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The US 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 is directly related to the near-constant nature of FRN prices and is correlated with measures reflecting investor demand for safe assets. Money market funds are often the primary investors in FRNs, and the FRN premium is related to flows into funds with fixed net asset values, but not to flows into funds with variable net asset values. 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

An extensive literature shows that markets incorporate a substantial liquidity premium into the prices of Treasury securities because of their near-money characteristics. The liquidity of many Treasury securities allows them to serve in a medium-of-exchange role because 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; Lewis et al., 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, 1994; Krishnamurthy, 2002).[1]

We provide evidence that the market incorporates a significant additional near-money premium into the prices of what could 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 $1.1 trillion issued as of November 2019. 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 et al. (2015), as their market values are virtually unaffected by either private or public information.

We begin by examining the relative valuation of FRNs and other types of Treasury debt. In doing this, we use a no-arbitrage approach in which we compare the prices of FRNs with 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 because 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 et al., 2019).[2]

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 with 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 vary significantly through time and can exceed 30 basis points (or more than 40 cents per $100 par amount). Furthermore, these premia are economically large, almost uniformly positive, and 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 shown 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, exchange-traded funds (ETFs), and other net asset value (NAV) sensitive institutional investors are the primary holders of FRNs. MMFs often represent the single largest class of investors in FRNs and frequently hold more than 50% 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 requirements that could 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 can 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 et al. (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. The Securities and Exchange Commission (SEC) money market reform of 2014 creates a discontinuity between MMFs that invest 99.50% or more of their assets in Treasury securities and those that do not. MMFs that meet this 99.50% threshold are exempt from having to report floating NAVs or subjecting investors to redemption fees and restrictions on withdrawals (gating), or both. 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. No relation exists between FRN premia and flows into nonexempt MMFs holding similar investment portfolios. These findings make a compelling case for

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

[2] In He et al. (2019), the value of a sovereign bond depends on the number of other investors willing to purchase it. If only a few investors are willing to buy new bonds as old bonds mature, a country perhaps is not able to rollover its existing debt and could potentially default. In this sense, rollover or refinancing risk can be viewed as a specific type of credit risk.

interpreting the richness of FRNs as evidence of a stability premium in their prices.

Finally, we consider and rule out a number of other 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 because 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 because 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 important implications. They suggest that economic agents place a high value on the capital-preservation or store-of-value function of FRNs. Our findings also have implications for the management of sovereign debt. The results suggest that the US Treasury could 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

A rapidly growing theoretical literature focuses on the unique role that safe assets such as Treasury securities play in the financial markets. Important examples include Caballero et al. (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 because these assets represent stable high-quality collateral. He et al. (2016, 2019) present models in which the capital-preservation aspect of safe assets plays a central role. Guibaud et al. (2013) present a clientele model of the optimal maturity structure of government debt. Greenwood et al. (2010, 2015) study optimal government debt maturity in a model in which 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 et al. (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.

An extensive empirical literature shows 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) finds idiosyncratic variation in the prices of Treasury bills. Longstaff (2004) and Lewis et al. (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 with 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 can 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 could 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; He et al., 2019). In light of this, our paper conducts an apples-to-apples comparison of the pricing of FRNs with 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.[3]

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 US government. The key difference is that the coupon cash flows of FRNs are indexed to the most recent 13-week Treasury bill auction high rate plus a constant spread.[4] 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.

[3] 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 et al. (2018) observe that spreads between long- and short-dated floating rate commercial paper are small compared with those on fixed rate commercial paper, which suggests that investors could be willing to accept a smaller spread in exchange for less rollover risk.

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

Table 1
Summary statistics for Treasury floating rate note (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	Standard deviation	Minimum	Median	Maximum	*N*
1	January 31, 2016	4.50	99.992	0.015	99.953	99.997	100.022	456
2	April 30, 2016	6.90	100.017	0.013	99.992	100.015	100.055	457
3	July 31, 2016	7.00	100.017	0.015	99.984	100.012	100.062	454
4	October 31, 2016	5.30	99.987	0.021	99.900	99.991	100.016	455
5	January 31, 2017	8.40	100.017	0.022	99.933	100.022	100.063	441
6	April 30, 2017	7.40	99.990	0.050	99.766	100.003	100.045	452
7	July 31, 2017	7.70	99.981	0.075	99.673	100.002	100.083	444
8	October 31, 2017	16.80	100.069	0.081	99.725	100.099	100.169	446
9	January 31, 2018	27.20	100.202	0.064	100.042	100.224	100.309	453
10	April 30, 2018	19.00	100.131	0.055	99.979	100.129	100.219	450
11	July 31, 2018	17.40	100.131	0.060	99.987	100.143	100.234	411
12	October 31, 2018	17.00	100.156	0.067	99.997	100.172	100.252	343
13	January 31, 2019	14.00	100.155	0.054	99.996	100.173	100.226	297
14	April 30, 2019	7.00	100.073	0.040	99.983	100.078	100.145	235
15	July 31, 2019	6.00	100.068	0.045	100.000	100.075	100.151	174
16	October 31, 2019	4.80	100.061	0.032	100.000	100.069	100.115	107
17	January 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

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%. 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 it 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. 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 Treasury bills and notes. 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. A key reason for this price stability is that the weekly reset of the FRN coupon significantly reduces the effective duration of the security. 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 could view them as attractive capital-preservation vehicles during turbulent periods in financial markets.

Table 2
Volatility of daily changes in Treasury security prices. This table reports the standard deviation of daily price changes for Treasury floating rate notes (FRNs) with the results 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 and are based on clean prices (without accrued interest). 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

Finally, FRNs are very similar in terms of their liquidity to the matched-maturity Treasury bills and notes. Table 3

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

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 because 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 because 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.[5]

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 report the cash flows from the individual components of the replicating strategy. The first column shows the cash flows from a long position in a two-year Treasury note with a coupon rate of 2.00%. The second column presents the cash flows from a standard interest rate swap in which the investor receives the London Interbank Offered Rate (LIBOR) L_t and pays the fixed swap rate of 2.332%. 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 and pays the LIBOR rate L_t. 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 reports 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 presents 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

[5] The Online Appendix provides a detailed discussion of the basis swap markets. Du et al. (2018) use the one-month and three-month LIBOR basis (tenor) swaps in their analysis.

Table 4
Numerical example of the cash flows from replicating a Treasury floating rate note (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% paid semiannually. The fixed market rate on a LIBOR interest rate swap is 2.3319% 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 under "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	$100 + X_t$	$100 + X_t$

example, a one-year Treasury FRN can be replicated by taking positions in three-, six-, nine-, and twelve-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 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 with 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. Also, because 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.[6]

We leave open the more-fundamental issue of whether the FRN premia we identify could be explained within the context of an equilibrium model in which economic agents derive additional utility from the non-pecuniary price-stability properties of FRNs. Important recent examples of theoretical models in which safe assets carry an additional near-money premium or convenience yield in equilibrium include Bansal et al. (2010), Krishnamurthy and Vissing-Jorgensen (2012), Greenwood et al. (2015), He et al. (2016, 2019), and Nagel (2016). The results in these papers raise the possibility that future research also could allow for stability premia within an equilibrium framework.

5. The premia

In this section, we use the replication approach described in Section 4 to estimate the premia in FRN prices. In some cases, we express the premia as cents per $100

[6] Approaches that compare yields of two-year FRNs directly with 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 et al. (2019).

Table 5
Summary statistics for the Treasury floating rate note (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	Standard deviation	Minimum	Maximum	Percent positive	*N*	Mean	Standard deviation	Minimum	Maximum	Percent positive	*N*
1	January 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	April 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	July 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	October 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	January 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	April 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	July 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	October 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	January 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	April 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	July 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	October 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	January 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	April 30, 2019	–	–	–	–	–	–	10.68	12.01	−7.58	32.63	83.40	235
15	July 31, 2019	–	–	–	–	–	–	11.97	10.64	−3.58	29.67	81.03	174
16	October 31, 2019	–	–	–	–	–	–	16.53	6.70	−0.79	25.89	99.07	107
17	January 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

par amount, which we denote as price premia. In general, however, we express the premia in terms of basis points, which we denote simply as premia.[7]

Table 5 reports summary statistics for the estimated premia by individual FRN issue. The table presents the results from the comparisons of FRNs to the replicating portfolio of Treasury bills.[8] 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. Fig. 1 plots the time series of the estimated price premia.

The results are striking. Regarding 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 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% of the estimated premia are positive. For some of the more recent FRNs 100% of the estimated premia are positive.

For 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% of the premia are positive.

While average premia on the order of 6 to 10 basis points may seem modest, these values are 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 4 basis points. Longstaff (2004) finds that the average flight-to-liquidity premium in Treasury bond prices relative to Treasury-guaranteed Refcorp bonds is roughly 10 basis points for maturities out to ten years.[9]

Another way of evaluating the economic importance of these results is by estimating the total value of the

[7] 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.

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

[9] If the matched-maturity Treasury bills and notes also contain stability premia, then our estimates could actually represent a lower bound on the size of the stability premia in FRN prices. We are grateful to the referee for this important insight.

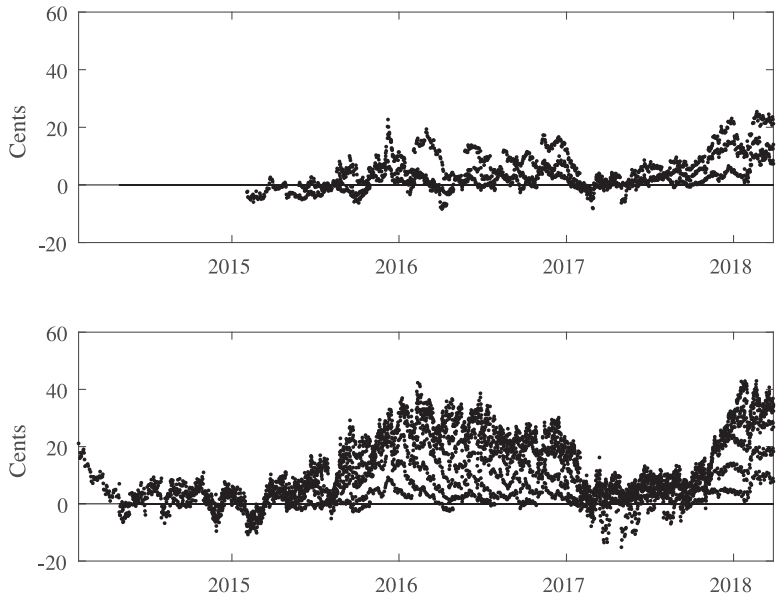

Fig. 1. Price premia. The top panel plots the time series of the price premia measured relative to Treasury bills. The lower panel plots the time series of the price premia measured relative to Treasury notes. The price premia are expressed in cents per $100 par amount.

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, Figs. 2 and 3 present three-dimensional plots of the price premia as functions of time to maturity over the sample period. The price premia are strongly related to the maturity of the FRNs and the corresponding matched-maturity Treasury bills and notes. In particular, a strong positive correlation exists 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. 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.[10] Thus, the replicating portfolio has nearly three times the daily mark-to-market volatility of the actual FRN. Similar results hold when the volatility of price changes is computed over longer horizons ranging from two to five days. An important implication is that investors who are sensitive to mark-to-market variability in their portfolios perhaps do 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 could be willing to pay an additional convenience yield for the mark-to-market stability that FRNs provide.

These premia differ from those previously documented in the literature. First, the credit/default risk of the FRNs is identical to that of the matched-maturity Treasury bills and notes as 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 et al. (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, 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 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 with 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 because they go in the wrong direction. Furthermore, in comparing FRNs with two-year Treasury notes, we compare one on-the-run security with another

[10] Despite being much smaller, the volatility of FRN price changes is still significant given the very short effective duration of the security. Ironically, variation in the stability premium could itself be a significant source of the variability in daily FRN price changes. We are grateful to the referee for raising this point.

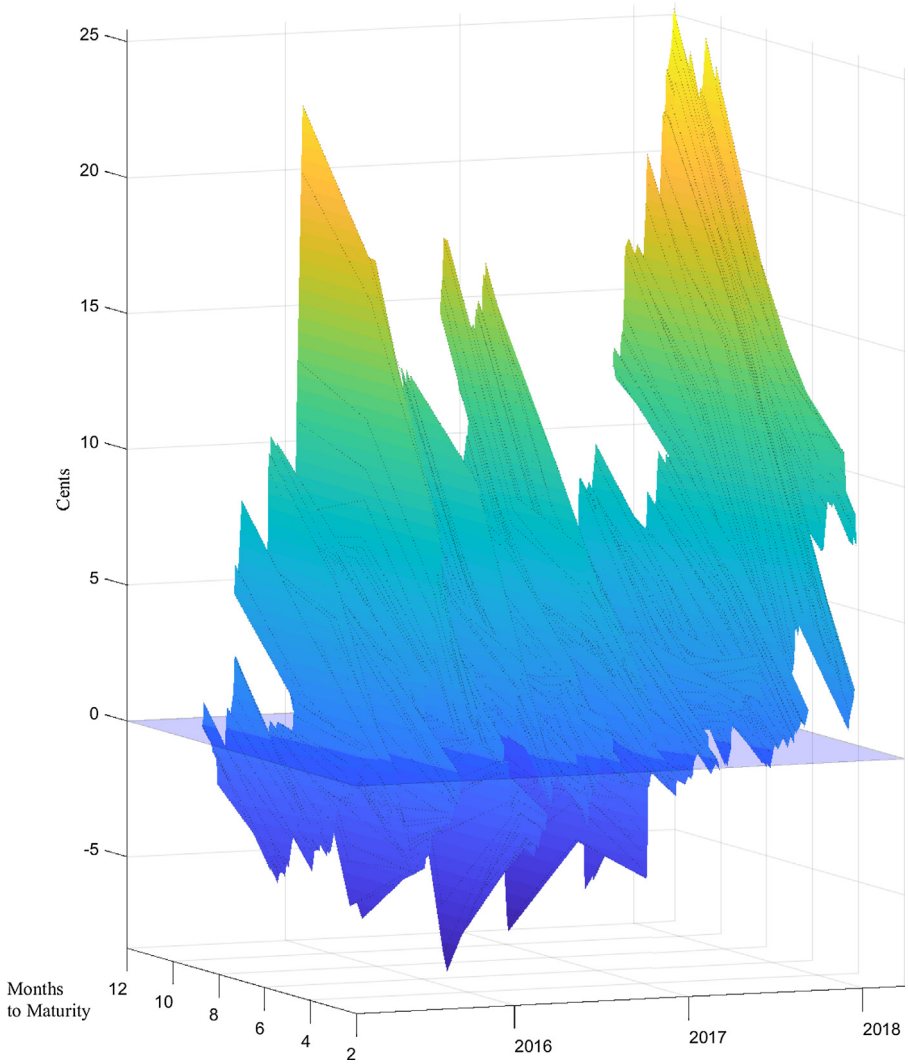

Fig. 2. Time series of price premia measured relative to Treasury bills by time to maturity. This figure plots the time series of the price premia measured relative to Treasury bills as a function of the time to maturity for the Treasury floating rate notes (FRNs). Price premia are expressed as cents per $100 par amount.

on-the-run security. 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). Nagel (2016) finds 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.

Fifth, these results raise the important issue of why the premia in FRN prices persist and are not eliminated by the actions of potential arbitrageurs shorting FRNs and taking long positions in the replicating portfolio. The most plausible explanation is that potential arbitrageurs could face a number of limits to arbitrage such as binding balance sheet, regulatory, and margin constraints similar to those discussed by Gârleanu and Pedersen (2011). Recent evidence by Du et al. (2018) indicates that balance sheet constraints can help explain why there are persistent violations of covered interest rate parity during the post-crisis period, as well as why the federal funds rate has often been below the Federal Reserve's Interest on Excess Reserves (IOER) rate since 2008. The persistent nature of the FRN premia throughout our sample period suggests

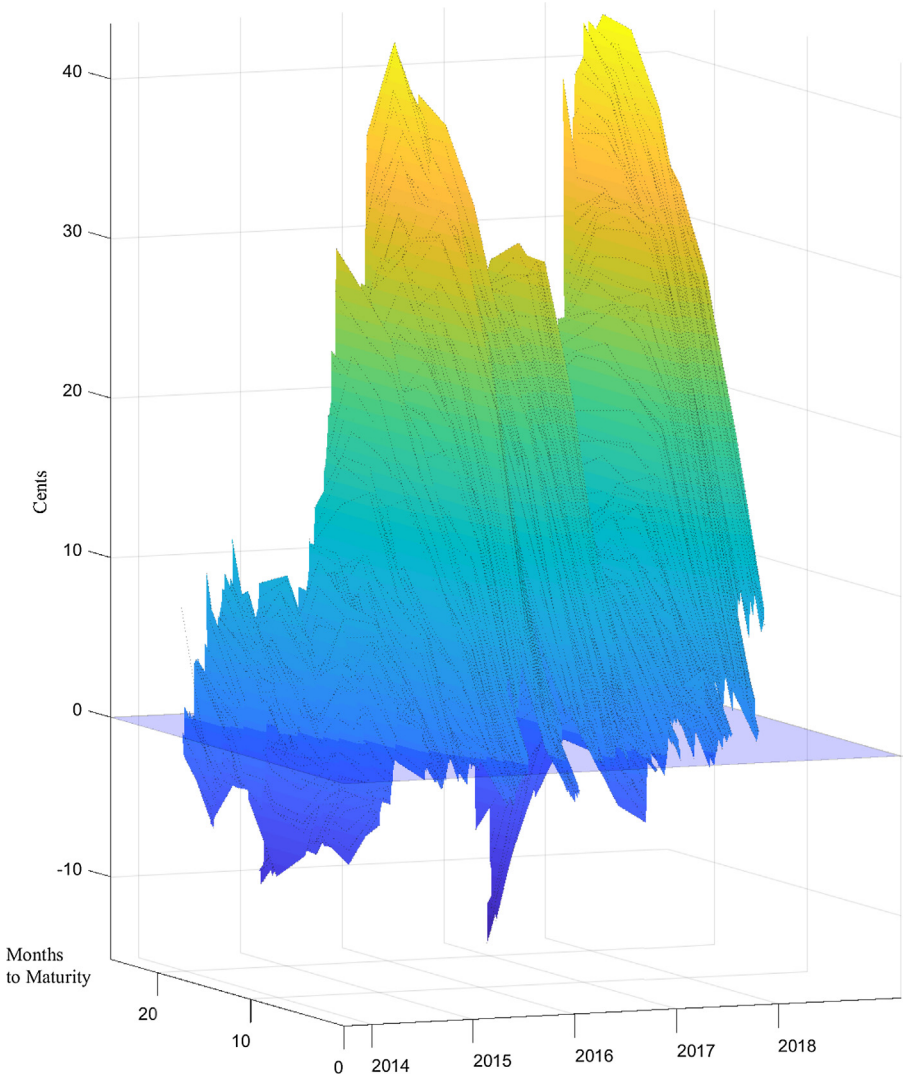

Fig. 3. Time series of price premia measured relative to Treasury notes by time to maturity. This figure plots the time series of the price premia measured relative to Treasury notes as a function of the time to maturity for the Treasury floating rate notes (FRNs). Price premia are expressed as cents per $100 par amount.

that some types of constraints or frictions, or both, must be present that prevent potential arbitrageurs from eliminating the differences between the prices of FRNs and the replicating portfolios.[11]

6. Who owns Treasury FRNs?

The results thus far and our 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 et al., 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. 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 US government, MMFs, mutual funds, ETFs, and hedge funds.[12] We augment this CUSIP-level data with data on aggregate Treasury security holdings from Table L.210 of the Federal

[11] We are grateful to the referee for raising this point.

[12] The Bloomberg system collects the holdings information from regulatory filings including Form 13F, Form N-MFP, Form 10-K, Internal Revenue Service (IRS) Form 990, Department of Labor Form 5500, National Association of Insurance Commissioners (NAIC) Form Schedule D, and public disclosures from pension funds, hedge funds, MMFs, and ETFs.

Table 6
Volatility of daily changes of Treasury floating rate note (FRN) and FRN replicating portfolio prices. This table reports the standard deviation of daily price changes for FRNs, with the results 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 and are based on clean prices (without accrued interest). The sample period is daily from January 31, 2014 to March 29, 2018.

Months to maturity			T-bill based	T-note based	
From	To	FRN	replicating portfolio	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 Treasury floating rate notes (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, Internal Revenue Service (IRS) Form 990, Department of Labor Form 5500, National Association of Insurance Commissioners (NAIC) Form Schedule D, and public disclosures from pension funds, hedge funds, money market funds, and exchange-traded funds (ETFs). These percentages are based on the FRNs and matched-maturity Treasury notes with maturity dates in April, July, and October 2019, January, April, and 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, with the percentages 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

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 times. Table 7 provides a snapshot of these average percentages as of March 31, 2019. Snapshots of the average percentages at other times are similar to those shown.

Table 7 reports that FRNs are held primarily by MMFs, mutual funds, ETFs, and other funds. MMFs owned nearly 40% of the FRNs, while the other types of funds collectively held slightly more than 50%. Since the total assets of MMFs are only about 20% 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 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 level throughout our sample period. This data are 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.[13] Table 8 reports summary statistics for the percentages of the individual FRNs in the sample held by MMFs. MMFs were major holders of FRNs

[13] 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).

Table 8
Summary statistics for the percentage of Treasury floating rate notes (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 Securities and Exchange Commission (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%. The sample period is monthly from January 2014 to March 2018.

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

throughout the sample period. The average percentages of the individual FRNs held by MMFs range from roughly 20% to nearly 50%.

It is important to stress 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% for ten of the 17 FRNs in the sample (and exceeds 45% 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 last point could seem counterintuitive because total assets held by MMFs are smaller than those held by other types of institutions such as mutual funds or ETFs.[14] The reason that MMFs are often the largest institutional holders of FRNs is that they tend to significantly overweight FRNs in their portfolio holdings. To illustrate, 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% Treasury bills, Treasury notes and bonds, and FRNs, respectively.[15] In contrast, the Treasury component of the portfolios held by MMFs consisted of 73.99%, 9.17%, and 16.84% Treasury bills, Treasury notes and bonds, and FRNs, respectively. Thus, FRNs were overweighted by a factor of 16.84/5.51 = 3.06. Fig. 4 plots the time series of the relative overweights/underweights for the three categories of Treasury securities. FRNs are heavily overweighted by MMFs throughout the sample period.

7. Why do MMFs hold FRNs?

A number of reasons exist for the strong demand from MMFs for FRNs. In this section, we discuss two important ones 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 could also lose their "mark-to-market" stability.[16] During

[14] For example, the total assets of MMFs, mutual funds, and ETFs as of Q4 2018 were $3038.3 billion, $14669.8 billion, and $3370.7 billion, respectively (see Tables L.121, L.122, and L.124 of the Federal Reserve Statistical Release Z.1, Fourth Quarter 2018).

[15] 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 $2284.4 billion, $3442.5 billion, and $334.0 billion, respectively.

[16] The SEC uses the term "principal stability" to describe an 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.

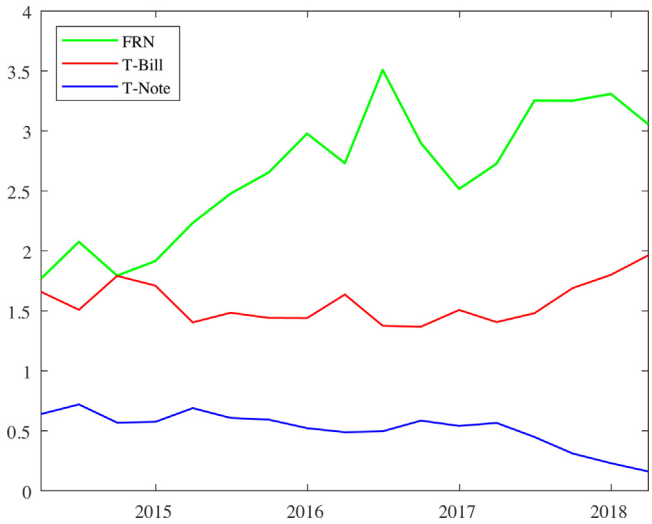

Fig. 4. Overweighting of Treasury floating rate notes (FRNs) and Treasury bills in money market fund (MMF) portfolios. This figure plots the time series of the ratio of the fraction of MMF portfolios invested in FRNs divided by the fraction that FRNs represent of all Treasury securities eligible to be held by MMFs and similarly for Treasury bills and eligible Treasury notes and bonds.

the week of September 15, 2008, investors withdrew approximately $300 billion (14% of total assets) from prime MMFs.[17]

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.[18] 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 and can also hold short-term securities issued by the US 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% of their total assets in cash, US government securities 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 US government [Rule 2a-7(a)(17); Section 2(a)(16)].[19]

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 example, these MMFs are required to impose a 1% fee on the NAV of investor shares when weekly liquid assets fall below 10% of total assets. The MMF's management, however, also has certain discretion to impose up to a 2% fee when weekly liquid assets fall below 30% of total assets. Investors may also be unable to redeem their shares periodically because 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 because they could no longer be able to redeem their shares instantaneously. For example, the SEC recognizes that because striking a market-based NAV price

[17] See Investment Company Institute (ICI), Report of the Money Market Working Group, 62, 3/17/2009, at http://www.ici.org/pdf/ppr_09_mmwg.pdf.

[18] 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.

[19] Certain issuers of US government securities, e.g., government-sponsored enterprises such as Federal National Mortgage Association (Fannie Mae), Federal Home Loan Mortgage Association (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 US Treasury.

can take several hours, floating NAV funds could no longer be able to offer trading times for same-day settlement late in the day (i.e., after 4 p.m.).[20] Moreover, floating NAVs complicate accounting for short-term investments because 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 it 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 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 10% of total assets under specific stress scenarios that include increases in the level of short-term interest 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.[21] Furthermore, Rule 2a-7 requires retail and government MMFs to calculate the market-based value of the portfolio (shadow price) periodically and compare it with 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 SEC's 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).[22]

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 because FRNs are considered to have a maturity date equal to the period remaining until the next readjustment of the interest rate.[23] This can create demand for FRNs by MMFs because 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 is a fundamental source of the premia in FRN prices. That is, institutions such as MMFs have incentives for holding FRNs and are 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 whether any evidence links the FRN premia and the demand by MMFs for FRNs. 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 included in the regression only for premia measured relative to Treasury notes because Treasury bills all have maturities of less than 397 days). The second is the fraction of the individual FRN issue held by government 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. 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 a strong relation between the premia measured relative to Treasury notes and the demand by MMFs for FRNs. In particular, the coefficient for the fraction of the FRN issue held by government MMFs is significant with a t-statistic of 2.06. 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.

While these results are consistent with the hypothesis, they are not sufficient to establish a causal relation. 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 could themselves be endogenously related. In light of this, our approach in subsequent sections is 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 that investors are willing to pay for the capital-preservation or store-of-value

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

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

[22] 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%."

[23] 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."

Table 9
Results from panel regressions of Treasury floating rate note (FRN) premia on money market fund FRN holdings. This table reports the results from regressing the monthly averages of the price premia expressed as cents per $100 par amount on the fraction of the FRN issue held by government 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 month-of-the-year and year fixed effects. The standard errors are based on the robust estimate of the covariance matrix clustered at the FRN level. The superscript ** denotes significance at the 5% level; the superscript *, at the 10% level. The sample period is monthly from February 2014 to March 2018.

	Relative to Treasury bills		Relative to Treasury notes	
Variable	Coefficient	*t*-statistic	Coefficient	*t*-statistic
Intercept	−1.7822	−0.44	−2.0940	−1.07
397-day dummy	–	–	0.5856	0.50
fraction held by government MMFs	−2.4230	−0.21	31.6399	2.06**
Month fixed effects		Yes		Yes
Year fixed effects		Yes		Yes
Adj. R^2		0.618		0.598
N		107		298

features of FRNs. Our approach is 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 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.[24]

In doing this, we use a simple panel regression approach. 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 include month-of-the-year and year 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. The coefficient for the difference in volatilities (measured in cents per $100 par amount) is 5.3167 with a *t*-statistic of 4.47 in the regression for premia measured relative to Treasury bills and 1.8745 with a *t*-statistic of 4.52 in the regression for premia measured relative to Treasury notes. These intuitive results are consistent with premia representing the additional value that 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 that investors are willing to pay for the mark-to-market stability of FRNs, then these premia could 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 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 we denote them as the FRN/T-Bill and FRN/T-Note indexes, respectively.

As proxies for systematic risk, we use 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

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

Table 10
Results from panel regressions of Treasury floating rate note (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 month of the year and year fixed effects. The standard errors are based on the robust estimate of the covariance matrix clustered at the FRN level. The superscript ** denotes significance at the 5% level; the superscript *, at the 10% level. The sample period is monthly from February 2014 to March 2018.

	Relative to Treasury bills		Relative to Treasury notes	
Variable	Coefficient	*t*-statistic	Coefficient	*t*-statistic
Intercept	−0.0633	−3.60**	−0.0232	−0.83
Difference in volatilities	5.3167	4.47**	1.8745	4.52**
Month fixed effects		Yes		Yes
Year fixed effects		Yes		Yes
Adj. R^2		0.557		0.512
N		105		286

bill rate. This spread, typically denoted as the TED spread, provides a measure of the systemic credit risk of the financial sector. 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. Fourth, we include the credit default swaps (CDS) spread for the US 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 be accompanied by an increase in the demand for safe assets.[25]

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 he identifies in Treasury bills is significantly related to the level of short-term interest rates. Furthermore, he finds 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. Regarding 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 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.

For the exogenous proxies for systemic risk, Table 11 shows that the coefficient for interest rate volatility is positive and significant (at the 10% 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.[26]

[25] Flights-to-quality and flights-to-liquidity are discussed in Longstaff (2004), Beber et al. (2009), and others.

[26] Several of the exogenous proxies for systematic risk could also proxy for changes in limits-to-arbitrage frictions and/or constraints faced by potential arbitrageurs.

Table 11
Results from regressions of changes in Treasury floating rate note (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 consensus 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 London Interbank Offered Rate (LIBOR) Treasury spread and is expressed in basis points. *Change in Treasury CDS* is the change in the credit default swap (CDS) spread on two-year U.S. Treasury debt and is expressed in basis points. The *t*-statistics are based on the Newey and West (1987) heteroskedasticity and autocorrelation consistent estimate of the covariance matrix (three lags). The superscript ** denotes significance at the 5%; the superscript *, at the 10% level. The sample period is monthly from January 2014 to March 2018.

	FRN/T-Bill index		FRN/T-Note index	
Variable	Coefficient	*t*-statistic	Coefficient	*t*-statistic
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

9.2. The relation to money supply measures

If the premia represent a convenience yield for the store-of-value function of FRNs, then a relation could exists between these premia and the demand for money itself. In particular, the revealed preference for money in the economy could 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 US Treasury, Federal Reserve banks, and the vaults of depository institutions. Total demand deposits include those at domestically chartered commercial banks, US 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 include savings deposits and small-denomination time deposits at commercial banks and thrift institutions.[27]

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 (at the 10% level) in the FRN/T-Bill index regression. The coefficient for changes in total demand deposits is positive and significant (at the 10% level) in the FRN/T-Note index regression.

10. Identifying the demand for price stability

In Section 9, 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 change in the regulatory treatment of MMFs to identify exogenous variation in investor demand for price stability.

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 1% 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 can redeem shares only at a substantial discount to their nominal $1.00 per share NAV. Furthermore, institutional MMFs now have floating NAVs that fluctuate with the value of their

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

Table 12
Results from regressions of changes in Treasury floating rate note (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 and West (1987) heteroskedasticity and autocorrelation consistent estimate of the covariance matrix (three lags). The superscript ** denotes significance at the 5% level; the superscript *, at the 10% level. The sample period is monthly from January 2014 to March 2018.

	FRN/T-Bill index		FRN/T-Note index	
Variable	Coefficient	*t*-statistic	Coefficient	*t*-statistic
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

portfolio holdings. 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% of their total assets in cash, US government securities, 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% Treasury securities and 0.50% agency debt would qualify as a government MMF. On the other hand, a MMF with a portfolio of 99.49% Treasuries and 0.51% agency debt would not qualify as a government MMF. The key point 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 liquidity fee regulatory requirements that would apply to the second MMF.[28]

An important aspect of this change 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. We use cross-sectional differences in the net flows into government versus retail or institutional MMFs to identify changes in the demand for investments that could serve as better store-of-value vehicles. Intuitively, when investors become more concerned about capital preservation, they tend to increase their allocations toward government MMFs because of the increased NAV stability provided by their regulatory treatment. Thus, differences in the relative flows into government versus retail or institutional MMFs essentially provide an "instrument" for measuring changes in the demand for mark-to-market stability.

A strong case can be made for the strict exogeneity of the relative flows. Specifically, the SEC's MMF reform was largely motivated by events associated with the financial crisis of 2008 such as the collapse 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.[29] Thus, the creation of the discontinuity at 99.50% 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 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 nongovernment MMFs were 5.23% and 3.85%, respectively. Thus, relatively little difference exists in portfolio allocations to FRNs across government and nongovern-

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

[29] 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).

ment 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.[30] Thus, an increase in the relative demand by investors for government MMFs versus other types of MMFs is unlikely to be driven by the pricing of FRNs in the market.

Finally, by focusing on variation in the exogenous demand for government MMFs by investors, instead of on the demand by MMFs for FRNs, we are able to avoid the endogeneity issues discussed previously. While the SEC's MMF reform provided MMFs with strong incentives to hold FRNs in their investment portfolio, we argue that causal inferences cannot be drawn from the relation between the premia and the demand for FRNs from MMFs. The primary reason is that the pricing of FRNs and the amount of FRNs held by MMFs could be endogenously determined.

In contrast, the identification provided by the change 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. We regress monthly changes in the FRN/T-Bill and FRN/T-Note indexes on the net flows into government MMFs and into nongovernment (combined retail and institutional) MMFs. We include net flows into nongovernment 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 versus 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 and shows 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 3.21 and 2.86, respectively. In contrast, the coefficient for the net flows into nongovernment 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.

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

11. Evaluating alternative explanations

Whether alternative factors could explain the size and persistence of the large premia in FRN prices is important to consider. To explore the robustness of our findings, we examine a number of possible explanations suggested by previous research in the literature. 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 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 are themselves mispriced (potentially because of counterparty credit risk or the lower liquidity of basis swaps relative to Treasury securities). If the results are due to the presence of a unique premium in FRN prices, 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 could be artifacts of the basis swap 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.[31] The floating rate cash 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 with the prices of the matched-maturity floating rate notes. Table 14 provides summary statistics for the estimated premia. No evidence exists 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 0.05 basis points which is not statistically significant. Furthermore, the premia are nearly evenly divided between positive and negative values; 52.02% 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 float-

[31] 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.

Table 13
Results from regressions of changes in Treasury floating rate note (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. *Nongovernment 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 and West (1987) heteroskedasticity and autocorrelation consistent estimate of the covariance matrix (three lags). The superscript ** denotes significance at the 5% level; the superscript *, at the 10% level. The sample period is monthly from January 2014 to March 2018.

	FRN/T-Bill index		FRN/T-Note index	
Variable	Coefficient	*t*-statistic	Coefficient	*t*-statistic
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**
Nongovernment 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 (FFCB) floating rate note (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 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	Standard deviation	Minimum	Maximum	Percent positive	*N*
Corporate	38	0.054	8.907	−21.460	21.381	52.02	6637
FFCB	32	−3.067	12.633	−28.317	23.407	56.28	4659

ing rate notes pay quarterly coupon cash flows based on the 13-week Treasury bill rate during the quarter plus a constant spread. 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 with the price of the floating rate note. Table 14 provides summary statistics for the premia estimated using the FFCB debt. No evidence emerges 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 −3.07 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. Because STRIPS could not be as liquid as Treasury bills, notes, or FRNs, whether the pricing of STRIPS or their bid-ask spreads could account for the FRN premia is important to consider. 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, 1% 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: "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)."[32]

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

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

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.

11.4. Collateral value

Recent papers point to the important role that high-quality assets such as Treasury securities can play in financial markets as collateral in secured transactions. A review of collateralization policies at major governmental and financial institutions 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 1% 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 2% haircut requirement as Treasury notes and bonds (see the 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.[33] Thus, there is no difference in the tax treatment of Treasury notes and FRNs.

11.6. The interest rate accrual floor

The daily interest rate accrual for FRNs is floored at zero. This raises the possibility of a small option premium embedded into the prices of FRNs. In reality, the value of this floor is zero unless the FRN spread is negative. Daily interest accrues at a rate equal to the sum of the most recent 13-week Treasury bill high yield plus the constant FRN spread, which is determined at the auction of the FRN. The auction high yield of the 13-week Treasury bill cannot be negative because negative discount yields are invalid bids at T-bill auctions.[34] Because 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, and the demand for money in the economy. We 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 find that this premium is distinct from the liquidity, safety, and on-the-run near-money premia previously documented. These results 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.

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

[34] 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-2014âtitle31-vol2-part356.pdf.

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