whether to revalue the MMF's securities above or below the $1.00 share price. Specifically, the MMF Reform requires government MMFs to publicly disclose when the MMF's current NAV per share deviates downward from its intended $1.00 stable price by more than 25 basis points (i.e., generally below $0.9975).[18]

In summary, a major consequence of the SEC's MMF Reform is that MMFs have significantly greater incentives to invest in securities that minimize the variation in their NAVs. In turn, this provides a strong motivation for MMFs to hold FRNs because of the mark-to-market stability of FRN prices.

7.2 MMF Maturity Limitations

Even before the 2014 reforms, SEC Rule 2a-7(c)(2) required that MMFs not acquire any security with a remaining maturity of more than 397 days, that the dollar-weighted average maturity of the securities owned not exceed 60 days, and that the dollar-weighted average life to maturity not exceed 120 days. FRNs, however, are not subject to the 397-day maturity restriction since FRNs are considered to have a maturity date equal to the period remaining until the next

[17]See SEC Rule 2a-7(g)-(j). This rule defines two types of liquid assets, daily and weekly, corresponding to the ability to convert to cash within one or five business days, respectively.

[18]Form N-CR Part D states that the disclosure requirement is triggered "[if] a retail money market fund's or a government money market fund's current net asset value per share deviates downward from its intended stable price per share by more than 1/4 of 1 percent [...]."

readjustment of the interest rate.[19] This may create demand for FRNs by MMFs since by investing in FRNs, MMFs can reduce the impact on their NAVs from rolling over portfolio positions while satisfying the maturity requirements.

8. FRN PREMIA AND MMF DEMAND

These considerations make a very plausible case for the hypothesis that institutional demand for the capital-preservation or store-of-value aspect of FRNs may be a fundamental source of the premia in FRN prices. Specifically, that institutions such as MMFs have incentives for holding FRNs and may be willing to pay an additional convenience yield for their mark-to-market price stability.

As a preliminary to the more formal tests of this hypothesis to be conducted in subsequent sections, it is worthwhile to examine first whether there is any evidence of a link between the FRN premia and the demand by MMFs for FRNs. To explore this, we use a panel regression framework in which we regress the premia on two measures of MMF demand. The first is a dummy variable that takes value one when the maturity of the FRN is greater than 397 days, and zero otherwise (this dummy variable is only included in the regression for premia measured relative to Treasury notes since Treasury bills all have maturities of less than 397 days). The second is the fraction of the individual FRN issue held by MMFs. Table 9 reports the results from the panel regressions.

The results suggest that the premia are not directly related to the maturity restrictions imposed on MMFs. Specifically, the coefficient for the 397-day dummy variable is not significant in the panel regression for premia measured relative to Treasury notes. In contrast, the results suggest that there is strong relation between the premia measured relative to Treasury notes and the demand

[19]Specifically, Rule 2a-7 provides that "an instrument that is issued or guaranteed by the United States government or any agency thereof which has a variable rate of interest adjusted no less frequently than every 762 days" is deemed to have a maturity equal to the period remaining until the next readjustment of the interest rate."

by MMFs for FRNs. In particular, the coefficient for the fraction of the FRN issue held by MMFs is highly significant with a t-statistic of 4.28. The positive sign of the coefficient is intuitive and consistent with the hypothesis that these premia are related to the factors driving MMF demand for FRNs.

It is important to recognize, however, that while these results are consistent with the hypothesis, they are not sufficient to establish a causal relationship. In particular, the correlation between the premia and MMF holdings could simply be due to a common dependence on an exogenous factor such as the demand for mark-to-market stability. Furthermore, FRN premia and the demand for FRNs by MMFs may themselves be endogenously related. In light of this, our approach in subsequent sections will be to test the hypothesis at a more fundamental level by examining the relation between FRN premia and exogenous instruments for institutional demand for mark-to-market stability.

9. ARE FRN PREMIA RELATED TO PRICE STABILITY?

In this section, we explore the hypothesis that the FRN premia represent the convenience yield investors are willing to pay for the capital-preservation or store-of-value features of FRNs. As discussed above, our approach will be to examine the relation between the premia and a number of exogenous measures that proxy for the current and/or potential future stability of FRN prices. We begin by examining whether the cross-section of FRN premia is related to the relative price volatility of the FRN and the Treasury bill or note used in the replicating portfolio. We then study whether changes in FRN premia are related to financial and macroeconomic variables reflecting the risk of a flight-to-security or other systematic event. Finally, we examine whether changes in FRN premia are related to changes in the demand for money as reflected by aggregate holdings of currency, demand deposits, and time deposits.

9.1 The Relation to Relative Volatility

If the estimated premia in FRN prices are in fact related to the role of these securities as more stable store-of-value vehicles relative to other Treasury securities, then we would expect that the cross-section of premia should be related to the relative magnitude of the price fluctuations between the FRNs and fixed rate Treasury securities. We can test this hypothesis directly by examining the relation between the premia and the relative volatility of the FRNs and the matched-maturity Treasury bills or notes used in the replicating portfolio.[20]

In doing this, we use a simple panel regression approach. Specifically, we compute the standard deviation of daily price changes for each FRN for each month during the sample period, and do the same for the matched-maturity Treasury bills and notes. We also compute the monthly averages of the price premia. We then regress the monthly averages of the price premia on the differences in the standard deviations of price changes for the FRNs and the matched Treasury bills or notes. To control for time-series variation, we also include monthly fixed effects in the panel regression.

The results from these panel regressions are shown in Table 10 and provide evidence that the premia are directly related to the relative price volatility of the FRNs and Treasury bills and notes. In particular, the coefficient for the difference in volatilities (measured in cents per $100 par amount) is 2.1604 with a t-statistic of 1.78 in the regression for premia measured relative to Treasury bills, and 1.3174 with a t-statistic of 3.11 in the regression for premia measured relative to Treasury notes. These intuitive results are consistent with premia representing the additional value investors are willing to pay for the nearest-to-money near-money assets.

9.2 The Relation to Financial and Macroeconomic Risk Factors

If FRN premia represent the convenience yield investors are willing to pay for the mark-to-market stability of FRNs, then these premia may be larger when investors fear potential instability in the financial markets. To explore this hypothesis, we regress changes in the FRN premia on a number of exogenous variables

[20] For a discussion of the interest-rate sensitivity of floating rate notes, see Fabozzi and Mann (2000) and Cochrane (2015).

proxying for systematic risk in the financial markets and the macroeconomy.

In conducting this analysis, we first construct indexes of the premia by taking simple averages of the premia across FRNs for each date in the sample. We construct separate indexes for the premia measured relative to Treasury bills and for premia measured relative to Treasury notes, and denote them as the FRN/T-Bill and FRN/T-Note indexes, respectively.

As proxies for systematic risk, we include four measures motivated by previous research in the asset pricing literature. First, we include the implied volatility of interest rates as a measure of potential future variation in the mark-to-market values of fixed income portfolios. This volatility measure is implied from the market prices of interest rate swaptions. Second, we include the spread between three-month Libor and the three-month Treasury bill rate. This spread—typically denoted as the TED spread—provides a measure of the systemic credit risk of the financial sector. In particular, an increase in the TED spread signals that market participants are increasingly concerned about the solvency of the large financial institutions in the Eurodollar market. Third, we include the Michigan Consumer Confidence Index as a proxy for investor sentiment. This index has also been used frequently as a measure of the level of concern in the market about major downturns in the macroeconomy. Finally, we include the CDS spread for the U.S. Treasury as a proxy for the risk of a systemic shock to the economy severe enough to result in the actual default of the United States on its debt obligations. Clearly, an increase in the systemic risk or potential risk of a flight-to-security reflected by any of these four variables would very likely also be accompanied by an increase in the demand for safe assets.[21]

We include several additional variables in the regression as controls for term structure effects. The first of these is motivated by Nagel (2016) who presents a model in which the premium in near-money assets is directly related to the opportunity cost of holding money. He shows that the near-money liquidity premium

[21]Flights-to-quality and flights-to-liquidity are discussed in Longstaff (2004), Beber, Brandt, and Kavajecz (2009), and others.

he identifies in Treasury bills is significantly related to the level of short-term interest rates. Furthermore, he shows that this relation subsumes many of the supply effects previously documented in the literature. Paralleling Nagel (2016), we include the three-month Treasury bill rate as a measure of the short-term opportunity cost of holding money. The second control is the consensus forecast of the two-year Treasury rate three months forward. This forecast provides a measure of market expectations of changes in the term structure and is motivated by the widely-held industry view that FRNs become particularly attractive investment vehicles when interest rates are expected to increase.

Table 11 reports the regression results. Focusing first on the control variables, changes in the three-month Treasury bill rate are positive and highly significant in both the FRN/T-Bill and FRN/T-Note index regressions. These results provide support for Nagel (2016) who argues that near-money premia should be directly related to the opportunity cost of holding money. Our results indicate that his results also extend to the FRN market. The table also shows that changes in the forecasted value of the two-year Treasury rate are significant in both regressions. The coefficients, however, are negative in sign which is not consistent with the widespread view among practitioners that FRNs become more popular when interest rates are expected to increase. Our results suggest that the nature of the FRN premia—which are estimated using a no-arbitrage replication approach—may be much deeper than envisioned by industry participants.

Turning now to the exogenous proxies for systemic risk, Table 11 shows that the coefficient for interest rate volatility is positive and significant (at the ten-percent level) in the FRN/T-Note index regression. Thus, the FRN premia computed relative to Treasury notes tend to increase during periods when volatility in rates makes larger changes in mark-to-market values more likely. The coefficients for changes in the TED spread are positive and significant in both the FRN/T-Bill and FRN/T-Note index regressions. This positive relation suggests that the premia tend to be larger during periods when systemic risk in the financial markets increases. The coefficients for changes in consumer confidence are negative and significant in both the FRN/T-Bill and FRN/T-Note index regressions. This means that the FRN premia increase during periods when consumer confidence declines. These intuitive results support the interpretation that FRN premia represent a convenience yield for the price stability of FRNs when investors are less confident about the macroeconomic outlook.

9.3 The Relation to Money Supply Measures

Finally, if the premia represent a convenience yield for the store-of-value function of FRNs, then there may be a relation between these premia and the demand for money itself. In particular, the revealed preference for money in the economy may provide a direct exogenous proxy for the demand for value stability.

To explore this, we collect data on the monthly changes in three monetary supply measures: the amount of currency, total demand deposits in depository institutions, and total time deposits. The first two are the primary components of M1 and the third is a key component of M2. The amount of currency includes currency outside U.S. Treasury, Federal Reserve Banks, and the vaults of depository institutions. Total demand deposits include those at domestically chartered commercial banks, U.S. branches and agencies of foreign banks, and Edge Act corporations less cash items in the process of collection and Federal Reserve float. Total time deposits includes include savings deposits and small-denomination time deposits at commercial banks and thrift institutions.[22]

Table 12 reports the results from the regressions of changes in the FRN/T-Bill and FRN/T-Note index on changes in these money supply measures. Following Nagel (2016), we also include the three-month Treasury bill rate as a control for the opportunity cost of holding money in these regressions. The results provide independent support for the hypothesis that the FRN premia represent a convenience yield for the unique near-money characteristics of FRNs. In particular, the coefficient for changes in the amount of currency is positive and significant

[22]Small-denomination time deposits are those issued in amounts of less than $100,000. Savings deposits include money market deposit accounts. All IRA and Keogh account balances at commercial banks and thrift institutions are subtracted from small time deposits.

(at the ten-percent level) in the FRN/T-Bill index regression. Similarly, the coefficient for changes in total demand deposits is positive and significant (at the ten-percent level) in the FRN/T-Note index regression.

10. IDENTIFYING THE DEMAND FOR PRICE STABILITY

In the previous section, we examined the relation between the premia and a number of exogenous variables proxying for the potential demand for securities that provide a store-of-value function. In this section, we explore the determinants of FRN premia at a more fundamental causal level by taking advantage of an important discontinuity in the regulatory treatment of MMFs to identify exogenous variation in investor demand for price stability.

Recall that the SEC's MMF Reform of 2014 created three distinct categories of MMFs that can be designated as retail, institutional, and government MMFs. Because of these reforms, investors in retail and institutional MMFs have an increased risk of not being able to redeem their shares at a fixed NAV of $1.00 per share. In particular, retail and institutional MMFs are mandated to impose a liquidity fee of one percent or more when investors redeem shares during periods in which the level of weekly liquid assets falls below a required threshold. This mandatory liquidity fee creates a state-contingent risk that investors may only be able to redeem shares at a substantial discount to their nominal $1.00 per share NAV. Furthermore, institutional MMFs now have floating NAVs which fluctuate with the value of their portfolio holdings. Specifically, institutional MMFs must sell and redeem shares based on the current mark-to-market value of their portfolios rounded to the fourth decimal place (e.g., $1.0000). The net effect of these regulatory requirements is to make retail and institutional MMFs less able to serve as a store-of-value in turbulent markets with higher mark-to-market variability in investment values.

In contrast, the government MMF category is not subject to the same types of regulatory requirements. Government MMFs are required to invest at least 99.50 percent of their total assets in cash, U.S. government securities and/or repurchase agreements that are collateralized fully by cash or government securities. A government security is defined as a security backed by the full faith and credit of the U.S. government (Rule 2a-7(a)(17); section 2(a)(16)). For example, a MMF with a portfolio of 99.50 percent Treasury securities and 0.50 percent agency debt would qualify as a government MMF. On the other hand, a MMF with a portfolio of 99.49 percent Treasuries and 0.51 percent agency debt would not qualify as a government MMF. The key point, however, is that even though the two MMFs have virtually the same risk and return profile, the government MMF is not subject to the floating NAV and/or liquidity fee regulatory requirements that would apply to the second MMF.[23]

An important aspect of this discontinuity in the regulatory treatment of MMFs is that it creates a natural experiment in which we can identify exogenous variation in the demand by market participants for mark-to-market stability. In particular, we use cross-sectional differences in the net flows into government vs. retail/institutional MMFs to identify changes in the demand for investments that may serve as better store-of-value vehicles. Intuitively, when investors become more concerned about capital preservation, they may tend to increase their allocations towards government MMFs because of the increased NAV stability provided by their regulatory treatment. Thus, differences in the relative flows into government vs. retail/institutional MMFs essentially provide an "instrument" for measuring changes in the demand for mark-to-market stability.

It is important to observe that a strong case can be made for the strict exogeneity of our instrument. Specifically, the SEC's MMF Reform was largely motivated by events associated with the financial crisis of 2008 such as the col-

[23]The 2014 MMF Reform lowered the percentage that a government MMF may invest in nongovernment securities from 20.00 to 0.50 percent. It is common industry practice to differentiate between government Treasury MMFs and government agency MMFs. The former invest solely in securities issued by the U.S. Treasury and thus meet the SEC's 99.50 percent threshold. The latter meet this requirement only if they do not hold more than the 0.50 percent de minimis threshold in agency securities that are not guaranteed by the full faith and credit of the federal government.

lapse of the Reserve Primary Fund. These events clearly predate the introduction of FRNs. Furthermore, many of the key elements of the MMF Reform were determined well before the SEC adopted the amendments to Rule 2a-7 of the Investment Company Act on July 23, 2014.[24] Thus, the creation of the discontinuity at 99.50 percent represents an exogenous regulatory action rather than an endogenous response to the pricing of FRNs.

Furthermore, differential flows into government MMFs relative to other types of MMFs can be attributed to the exogenous demand for NAV stability rather than to investor demand for FRNs. The reason for this is that the portfolio weights invested in FRNs are very similar across government, retail, and institutional MMFs. For example, during the sample period, the average portfolio weights for FRNs in government and non-government MMFs were 5.23 and 3.85 percent, respectively. Thus, there is relatively little difference in portfolio allocations to FRNs across government and non-government MMFs. Furthermore, investors have a number of other options for investing in FRNs besides MMFs. For example, FRN and other floating rate note ETFs are one of the most-rapidly-growing sectors of fixed income markets.[25] Thus, an increase in the relative demand by investors for government MMFs vs. other types of MMFs is unlikely to be driven by the pricing of FRNs in the market.

Finally, we note that by focusing on variation in the exogenous demand for government MMFs by investors—rather than the demand by MMFs for FRNs—we are able to avoid the endogeneity issues discussed previously. Recall that while the SEC's MMF Reform provided MMFs with strong incentives to hold FRNs in their investment portfolio, we argued that causal inferences cannot be drawn from the relation between the premia and the demand for FRNs from MMFs. The primary reason for this is that the pricing of FRNs and the amount

[24]The 2014 MMF Reform amended and supplemented reforms the SEC had previously adopted in 2010. See, Money Market Fund Reform, Investment Company Act Release No. 29132 (February 23, 2010).

[25]See https://www.etf.com/sections/features-and-news/big-flows-floating-rate-etfs.

of FRNs held by MMFs may be endogenously determined.

In contrast, the identification provided by the discontinuity in the regulatory treatment of MMFs allows us to test whether exogenous shifts in the demand for price stability result in changes in FRN premia. Specifically, we regress monthly changes in the FRN/T-Bill and FRN/T-Note indexes on the net flows into government MMFs and into non-government (combined retail and institutional) MMFs. We include net flows into non-government MMFs in the regression as a control for general trends in the money markets. By including this control in the regression, the coefficient for net flows into government MMFs has a clear interpretation as the marginal demand for the unique characteristics offered by government MMFs relative to other MMFs with similar risk and return properties (e.g., their exemption from regulations that impair the ability of other MMFs to function in a store-of-value role). In this sense, our analysis parallels a standard difference-in-differences framework by estimating the incremental effects of the specific demand for government MMFs vs. other MMFs on the FRN premia. Finding that the FRN premia increase when the demand for government MMFs increases—while controlling for flows into other types of MMFs—would provide direct causal evidence in support of the hypothesis that the premia represent a convenience yield for the store-of-value aspect of FRNs.

Table 13 reports the results from the regressions. As shown, there is strong support for the hypothesis. The coefficient for the net flows into government MMFs is positive and highly significant in both the FRN/T-Bill and FRN/T-Note index regressions, with t-statistics of 3.20 and 3.40, respectively. In contrast, the coefficient for the net flows into non-government MMFs is not significant in either of the regressions. Thus, changes in the FRN premia are related only to the net flows into MMFs that are exempt from the liquidity fees and floating NAV requirement imposed by the SEC's MMF Reform. These results provide persuasive evidence that FRN premia are driven by the demand for securities whose price stability allows them to serve as a more effective store-of-value option.

11. EVALUATING ALTERNATIVE EXPLANATIONS

Finally, it is important to consider whether there might be alternative factors that could explain the size and persistence of the large premia in FRN prices. To explore the robustness of our findings, we examine a number of possible explanations suggested by previous research in the literature. As we show, however, none of these potential explanations appears to be able to account for the premia in FRN prices. This section provides brief summaries of the results; the Online Appendix provides more detailed discussion.

11.1 Mispricing of Basis Swaps

We find that FRNs trade at a premium relative to a replicating portfolio that includes Treasury bills or notes and swaps. A natural question, however, is whether the results are due to the actual pricing of FRNs relative to Treasury bills and notes, or to the possibility that the swaps used in the replication approach may themselves be mispriced (potentially because of bid/ask spreads, transaction costs, illiquidity, counterparty credit risk, etc.). If the results are due to the presence of a unique premium in FRN prices, however, then we would not expect to find the same type of premia in other floating rate securities when the same set of swap prices is used in the analysis. To test whether the estimated FRN premia might be artifacts of the basis swap and/or interest rate swap data, we apply our methodology to two alternative classes of floating rate notes.

The first class consists of a set of 38 pairs of two-year matched-maturity fixed/floating rate corporate notes issued during the study period by Amgen, Apple, Berkshire Hathaway, Caterpillar, Chevron, CVS Health, Daimler, Discovery, Ford Motor, Gilead Sciences, Honeywell, HP, Honda Motor, IBM, Met Life, PepsiCo, Shire, Toyota, Walmart, and Wells Fargo.[26] The floating rate cash

[26]These securities are identified using the Bloomberg system by searching for floating rate corporate debt that was issued during our sample period between 2014 and 2018 with a two-year maturity and for which there is a fixed rate note with the same maturity. See the description of the corporate notes in the Online Appendix.

flows on these corporate FRNs are based on three-month Libor rates. We use the same methodology and swap data as for Treasury FRNs to swap the corporate fixed rate bonds into floating. Analogous to how we compute FRN premia, we then compare the prices of the replicating portfolios to the prices of the matched-maturity floating rate notes. Table 14 provides summary statistics for the estimated premia. As shown, there is no evidence of systematic pricing differences between the corporate floating rate notes and the replicating portfolios of swapped fixed rate debt. The average premium across all 38 pairs of matched-maturity floating rate and fixed rate corporate debt is -0.13 basis points which is not statistically significant. Furthermore, the premia are nearly evenly divided between positive and negative values; 50.35 percent of the premia are positive.

The second class consists of a set of 32 pairs of two-year matched-maturity fixed/floating rate notes issued by the Federal Farm Credit Bank (FFCB) during the 2014 to 2018 study period. Similar to Treasury FRNs, FFCB floating rate notes pay quarterly coupon cash flows based on the 13-week Treasury bill rate during the quarter plus a constant spread. As before, we use the same methodology and swap data to swap the matched-maturity fixed rate FFCB note into floating, and estimate the premium by comparing the price of the replicating portfolio to the price of the floating rate note. Table 14 provides summary statistics for the premia estimated using the FFCB debt. As before, there is no evidence of a significant premium in FFCB floating rate note prices. The average premium across all 32 pairs of matched-maturity floating rate and fixed rate FFCB securities is -3.08 basis points, which has the opposite sign to the average for the Treasury FRNs. These results provide clear evidence that the estimated premia in FRN prices are not simply artifacts of the mispricing of basis swaps.

11.2 STRIPS Pricing and Bid/Ask Spreads

As discussed in Section 4, the replicating portfolio typically involves taking a small position in Treasury STRIPS to match exactly the cash flows from the FRN. Since STRIPS may not be as liquid as Treasury bills, notes, or FRNs, it is important to consider whether the pricing of STRIPS or their bid/ask spreads may account for the FRN premia. It is easily shown, however, that the notional amounts of STRIPS required in the replicating portfolios are uniformly so small that the bid/ask spreads or potential mispricing of STRIPS cannot begin to account for the magnitudes of the estimated FRN premia. To illustrate, the numerical example in Table 4 shows that the total dollar value of the STRIPS used in the replicating portfolio is only 6.85 cents. Furthermore, the sum of the absolute values of the notional positions for the STRIPS is roughly 66 cents. Thus, even using a very extreme assumption about the bid/ask spread or potential mispricing of STRIPS (say, one percent of par amount), the FRN premium of 38.88 cents cannot be explained by STRIPS pricing or transaction costs.

11.3 Margins and Financing Rates in the Repo Market

Since their initial issuance, Treasury FRNs receive the same treatment in the repo markets as other Treasury securities. For example, on December 2, 2013, the Fixed Income Clearing Corporation (FICC) announced its intent to add FRNs to its netting service and GCF Repo service. The FICC stated that: "With respect to the GCF Repo service, the Floating Rate Notes will be eligible as good collateral in the following GCF Repo Generic CUSIPS: 371487AD1 U.S. Treasury Maturing in Less than 10 Years (TU10), 371487AE9 U.S. Treasury Maturing in Less than 30 Years (TU30)."[27]

Because GCF Repo is typically based on general collateral for generic classes of securities such as Treasury, agency, or investment grade corporate bonds, the repo margins for Treasury FRNs are the same as for other Treasury securities in the GCF Repo market. The same is also true for the repo rates associated with financing FRNs in the GCF Repo market (Agueci et al. (2014)).

While we do not have data on the financing rates and margins specifically for FRNs in the tri-party repo market, aggregate statistics on primary dealer activity from the Federal Reserve Bank of New York suggest that the repo rates and margins for FRNs are likely similar to those of other Treasury securities.

[27]See Securities and Exchange Commission, Release No. 34-71091; File No. SR-FICC-2013-09.

11.4 Collateral Value

Recent papers point to the important role that high-quality assets such as Treasury securities may play in financial markets as collateral in secured transactions. A review of collateralization policies at major governmental and financial institutions, however, suggests that Treasury FRNs have the same value as collateral as Treasury bills, notes, and bonds. For example, the Federal Reserve accepts Treasury FRNs as collateral for Discount Window lending and Payment System Risk purposes and FRNs receive the same collateral margin treatment as Treasury bills, notes, and bonds. FRNs are also specifically designated as accepted collateral for the Treasury Tax and Loan Program and for Depositaries and Financial Agents of the Federal Government (31 CFR Parts 202 and 203) and face the same one-percent haircut as Treasury notes and bonds with the same maturity. Treasury FRNs are also accepted collateral for the purposes of the Chicago Mercantile Exchange and have the same two-percent haircut requirement as Treasury notes and bonds (see Online Appendix for references and citations).

11.5 Tax Differences

Treasury notes and bonds pay coupons semiannually and the interest is subject to federal income taxation, but exempt from state and local taxation. FRNs pay coupons quarterly and their interest is similarly subject to federal taxation and exempt from state and local taxation.[28] Thus, there is no difference in the tax treatment of Treasury notes and FRNs.

11.6 The Interest Rate Accrual Floor

As described earlier, the daily interest rate accrual for FRNs is floored at zero. This raises the possibility that there could be a small option premium embedded into the prices of FRNs for this floor. In reality, however, the value of this floor is zero unless the FRN spread is negative. Recall that daily interest accrues at a rate equal to the sum of the most recent 13-week Treasury bill high yield

[28] See https://www.treasurydirect.gov/indiv/research/indepth/frns/res_frn_tax.htm.

plus the constant FRN spread which is determined at the auction of the FRN. However, the auction high yield of the 13-week Treasury bill cannot be negative since negative discount yields are invalid bids at T-bill auctions.[29] Since the FRN spread was never negative during the sample period, this requirement precluded the daily accrual from becoming negative. Thus, the value of the floor is zero throughout the sample period.

12. CONCLUSION

We extend the literature on the pricing of safe assets by showing that Treasury FRNs are valued at a significant premium relative to replicating portfolios that include matched-maturity Treasury bills and notes. The premia in FRN prices are related to a number of exogenous instruments for the risk of mark-to-market variability in fixed income portfolios, other systematic financial risks, as well as the demand for money in the economy. We also use a key discontinuity in the regulatory treatment of MMFs to identify exogenous variation in the demand for assets with lower mark-to-market variability. We find strong evidence that the FRN premia are directly related to the demand for investment vehicles with more stable NAVs. This additional premium has a clear interpretation as a price-stability or store-of-value near-money premium. We show that this premium is distinct from the liquidity, safety, and on-the-run near-money premia previously documented. These results also have implications for Treasury debt management by raising the possibility that the Treasury could reduce its cost of debt financing significantly—without increasing the rollover risk of its debt portfolio—by issuing debt securities such as FRNs.

[29]See Treasury Uniform Offering Circular and Auction Rules for the Sale and Issue of Marketable Book-Entry Treasury Bills, Notes, and Bonds, CFR 356.20, available at https://www.treasurydirect.gov/instit/statreg/auctreg/CFR-2014 title31-vol2-part356.pdf.

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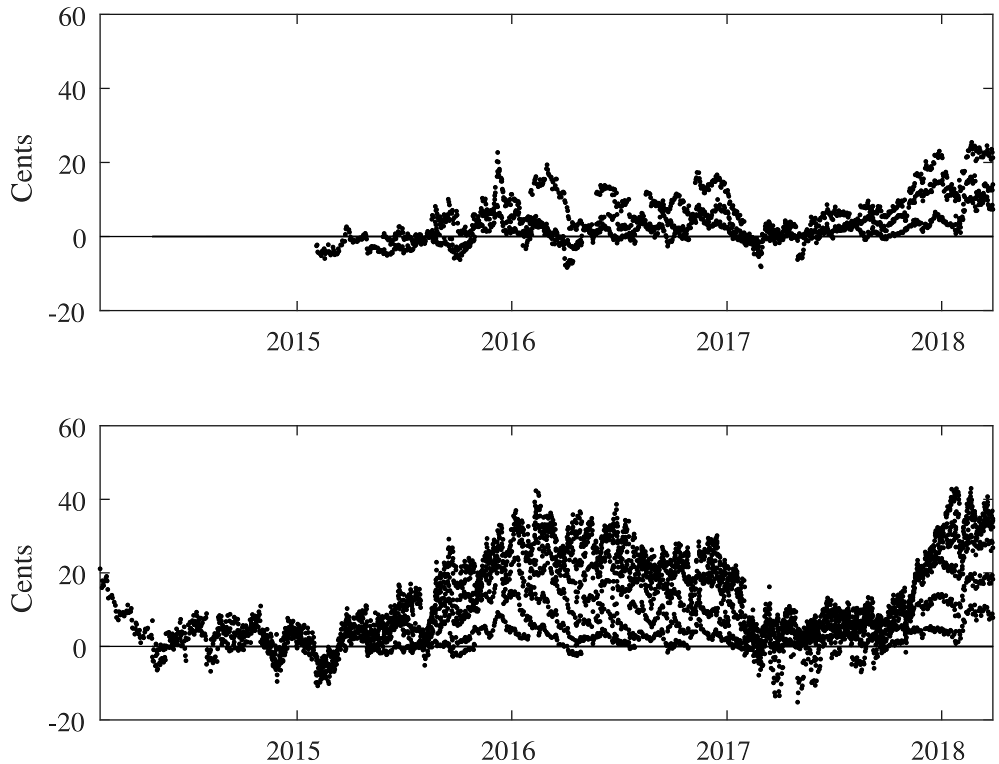

Figure 1. Price Premia. The top panel plots the time series of the price premia measured relative to Treasury bills. The lower panel plots the time series of the price premia measured relative to Treasury notes. The price premia are expressed in cents per $100 par amount.

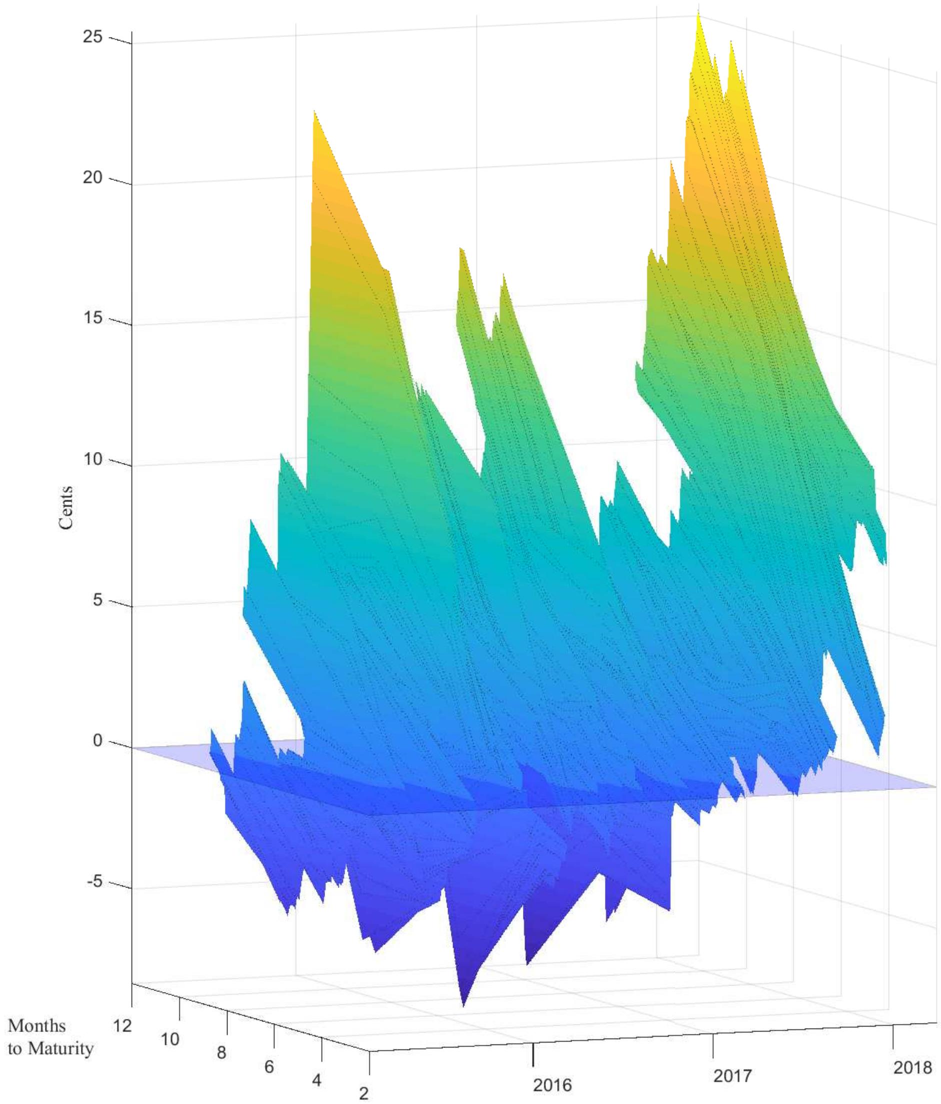

Figure 2. Time Series of Price Premia Measured Relative to Treasury Bills by Time to Maturity. This figure plots the time series of the price premia measured relative to Treasury bills as a function of the time to maturity for the FRNs. Price premia are expressed as cents per $100 par amount.

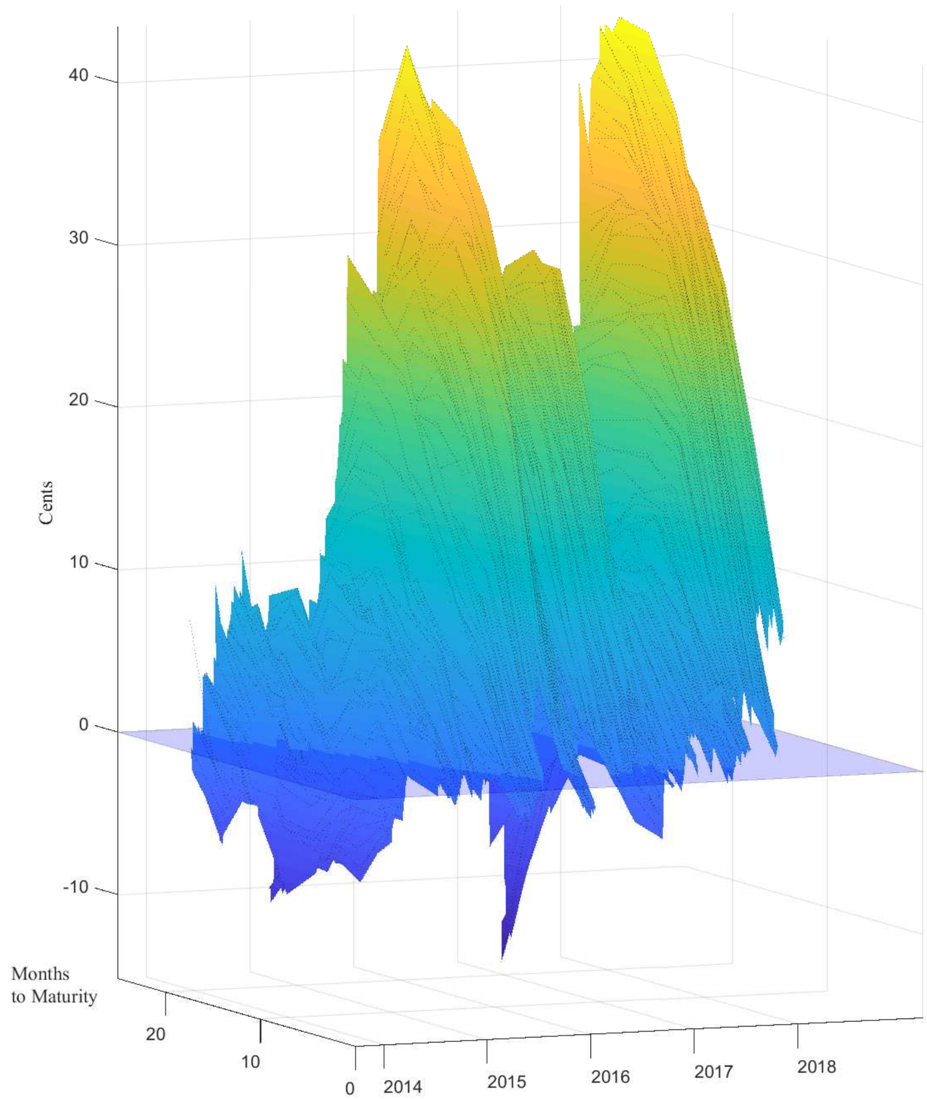

Figure 3. Time Series of Price Premia Measured Relative to Treasury Notes by Time to Maturity. This figure plots the time series of the price premia measured relative to Treasury notes as a function of the time to maturity for the FRNs. Price premia are expressed as cents per $100 par amount.

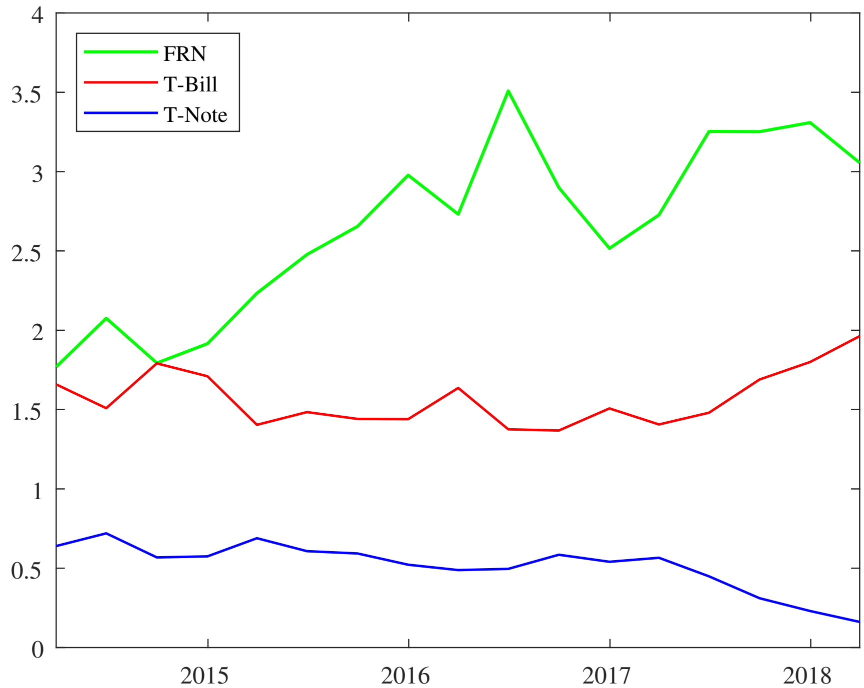

Figure 4. Overweighting of FRNs and Treasury Bills in MMF Portfolios. This figure plots the time series of the ratio of the fraction of MMF portfolios invested in FRNs divided by the fraction that FRNs represent of all Treasury securities eligible to be held by MMFs, and similarly for Treasury bills and eligible Treasury notes and bonds.

Table 1

Summary Statistics for Treasury FRN Prices. This table presents summary statistics for the prices (without accrued coupon) of the two-year Treasury FRNs issued during the sample period. The FRN spread is measured in basis points. The summary statistics are based on prices for the FRNs from their issue date until three months before their maturity date. N denotes the number of observations. The sample period is daily from January 31, 2014 to March 29, 2018.

FRN	Maturity	Spread	Mean	Std Dev	Min	Median	Max	N
1	1–31–2016	4.50	99.992	0.015	99.953	99.997	100.022	456
2	4–30–2016	6.90	100.017	0.013	99.992	100.015	100.055	457
3	7–31–2016	7.00	100.017	0.015	99.984	100.012	100.062	454
4	10–31–2016	5.30	99.987	0.021	99.900	99.991	100.016	455
5	1–31–2017	8.40	100.017	0.022	99.933	100.022	100.063	441
6	4–30–2017	7.40	99.990	0.050	99.766	100.003	100.045	452
7	7–31–2017	7.70	99.981	0.075	99.673	100.002	100.083	444
8	10–31–2017	16.80	100.069	0.081	99.725	100.099	100.169	446
9	1–31–2018	27.20	100.202	0.064	100.042	100.224	100.309	453
10	4–30–2018	19.00	100.131	0.055	99.979	100.129	100.219	450
11	7–31–2018	17.40	100.131	0.060	99.987	100.143	100.234	411
12	10–31–2018	17.00	100.156	0.067	99.997	100.172	100.252	343
13	1–31–2019	14.00	100.155	0.054	99.996	100.173	100.226	297
14	4–30–2019	7.00	100.073	0.040	99.983	100.078	100.145	235
15	7–31–2019	6.00	100.068	0.045	100.000	100.075	100.151	174
16	10–31–2019	4.80	100.061	0.032	100.000	100.069	100.115	107
17	1–31–2020	0.00	99.980	0.015	99.928	99.978	100.000	41
All	—	—	100.060	0.088	99.673	100.029	100.309	6,116

Table 2

Volatility of Daily Changes in Treasury Security Prices. This table reports the standard deviation of daily price changes for FRNs where the results are stratified based on the number of months to maturity for the FRNs. The table also reports the standard deviation of daily price changes for matched-maturity Treasury bills and two-year Treasury notes. The standard deviations are computed using only data for days on which price change observations are available for the individual FRN as well as both the matched-maturity Treasury bill and two-year Treasury note (or only the two-year Treasury note for horizons longer than one year). Standard deviations are expressed as cents per $100 notional. The sample period is daily from January 31, 2014 to March 29, 2018.

Months to Maturity					
From	To	FRN	T-Bill	T-Note	*N*
3	4	0.189	0.381	0.468	209
4	5	0.251	0.639	0.690	247
5	6	0.262	0.644	0.659	237
6	9	0.354	0.926	0.911	743
9	12	0.422	1.358	1.251	798
12	15	0.589	—	1.890	863
15	18	0.659	—	3.262	903
18	21	0.652	—	4.199	983
21	24	0.783	—	5.025	1,026

Table 3

Liquidity Measures for Treasury FRNs and Matched-Maturity Treasury Bills and Notes. This table reports the total amount issued, the bid-ask spread, and the bid to cover ratio for the two-year FRNs issued during the sample period, along with the same measures for the matched-maturity Treasury bills and two-year Treasury notes. Amount issued denotes the total par amount issued by the Treasury and is measured in billions of dollars. Bid-ask spread denotes the average bid-ask spread in cents per $100 par amount of the indicated securities. Bid to cover denotes the bid to cover ratio for the security at the initial auction. The sample period is daily from January 31, 2014 to March 29, 2018.

		Amount Issued			Bid-Ask Spread			Bid to Cover		
FRN	Maturity	FRN	T-Bill	T-Note	FRN	T-Bill	T-Note	FRN	T-Bill	T-Note
1	1–31–2016	41.00	25.00	32.00	0.377	0.334	1.115	5.67	3.81	3.30
2	4–30–2016	41.00	25.00	32.00	0.358	0.324	1.116	4.69	4.11	3.35
3	7–31–2016	41.01	25.00	29.01	0.355	0.372	1.113	4.45	3.37	3.22
4	10–31–2016	41.00	12.00	29.00	0.378	0.340	1.114	4.00	4.03	3.11
5	1–31–2017	41.00	18.00	26.00	1.158	0.325	1.254	4.34	3.59	3.74
6	4–30–2017	41.05	20.00	26.10	1.134	0.327	1.113	4.01	3.17	3.30
7	7–31–2017	41.00	20.00	26.00	1.114	0.323	1.102	3.93	3.65	3.42
8	10–31–2017	41.00	20.00	26.00	1.121	0.339	1.098	3.48	3.35	3.01
9	1–31–2018	41.27	20.00	26.47	1.136	0.415	1.112	3.67	3.48	2.90
10	4–30–2018	44.99	20.00	32.91	1.123	0.642	1.103	3.57	3.23	2.64
11	7–31–2018	42.84	20.00	27.82	1.163	0.873	1.141	3.82	3.17	2.52
12	10–31–2018	41.91	20.00	27.57	1.285	1.170	1.252	3.80	3.34	2.53
13	1–31–2019	43.53	20.00	27.65	1.419	1.008	1.386	3.43	3.36	2.68
14	4–30–2019	44.63	—	29.55	1.537	—	1.506	3.35	—	2.85
15	7–31–2019	42.53	—	28.64	1.666	—	1.631	3.46	—	3.06
16	10–31–2019	42.38	—	26.65	1.784	—	1.736	3.69	—	2.74
17	1–31–2020	49.85	—	29.82	1.899	—	1.852	3.38	—	3.22

Table 4

Numerical Example of the Cash Flows from Replicating a FRN Using a Treasury Note. This table provides a numerical illustration of the cash flows from the replication strategy for a two-year FRN. The replication strategy consists of taking a long position in a two-year Treasury note, swapping its fixed coupon cash flows into floating using interest rate and basis swaps, and taking a small position in Treasury STRIPS to match the FRN spread. This example is based on market prices as of January 31, 2018. The Treasury FRN being replicated was issued on January 31, 2018 and has a maturity date of January 31, 2020 and a fixed spread of 0.00 basis points. The matched-maturity Treasury note was issued on January 31, 2018 and has a maturity date of January 31, 2020 and a fixed coupon rate of 2.00 percent paid semiannually. The fixed market rate on a Libor interest rate swap is 2.3319 percent paid semiannually, in exchange for three-month Libor paid quarterly (actual/360) L_t, where Libor is set at the beginning of the quarter in which it is paid. The Treasury bill basis swap pays a quarterly stream of cash flows equal to the Treasury bill rate averaged over the quarter in which it is paid (actual/360) X_t, plus the basis swap spread of 36.16 basis points (actual/360), in exchange for quarterly three-month Libor cash flows (actual/360) L_t. The cost of taking a position in Treasury STRIPS to match exactly the fixed cash flows on the FRN is −0.0685. The columns titled Synthetic FRN illustrate the cash flows from the replication strategy. The column titled Treasury FRN illustrates the cash flows from the two-year FRN being replicated.

	Synthetic FRN					Treasury FRN
Timing of Cash Flow	T-Note Cash Flow	Swap Cash Flow	Basis Swap Cash Flow	STRIPS Cash Flow	Total Cash Flow	Total Cash Flow
0.00	−99.6836	–	–	0.0685	−99.6151	−100.0039
0.25	–	L_t	$(X_t + 0.0882) - L_t$	−0.0882	X_t	X_t
0.50	1.0000	$-1.1660 + L_t$	$(X_t + 0.0924) - L_t$	0.0736	X_t	X_t
0.75	–	L_t	$(X_t + 0.0924) - L_t$	−0.0924	X_t	X_t
1.00	1.0000	$-1.1660 + L_t$	$(X_t + 0.0924) - L_t$	0.0736	X_t	X_t
1.25	–	L_t	$(X_t + 0.0894) - L_t$	−0.0894	X_t	X_t
1.50	1.0000	$-1.1660 + L_t$	$(X_t + 0.0924) - L_t$	0.0736	X_t	X_t
1.75	–	L_t	$(X_t + 0.0924) - L_t$	−0.0924	X_t	X_t
2.00	101.0000	$-1.1660 + L_t$	$(X_t + 0.0924) - L_t$	0.0736	$100 + X_t$	$100 + X_t$

Table 5

Summary Statistics for the FRN Premia. This table presents summary statistics for the FRN premia measured relative to Treasury bills and Treasury notes. The premia are expressed in basis points. A positive premium means that the price of the FRN is higher than the value of the replicating portfolio. The sample period is daily from January 31, 2014 to March 29, 2018.

		Relative to T-Bills						Relative to T-Notes					
FRN	Maturity	Mean	Std Dev	Min	Max	Percent Positive	N	Mean	Std Dev	Min	Max	Percent Positive	N
1	1–31–2016	−4.33	2.86	−11.34	3.13	6.70	194	0.62	3.17	−8.04	10.59	56.36	456
2	4–30–2016	2.07	5.51	−10.95	21.46	66.29	178	3.86	5.03	−6.46	23.45	80.74	457
3	7–31–2016	6.36	7.85	−11.40	27.86	85.87	184	5.72	8.22	−8.88	34.06	79.30	454
4	10–31–2016	2.05	6.76	−14.73	25.41	61.17	188	8.36	8.12	−4.44	33.62	89.89	455
5	1–31–2017	6.39	6.03	−7.80	21.13	87.50	184	9.83	8.50	−5.39	31.20	90.48	441
6	4–30–2017	7.41	4.53	−3.89	16.32	93.30	179	12.33	6.78	−2.72	27.78	96.90	452
7	7–31–2017	5.63	6.02	−10.51	16.07	77.72	184	12.83	7.66	−10.18	26.15	91.22	444
8	10–31–2017	5.87	6.28	−6.23	19.13	82.54	189	14.08	6.57	−5.24	24.84	97.98	446
9	1–31–2018	0.44	3.17	−8.88	6.02	59.49	195	12.02	6.59	−3.15	25.59	97.35	453
10	4–30–2018	8.42	3.69	2.62	20.23	100.00	181	11.18	4.55	−0.25	21.92	99.78	450
11	7–31–2018	16.25	7.14	5.80	31.18	100.00	162	10.95	6.34	−1.43	29.06	98.54	411
12	10–31–2018	18.77	5.06	1.58	27.82	100.00	103	11.93	9.29	−3.12	33.57	95.92	343
13	1–31–2019	23.67	4.12	12.60	28.59	100.00	42	10.10	11.80	−7.17	33.89	81.15	297
14	4–30–2019	—	—	—	—	—	—	10.68	12.01	−7.58	32.63	83.40	235
15	7–31–2019	—	—	—	—	—	—	11.97	10.64	−3.58	29.67	81.03	174
16	10–31–2019	—	—	—	—	—	—	16.53	6.70	−0.79	25.89	99.07	107
17	1–31–2020	—	—	—	—	—	—	16.91	2.34	10.63	21.18	100.00	41
All		5.97	8.28	−14.73	31.18	75.59	2,163	9.73	8.50	−10.18	34.06	88.67	6,116

Table 6

Volatility of Daily Changes of FRN and FRN Replicating Portfolio Prices. This table reports the standard deviation of daily price changes for FRNs where the results are stratified based on the number of months to maturity for the FRNs. The table also reports the standard deviation of daily price changes for the FRN replicating portfolios using Treasury bills and two-year Treasury notes. The standard deviations are computed using only data for days on which price change observations are available for the individual FRN as well as for both the matched-maturity Treasury bill and two-year Treasury note (or only for the two-year Treasury note for horizons longer than one year). Standard deviations are expressed as cents per $100 par amount. The sample period is daily from January 31, 2014 to March 29, 2018.

Months to Maturity					
From	To	FRN	T-Bill-Based Replicating Portfolio	T-Note-Based Replicating Portfolio	N
3	4	0.189	0.379	0.511	209
4	5	0.251	0.623	0.653	247
5	6	0.262	0.785	0.832	237
6	9	0.354	1.047	1.041	743
9	12	0.422	1.212	1.251	798
12	15	0.589	—	1.470	863
15	18	0.659	—	1.921	903
18	21	0.652	—	2.095	983
21	24	0.783	—	2.228	1,026

Table 7

Institutional Ownership Distribution of FRNs and Treasury Notes. This table reports the percentages of the total notional amounts of the indicated classes of securities held by the respective categories of institutions as of April 2019. The percentages for the FRNs and matched-maturity Treasury notes are based on institutional holdings reports from the Bloomberg system. The reports are based on filings from Form 13F, Form N-MFP, Form 10-K, IRS Form 990, Department of Labor Form 5500, NAIC Form Schedule D, and public disclosures from pension funds, hedge funds, money market funds, and ETFs. These percentages are based on the FRNs and matched-maturity Treasury notes with maturity dates in April, July, October 2019, January, April, July 2020, and January 2021. The percentages for all Treasury securities are based on Table L.210 of the Federal Reserve Board Z.1 Release and where the percentages are based only on the totals for the categories that can be mapped into holder categories used in the Bloomberg reports.

Institution	FRNs	Matched-Maturity T-Notes	All Treasury Securities
Banks	0.44	0.97	7.76
Brokers, Dealers	0.21	1.26	2.65
Holding Companies	0.00	0.11	0.37
Corporations	0.05	0.00	0.39
Unincorporated Businesses	0.00	0.36	0.85
Insurance Companies	0.80	8.06	3.86
Pension Funds	0.00	0.05	28.41
Government	6.87	33.63	31.91
Money Market Funds	39.68	1.47	9.21
Mutual Funds, ETFs, Hedge Funds	51.95	54.09	14.59
Total	100.00	100.00	100.00

Table 8

Summary Statistics for the Percentage of FRNs Held by Money Market Funds. This table reports summary statistics for the percentages of the total par amounts of the indicated FRNs held by money market funds during the sample period. The percentages are based on Form N-MFP filings of money market funds with the SEC. The summary statistics are based on the percentages computed for each month for the indicated FRNs (excluding the month of issuance). > 50 denotes the number of months in which money market fund ownership of the FRN is greater than 50 percent. The sample period is monthly from January 2014 to March 2018.

FRN	Maturity	Mean	Min	Median	Max	> 50	N
1	1–31–2016	30.95	17.02	29.30	53.62	0	24
2	4–30–2016	24.50	8.59	22.41	48.34	0	24
3	7–31–2016	21.05	8.33	15.51	55.61	2	24
4	10–31–2016	38.13	16.54	32.90	58.08	6	23
5	1–31–2017	36.09	22.22	28.96	54.49	4	23
6	4–30–2017	27.86	12.63	27.26	48.22	0	24
7	7–31–2017	37.20	17.04	35.99	58.65	2	23
8	10–31–2017	45.94	25.98	46.68	58.48	8	23
9	1–31–2018	41.70	20.38	37.37	58.51	8	23
10	4–30–2018	46.81	24.39	48.61	57.84	10	23
11	7–31–2018	36.39	17.67	37.17	49.76	0	22
12	10–31–2018	39.11	28.74	38.94	47.38	0	19
13	1–31–2019	33.64	25.74	34.75	39.24	0	16
14	4–30–2019	37.26	23.12	37.42	46.09	0	13
15	7–31–2019	32.03	25.50	31.73	40.68	0	10
16	10–31–2019	48.67	36.95	50.63	51.79	4	7
17	1–31–2020	38.09	29.84	34.96	52.63	1	4

Table 9

Results from Panel Regressions of FRN Premia on Money Market Fund FRN Holdings. This table reports the results from regressing the FRN premia expressed in basis points on the fraction of the FRN issue held by money market funds. 397-Day Dummy is a dummy variable that takes value one when the FRN has a maturity greater than 397 days, and zero otherwise. The regression includes monthly fixed effects. The t-statistics are based on the White (1980) heteroskedasticity consistent estimate of the covariance matrix. The superscript ** denotes significance at the five-percent level; the superscript * denotes significance at the ten-percent level. The sample period is monthly from February 2014 to March 2018.

	Relative to Treasury Bills		Relative to Treasury Notes	
Variable	Coefficient	$t-$Stat	Coefficient	$t-$Stat
Intercept	7.8926	2.65^{**}	8.1145	3.16^{**}
397-Day Dummy	—	—	0.6495	0.59
Fraction Held by MMFs	2.5741	0.51	16.8993	4.28^{**}
Monthly Fixed Effects		Yes		Yes
Adj. R^2		0.198		0.152
N		107		298

Table 10

Results from Panel Regressions of Average FRN Premia on the Difference in Treasury Security Volatilities. This table reports the results from regressing the monthly averages of the price premia expressed as cents per $100 par amount on the difference between the standard deviation of daily changes in the corresponding matched-maturity Treasury bill or note and the standard deviation of daily changes in the price of the FRN. The difference in standard deviations is expressed as cents per $100 par amount. The regression includes monthly fixed effects. The t-statistics are based on the White (1980) heteroskedasticity consistent estimate of the covariance matrix. The superscript ** denotes significance at the five-percent level; the superscript * denotes significance at the ten-percent level. The sample period is monthly from February 2014 to March 2018.

	Relative to Treasury Bills		Relative to Treasury Notes	
Variable	Coefficient	$t-$Stat	Coefficient	$t-$Stat
Intercept	0.0437	2.77**	0.1424	5.34
Difference in Volatilities	2.1604	1.78*	1.3174	3.11**
Monthly Fixed Effects		Yes		Yes
Adj. R^2		0.129		0.083
N		105		286

Table 11

Results from Regressions of Changes in FRN Premia on Explanatory Variables. This table reports the results from regressing monthly changes in the FRN/T-Bill and FRN/T-Note indexes of premia on changes in the indicated explanatory variables. Premia are expressed in basis points. Change in T-Bill Rate denotes the change in the three-month Treasury bill rate and is expressed in basis points. Change in Forecast denotes the change in the concensus forecast for the two-year Treasury rate and is expressed in basis points. Change in Volatility denotes the change in the basis point volatility of interest rates implied from swaptions. Change in Confidence denotes the change in the Michigan Consumer Confidence Index. Change in TED Spread denotes the change in the three-month Libor-Treasury spread and is expressed in basis points. Change in Treasury CDS is the change in the CDS spread on two-year U.S. Treasury debt and is expressed in basis points. The t-statistics are based on the Newey-West (1987) heteroskedasticity and autocorrelation consistent estimate of the covariance matrix (three lags). The superscript ** denotes significance at the five-percent level; the superscript * denotes significance at the ten-percent level. The sample period is monthly from January 2014 to March 2018.

	FRN/T-Bill Index		FRN/T-Note Index	
Variable	Coefficient	$t-$Stat	Coefficient	$t-$Stat
Intercept	−1.3963	-1.77^{*}	−0.2623	−0.48
Change in T-Bill Rate	0.6267	5.13^{**}	0.3198	4.20^{**}
Change in Forecast	−0.2230	-2.57^{**}	−0.0956	-1.98^{*}
Change in Volatility	−0.0693	−0.42	0.1607	1.87^{*}
Change in TED Spread	0.2964	3.26^{**}	0.2056	2.53^{**}
Change in Confidence	−0.5181	-2.32^{**}	−0.3666	-2.01^{**}
Change in Treasury CDS	−0.0896	−0.27	0.2531	1.28
Adj. R^2		0.385		0.312
N		36		48

Table 12

Results from Regressions of Changes in FRN Premia on Monetary Variables. This table reports the results from regressing monthly changes in the FRN/T-Bill and FRN/T-Note indexes of premia on changes in the indicated components of the M1 and M2 aggregates. Premia are expressed in basis points. Change in T-Bill Rate denotes the change in the three-month Treasury bill rate and is expressed in basis points. Change in Currency denotes the change in the currency component of M1. Change in Demand Deposits denotes the change in the total of the demand deposits and other checkable deposit components of M1. Change in Time Deposits denotes the change in the total of the savings deposits and small time deposit components of M2 and includes both banks and thrifts. Changes in currency, demand deposits, and time deposits are based on non-seasonally adjusted values and are measured in billions of dollars. The t-statistics are based on the Newey-West (1987) heteroskedasticity and autocorrelation consistent estimate of the covariance matrix (three lags). The superscript ** denotes significance at the five-percent level; the superscript * denotes significance at the ten-percent level. The sample period is monthly from January 2014 to March 2018.

	FRN/T-Bill Index		FRN/T-Note Index	
Variable	Coefficient	$t-$Stat	Coefficient	$t-$Stat
Intercept	−4.1215	-2.23^{**}	−1.0473	−1.09
Change in T-Bill Rate	0.3474	3.12^{**}	0.2507	3.29^{**}
Change in Currency	0.3597	1.77^{*}	−0.0348	−0.38
Change in Demand Deposits	0.0077	0.46	0.0191	1.71^{*}
Change in Time Deposits	0.0138	0.57	0.0192	1.49
Adj. R^2		0.294		0.147
N		37		49

Table 13

Results from Regressions of Changes in FRN Premia on Net Cash Flows into Money Market Funds. This table reports the results from regressing monthly changes in the FRN/T-Bill and FRN/T-Note indexes of premia on the indicated net flows into government and non-government (combined retail and institutional) money market funds. Premia are expressed in basis points. Change in T-Bill Rate denotes the change in the three-month Treasury bill rate and is expressed in basis points. Government Fund Net Flows denotes the net flows into government money market funds. Non-Government Fund Net Flows denotes the combined net flows into retail and institutional money market funds. Fund net flows are measured in billions of dollars. The t-statistics are based on the Newey-West (1987) heteroskedasticity and autocorrelation consistent estimate of the covariance matrix (three lags). The superscript ** denotes significance at the five-percent level; the superscript * denotes significance at the ten-percent level. The sample period is monthly from January 2014 to March 2018.

	FRN/T-Bill Index		FRN/T-Note Index	
Variable	Coefficient	$t-$Stat	Coefficient	$t-$Stat
Intercept	−1.7667	−2.00**	−0.6485	−1.08
Change in T-Bill Rate	0.3638	4.47**	0.2071	3.74**
Government Fund Net Flows	0.2235	3.21**	0.1269	2.86**
Non-Government Fund Net Flows	0.0344	1.50	0.0172	1.05
Adj. R^2		0.403		0.246
N		37		49

Table 14

Summary Statistics for the Corporate and Federal Farm Credit Bank FRN Premia. The row labeled Corporate presents summary statistics for the average premia in corporate floating rate notes measured relative to fixed rate notes of the same firm. The row labeled FFCB presents summary statistics for the average premia in Federal Farm Credit Bank (FFCB) notes measured relative to FFCB fixed rate notes. Premia are measured in basis points. A positive premium indicates that the value of the floating rate note is greater than that of the replicating portfolio. The sample period is daily from January 31, 2014 to March 29, 2018.

Category	Number of Pairs	Mean	Std Dev	Min	Max	Percent Positive	N
Corporate	38	0.054	8.907	−21.460	21.381	52.02	6,637
FFCB	32	−3.067	12.633	−28.317	23.407	56.28	4,659

ONLINE APPENDIX

THE U.S. TREASURY FLOATING RATE NOTE PUZZLE: IS THERE A PREMIUM FOR MARK-TO-MARKET STABILITY?

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Francis A. Longstaff

A.1 Data Sources

Table A1 provides a description of the data and variables used in the study along with their definitions and corresponding sources for the data.

A.2 The U.S. Treasury Floating Rate Note Market

The U.S. Treasury floating rate note (FRN) market had its inception in January 2014. FRNs are issued with a maturity of two years and their coupon cash flows are indexed to the most recent 13-week Treasury bill auction high rate plus a constant spread (for details, see https://www.treasurydirect.gov/instit/marketables /frn/frn.htm). The Treasury auctions FRNs every three months in January, April, July, and October, and reopens each FRN issue in the two subsequent months after original issuance. When a FRN is reopened, it has the same maturity date, spread, and coupon dates as the original issue, but a different issue date and issue price. Original issue offerings are issued on the last calendar day of a month, or the first business day thereafter. Reopening offerings are issued on the last Friday of a month, or the first business day thereafter.

Similar to Treasury notes, FRNs are auctioned using a single-price auction mechanism in which each competitive bidder specifies a discount margin, expressed in tenths of a basis point, which can be positive, zero, or negative. The Treasury first accepts in full all noncompetitive tenders up to $5 million per submitter. The Treasury announces its auction schedule at https://www.treasury direct.gov/instit/instit.htm?upcoming. Competitive tenders are accepted in order of discount margin, from the lowest discount margin to the highest discount margin at which the quantity of awarded bids reaches the offering amount. The Treasury awards FRNs to both noncompetitive and competitive bidders at the price equivalent to the highest accepted discount margin at which bids were accepted. Thus, all bidders receive the same discount margin at the highest accepted bid. For example, if 80.15 percent is the announced percentage at the highest discount margin, the Treasury awards 80.15 percent of the amount of each bid at that discount margin. The usual Treasury proration rules apply if the amount of tenders at the highest accepted discount margin exceeds the amount of the remaining offering amount. The Treasury's auction rules are available at https://www.treasurydirect.gov/instit/statreg/auctreg/auctreg.htm.

FRNs pay quarterly coupon cash flows on the last calendar day of the month from the dated date to and including the maturity date. The dollar amount of the coupon payment is the cumulative total of daily interest which accrues at a rate equal to the most recent 13-week Treasury bill auction high yield plus a spread which is determined at the initial auction. The spread on a FRN at the initial auction is set at the highest accepted discount margin in that auction, and when a FRN is reopened, the spread remains equal to the spread set at the initial auction. The daily interest accrual rate is floored at zero percent. FRNs are redeemed at their par amount at maturity.

For a given day t, let r_t denote the 13-week Treasury bill auction high yield from the last Treasury bill auction at least two business days prior to day t (expressed as a money-market equivalent yield). Let S denote the spread on a FRN which is determined at the initial auction and expressed in tenths of a basis point. The conversion formulas are published in the Treasury's Uniform Offering Circular at https://www.treasurydirect.gov/instit/statreg/auctreg/2013-18178.pdf. On each day, accrued interest per dollar of par amount is $\max\left[0, (r_t + S)/360\right]$. When the auction rate from the most recent 13-week Treasury bill auction becomes effective within two business days of a coupon date (lock-out period), then interest on the days prior to the coupon payment accrues at the auction rate from the auction prior to the start of the lock-out period. Each accrual period is from and including the last coupon cash flow date (or the dated date) to, but excluding the next coupon payment date (or the maturity date). FRNs follow the actual/360 daycount convention. The dated date is always the last calendar day of a month.

The first Treasury FRN was auctioned on January 29, 2014 and issued on January 31, 2014. The size of the FRN market has grown significantly since its inception. As of the end of March 2018, the total FRN dollar amount outstanding was $334 billion which represented 2.28 percent of total marketable Treasury debt, 3.75 percent of total Treasury notes, and 16.07 percent of the total amount of Treasury bills outstanding. The total par amount of FRNs issued from the inception of the market through March 2018 was $720.969 billion. Table 3 of the paper shows the total par amount for each of the FRN issues auctioned through March 2018. These data are from SIFMA at https://www.sifma.org/resources/research/us-marketable-treasury-issuance-outstanding-and-interest-rates/.

A.3 The Basis Swap Market

In a standard interest rate swap, counterparties exchange a stream of quarterly floating payments tied to three-month Libor for a stream of fixed semiannual payments. In many cases, however, a counterparty may prefer floating rate payments to be linked to a different index than three-month Libor. Rather than introducing fixed-for-floating swaps using a variety of floating indexes (which would likely be far less liquid than a standard swap), an important side market has emerged which is known as the basis swap market. In a basis swap, counterparties exchange one stream of floating cash flows for another stream of floating cash flows. For example, in a three-month/six-month Libor basis swap, a counterparty pays three-month Libor quarterly in exchange for receiving six-month Libor semiannually (plus a fixed basis swap spread). Combining a three-month/six-month Libor basis swap with a standard interest rate swap results in a structure with the same cash flows as if the original floating coupon payments for the interest rate swap were tied to six-month Libor. The basis swap market allows counterparties to exchange streams of floating cash flows tied to any of the following indexes: one-month Libor, three-month Libor, six-month Libor, the Treasury bill rate, the overnight index swap rate (OIS), the prime rate, and others.

A Treasury bill basis swap is a floating-for-floating exchange of (netted) cash flows where the quarterly cash flows on both legs reference a distinct floating rate index. One leg of the basis swap pays a quarterly floating cash flow of X_t based on the Treasury bill secondary market rate plus a market-determined basis swap spread B. The value of X_t is based on the arithmetic average of the daily 13-week Treasury bill secondary market rate during the quarter. The floating cash flow X_t plus B is paid at time t at the end of the quarter over which X_t is calculated. The other leg of the basis swap pays quarterly cash flows based on the three-month Libor rate L_t set at the beginning of the quarter, but is paid at the end of the quarter. Both legs of the swap pay cash flows on an actual/360 daycount basis. The reason for the market-determined basis swap spread B is that the present values of the streams of floating cash flows from the two legs of the swap may be different. To set the present values of the two legs equal to each other, the basis swap requires that one leg of the swap pay a fixed basis swap spread B in addition to the floating cash flows.

Market prices in the basis swap markets are quoted in terms of the basis swap spread. To illustrate, the basis swap spread for a 13-week Treasury bill/three-month Libor basis swap with a two-year horizon was 41.59 basis points on February 23, 2018. Thus, a counterparty in this basis swap would pay quarterly floating payments based on the 13-week Treasury bill rate plus a fixed spread of 41.59 basis points, and receive quarterly floating payments based on the three-month Libor rate. Table A2 reports summary statistics for the 13-week Treasury bill/three-month Libor basis swap spreads for various tenors. For comparison, Table A3 reports summary statistics for the swap rates for the standard Libor swaps used in the replicating portfolios for the same tenors.

A.4 Replicating Treasury FRNs with Treasury Notes

We use a simple three-step approach in replicating the cash flows of a FRN using a two-year Treasury note. First, we use a standard interest rate swap to convert the fixed coupon cash flows from the Treasury note into floating cash flows based on the three-month Libor rate. Second, we use a basis swap to convert the resulting Libor cash flows into a stream of floating coupon payments based on the 13-week Treasury bill rate. Third, we use a series of Treasury STRIPS to match exactly the small fixed spread associated with the FRN. The net cash flows of the combined position in the two-year Treasury note and other components of the strategy replicates the cash flows that the investor receives from a Treasury FRN.

Table A4 illustrates the cash flows from creating a synthetic FRN that replicates a two-year Treasury FRN. In this example, C denotes the semiannual coupon of a matched-maturity Treasury note. F denotes the semiannual fixed coupon cash flow of a standard interest rate swap with the same maturity date as the Treasury FRN. The quarterly payment on the interest rate swap L_t equals the Libor rate times the actual/360 daycount fraction for the quarter, where the Libor rate is set at the beginning of the quarter in which this cash flow is paid. On the basis swap, the quarterly cash flow X_t is the average 13-week Treasury bill rate times the actual/360 daycount fraction for the quarter, where X_t is averaged over the quarter in which this cash flow is paid. The quarterly cash flows B and S denote the basis swap spread and the FRN spread, respectively, and are based on the annualized values for these spreads times the actual/360 daycount fraction for the quarter in which they are paid.

The first column in Table A4 shows the cash flows from buying a two-year Treasury note. The initial cash outflow paid for the note is based on the market price P_N. The note pays fixed semiannual coupons of C and pays the par amount of 100 at maturity. The second column shows the cash flows of a standard interest rate swap. The initial cash flow for the swap is zero. The third column shows the cash flows from a basis swap. The initial cash flow for this swap is again zero. The fourth column shows the cash flows from a portfolio of Treasury STRIPS with the indicated par amounts and maturities. The market price of this portfolio of STRIPS is denoted ϵ. As shown in the fifth column, the future net cash flows from the synthetic FRN created by the replicating strategy are identical to those of the actual Treasury FRN shown in the last column. The difference between the price of the Treasury FRN, P_{FRN}, and the value of the replicating portfolio, $P_N + \epsilon$, is the price premium. The premium is computed by converting the price premium into basis points as described in the paper. Table 4 in the paper presents a specific numerical example illustrating the replicating strategy for a two-year FRN.

Although simple, the replicating strategy requires us to take several institutional details and market conventions into account. First, since the floating Treasury bill leg of the basis swap is indexed to the Treasury bill yield in the secondary market, and since the Treasury bill cash flows for the FRN are indexed to the most recent Treasury bill auction high yield, we make a small adjustment to the basis swap spread. Specifically, the quarterly FRN coupon cash flows are the cumulative total arithmetic sum of daily accrued interest calculated from the most-recent 13-week Treasury bill auction high rate. The quarterly cash flows on a Treasury bill basis swap, however, are calculated by accruing daily simple interest using the 13-week Treasury bill secondary market rate. Thus, the two Treasury bill indexes are slightly different. We verify, however, that the differences between the auction high rates and the secondary market Treasury bill rates are on the order of a small fraction of a basis point. Specifically, the average weekly difference between the most-recent Treasury bill auction high yield and the secondary market yield for the 2009–2013 pre-sample period is only 0.226 basis points in money market terms. Although very small, we adjust the Treasury basis swap rate by this difference. Using alternative pre-sample windows has virtually no impact on our results.

Second, the replicating procedure illustrated in Table A4 is straightforward to apply when the maturity of the Treasury FRN is an integral multiple of a semiannual period. For other maturities, however, we need to make a slight adjustment for the stub period using a simple interpolation procedure. One reason for this is the lookback accruals for the floating indexes L_t and X_t. To make this interpolation as accurate as possible, however, it is useful to first re-express the semiannual fixed cash flows in the replicating portfolio as quarterly cash flows. This re-annuitization is done by calculating the stream of quarterly fixed cash flows that has the same present value as the original stream of semiannual fixed cash flows using the discount function computed from general collateral Treasury repo rate and Treasury STRIPS data (see Liu, Longstaff, and Mandell (2006)). This conversion allows us to interpolate all cash flows on a quarterly basis, but has no effect on the values of the various components of the replicating portfolio.

To illustrate the interpolation methodology, consider a 13-month Libor interest rate swap, paying quarterly, in conjunction with a 13-month Treasury bill basis swap. Clearly, the combination of these two swaps is equivalent to a single swap exchanging quarterly fixed cash flows, say H, for floating cash flows based on the average 13-week Treasury bill rate averaged over the quarter, X_t. This composite 13-month swap has five cash flows at times $t = 0.08, 0.33, 0.58, 0.83, 1.08$. Next, consider taking an analogous position in a composite 12-month Libor/basis swap. In the 12-month swap, we make four payments X_t at times $t = 0.25, 0.50$, $0.75, 1.00$ and receive four fixed cash flows. Similarly, in a composite 15-month Libor/basis swap, we make five payments X_t at times $t = 0.25, 0.50, 0.75, 1.00, 1.25$ and receive five fixed cash flows. Since the market-determined fixed cash flows on the 12-month, 13-month, and the 15-month swaps may differ, we denote these fixed cash flows by $H(12)$, $H(13)$, and $H(15)$, respectively.

Neither the 12-month nor the 15-month swap has time $t = 0$ cash flows. Instead, suppose we have a modified 12-month swap in which we exchange cash flows at time zero. Specifically, at time $t = 0$, we pay $X_{0.00}$ (the average Treasury bill rate over the prior three months) and receive the spread $\hat{H}(12)$. This swap has five cash flows at times $t = 0.00, 0.25, 0.50, 0.75, 1.00$ months. Thus, the 13-month swap is a five-payment swap with the first cash flows at time $t = 0.08$. The 15-month swap is a five-payment swap with the first cash flow at time $t = 0.25$ and the modified 12-month swap is a five-payment swap with first cash flow at time $t = 0$. In order to find $H(13)$, we simply interpolate between $\hat{H}(12)$ and $H(15)$. The spread $\hat{H}(12)$ is determined by simply setting the present values of cash flows from the 12-month and modified 12-month swaps equal to each other. The spread $\hat{H}(12)$ is

$$\hat{H}(12) = \frac{(L_{0.00} - X_{0.00}) + H_{12}\,(D(0.25) + D(0.50) + D(0.75) + D(1.00))}{1 + D(0.25) + D(0.5) + D(0.75) + D(1.00)},$$

where $D(t)$ denotes the discount factor for times $t = 0.25, 0.50, 0.75, 1.00$ years. The stub adjustments for other swap tenors are analogous.

A.5 Replicating Treasury FRNs with Treasury Bills

The process of replicating the cash flows from a Treasury FRN using Treasury bills is very similar to that described in the previous section. To illustrate the approach, we consider the case of a Treasury FRN with 12 months to maturity. In this case, there are market prices for 3-, 6-, 9-, and 12-month Treasury bills. We denote these prices as $P(0.25), P(0.50), P(0.75)$, and $P(1.00)$, respectively. Without loss of generality, we assume that all Treasury bills are normalized to have a one dollar notional value.

Now consider an investor who purchases the portfolio of Treasury bills shown in the first column of Table A5. Analogous to the example in Table A4, the investor executes a standard Libor interest rate swap and a Treasury bill basis swap. The only difference is that the replicating portfolio no longer needs to take a small position in Treasury STRIPS to match the spread on the FRN since the individual Treasury bills play the same role in this approach. As in the previous section, we define the FRN price premium relative to Treasury bills as the price difference between the actual Treasury FRN and the price of the replicating portfolio. The resulting price premium is then converted into a basis point premium in the same way as described above.

Table A6 presents a specific numerical example of replicating the cash flows from a 12-month FRN using a series of Treasury bills. The FRN price premium relative to Treasury bills is 15.19 cents, which maps into a premium of 15.42 basis points.

A.6 The SEC Money Market Reform

In response to disruptions in the money market during the 2008 financial crisis when the Reserve Primary Fund "broke the buck," the SEC announced amendments to Rule 2a-7 of the Investment Company Act of 1940 on July 12, 2014 which were set to take effect on October 14, 2016 after a two-year transition period (see Money Market Fund Reform; Amendments to Form PF: Final Rule, Securities and Exchange Commission, 79 Fed. Reg at 47,736 (14 August 2014), Section III.N). Under the new rules, some money market funds (MMFs) are required to impose mandatory redemption restrictions on investors, i.e. to "gate" withdrawals, and to charge a liquidity fee if their holdings of liquid assets (assets that can be converted to cash within five business days or less) falls below a required threshold. In addition, some MMFs are no longer allowed to report a stable $1.00 per share net asset value (NAV). Instead, these MMFs became floating NAV MMFs which means that their prices fluctuate as the value of their portfolio holdings changes.

It is significant that MMFs are affected differently by the new MMF requirements depending on the types of assets they hold in their portfolios. The MMF Reform can be viewed as having created three distinct categories of MMFs: government, retail, and institutional. To be classified as a government MMF, MMFs are required to invest at least 99.50 percent of their total assets in cash, U.S. government securities and/or repurchase agreements that are collateralized fully by cash or government securities (a government security is defined as a security backed by the full faith and credit of the U.S. government (Rule 2a-7(a)(17); section 2(a)(16))). A key feature of government MMFs is that they are not subject to the mandatory fees, gates, and floating NAV requirements imposed by the reforms on other MMFs.

It is industry practice to differentiate between government treasury and government agency MMFs. The former invest solely in securities issued by the U.S. Treasury and thus meet the SEC's 99.50 percent threshold. The latter also invest in securities issued by government agencies and thus meet the 99.50 percent requirement only if they do not hold more than 0.50 percent in agency securities that are not guaranteed by the full faith and credit of the federal government. We note that certain issuers of U.S. government securities, e.g., government-sponsored enterprises such as Fannie Mae, Freddie Mac, and the Federal Home Loan Banks are sponsored or chartered by Congress, but their securities are neither issued by nor guaranteed by the U.S. Treasury, so they do not qualify as a government security in the sense of MMF Reform.

Retail MMFs are only available to retail investors (retail MMFs must have policies and procedures reasonably designed to limit all beneficial owners of the MMF to natural persons). Retail MMFs can be further divided into prime and tax exempt MMFs. Prime MMFs invest in high-quality commercial paper, certificates of deposit, bankers' acceptances, and repurchase agreements collateralized by such securities, but can also hold short-term securities issued by the U.S. Treasury and agencies. Tax-exempt MMFs invest in municipal debt securities that pay interest that is not taxed by the federal government, and in some cases state and municipalities. Institutional MMFs can also be divided into prime and tax exempt MMFs, but their beneficial owners include, but are not limited to, defined benefit plans, endowments and foundations, corporations, and retirement savings trusts.

In contrast to government MMFs, both retail and institutional MMFs now face new rules and more stringent requirements. In particular, investors in retail and institutional MMFs face a greater risk of not being able to redeem shares at a fixed NAV of $1.00 per share than before the MMF Reform. This is because both retail and institutional MMFs are now subject to gating restrictions and liquidity fees that are triggered based on a MMF's liquid assets.

Specifically, SEC Rule 2a-7(g)-(j) defines two types of liquid assets, daily and weekly, corresponding to the ability to convert to cash within one or five business days, respectively. Daily liquid assets are cash, direct obligations of the U.S. government, securities that will mature or are subject to a demand feature that is exercisable and payable within one business day, and receivables scheduled to be paid within one business day. At least ten percent of a MMF's total assets must qualify as daily liquid assets. Weekly liquid assets are cash, U.S. Treasury securities, and certain other government agency securities with remaining maturities of 60 days or less, or securities that will mature or are subject to a demand feature that is exercisable and payable within five business days, and receivables scheduled to be paid within five business days.

Retail and institutional MMFs are required to impose a one-percent fee on the NAV of investor shares when weekly liquid assets fall below ten percent of total assets. The MMF's management, however, also has certain discretion to impose up to a two-percent fee when weekly liquid assets fall below 30 percent of total assets. Moreover, a MMF's board may impose a temporary suspension of redemptions for up to ten business days in any 90-day period if the MMF's weekly liquid assets fall below 30 percent of total assets. MMFs are required to report weekly liquidity percentages to provide transparency to investors if there is the potential for a fee or gate.

In addition to fees and gates, institutional MMFs are no longer allowed to report a stable $1.00 per share NAV. Instead, they became floating NAV MMFs. Specifically, institutional MMFs are required to sell and redeem shares based on the current mark-to-market value of the securities in their underlying portfolios rounded to the fourth decimal place (e.g., $1.0000), i.e., transact at a floating NAV. As a result, the NAV can fluctuate, or float. In contrast, retail MMFs are still allowed to round up their NAV to $1.00 provided that the amortized cost per share is greater than or equal to $0.9950. Floating NAV requirements create significant complications for investors who use these MMFs to manage their short-term liquidity needs since they may no longer be able to redeem their shares instantaneously. For example, the SEC recognizes that since it may take several hours to strike a market-based NAV price, floating NAV MMFs may no longer be able to offer trading times for same day settlement late in the day, i.e., after 4 p.m. (see Money Market Fund Reform; Amendments to Form PF, Investment Company Act Release No. 31166 (July 23, 2014), pp. 192-193).

Finally, as a result of the reforms, all MMFs are now subject to more stringent constraints on their portfolio holdings and to enhanced stress-testing and reporting requirements. It is important to note that even before the 2014 reform, SEC Rule 2a-7(c)(2) required that MMFs not acquire any security with a remaining maturity greater than 397 days, that the dollar-weighted average maturity of the securities owned by the MMF may not exceed 60 days, and that the MMF's dollar-weighted average life to maturity may not exceed 120 days. However, the MMF Reform also introduced new requirements for daily and weekly liquid assets and concentration limits on portfolio holdings.

Specifically, institutional and retail MMFs are required to test their ability to maintain weekly liquid assets of at least ten percent of total assets under specific stress scenarios which include increases in the level of short-term interest rates, the downgrade or default of particular portfolio security positions, a widening of spreads in various sectors to which the MMF's portfolio is exposed, each in combination with various increases in shareholder redemptions. Since 2010, when a MMF's daily liquid assets drop below ten percent of total assets, the MMF (other than municipal MMFs, which are exempt from this requirement) is prohibited from acquiring any new asset other than daily liquid assets. Similarly, if weekly liquid assets drop below 30 percent of total assets, the MMF cannot acquire any new asset other than a weekly liquid asset. Moreover, government MMFs are required to test their ability to keep a stable NAV, and prime MMFs are required to minimize principal volatility in response to the specified stress events.

In addition to making the stability of NAVs subject to stress tests, Rule 2a-7 also includes certain procedural standards overseen by the MMF's board of directors. These include the requirement that the MMF periodically calculate the market-based value of the portfolio ("shadow price") and compare it to the MMF's stable share price. If the deviation between these two values exceeds 50 basis points, the MMF's board of directors must consider what action, if any, should be taken by the board, including whether to re-price the MMF's securities above or below the MMF's $1.00 share price. Specifically, the MMF Reform requires government MMFs to publicly disclose when their current NAV per share deviates downward from its intended $1.00 stable price by more than 25 basis points (i.e., generally below $0.9975). Form N-CR Part D, states that the disclosure requirement is triggered "[if] a retail money market fund's or a government money market fund's current net asset value per share deviates downward from its intended stable price per share by more than 1/4 of 1 percent [...]." In turn, for each day the MMF's current NAV is below this threshold, a MMF must disclose the following information: (i) the date or dates on which such downward deviation exceeded 1/4 of 1 percent; (ii) the extent of deviation between the MMF's current NAV per share and its intended stable price; and (iii) the principal reason or reasons for the deviation, including the name of any security whose market-based value or sale price, or whose issuer's downgrade, default, or event of insolvency (or similar event) has contributed to the deviation.

The MMF Reform not only had substantial implications for the MMFs themselves, but also for many investors who held MMFs for their price stability and liquidity—MMFs had previously maintained a stable $1.00 NAV and were redeemable on demand. Investors started to vote with their feet and withdrew $404.3 billion in assets, or 29.2 percent, from prime institutional MMFs, and moved $432.8 billion, or 42.8 percent, into government MMFs between October 2015 and May 2016 (see Crane Data, Money Market Funds News, 08/02/2016, www.cranedata.com). Investors withdrew an additional $500 billion from prime MMFs in the summer months prior to October 2016. "The steady, persistent trickle of redemptions turned into a flood as the October 14 deadline for compliance with the new rules approached. [...] More than $500 billion was withdrawn from prime funds over the summer including an eye-popping $250 billion in September alone" (see Faye Kilburn and Robert MacKenzie Smith, How Banks Weathered the Money Market Storm, Risk.net, 10/17/2016).

There are several reasons why MMF investors not only demand liquid, money-like investments, but view price-stability as a key characteristic driving their investment decisions. "Others are more direct: if treasurers can no longer redeem daily at par, then they'll stop using them. If the stable-NAV basis were to disappear and capital was put at risk, we'd certainly stop investing in them, and I suspect many other corporates would too, says John Jackson, group treasurer for The Weir Group, a Glasgow-based engineering company" (see Tom Newton, Corporate Cash Seeks New Home as Money-Market Reforms Loom, Risk.net, 04/29/2013). Many firms use MMFs to manage their short-term liquidity needs. Gates and fees raise the prospect of failing to meet short-term funding needs and by investing in prime MMFs, firms risk that they cannot redeem their shares instantaneously. This is because prime MMFs strike multiple NAVs during the day and firms must consider the MMF's schedule and time their redemptions according to when they need liquidity. Moreover, floating NAVs complicate accounting for short-term investments since they are marked to market with gains and losses flowing through to earnings.

Many investors also face institutional constraints that prevent them from holding shares in floating NAV MMFs. For instance, public agencies may be required by their investment policy to only hold MMFs that maintain a stable $1.00 NAV per share. "... If the policy authorizes an investment in mutual funds, it shall indicate whether the authorization is limited to securities whose intention is to maintain a net asset value of $1.00 per share or also includes securities whose net asset value per share may fluctuate on a periodic basis" (see Michigan Department of Treasury, Public Act 196 of 1997, Amendments to Public Act 20 of 1943, Basic Investment Policy, March 1998). Moreover, local government investment pools (LGIPs) may be required to invest only in MMFs designated "AAAm" by Standard and Poor's (S&P) Principal Stability Rating Guidelines (PSFR) which is assigned to MMFs whose investment policies are consistent with providing a stable NAV. For instance, the Commonwealth of Pennsylvania Treasury Investment Policy mandates the fund "Pool 99" to invest in MMFs rated AAAm or its equivalent. In addition, the investment policy requires Pool 99 to maintain a stable NAV per share of $1.00, to calculate the value of a share in Pool 99 daily, incorporating all realized and unrealized gains and losses, and any cash returned from investments, and to notify the Treasurer or designee(s) at any time the value of one share in Pool 99 declines to or below a rounded value of $0.9985 or exceeds $1.0015 (see Commonwealth of Pennsylvania Treasury Investment Policy, Effective February 19, 2014).

New regulations introduced by Basel III and the Dodd-Frank Act also increased demand for MMFs from many investors including asset managers and private equity firms. This is because many banks substantially tightened short-term funding by cutting back or even exiting the cash management business as a result of the Basel III liquidity coverage ratio (LCR) and net stable funding ratio (NSFR) requirements (see Tom Newton, Corporate Cash Seeks New Home as Money-Market Reforms Loom, Risk.net, 04/29/2013). Specifically, under Basel III liquidity requirements, for deposits designated as non-operational, the incoming cash is considered "fast outflow money" subject to withdrawal from the banks in the event of a liquidity crisis. As a result, banks are required to finance high quality liquid assets (HQLA) against these cash positions. In other words, for every dollar in short-term deposits a bank holds, it will be required to hold one dollar in HQLA which means that banks are required to put aside additional lower yielding HQLA in order to support deposits from asset managers.

In summary, a major consequence of the SEC's MMF Reform is that MMFs now have significantly greater incentives to invest in securities that minimize the potential variation in their NAVs. In turn, this provide a strong motivation for MMFs to hold FRNs in their portfolios because of the mark-to-market stability of FRN prices.

A.7 Evaluating Alternative Explanations

This section provides additional details for some of the robustness checks presented in Section 11 of the paper.

A.7.1 Robustness to Swap Mispricing

To test whether the estimated FRN premia might be driven by the basis swap and/or interest rate swap data we use in swapping fixed cash flows into floating, we apply our methodology to two alternative classes of floating rate notes. We use two sets of securities to show that neither the Treasury bill basis swaps nor the plain-vanilla Libor interest rate swaps are driving the near-money premium in FRN prices.

The first class of securities consists of pairs of floating/fixed rate corporate notes. The floating rate cash flows on corporate floating rate notes are based on three-month Libor rates. We apply the same Libor interest rate swaps to the corporate fixed coupon notes and swap these notes into floating. Analogous to how we compute FRN premia, we then compare the yields of the swapped fixed rate notes to the yields of matched floating rate notes from the same firm that have the same maturity as the swapped fixed rate note. Finding no evidence of statistically significant premia would suggest that the standard Libor interest rate swaps we use in our main analysis are not driving the results.

The data on floating and fixed rate corporate debt consist of 38 matched-maturity pairs of two-year floating/fixed rate corporate notes during the 2014 to 2018 period from Amgen, Apple, Berkshire Hathaway, Caterpillar, Chevron, CVS Health, Daimler, Discovery, Ford Motor, Gilead Sciences, Honeywell, HP, Honda Motor, IBM, Met Life, PepsiCo, Shire, Toyota, Walmart, and Wells Fargo. We identify these corporate notes in the Bloomberg system by searching for floating rate corporate debt that was issued with two years to maturity during our sample between 2014 and 2018, and for which there was a fixed rate note with the same maturity. This criterion helps us to identify corporate debt that is similar in terms of time to maturity and issuance dates to our set of Treasury FRNs. Table A7 provides descriptive statistics for these pairs of floating/fixed rate securities.

The second class of securities consists of pairs of floating/fixed rate Federal Farm Credit Bank (FFCB) notes. The floating rate cash flows on FFCB notes are indexed to 13-week Treasury bills. For each floating rate FFCB note we also collect prices of FFCB fixed rate notes that have the same maturity date. Next, analogous to how we swap Treasury notes into FRNs, we first enter into a plain-vanilla Libor interest rate swap, receiving fixed and paying floating. Then we swap the floating Libor leg from interest rate swap into floating cash flows indexed to 13-week Treasury bill rates using the same set of basis swaps that we apply to swap Treasury notes into FRNs. This means that we not only use the same set of swaps, but we also keep all adjustments that we describe in Appendix A.4 fixed. Again, finding no statistically significant premia in the prices of FFCB floating rate notes would suggest that the Treasury bill basis swaps that we use in our main analysis are not driving our FRN stability premia estimates.

The data on FFCB notes consist of 32 pairs of two-year floating and fixed rate notes during the 2014 to 2018 period. Similar to Treasury FRNs, the floating rate notes pay quarterly coupon cash flows based on the 13-week Treasury bill rate during the quarter plus a constant spread expressed in basis points. For each of the 32 floating rate notes we identify a matching fixed rate note that is closest in maturity to the floating rate issue. Table A8 provides descriptive statistics for these pairs of floating/fixed rate FFCB securities.

A.7.2 Collateral Values

As discussed, the Federal Reserve accepts Treasury FRNs as collateral for Discount Window Lending and Payment System Risk purposes, and FRNs receive the same collateral margin treatment as Treasury bills, notes, and bonds. For example, see https://www.frbdiscountwindow.org/articles/2014/07/23/11/18/acceptance-of-us-treasury-floating-rate. FRNs are also specifically designated as accepted collateral for the Treasury Tax and Loan Program and for Depositaries and Financial Agents of the Federal Government (31 CFR parts 202 and 203) and face the same one-percent haircut as Treasury notes and bonds with the same maturity. In particular, see https://www.treasurydirect.gov/instit/statreg/collateral/collateral.htm. Treasury FRNs are also acceptable as collateral at the Chicago Mercantile Exchange and have the same two-percent haircut requirement as Treasury notes and bonds, see https://www.cmegroup.com/clearing/financial-and-collateral-management/acceptable-collateral-for-treasuries-tips-and-strips.html.

A.7.3 Tax Differences

As discussed in the paper, there is no difference in the tax treatment of FRNs and Treasury notes. The tax treatment of Treasury bills and STRIPS is similar to that of Treasury notes and bonds with the exception that some taxable investors must include an imputed accretion in the principal amount of the Treasury bill or STRIP as interest income (essentially an original issue discount (OID) amortization). We note, however, that studies of the pricing of Treasury securities issued at discounts have not found evidence of inputed accretion tax effects. For example, see Grinblatt and Longstaff (2000) and Jordan, Jorgensen, and Kuipers (2000).

REFERENCES FOR ONLINE APPENDIX

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Jordan, Bradford D., Randy D. Jorgensen, and David R. Kuipers, 2000, The Relative Pricing of U.S. Treasury STRIPS: Empirical Evidence, Journal of Financial Economics 56, 89-123.

Longstaff, Francis A., Jun Liu, Ravit E. Mandell, 2006, The Market Price of Risk in Interest Rate Swaps: The Roles of Default and Liquidity Risk, Journal of Business 79, 2337, 2360.

Table A1

Data Definitions and Sources. This table summarizes the datasets used in this study. Frequency shows at what intervals the data are available. Description and Source show the data source and its definition. All data are for the period from January 2014 through March 2018.

	Data	Frequency	Description and Source
1	Treasury Floating Rate Note Prices	Daily	Two-year U.S. Treasury floating rate notes end-of-day closing mid, bid, and ask prices, floating rate spreads, issue and maturity dates from the Bloomberg system and from Thomson Reuters.
2	Treasury Floating Rate Reference Index	Daily	Two-year U.S. Treasury floating rate notes reference index. Treasury FRNs are indexed to the most recent 13-week Treasury bill auction high yield prior to the lockout period, which is the highest accepted discount rate in a Treasury bill auction. The U.S. Treasury publishes this index at https://www.treasurydirect.gov/instit /annceresult/annceresult/frn.htm
3	Treasury Note Prices	Daily	Two-year U.S. Treasury notes end-of-day mid, bid, and ask prices, yields, coupon rates, issue and maturity dates from the Bloomberg system and from the Thomson Reuters Eikon system.
4	Treasury Bill Prices	Daily	U.S. Treasury bill end-of-day mid, bid, and ask prices, and issue and maturity dates from the Bloomberg system and the U.S. Treasury auction tables. Data consists of Treasury bills with tenors of 4-, 13-, 26-, and 52-weeks to maturity.
5	Treasury Auction Data	Monthly	Two-year U.S. Treasury floating rate notes, two-year Treasury notes and Treasury bill auction results from the website of U.S. Treasury at https://www.treasury direct.gov/instit/annceresult/press/press.htm. For Treasury floating rate notes, data are the floating rate auction spread, the auction high discount margin, and the floating rate index determination date. For two-year Treasury notes, the auction data are the coupon rate and the auction high yield and for 4-, 13-, 26- and 52-week Treasury bills the auction high yield. In addition, the auction results include prices and accrued interest at auction, auction announcement and auction dates, dated dates, issue dates, and maturity dates, amounts bid by competitive and non-competitive bidders, amounts issued, and bid-to-cover ratios.
6	Treasury STRIPS	Daily	Zero coupon rates of U.S. Treasury STRIPS for six months, one year, and two years to maturity from the Bloomberg system.
7	Discount Function	Daily	Discount function out to two years calculated from GC repo rates and Treasury STRIPS data (see Liu, Longstaff, Mandell (2006)).
8	Treasury Bill Basis Swap Spreads	Daily	Thirteen-week U.S. Treasury bill yield into three-month Libor basis swap spreads. Spreads on U.S. Treasury basis swaps with quarterly cash flows are quoted on the Bloomberg system for tenors of 3, 6, 9, 12, 18, and 24 months.

Table A1 - Continued

	Data	Frequency	Description and Source
9	Libor Interest Rate Swap Spreads	Daily	Three-month Libor into fixed interest rate swap rates. Cash flows on the fixed leg are semiannual, and the floating leg pays three-month Libor each quarter.
10	Thirteen-week Treasury Bill Yields	Daily	Discount yields of the on-the-run 13-week U.S. Treasury bill.
11	Treasury CMT Rate	Daily	One-year constant maturity Treasury rate from Federal Reserve H.15 Selected Interest Rates Release.
12	Institutional Ownership	Quarterly	Institutional ownership of Treasury FRNs and Notes collected from the Bloomberg system via its HDS reports. The Bloomberg system collects the holdings information from regulatory filings including Form 13F, Form N-MFP, Form 10-K, IRS Form 990, Department of Labor Form 5500, NAIC Form Schedule D, and public disclosures from pension funds, hedge funds, money market funds, and ETFs.
13	Money Market Fund Holdings	Monthly	Portfolio holdings of money market funds obtained from Form N-MFP filings with the SEC and downloaded via the SEC's EDGAR (Electronic Data Gathering, Analysis, and Retrieval) database.
14	Interest Rate Forecasts	Monthly	Interest rate forecasts of two-year Treasury yields and of three-month Libor rates from the Bloomberg Professional Survey (BY2 US and EC3MUS). Forecasts are at the monthly frequency for interest rates three months ahead.
15	Swaption Volatility Index	Monthly	Index of basis point volatility of interest rates implied from swaptions. Index data from the Bloomberg system.
16	TED Spread	Monthly	The spread between three-month dollar Libor and three-month Treasury bill rates. Data from the Bloomberg system.
17	Consumer Confidence	Monthly	The Michigan Consumer Sentiment Index (MCSI) of U.S. consumer confidence levels conducted by the University of Michigan.
18	Treasury CDS	Monthly	The two-year sovereign credit default swap spread on U.S. Treasury debt from the Bloomberg system.
19	Money Supply	Monthly	Amount of currency, total demand deposits in depository institutions, and total time deposits. Data from the Federal Reserve, Money Stock and Debt Measures H.6 Release.

Table A1 - Continued

	Data	Frequency	Description and Source
20	Money Market Fund Flows	Monthly	Net cash flows into government and non-government (combined retail and institutional) money market funds. Non-government funds consist of prime, municipal and tax-exempt money market funds. Data from the Investment Company Institute.
21	Money Market Fund Assets	Monthly	Net assets of government and non-government (combined retail and institutional) money market funds. Non-government funds consist of prime, municipal and tax-exempt money market funds. Data from the Investment Company Institute.
22	Corporate Floating Rate Notes	Daily	Two-year U.S. corporate floating rate notes end-of-day closing mid, bid, and ask prices, floating rate spreads, issue and maturity dates from the Bloomberg system. All bonds are issued between January 2014 and March 2018, have two years to maturity at issue, no embedded options, and pay off par at maturity.
23	Federal Farm Credit Bank Notes	Daily	Federal Farm Credit Bank (FFCB) floating rate notes end-of-day closing mid, bid, and ask prices, floating rate spreads, issue and maturity dates from the Bloomberg system. All FFCB bonds are indexed to three-month Treasury bills, are issued between January 2014 and March 2018, and have no embedded options.

Table A2

Summary Statistics for Treasury Bill Basis Swaps. This table presents summary statistics for Treasury bill basis swaps. Treasury bill basis swaps exchange the floating 13-week Treasury bill market rate plus a spread B for three-month Libor on a quarterly basis over the life of the contract. The spread B is annualized and measured in basis points. The column titled Months to Maturity lists the tenors of the basis swap contracts in months. The columns titled Mean, Median, Min, and Max show the average, median, smallest, and largest spreads B over the sample period. The column titled Std Dev shows the sample standard deviation of B. N denotes the number of observations. The sample period is daily from January 2014 to March 2018.

Months to Maturity	Mean	Std Dev	Min	Median	Max	N
3	29.45	11.57	12.59	23.93	70.81	1,085
6	30.25	10.52	14.73	25.01	63.34	1,085
9	30.48	10.05	15.72	25.53	56.65	1,085
12	31.13	9.74	16.29	26.67	55.92	1,085
15	31.75	9.42	16.68	27.88	55.75	1,085
18	32.36	9.13	16.90	29.08	55.58	1,085
21	33.03	9.15	17.28	29.89	55.42	1,085
24	33.69	9.21	17.66	30.61	55.26	1,085

Table A3

Summary Statistics for Three-Month Libor Interest Rate Swaps. This table presents summary statistics for three-month Libor interest rate swaps. Interest rate swaps exchange the floating three-month Libor rate set at the beginning of each quarter against a fixed rate F on a quarterly basis over the life of the contract. The spread F is annualized and measured in basis points. The column titled Months to Maturity lists the tenors of the basis swap contracts in months. The columns titled Mean, Median, Min, and Max show the average, median, smallest, and largest spreads F over the sample period. The column titled Std Dev shows the sample standard deviation of F. N denotes the number of observations. The sample period is daily from January 2014 to March 2018.

Months to Maturity	Mean	Std Dev	Min	Median	Max	N
3	73.19	51.48	22.78	63.55	235.32	1,085
6	78.09	53.50	23.05	68.16	235.77	1,085
9	83.19	54.53	23.85	72.01	238.75	1,085
12	88.62	54.74	25.30	75.02	243.35	1,085
15	94.31	54.14	28.29	78.54	249.57	1,085
18	100.37	53.19	31.95	82.46	255.13	1,085
21	106.55	51.87	36.63	87.41	259.87	1,085
24	112.78	50.35	42.50	93.69	263.91	1,085

Table A4

Cash Flows from Replicating a FRN Using a Treasury Note. This table illustrates the cash flows from the replication strategy for a two-year FRN. The replication strategy consists of taking a long position in a two-year Treasury note, swapping its fixed coupon cash flows into floating using interest rate and basis swaps, and taking a small position in Treasury STRIPS to match the FRN spread. C denotes the semiannual coupon of the Treasury note. F denotes the semiannual fixed coupon payment for the interest rate swap. B denotes the quarterly fixed basis swap spread (actual/360). S denotes the quarterly spread for the FRN (actual/360). L_t denotes the quarterly Libor cash flow based on the three-month Libor rate set at the beginning of the quarter in which the cash flow is paid (actual/360). X_t denotes the floating cash flow computed as the average of the 13-week Treasury bill rates averaged over the quarter in which the cash flow is paid (actual/360). P_N denotes the price of the two-year Treasury note. P_{FRN} denotes the price of the Treasury FRN. ϵ denotes the sum of the prices of the STRIPS in the replicating portfolio. The columns titled Synthetic FRN illustrate the cash flows from the replication strategy. The column titled Treasury FRN illustrates the cash flows from the two-year FRN being replicated.

	Synthetic FRN					Treasury FRN
Timing of Cash Flow	T-Note Cash Flow	Swap Cash Flow	Basis Swap Cash Flow	STRIPS Cash Flow	Total Cash Flow	Total Cash Flow
0.00	$-P_N$	–	–	$-\epsilon$	$-(P_N + \epsilon)$	$-P_{FRN}$
0.25	–	L_t	$(X_t + B) - L_t$	$S - B$	$S + X_t$	$S + X_t$
0.50	C	$-F + L_t$	$(X_t + B) - L_t$	$S - C - B + F$	$S + X_t$	$S + X_t$
0.75	–	L_t	$(X_t + B) - L_t$	$S - B$	$S + X_t$	$S + X_t$
1.00	C	$-F + L_t$	$(X_t + B) - L_t$	$S - C - B + F$	$S + X_t$	$S + X_t$
1.25	–	L_t	$(X_t + B) - L_t$	$S - B$	$S + X_t$	$S + X_t$
1.50	C	$-F + L_t$	$(X_t + B) - L_t$	$S - C - B + F$	$S + X_t$	$S + X_t$
1.75	–	L_t	$(X_t + B) - L_t$	$S - B$	$S + X_t$	$S + X_t$
2.00	$100 + C$	$-F + L_t$	$(X_t + B) - L_t$	$S - C - B + F$	$100 + S + X_t$	$100 + S + X_t$

Table A5

Cash Flows from Replicating a FRN Using Treasury Bills. This table illustrates the cash flows from the replication strategy for a FRN with one year to maturity. The replication strategy consists of positions in 3-, 6-, 9-, and 12-month Treasury bills combined with interest rate and basis swaps. F denotes the semiannual fixed coupon payment for the interest rate swap. B denotes the quarterly fixed basis swap spread (actual/360). S denotes the quarterly spread for the FRN (actual/360). L_t denotes the quarterly Libor cash flow based on the three-month Libor rate set at the beginning of the quarter in which the cash flow is paid (actual/360). X_t denotes the quarterly cash flow computed as the average of the 13-week Treasury bill rates averaged over the quarter in which the cash flow is paid (actual/360). $P(T)$ denotes the price of a Treasury bill with maturity T. P_{FRN} denotes the price of the Treasury FRN. The columns titled Synthetic FRN illustrate the cash flows from the replication strategy. The column titled Treasury FRN illustrates the cash flows from the two-year FRN being replicated.

	Synthetic FRN				Treasury FRN
Timing of Cash Flow	T-Bill Portfolio	Swap Cash Flow	Basis Swap Cash Flow	Total Cash Flow	Total Cash Flow
0.00	$-(S-B)\ P(0.25)$ $-(S-B+F)\ P(0.50)$ $-(S-B)\ P(0.75)$ $-(100+S-B+F)\ P(1.00)$	–	–	$-(S-B)\ P(0.25)$ $-(S-B+F)\ P(0.50)$ $-(S-B)\ P(0.75)$ $-(S-B+F+100)\ P(1.00)$	$-P_{FRN}$
0.25	$S-B$	L_t	$(X_t+B)-L_t$	$S+X_t$	$S+X_t$
0.50	$S-B+F$	$-F+L_t$	$(X_t+B)-L_t$	$S+X_t$	$S+X_t$
0.75	$S-B$	L_t	$(X_t+B)-L_t$	$S+X_t$	$S+X_t$
1.00	$100+S-B+F$	$-F+L_t$	$(X_t+B)-L_t$	$100+S+X_t$	$100+S+X_t$

Table A6

Numerical Example of the Cash Flows from Replicating a FRN Using Treasury Bills. This table provides a numerical illustration of the cash flows from the replication strategy for a FRN with one year to maturity. The replication strategy consists of positions in 3-, 6-, 9-, and 12-month Treasury bills combined with interest rate and basis swaps. This example is based on market prices as of January 31, 2017. The Treasury FRN being replicated was issued on January 31, 2017 and has a maturity date of January 31, 2019 and a fixed spread of 14.00 basis points. The 3-, 6-, 9-, and 12-month Treasury bills have market prices of 99.6455, 99.1868, 98.7402, and 98.1374, respectively. The fixed market rate on a Libor interest rate swap is 2.0960 percent paid semiannually, in exchange for three-month Libor paid quarterly (actual/360) L_t, where Libor is set at the beginning of the quarter in which it is paid. The Treasury bill basis swap pays a quarterly stream of cash flows equal to the Treasury bill rate averaged over the quarter in which it is paid (actual/360) X_t, plus the basis swap spread of 30.55 basis points (actual/360), in exchange for quarterly three-month Libor cash flows (actual/360) L_t. The cost of taking a position in Treasury bills and swaps to match exactly the cash flows on the FRN is 100.0395. The market price of the FRN being replicated is 100.1914. The columns titled Synthetic FRN illustrate the cash flows from the replication strategy. The column titled Treasury FRN illustrates the cash flows from the FRN being replicated.

	Synthetic FRN				Treasury FRN
Timing of Cash Flow	T-Bill Portfolio	Swap Cash Flow	Basis Swap Cash Flow	Total Cash Flow	Total Cash Flow
0.00	0.0408	–	–	−100.0395	−100.1914
	−0.9976				
	0.0417				
	−99.1244				
0.25	−0.0409	L_t	$(X_t + 0.0750) - L_t$	$0.0341 + X_t$	$0.0341 + X_t$
0.50	1.0057	$-1.0480 + L_t$	$(X_t + 0.0776) - L_t$	$0.0353 + X_t$	$0.0353 + X_t$
0.75	−0.0423	L_t	$(X_t + 0.0776) - L_t$	$0.0353 + X_t$	$0.0353 + X_t$
1.00	101.0057	$-1.0480 + L_t$	$(X_t + 0.0776) - L_t$	$100.0353 + X_t$	$100.0353 + X_t$

Table A7

Descriptive Statistics for U.S. Corporate Bond Floating Rate/Fixed Rate Note Pairs. This table presents descriptive statistics for the two-year U.S. corporate floating rate bonds and and matched-maturity fixed rate notes of the same parent company in the sample. The spread of the floating rate bond is measured in basis points. The fixed rate bond coupon rate is expressed as a percentage. Amount denotes the total par amount issued by the parent company and is measured in millions of dollars. NC denotes the number of coupon cash flows per year. The sample period is daily from June 2015 to March 2018.

		Two-Year Corporate Floating Rate Bond				Matched-Maturity Corporate Fixed Rate Bond			
Pair	Parent Company	Maturity	Spread	NC	Issued	Maturity	Coupon	NC	Issued
1	CVS Health	3–9–2020	63	4	1000	3–9–2020	3.125	2	2000
2	Caterpillar	3–22–2019	28	4	250	3–22–2019	1.900	2	650
3	Caterpillar	11–29–2019	13	4	300	11–29–2019	2.000	2	600
4	Wells Fargo	11–28–2018	50	4	700	11–28–2018	1.800	2	800
5	Wells Fargo	1–15–2020	23	4	1000	1–15–2020	2.400	2	1750
6	Discovery	9–20–2019	71	4	400	9–20–2019	2.200	2	500
7	Honda Motor	11–19–2018	28	4	750	11–19–2018	1.500	2	450
8	Apple	2–8–2019	8	4	500	2–8–2019	1.550	2	500
9	Gilead Sciences	9–20–2019	25	4	500	9–20–2019	1.850	2	1000
10	Amgen	5–10–2019	32	4	300	5–10–2019	1.900	2	700
11	Honeywell	10–30–2019	4	4	450	10–30–2019	1.800	2	750
12	PepsiCo	5–2–2019	4	4	350	5–2–2019	1.550	2	750
13	Toyota Motor	1–10–2020	10	4	400	1–10–2020	2.200	2	750
14	IBM	9–6–2019	15	4	600	9–6–2019	1.625	2	800
15	Toyota Motor	1–9–2019	26	4	400	1–9–2019	1.700	2	850
16	Chevron	2–28–2019	9	4	450	2–28–2019	1.686	2	550
17	Walmart	10–9–2019	-3	4	300	10–9–2019	1.750	2	1200
18	Shire	6–22–2018	78	4	375	6–22–2018	2.000	2	374
19	Honda Motor	11–13–2019	15	4	350	11–13–2019	2.000	2	600
20	Metropolitan Life	9–19–2019	22	4	950	9–19–2019	1.750	2	500
21	Metropolitan Life	12–19–2018	43	4	500	12–19–2018	1.750	2	500
22	Metropolitan Life	9–14–2018	34	4	350	9–14–2018	1.350	2	550
23	Metropolitan Life	9–14–2018	34	4	350	9–14–2018	1.350	2	550
24	Metropolitan Life	9–19–2019	22	4	950	9–19–2019	1.750	2	500
25	Wells Fargo	1–22–2018	74	4	2000	1–22–2018	1.650	2	2000

Table A7 – continued

Descriptive Statistics for U.S. Corporate Bond Floating Rate/Fixed Rate Note Pairs. This table presents descriptive statistics for the two-year U.S. corporate floating rate bonds and and matched-maturity fixed rate notes of the same parent company in the sample. The spread of the floating rate bond is measured in basis points. The fixed rate bond coupon rate is expressed as a percentage. Amount denotes the total par amount issued by the parent company and is measured in millions of dollars. NC denotes the number of coupon cash flows per year. The sample period is daily from June 2015 to March 2018.

		Two-Year Corporate Floating Rate Bond				Matched-Maturity Corporate Fixed Rate Bond			
Pair	Parent Company	Maturity	Spread	NC	Issued	Maturity	Coupon	NC	Issued
26	Metropolitan	12–19–2018	43	4	500	12–19–2018	1.750	2	500
27	Caterpillar	2–23–2018	70	4	425	2–23–2018	1.500	2	775
28	Berkshire Hathaway	3–7–2018	55	4	1000	3–7–2018	1.450	2	750
29	Daimler AG	8–3–2017	71	4	550	8–3–2017	1.600	2	450
30	Apple	5–12–2017	5	4	250	5–12–2017	0.900	2	750
31	PepsiCo	7–17–2017	25	4	600	7–17–2017	1.125	2	650
32	Ford Motor	3–27–2017	63	4	500	3–27–2017	1.461	2	650
33	Chevron	11–9–2017	36	4	500	11–9–2017	1.344	2	1000
34	PepsiCo	10–13–2017	35	4	700	10–13–2017	1.000	2	450
35	Hewlett Packard	10–5–2017	174	4	350	10–5–2017	2.450	2	2250
36	Hewlett Packard	10–5–2017	174	4	350	10–5–2017	2.450	2	2250
37	Toyota Motor	4–6–2018	38	4	350	4–6–2018	1.200	2	900
38	Daimler AG	8–3–2017	71	4	550	8–3–2017	1.600	2	450

Table A8

Descriptive Statistics for Federal Farm Credit Bank Floating Rate/Fixed Rate Note Pairs. This table presents descriptive statistics for the Federal Farm Credit Bank floating rate bonds and matched-maturity fixed rate notes. The floating rate bonds pay quarterly coupon cash flows based on the 13-week Treasury bill rate during the quarter plus a constant spread expressed in basis points. The coupon rate of the matched-maturity semi-annual fixed rate bonds are expressed as a percentage. Maturity Date and Issue Date denote the maturity and issue dates of the bonds, respectively. Amount denotes the total par amount issued and is measured in millions of dollars. NC denotes the number of coupon cash flows per year. The sample period is daily from January 2014 to March 2018.

Pair	Maturity	Issue Date	Spread	NC	Amount	Maturity Date	Issue Date	Coupon	NC	Amount
1	8–1–2018	8–1–2016	35	4	100	8–1–2018	8–1–2008	5.05	2	183
2	11–13–2018	1–13–2017	28	4	200	11–14–2018	11–14–2011	1.78	2	63
3	11–14–2018	2–14–2017	20	4	100	11–14–2018	11–14–2011	1.78	2	63
4	12–3–2018	2–28–2017	19	4	100	12–3–2018	12–3–2015	1.3	2	105
5	12–5–2018	12–5–2016	30	4	200	12–5–2018	12–5–2016	1.1	2	394
6	12–5–2018	6–5–2017	5	4	200	12–5–2018	12–5–2016	1.1	2	394
7	1–25–2019	4–25–2017	10	4	100	1–24–2019	4–24–2017	1.22	2	100
8	2–19–2019	7–19–2017	9	4	100	2–15–2019	2–15–2018	1.95	2	60
9	3–12–2019	6–12–2017	6.5	4	100	3–15–2019	3–15–2007	5.05	2	15
10	3–13–2019	3–13–2017	15	4	100	3–15–2019	3–15–2007	5.05	2	15
11	3–22–2019	3–22–2017	16	4	100	3–22–2019	3–22–2018	2.13	2	100
12	3–25–2019	5–25–2017	8	4	100	3–25–2019	11–25–2005	5.125	2	10
13	4–12–2019	4–12–2017	15	4	150	4–17–2019	4–17–2017	1.32	2	220
14	5–8–2019	5–8–2017	12	4	100	5–8–2019	2–8–2018	2	2	100
15	6–19–2019	6–19–2017	9	4	100	6–19–2019	9–19–2017	1.375	2	93
16	6–27–2019	6–27–2017	10	4	100	6–27–2019	3–27–2018	2.25	2	45
17	7–3–2019	7–3–2017	10	4	100	7–2–2019	7–2–2012	1.48	2	17
18	7–5–2019	10–5–2017	8.5	4	125	7–2–2019	7–2–2012	1.48	2	17
19	7–26–2019	7–26–2017	9	4	150	7–24–2019	7–24–2017	1.4	2	226
20	8–8–2019	8–8–2017	8.5	4	100	8–5–2019	8–5–2015	1.5	2	75
21	9–20–2019	9–20–2017	9.5	4	250	9–18–2019	9–18–2008	4.5	2	30
22	10–18–2019	10–18–2017	7.5	4	125	10–17–2019	10–17–2016	1.05	2	95
23	10–18–2019	12–18–2017	5	4	200	10–17–2019	10–17–2016	1.05	2	95
24	11–1–2019	11–1–2017	7.5	4	125	11–1–2019	3–22–2017	1.64	2	30
25	11–4–2019	1–4–2018	5	4	100	11–5–2019	1–5–2015	1.8	2	25
26	11–20–2019	11–20–2017	6.5	4	200	11–19–2019	11–19–2015	1.6	2	40
27	11–29–2019	11–29–2017	6.5	4	100	11–26–2019	11–26–2012	1.18	2	23
28	12–26–2019	12–26–2017	7.5	4	100	12–26–2019	5–26–2017	1.4	2	90
29	2–12–2020	2–12–2018	4	4	100	2–11–2020	2–11–2013	1.45	2	15
30	2–19–2020	3–19–2018	5	4	100	2–19–2020	3–19–2018	2.3	2	47
31	3–26–2020	3–26–2018	8.5	4	200	3–27–2020	3–27–2018	2.375	2	470
32	11–12–2020	12–12–2017	13	4	100	11–12–2020	11–12–2013	2.375	2	5