Treasury Presentation to TBAC

Office of Debt Management

Fiscal Year 2019 Q2 Report

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Section I:
Executive Summary

Highlights of Treasury's May 2019 Quarterly Refunding Presentation to the Treasury Borrowing Advisory Committee (TBAC)

Receipts and Outlays

- FY 2019 year-to-date receipts were $10 billion (1%) higher than the comparable period last year. Customs duties rose $17 billion (87%), largely resulting from new tariffs. Individual refunds were $14 billion (9%) lower. Gross excise taxes were $10 billion (24%) higher, due primarily to a one-year return of the Health Insurance Providers tax in October 2018. Non-withheld income and SECA taxes were up $9 billion (5%). Withheld income and FICA taxes were down $6 billion (<1%), driven by lower withholding rates. Federal reserve earnings were $14 billion (35%) lower, due to the Federal Reserve paying higher short-term interest rates to depository institutions. Gross corporate taxes were $20 billion (18%) lower, due to the lower corporate tax rates established by the Tax Cuts and Jobs Act (TCJA).

- After calendar adjustments, FY 2019 year-to-date outlays were $98 billion (5%) higher than the comparable period last year. Defense expenditures were up $27 billion (9%) due to increased spending for military personnel, operations, maintenance, and procurement. Social Security Administration outlays were $27 billion (5%) higher, and Veterans Affairs expenditures were $4 billion (4%) higher, both due to increases in enrollment, the average benefit, and a cost-of-living adjustment of 2.8%. Treasury outlays were $16 billion (5%) higher due primarily to increased interest on the Public Debt. Health and Human Services spending was $16 billion (3%) higher due to increased Medicare and Medicaid expenditures.

Projected Net Marketable Borrowing (FY 2019)

- Based on the quarterly borrowing estimate, Treasury's Office of Fiscal Projections (OFP) currently forecasts a net privately-held marketable borrowing need of $30 billion for Q3 FY 2019, with an end-of-June cash balance of $270 billion. For Q4 FY 2019, the net privately-held marketable borrowing need is projected to be $160 billion, with an end-of-September cash balance of $85 billion. Privately-held marketable borrowing excludes rollovers (auction "add-ons") of Treasury securities held in the Federal Reserve's System Open Market Account (SOMA), but includes financing required due to SOMA redemptions.

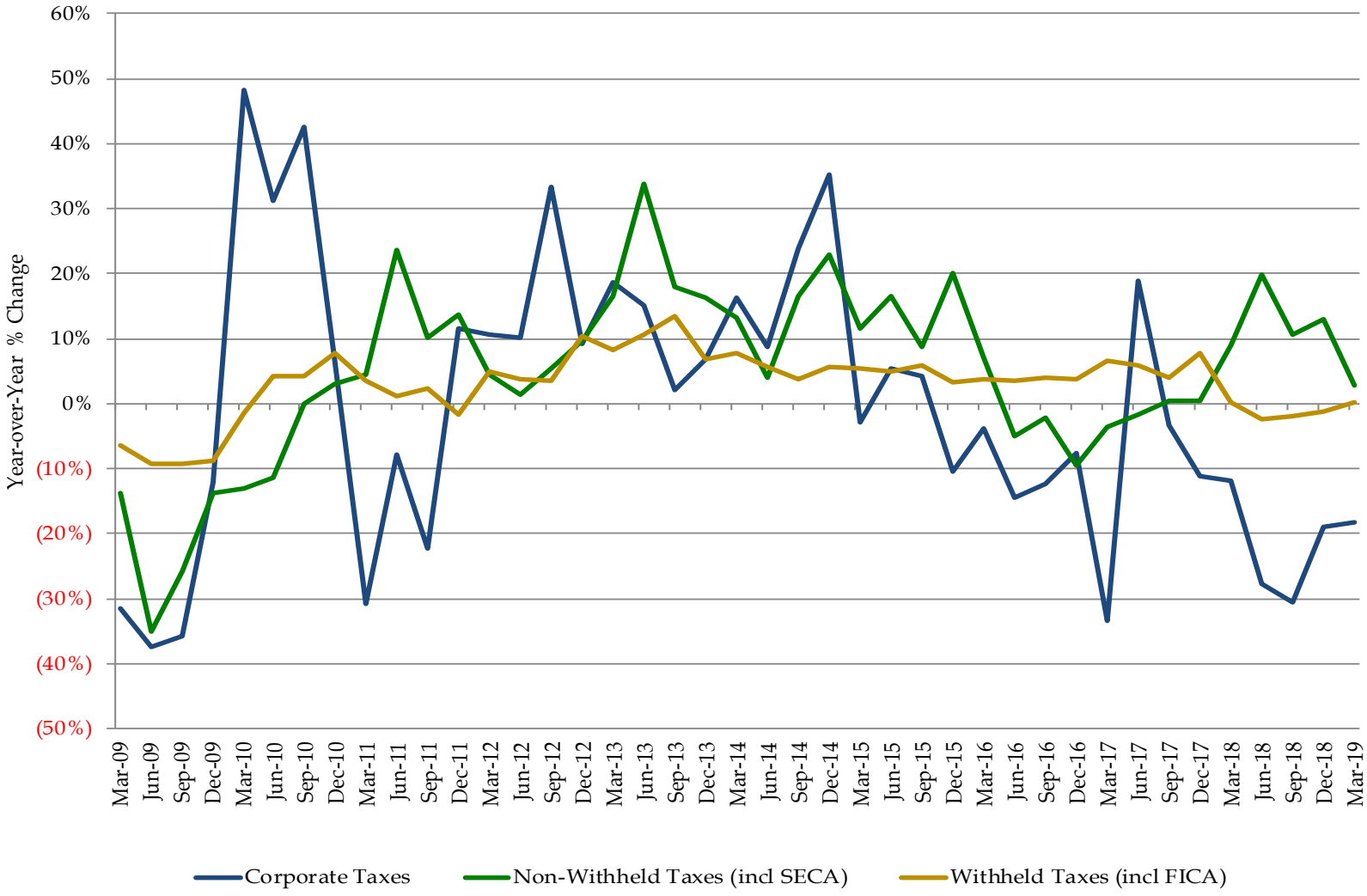
Demand for Treasury Securities

- Bid-to-cover ratios for all securities were largely stable over the last quarter.

- Foreign demand remained steady.

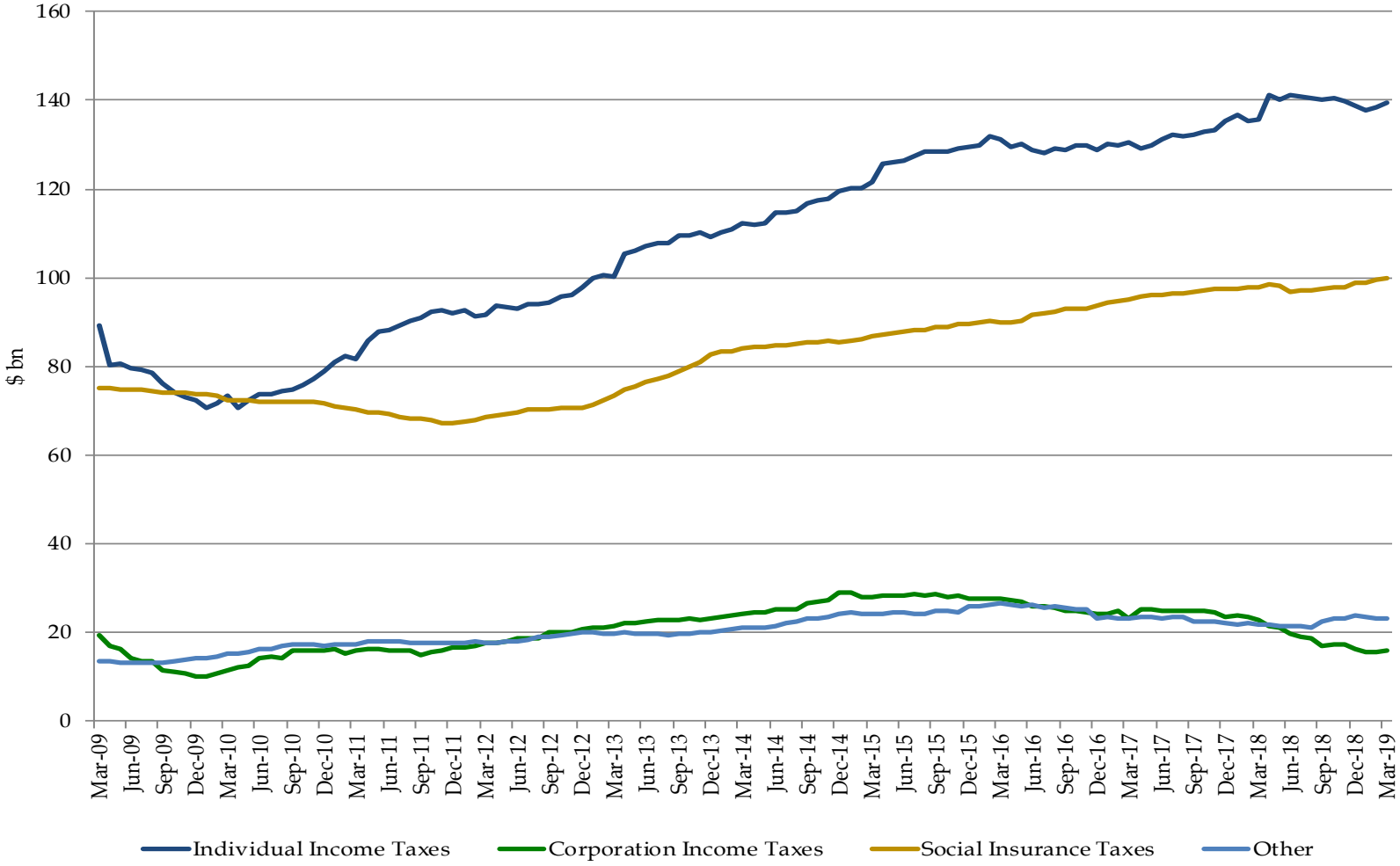
Section II: Fiscal

Quarterly Tax Receipts



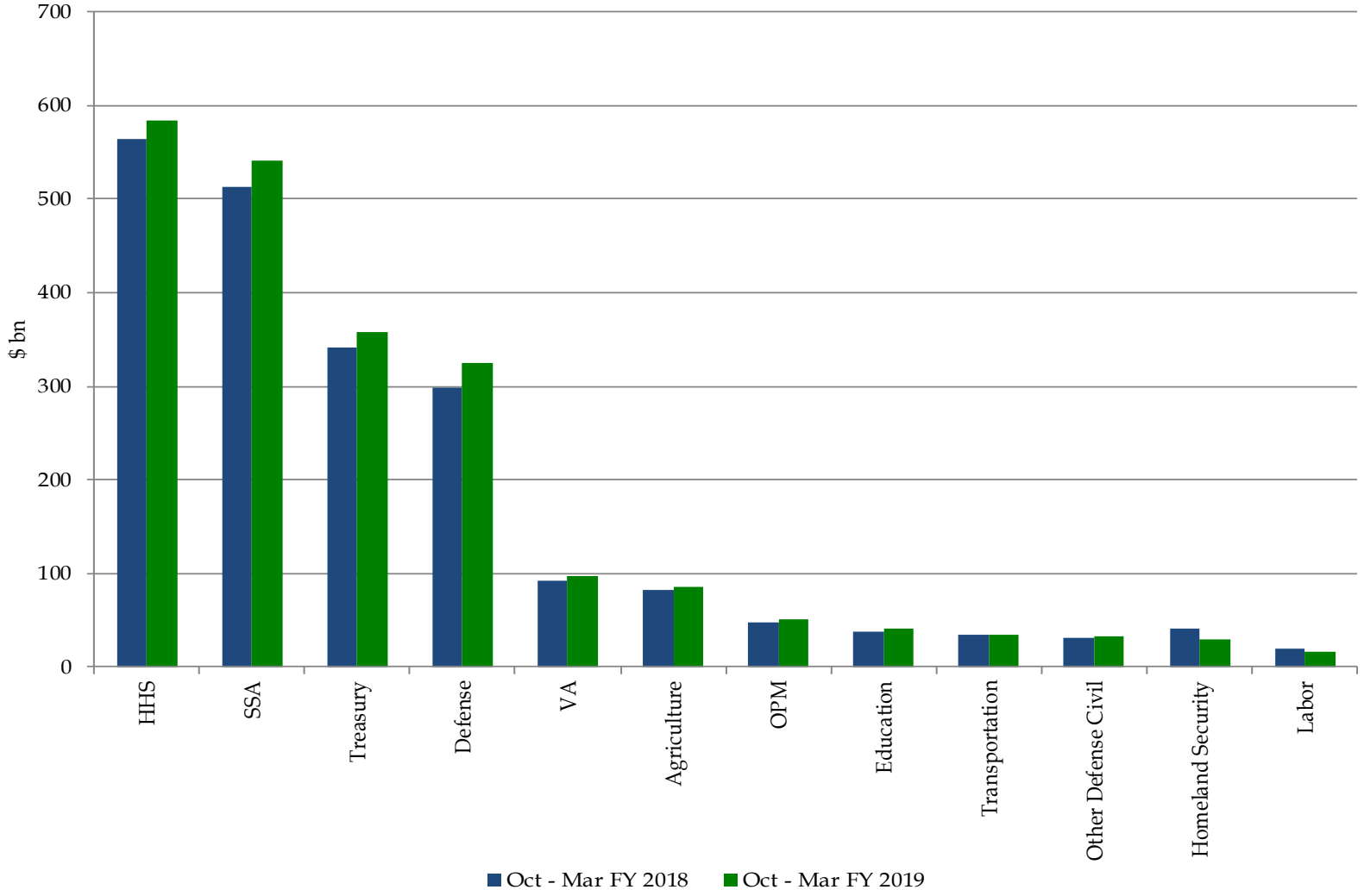
Source: United States Department of the Treasury

Monthly Receipt Levels
(12-Month Moving Average)



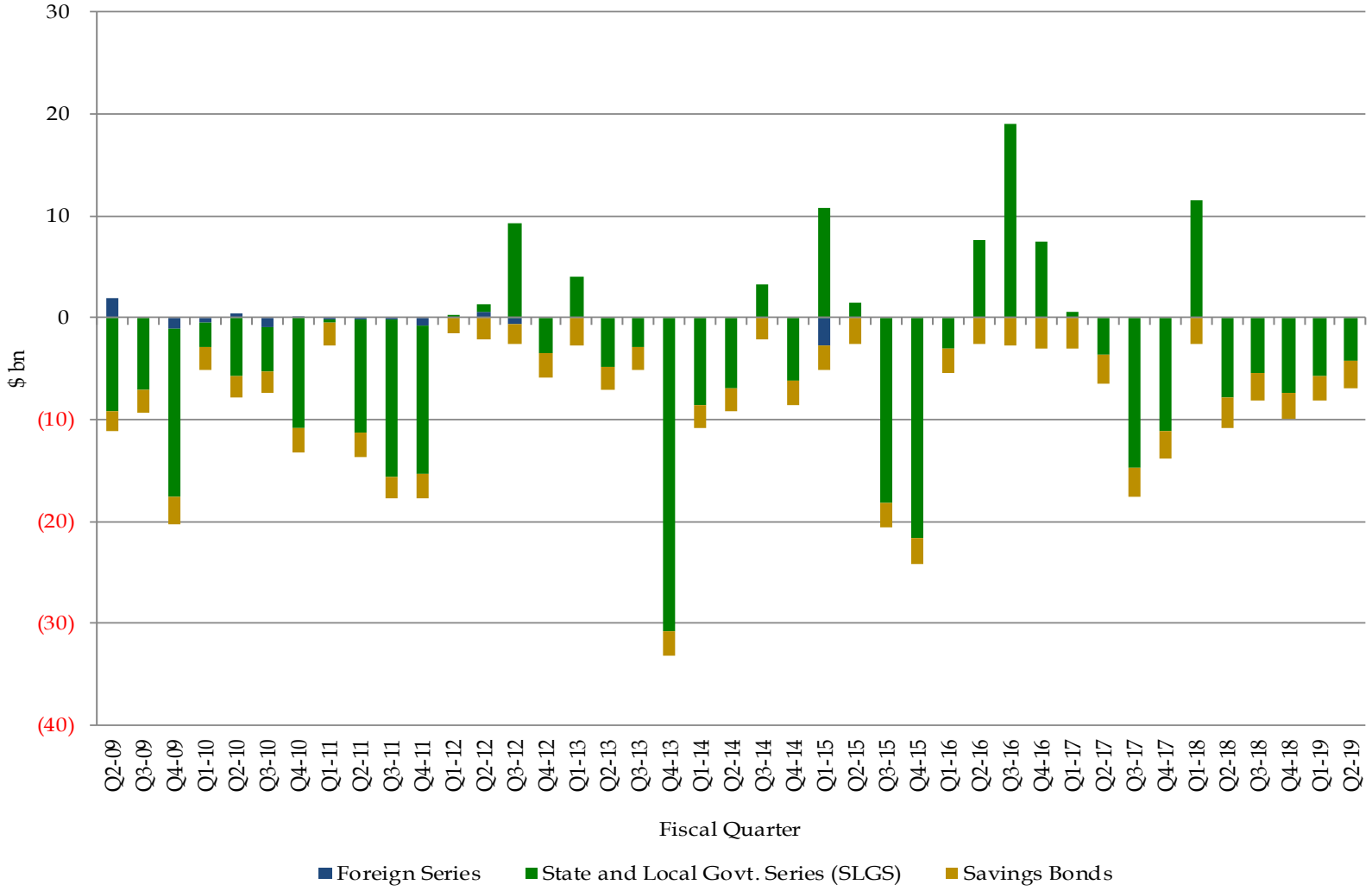
Individual Income Taxes include withheld and non-withheld. Social Insurance Taxes include FICA, SECA, RRTA, UTF deposits, FUTA and RUIA. Other includes excise taxes, estate and gift taxes, customs duties and miscellaneous receipts.
Source: United States Department of the Treasury

Largest Outlays



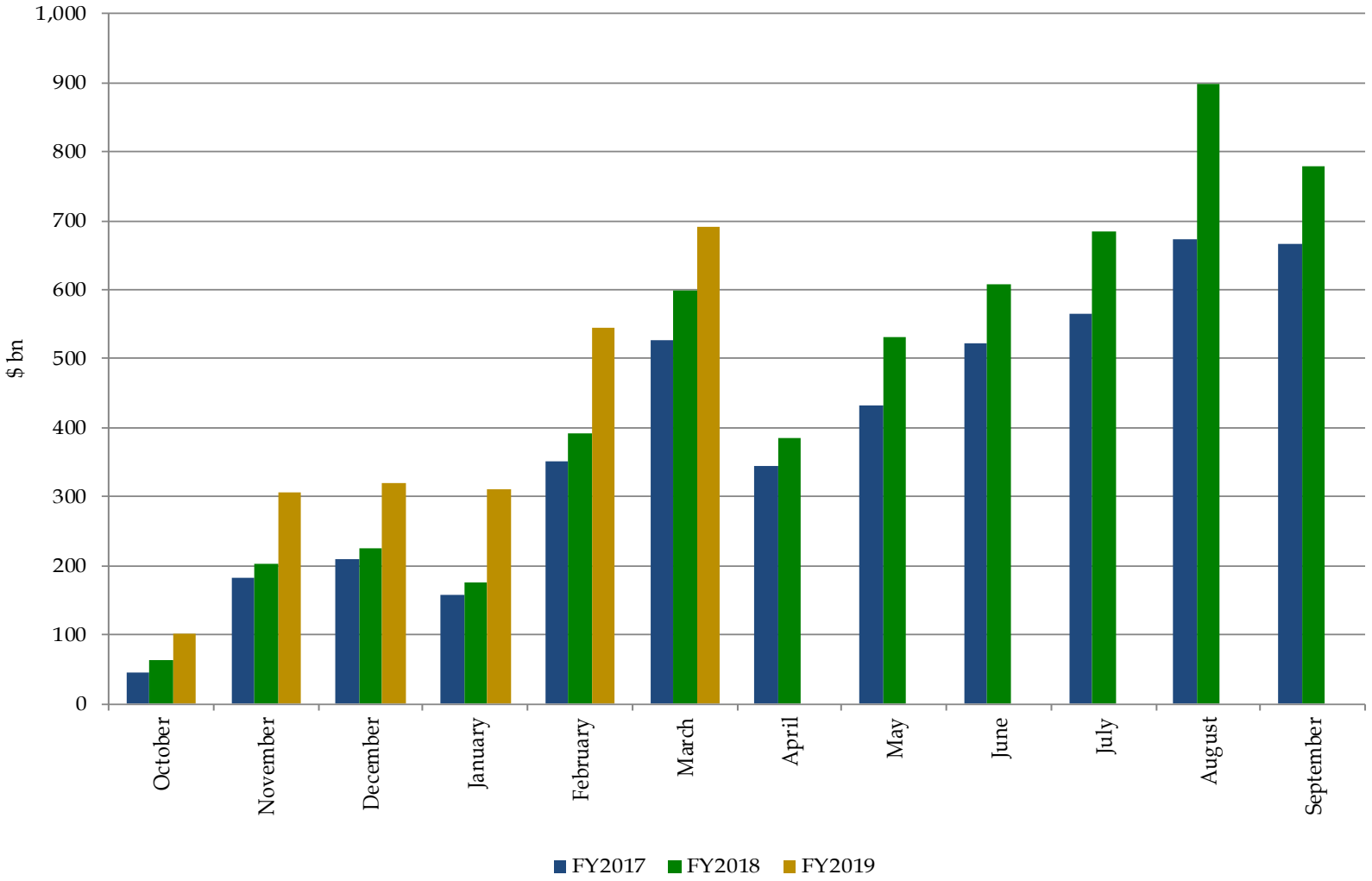
Source: United States Department of the Treasury

Treasury Net Nonmarketable Borrowing



Source: United States Department of the Treasury

Cumulative Budget Deficits by Fiscal Year



Source: United States Department of the Treasury

FY 2019-2021 Deficits and Net Marketable Borrowing Estimates*, in $ billions

	Primary Dealers[1]	OFP[2]	OMB[3]	CBO[4]	CBO[5]
FY 2019 Deficit Estimate	950		1,091	897	955
FY 2020 Deficit Estimate	1,010		1,101	903	866
FY 2021 Deficit Estimate	1,100		1,069	974	945
FY 2019 Deficit Range	870-1,075				
FY 2020 Deficit Range	900-1,250				
FY 2021 Deficit Range	975-1,300				
FY 2019 Privately-Held Net Marketable Borrowing Estimate	1,183	990			
FY 2020 Privately-Held Net Marketable Borrowing Estimate	1,097				
FY 2021 Privately-Held Net Marketable Borrowing Estimate	1,135				
FY 2019 Privately-Held Net Marketable Borrowing Range	850-1,387				
FY 2020 Privately-Held Net Marketable Borrowing Range	905-1,242				
FY 2021 Privately-Held Net Marketable Borrowing Range	851-1,300				
FY 2019 SOMA Redemption Estimate	245	262			
FY 2020 SOMA Redemption Estimate					
FY 2021 SOMA Redemption Estimate					
FY 2019 Net Marketable Borrowing Estimate	938	728	1,168	885	1,049
FY 2020 Net Marketable Borrowing Estimate	1,097		1,168	965	924
FY 2021 Net Marketable Borrowing Estimate	1,135		1,136	1,025	993
Estimates as of:	Apr-19	Apr-19	Mar-19	Jan-19	Aug-18

1Based on primary dealer feedback in April 2019. Estimates above are medians.

2Treasury's Office of Fiscal Projections (OFP) borrowing estimates announced on April 29, 2019.

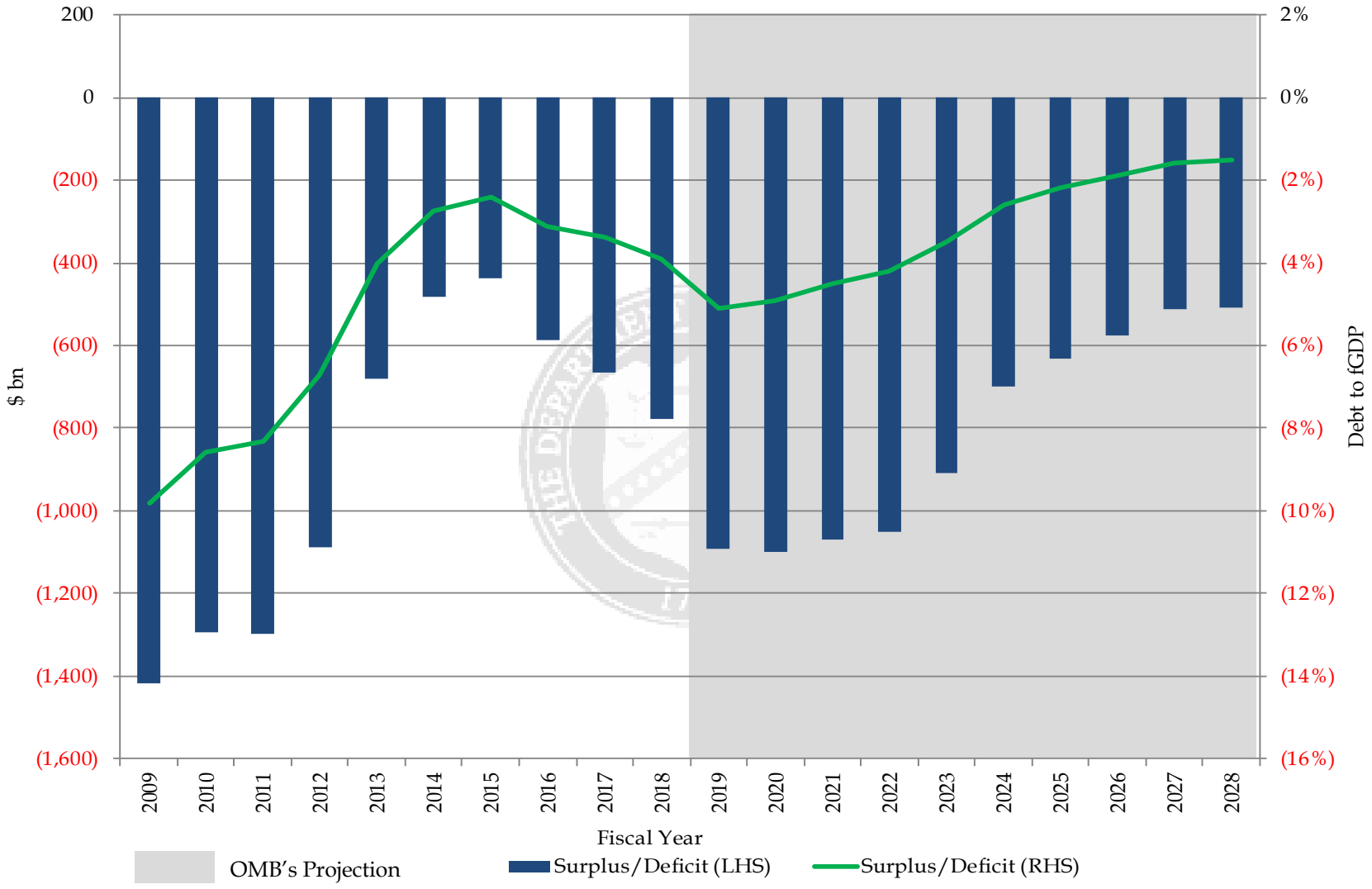
3Table S-10 of OMB's "A Budget for a Better America, Fiscal Year 2020," March 2019.

4Table 1-1 of CBO's "The Budget and Economic Outlook: 2019 to 2029," January 2019 (current law).

5Table 2 of CBO's "An Analysis of the President's 2019 Budget," August 2018.

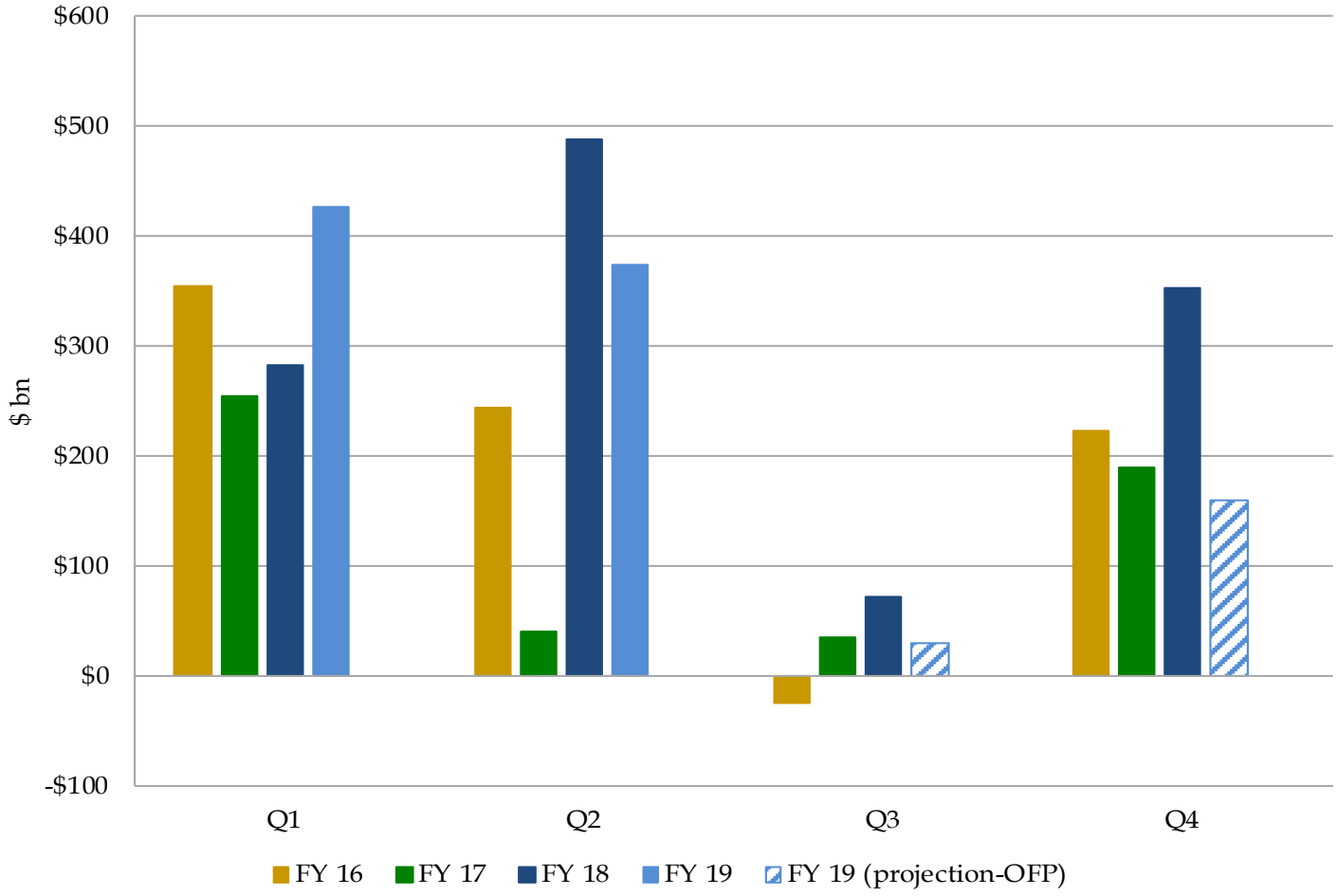
*Privately-held marketable borrowing excludes rollovers (auction "add-ons") of Treasury securities held in the Federal Reserve's System Open Market Account (SOMA), but includes financing required due to SOMA redemptions.

Budget Surplus/Deficit



Projections are from OMB's Table S-10 of "A Budget for a Better America, Fiscal Year 2020," March 2019.

Privately-Held Net Marketable Borrowing Outlook



Note: Privately-held marketable borrowing excludes rollovers (auction "add-ons") of Treasury securities held in the Federal Reserve's System Open Market Account (SOMA), but includes financing required due to SOMA redemptions.

Section III: Financing

Assumptions for Financing Section (pages 16 to 21)

- Portfolio and SOMA holdings as of 03/31/2019.
- Estimates reflect a reduction in SOMA's monthly Treasury redemption cap from $30 billion to $15 billion beginning in May 2019 and an end date for SOMA capped redemptions at the end of September 2019, according to the FOMC's "Balance Sheet Normalization Principles and Plans" published on March 20, 2019.
- Estimates assume announced issuance sizes and patterns remain constant for nominal coupons, TIPS, and FRNs given changes made at the February 2019 refunding, while using a total of ~$2.48 trillion of bills outstanding.
- The principal on the TIPS securities was accreted to each projection date based on market ZCIS levels as of 03/31/2019.
- No attempt was made to account for future financing needs.

Sources of Privately-Held Financing in FY19 Q2*

January - March 2019	
Net Bill Issuance	140
Net Coupon Issuance	234
Subtotal: Net Marketable Borrowing	374
Ending Cash Balance	334
Beginning Cash Balance	402
Subtotal: Change in Cash Balance	(68)
Net Implied Funding for FY19 Q2**	442

Security	January - March 2019 Bill Issuance			Fiscal Year-to-Date Bill Issuance		
	Gross	Maturing	Net	Gross	Maturing	Net
4-Week	645	565	80	1,210	1,150	60
8-Week	435	395	40	750	470	280
13-Week	576	558	18	1,134	1,203	(69)
26-Week	498	567	(69)	993	1,113	(120)
52-Week	104	86	18	182	146	36
CMBs	103	50	53	103	50	53
Bill Subtotal	2,361	2,221	140	4,372	4,132	240

Security	January - March 2019 Coupon Issuance			Fiscal Year-to-Date Coupon Issuance		
	Gross	Maturing	Net	Gross	Maturing	Net
2-Year FRN	56	41	15	111	82	29
2-Year	80	52	28	234	156	78
3-Year	114	72	42	225	144	81
5-Year	82	63	19	240	157	83
7-Year	64	47	17	190	138	52
10-Year	75	25	50	149	52	97
30-Year	51	6	45	101	9	92
5-Year TIPS	0	0	0	14	0	14
10-Year TIPS	24	15	9	35	15	20
30-Year TIPS	8	0	8	13	0	13
Coupon Subtotal	554	320	234	1,312	752	560

*Privately-held marketable borrowing excludes rollovers (auction "add-ons") of Treasury securities held in the Federal Reserve's System Open Market Account (SOMA), but includes financing required due to SOMA redemptions.
**An end-of-March 2019 cash balance of $334 billion versus a beginning-of-January 2019 cash balance of $402 billion. By keeping the cash balance constant, Treasury arrives at the net implied funding number.

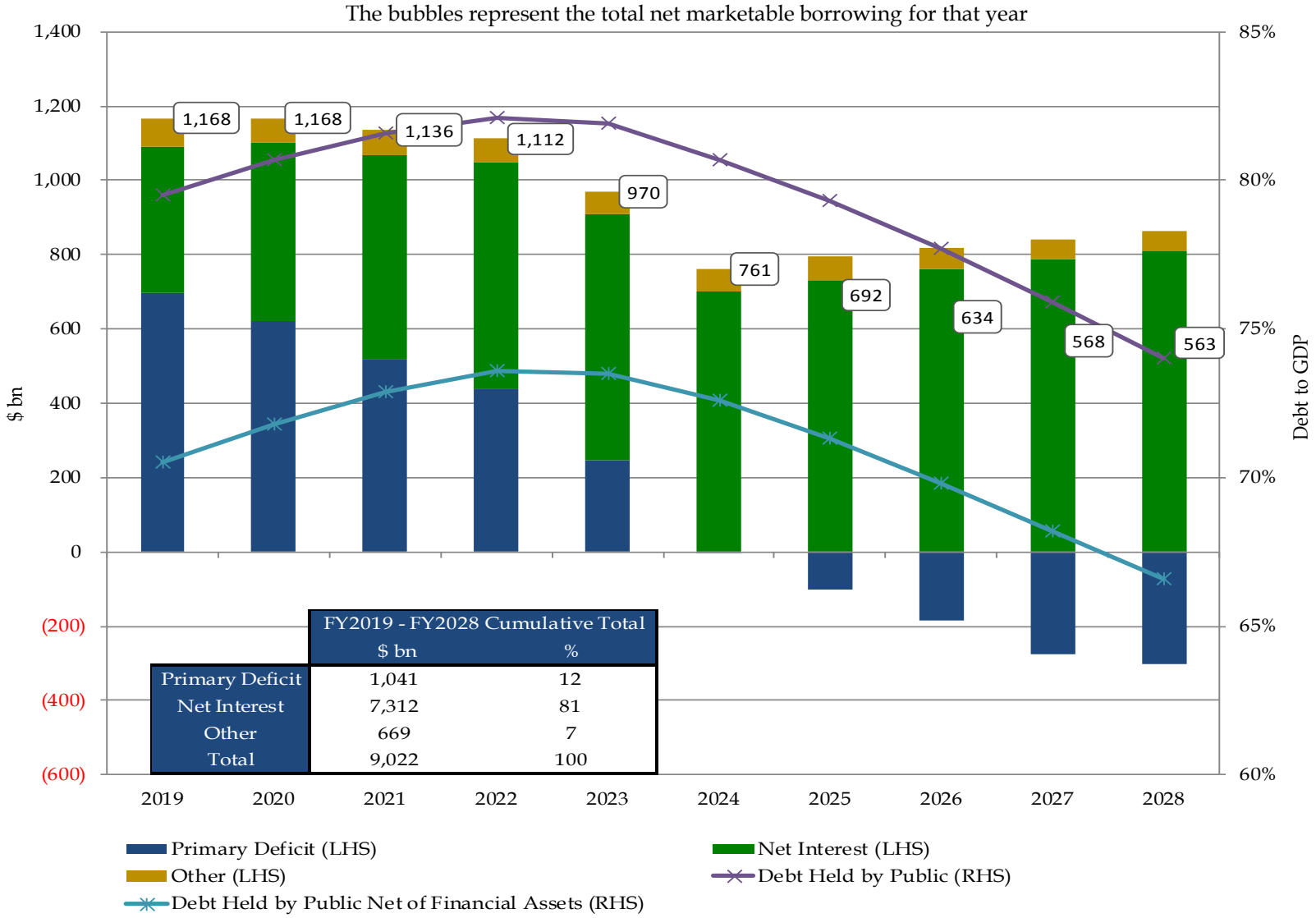
Sources of Privately-Held Financing in FY19 Q3*

April - June 2019	
Assuming Constant Coupon Issuance Sizes**	
Treasury Announced Net Marketable Borrowing***	30
Net Coupon Issuance	269
Implied Change in Bills	(239)

Security	April - June 2019 Coupon Issuance			Fiscal Year-to-Date Coupon Issuance		
	Gross	Maturing	Net	Gross	Maturing	Net
2-Year FRN	56	41	15	167	123	44
2-Year	120	52	68	354	208	146
3-Year	114	72	42	339	216	123
5-Year	123	99	24	363	256	107
7-Year	96	59	37	286	197	89
10-Year	75	31	44	224	83	141
30-Year	51	0	51	152	9	143
5-Year TIPS	32	54	(22)	46	54	(8)
10-Year TIPS	11	0	11	46	15	31
30-Year TIPS	0	0	0	13	0	13
Coupon Subtotal	678	409	269	1,990	1,161	829

*Privately-held marketable borrowing excludes rollovers (auction "add-ons") of Treasury securities held in the Federal Reserve's System Open Market Account (SOMA), but includes financing required due to SOMA redemptions.
**Keeping announced issuance sizes and patterns constant for nominal coupons, TIPS, and FRNs based on changes made at the February 2019 refunding.
***Assumes an end-of-June 2019 cash balance of $270 billion versus a beginning-of-April 2019 cash balance of $334 billion.
Financing Estimates released by the Treasury can be found here: http://www.treasury.gov/resource-center/data-chart-center/quarterly-refunding/Pages/Latest.aspx

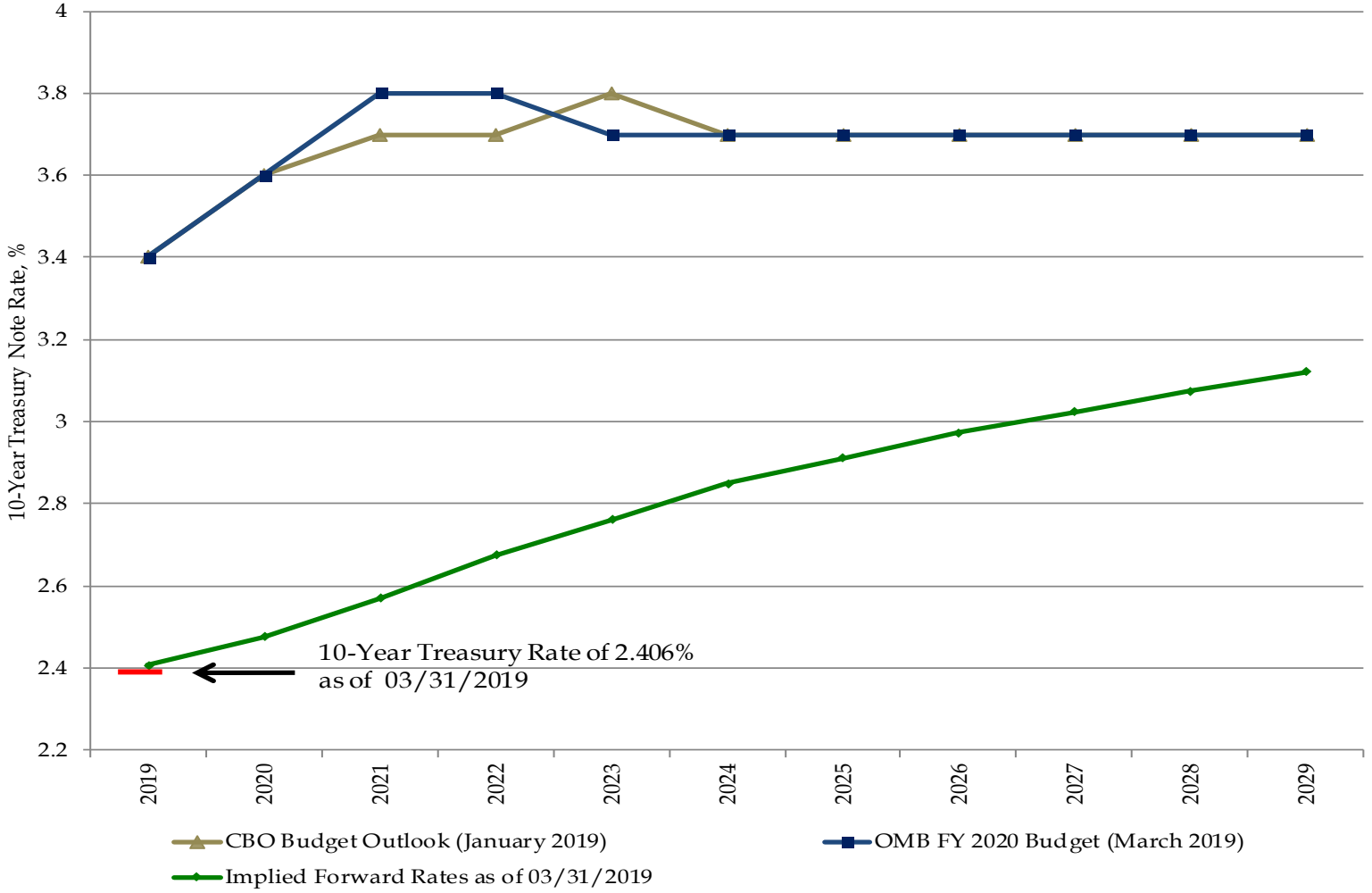
OMB's Projection of Borrowing from the Public



	FY2019 - FY2028 Cumulative Total	
	$ bn	%
Primary Deficit	1,041	12
Net Interest	7,312	81
Other	669	7
Total	9,022	100

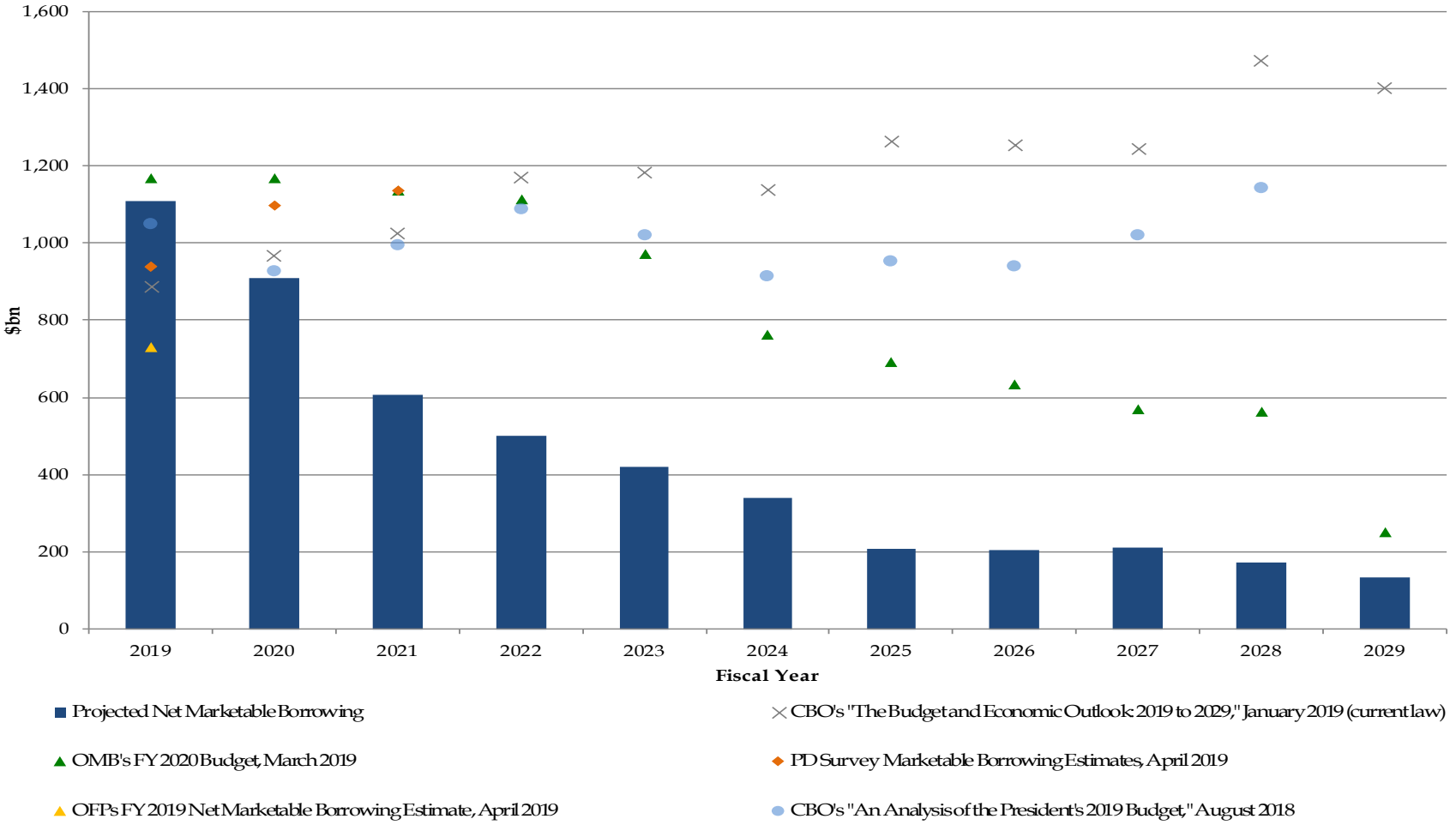
OMB's projections of the change in debt held by the public (borrowing) are from Table S-10 of "A Budget for a Better America, Fiscal Year 2020," March 2019. "Other" represents borrowing from the public to provide direct and guaranteed loans.

Interest Rate Assumptions: 10-Year Treasury Note



OMB's economic assumption of the 10-Year Treasury note rates are from Table 2 of OMB's "A Budget for a Better America, Fiscal Year 2020," March 2019. CBO's economic assumption of the 10-Year Treasury note rates are from Table E-1 of CBO's "The Budget and Economic Outlook: 2019 to 2029," January 2019. The forward rates are the implied 10-Year Treasury note rates on March 31, 2019.

Projected Net Marketable Borrowing
Assuming Future Issuance Remains Constant*

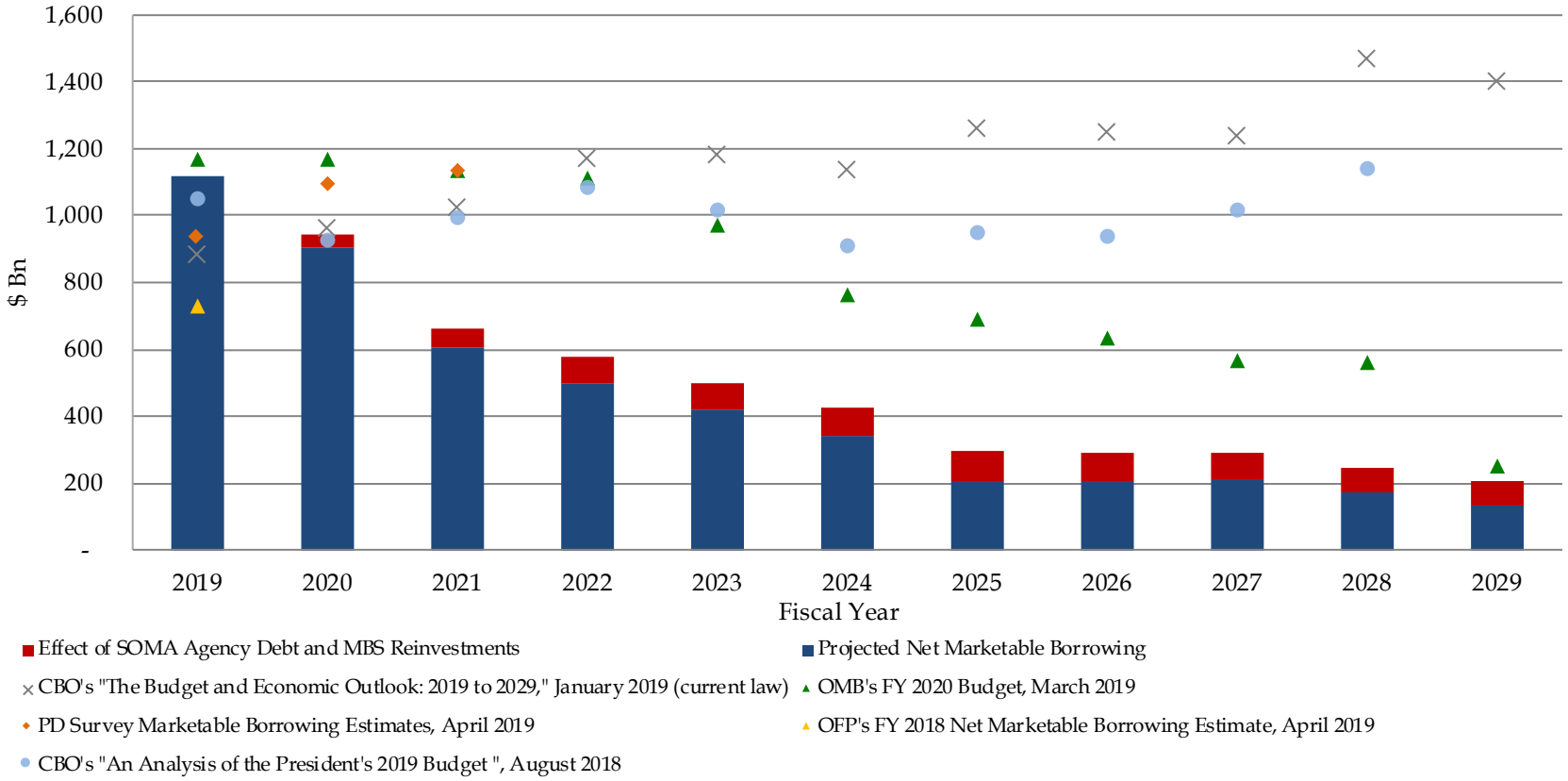


Treasury's latest primary dealer survey estimates can be found on page 11. OMB's projections of the change in debt held by the public are from Table S-10 of "A Budget for a Better America, Fiscal Year 2020," March 2019. CBO's current law budget projections of the change in debt held by the public are from Table 1-1 of "The Budget and Economic Outlook: 2019 to 2029," January 2019. CBO's budget projections of the change in debt held by the public are from Table 2 of "An Analysis of the President's 2019 Budget," August 2018. See table in the appendix section for details.

* Projections reflect a reduction in SOMA's monthly Treasury redemption cap from $30 billion to $15 billion beginning in May 2019 and an end date for SOMA capped redemptions at the end of September 2019, according to the FOMC's "Balance Sheet Normalization Principles and Plans" published on March 20, 2019.

Estimate of the Effect of SOMA Purchases on Projected Net Borrowing

Assuming SOMA Agency Debt and Mortgage Reinvestments Match Treasury Securities Outstanding and Future Issuance Remains Constant*



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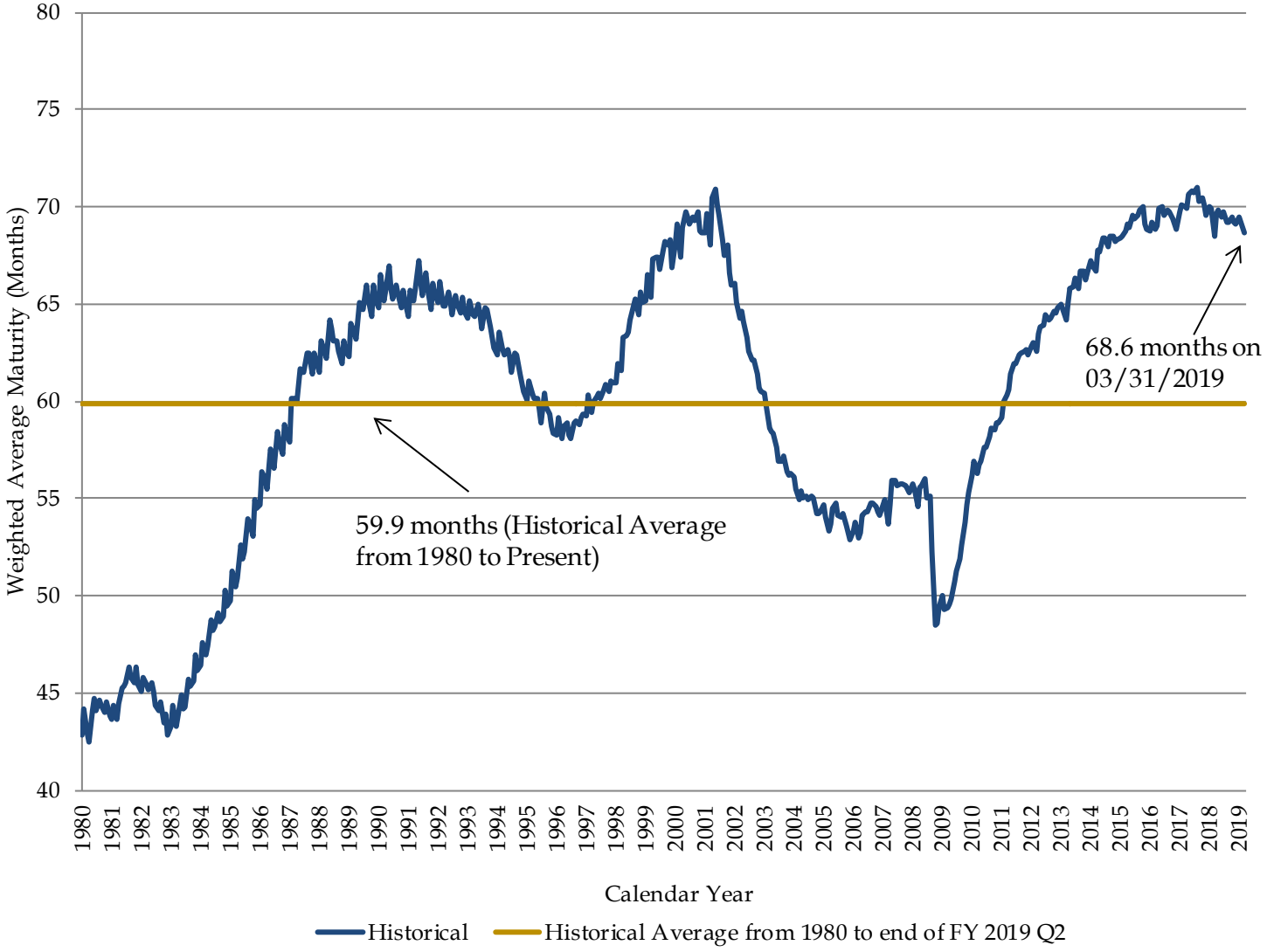
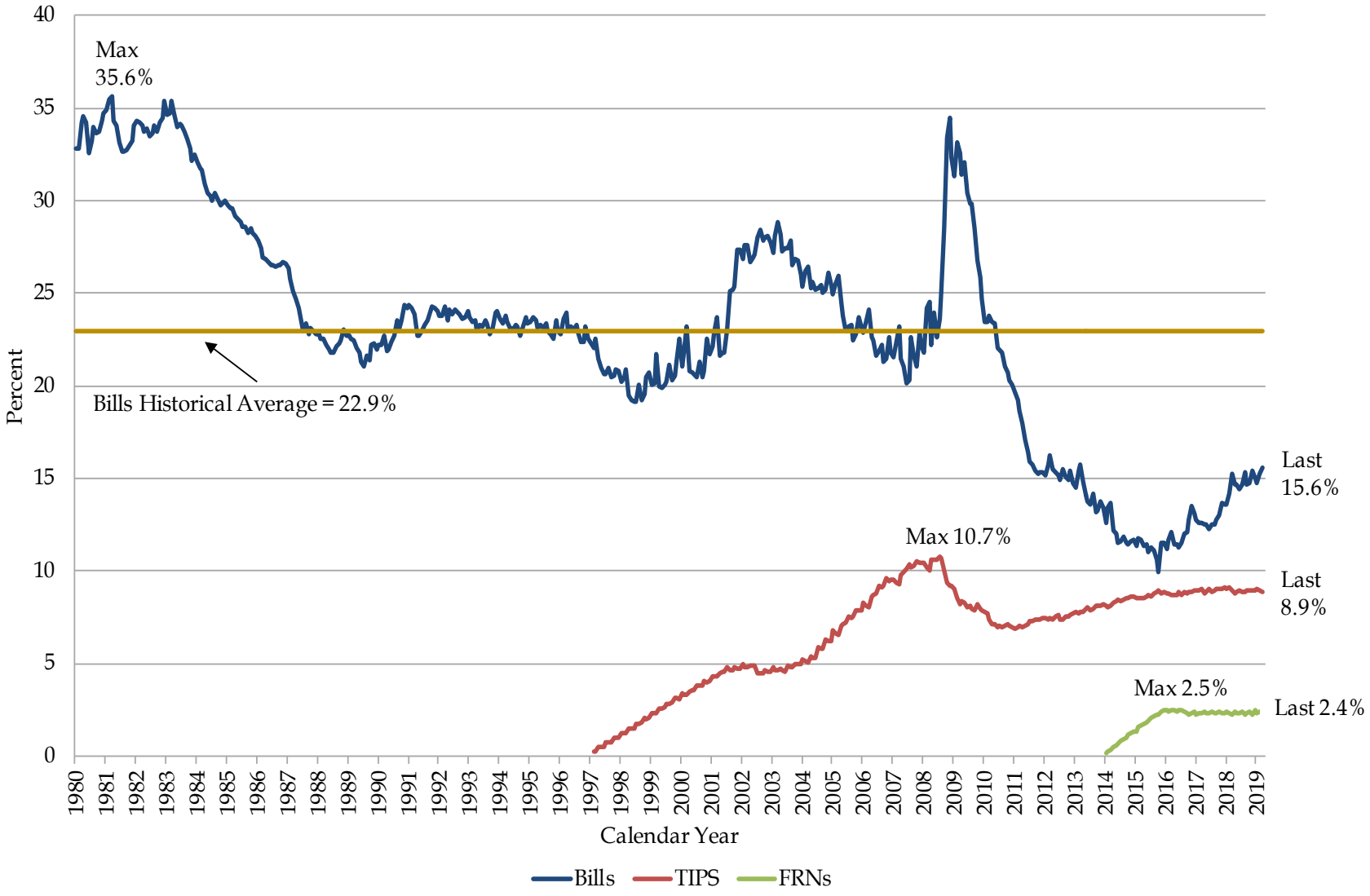
*Projections reflect a reduction in SOMA's monthly Treasury redemption cap from $30 billion to $15 billion beginning in May 2019 and an end date for SOMA capped redemptions at the end of September 2019, according to the FOMC's "Balance Sheet Normalization Principles and Plans" published on March 20, 2019. Projections assume a prepayment of the most recent realized 3M CPR. The total principal payments are then used to purchase Treasury securities that match the maturity composition of Treasury securities outstanding from the private market. These purchases increase marketable borrowing when they mature and are rolled over at Treasury auctions as add-ons.

Section IV:
Portfolio Metrics

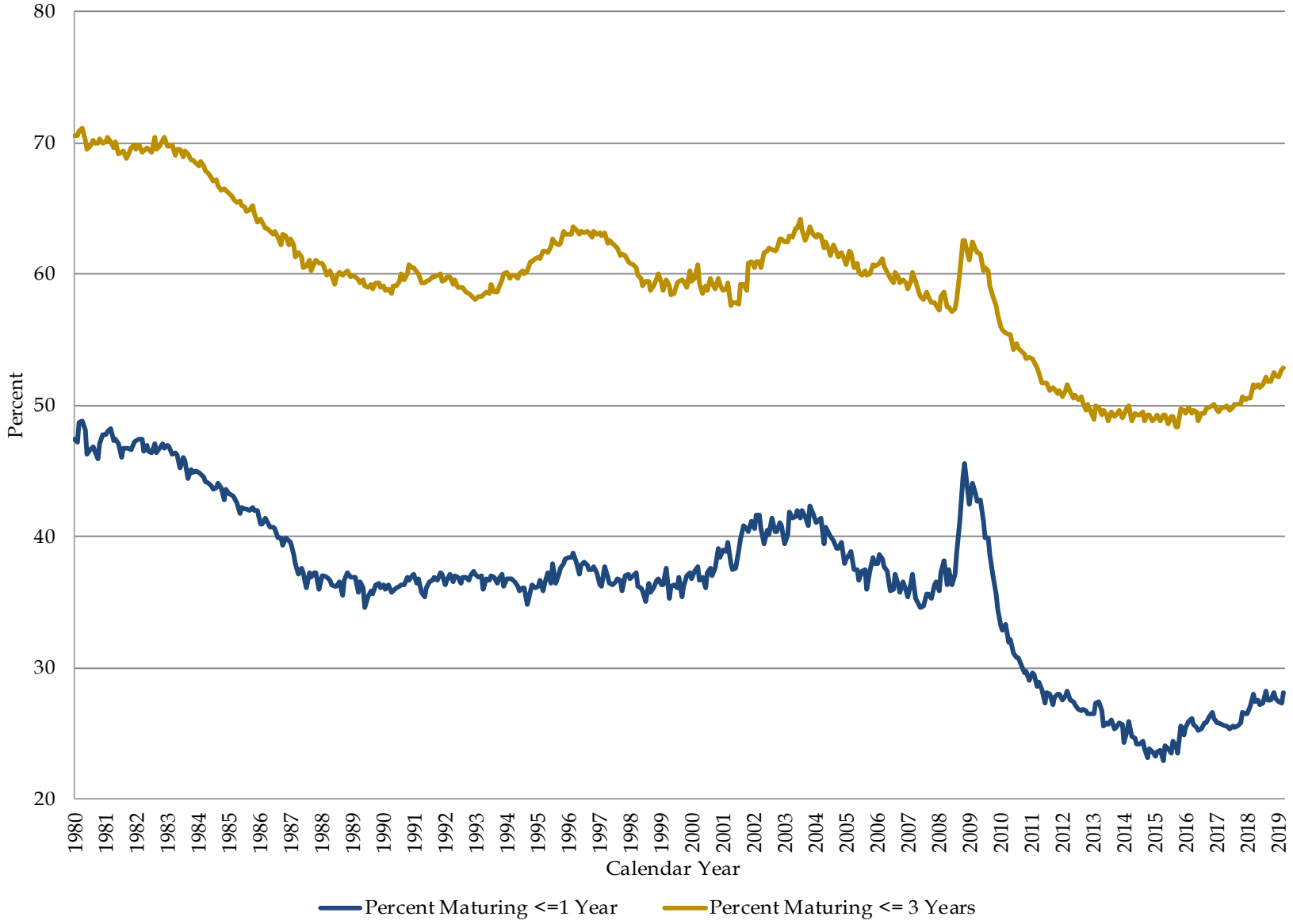
Historical Weighted Average Maturity of Marketable Debt Outstanding



Bills, TIPS & FRNs Outstanding as a Percent of Marketable Debt Outstanding



Treasury Maturity Profile History



End of Fiscal Year & Most Recent Quarter Maturity Profile, $ billions

Date	(0,1]	(1,2]	(2,3]	(3,5]	(5,7]	(7,10]	(10,30]	Total	(0,5]
Sep-11	2,620	1,334	980	1,541	1,070	1,053	1,017	9,616	6,476
Sep-12	2,951	1,373	1,104	1,811	1,214	1,108	1,181	10,742	7,239
Sep-13	2,939	1,523	1,242	1,965	1,454	1,136	1,331	11,590	7,669
Sep-14	2,935	1,739	1,319	2,207	1,440	1,113	1,528	12,281	8,199
Sep-15	3,097	1,775	1,335	2,382	1,478	1,121	1,654	12,841	8,589
Sep-16	3,423	1,828	1,538	2,406	1,501	1,151	1,800	13,648	9,195
Sep-17	3,631	2,027	1,504	2,433	1,466	1,180	1,946	14,188	9,596
Sep-18	4,299	2,076	1,603	2,472	1,531	1,209	2,077	15,268	10,450
Mar-19	4,580	2,190	1,716	2,471	1,580	1,230	2,161	15,929	10,958

End of Fiscal Year & Most Recent Quarter Maturity Profile, percent

Date	(0,1]	(1,2]	(2,3]	(3,5]	(5,7]	(7,10]	(10,30]	(0,3]	(0,5]
Sep-11	27.2	13.9	10.2	16.0	11.1	10.9	10.6	51.3	67.3
Sep-12	27.5	12.8	10.3	16.9	11.3	10.3	11.0	50.5	67.4
Sep-13	25.4	13.1	10.7	17.0	12.5	9.8	11.5	49.2	66.2
Sep-14	23.9	14.2	10.7	18.0	11.7	9.1	12.4	48.8	66.8
Sep-15	24.1	13.8	10.4	18.5	11.5	8.7	12.9	48.3	66.9
Sep-16	25.1	13.4	11.3	17.6	11.0	8.4	13.2	49.7	67.4
Sep-17	25.6	14.3	10.6	17.1	10.3	8.3	13.7	50.5	67.6
Sep-18	28.2	13.6	10.5	16.2	10.0	7.9	13.6	52.3	68.4
Mar-19	28.8	13.7	10.8	15.5	9.9	7.7	13.6	53.3	68.8

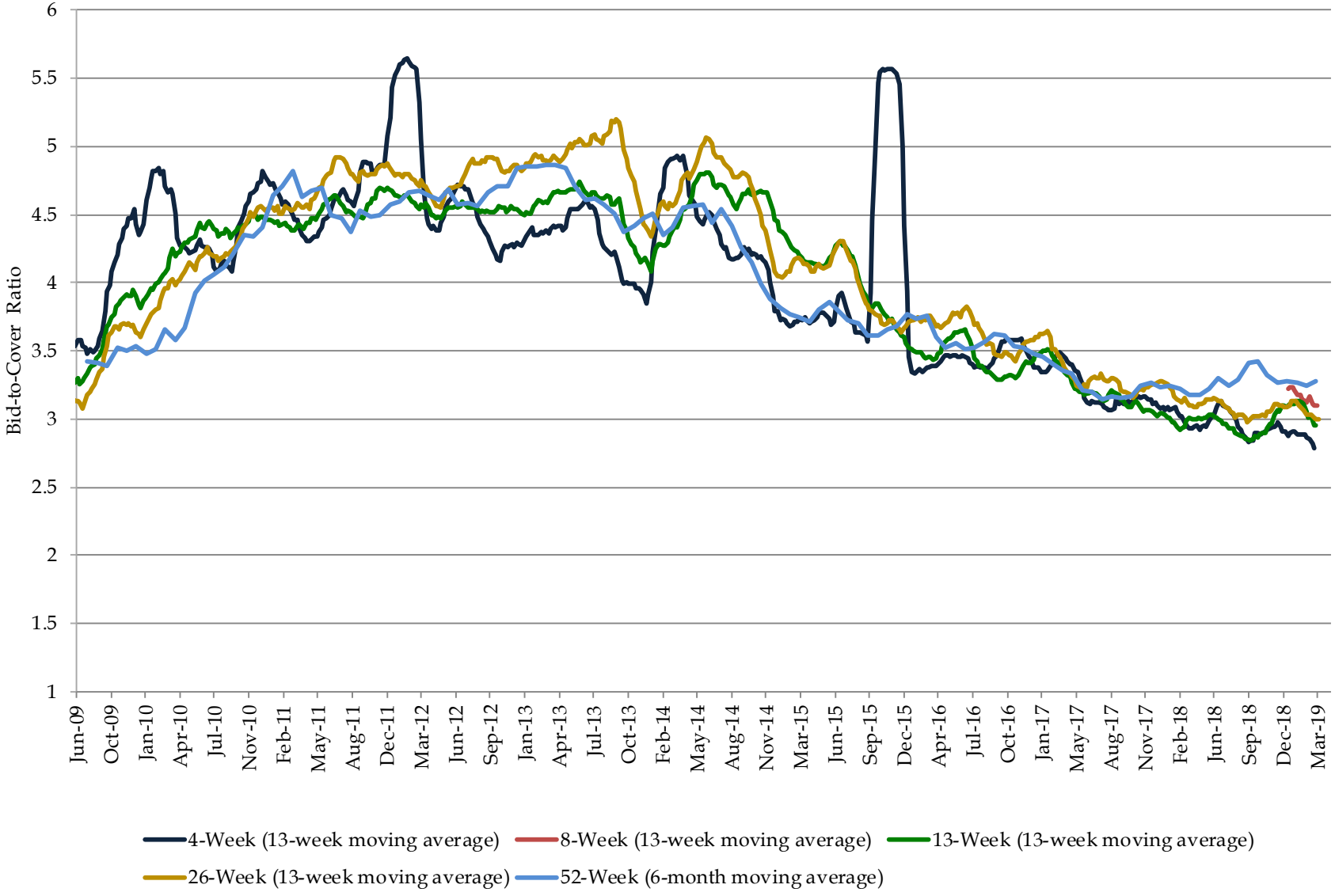
Section V: Demand

Summary Statistics for Fiscal Year 2019 Q2 Auctions

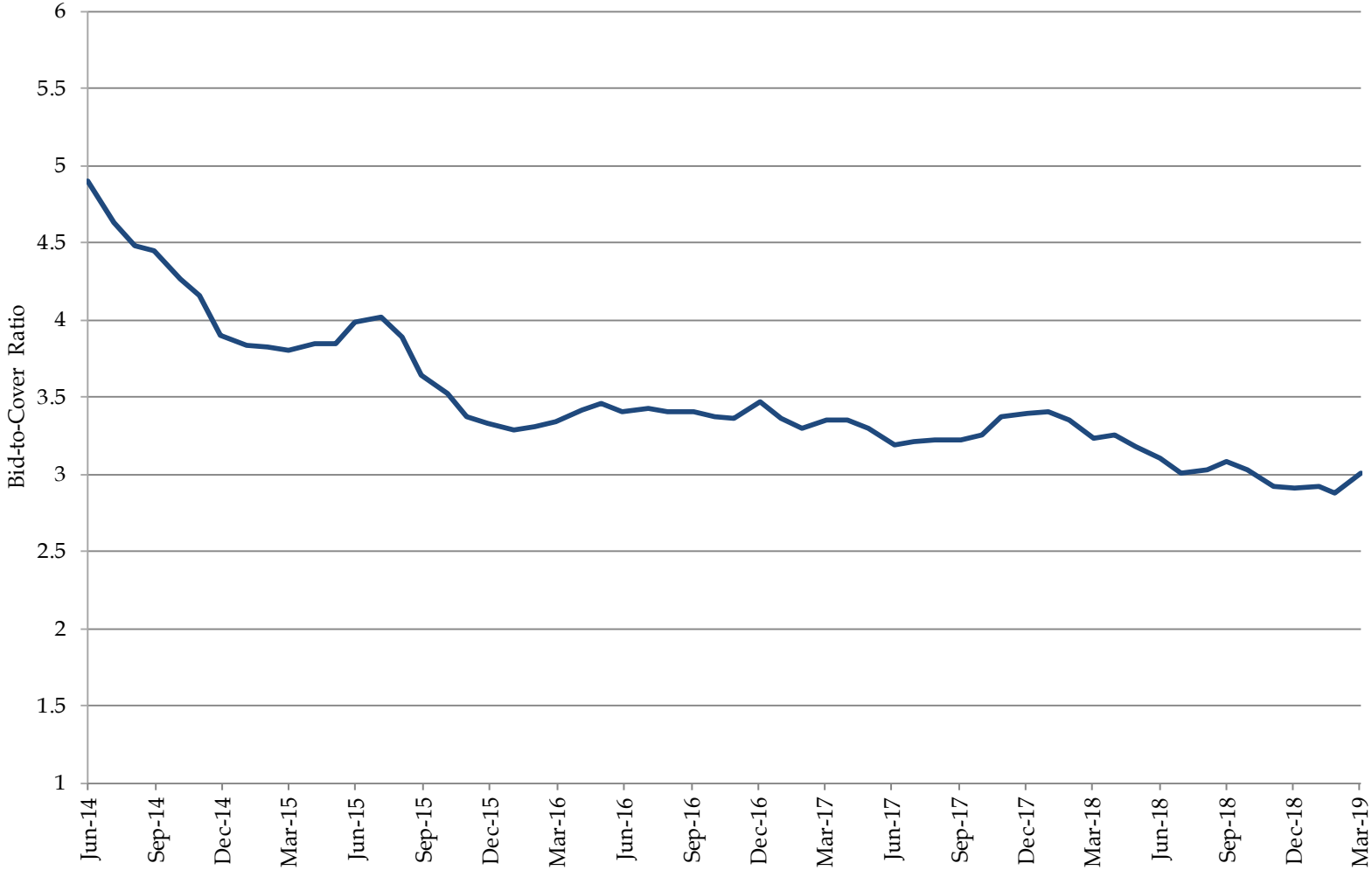
Security Type	Term	Stop Out Rate (%)*	Bid-to-Cover Ratio*	Competitive Awards ($bn)	% Primary Dealer*	% Direct*	% Indirect*	Non-Competitive Awards ($bn)	SOMA "Add-Ons" ($bn)	10-Year Equivalent ($bn)**
Bill	4-Week	2.400	2.8	635.3	58.3	3.6	38.1	19.7	0.0	5.8
Bill	8-Week	2.394	3.1	435.1	58.1	3.5	38.4	4.9	0.0	7.8
Bill	13-Week	2.400	3.0	520.1	50.5	4.1	45.4	16.9	0.0	15.5
Bill	26-Week	2.451	3.0	443.2	54.3	4.0	41.6	18.8	0.0	26.7
Bill	52-Week	2.448	3.5	75.2	50.3	6.0	43.7	2.8	0.0	8.9
Bill	CMB	2.400	3.1	103.0	53.6	2.6	43.7	0.0	0.0	1.0
Coupon	2-Year	2.455	2.6	118.6	32.3	18.3	49.3	1.4	1.9	27.6
Coupon	3-Year	2.503	2.5	113.5	39.1	15.2	45.7	0.5	9.2	41.8
Coupon	5-Year	2.412	2.4	122.9	22.7	18.3	58.9	0.1	2.0	68.4
Coupon	7-Year	2.481	2.6	96.0	16.0	24.7	59.3	0.0	1.5	72.7
Coupon	10-Year	2.678	2.5	75.0	24.2	13.9	61.8	0.0	6.5	83.0
Coupon	30-Year	3.024	2.2	51.0	27.1	15.7	57.1	0.0	4.6	127.8
TIPS	10-Year	0.763	2.4	23.9	17.0	10.3	72.7	0.1	0.0	26.6
TIPS	30-Year	1.093	2.5	8.0	15.0	3.0	82.0	0.0	0.4	24.8
FRN	2-Year	0.147	3.1	55.9	48.8	0.4	50.8	0.1	0.0	0.0
Total Bills		2.411	3.0	2,211.9	55.2	3.8	41.0	63.1	0.0	65.9
Total Coupons		2.539	2.5	576.9	27.4	18.0	54.6	2.1	25.7	421.2
Total TIPS		0.845	2.4	31.9	16.5	8.5	75.0	0.1	0.4	51.4
Total FRN		0.147	3.1	55.9	48.8	0.4	50.8	0.1	0.0	0.0

*Weighted averages of Competitive Awards. FRNs are reported on discount margin basis.
**Approximated using prices at settlement and includes both Competitive and Non-Competitive Awards. For TIPS 10-year equivalent, a constant auction BEI is used as the inflation assumption.

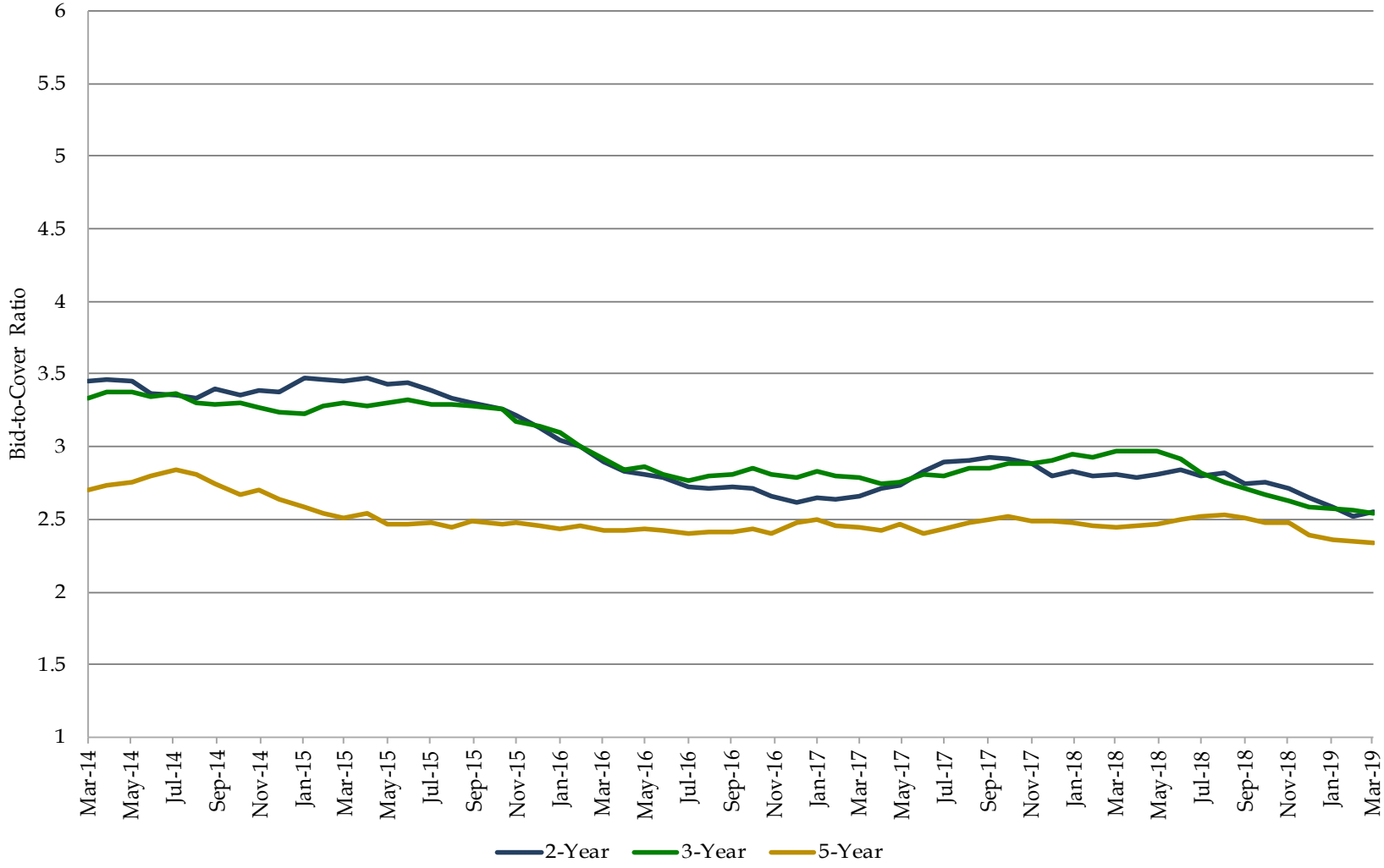
Bid-to-Cover Ratios for Treasury Bills



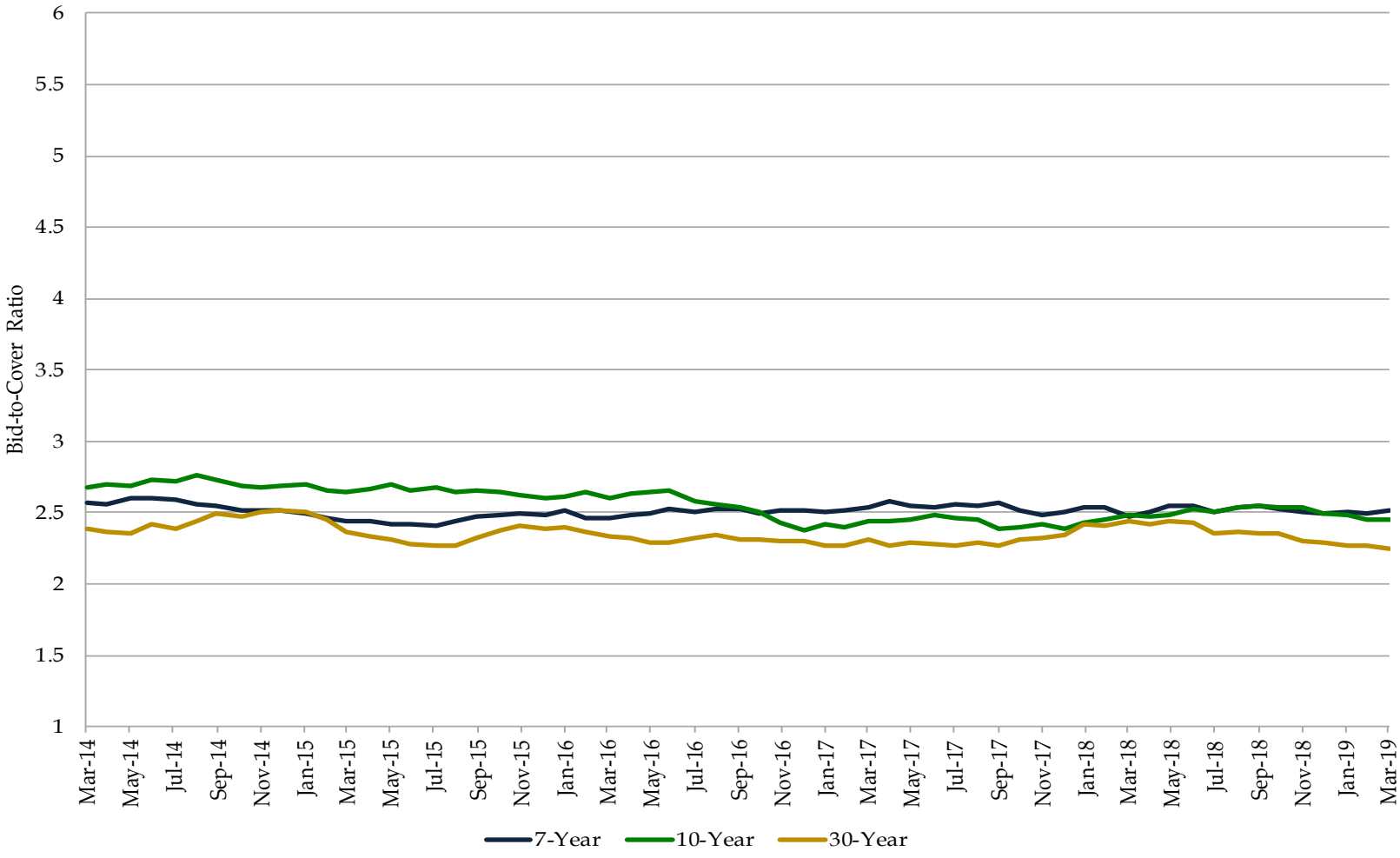
Bid-to-Cover Ratios for FRNs
(6-Month Moving Average)



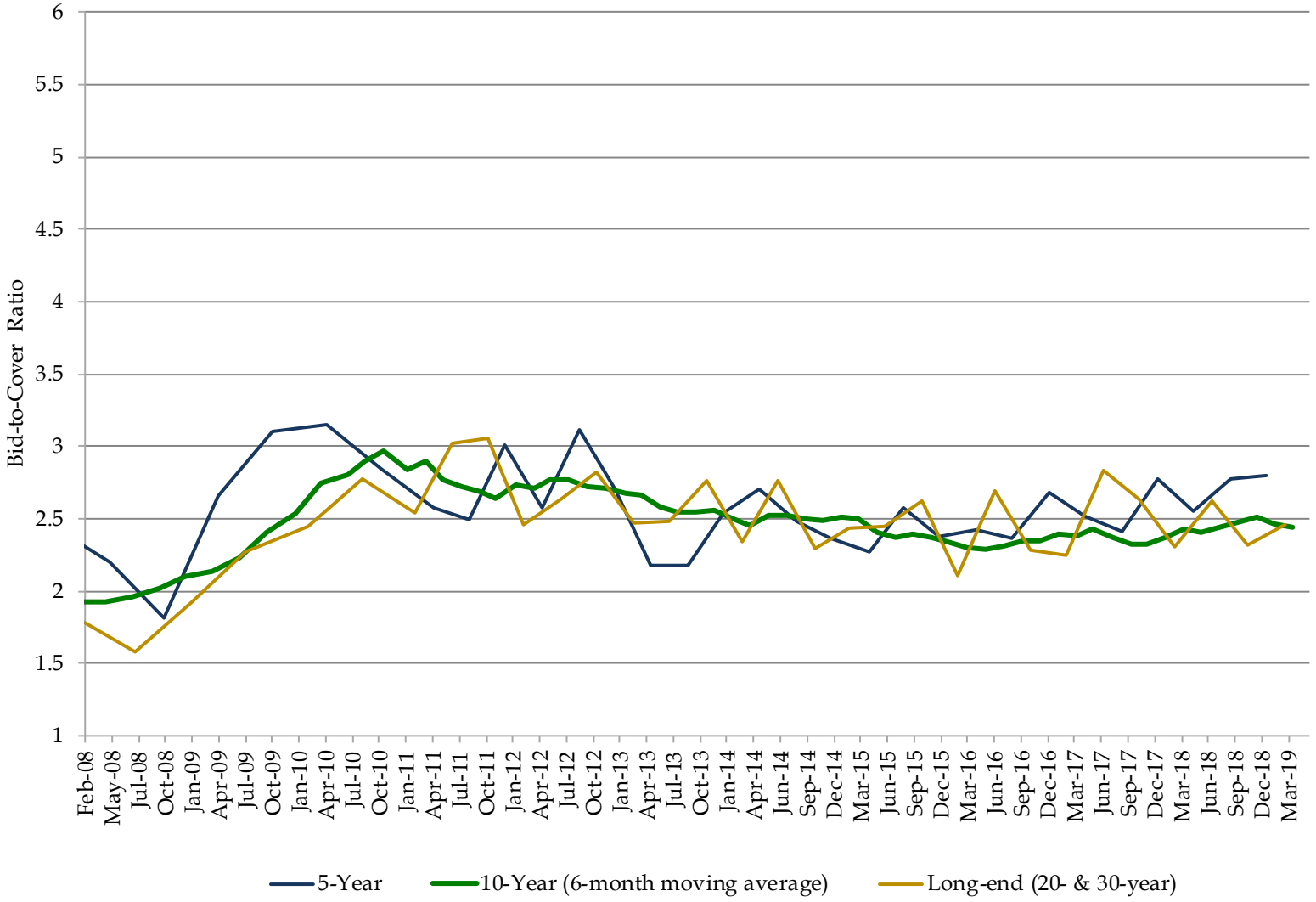
Bid-to-Cover Ratios for 2-, 3-, and 5-Year Nominal Securities (6-Month Moving Average)



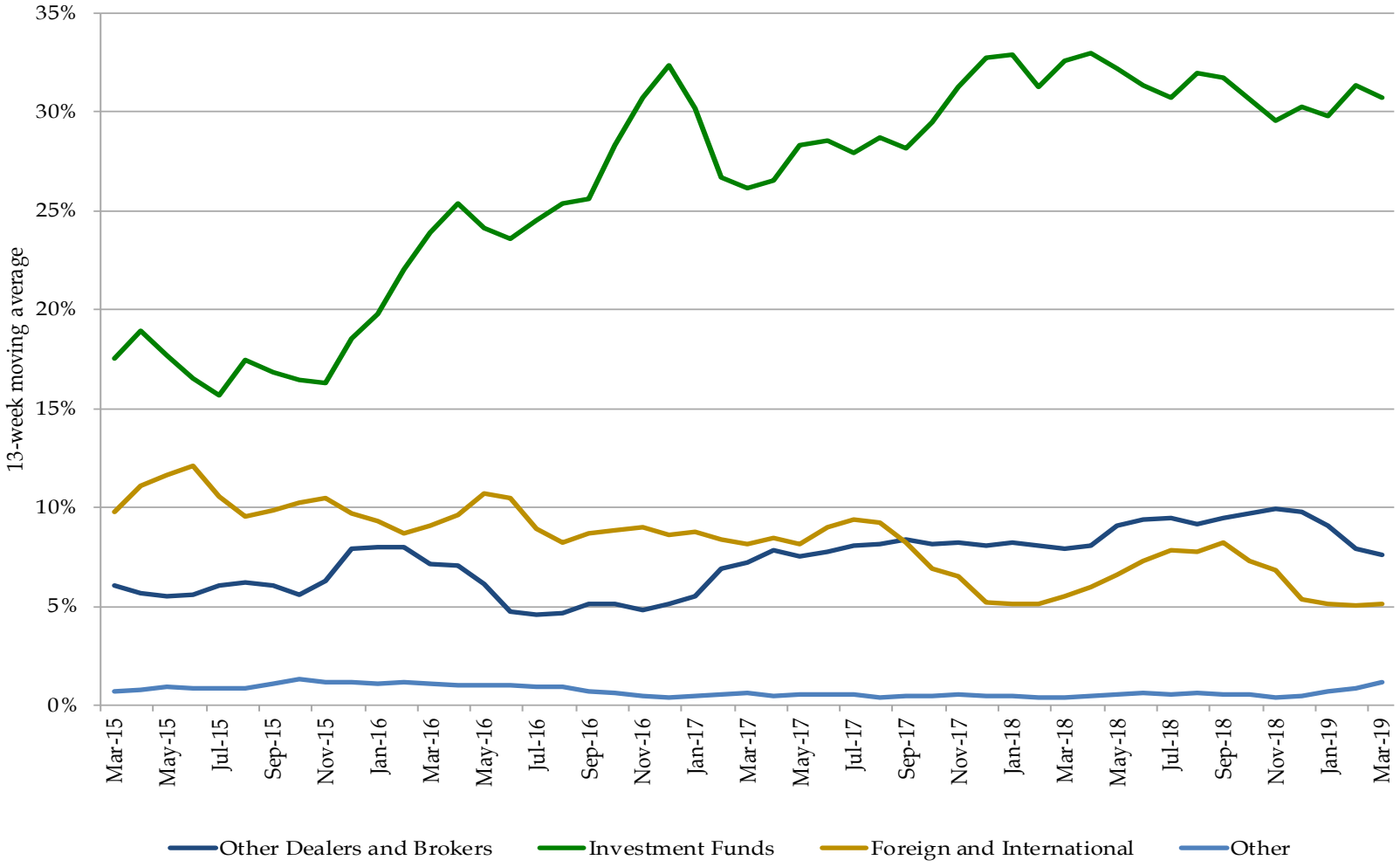
Bid-to-Cover Ratios for 7-, 10-, and 30-Year Nominal Securities (6-Month Moving Average)



Bid-to-Cover Ratios for TIPS

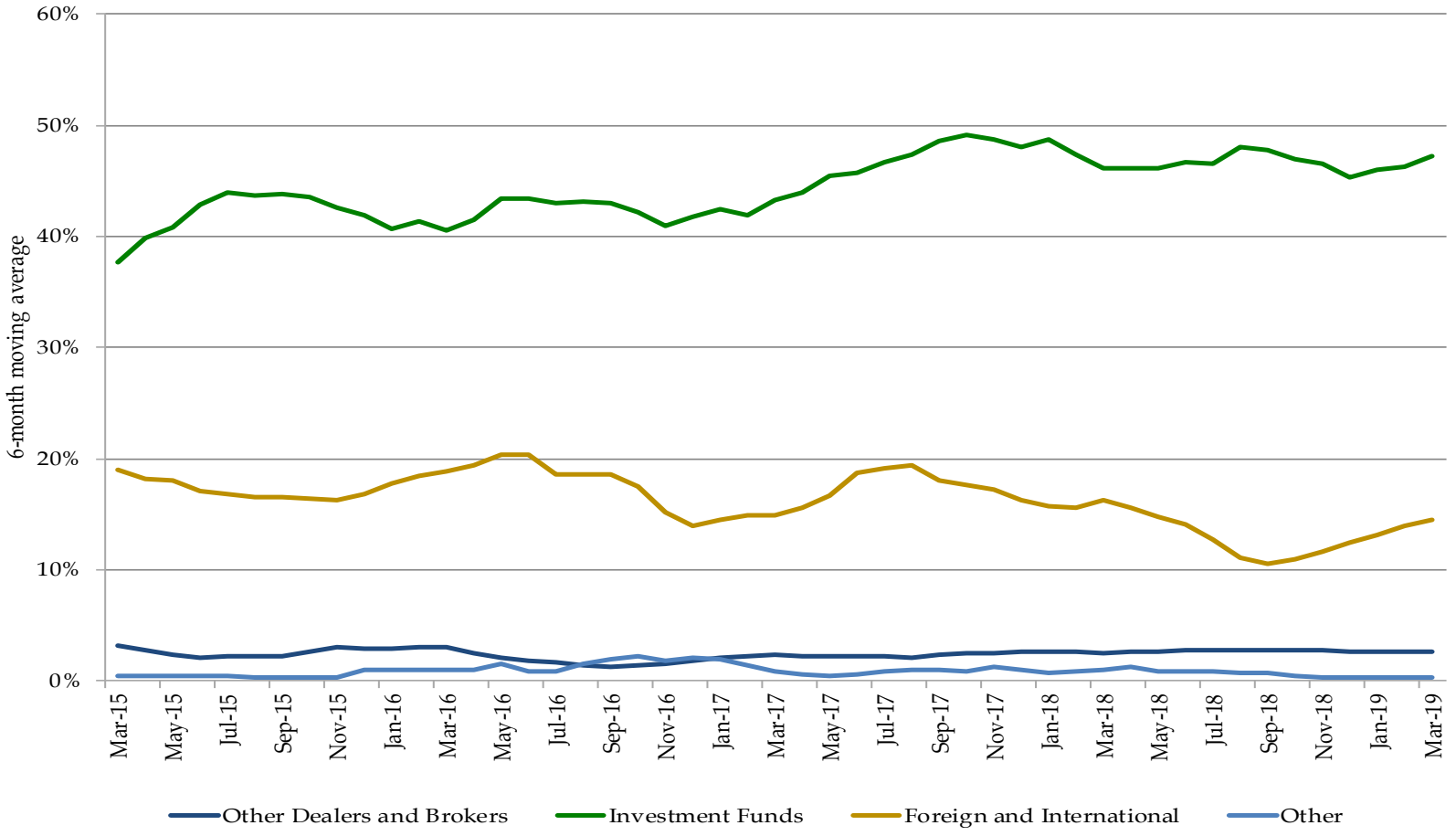


Percent Awarded in Bill Auctions by Investor Class (13-Week Moving Average)



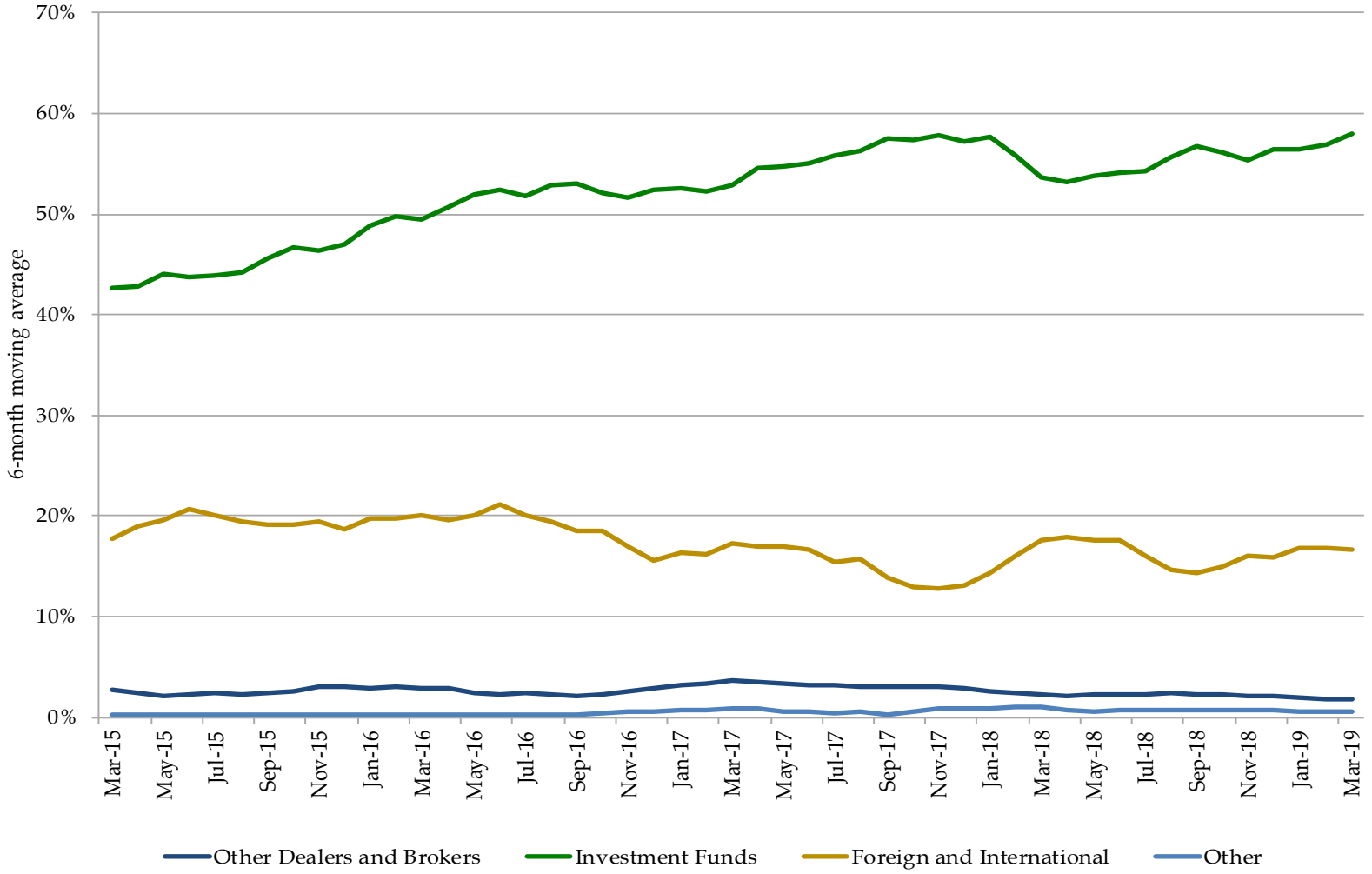
Excludes SOMA add-ons. The "Other" category includes categories that are each less than 5%, which include Depository Institutions, Individuals, Pension and Insurance.

Percent Awarded in 2-, 3-, and 5-Year Nominal Security Auctions by Investor Class (6-Month Moving Average)



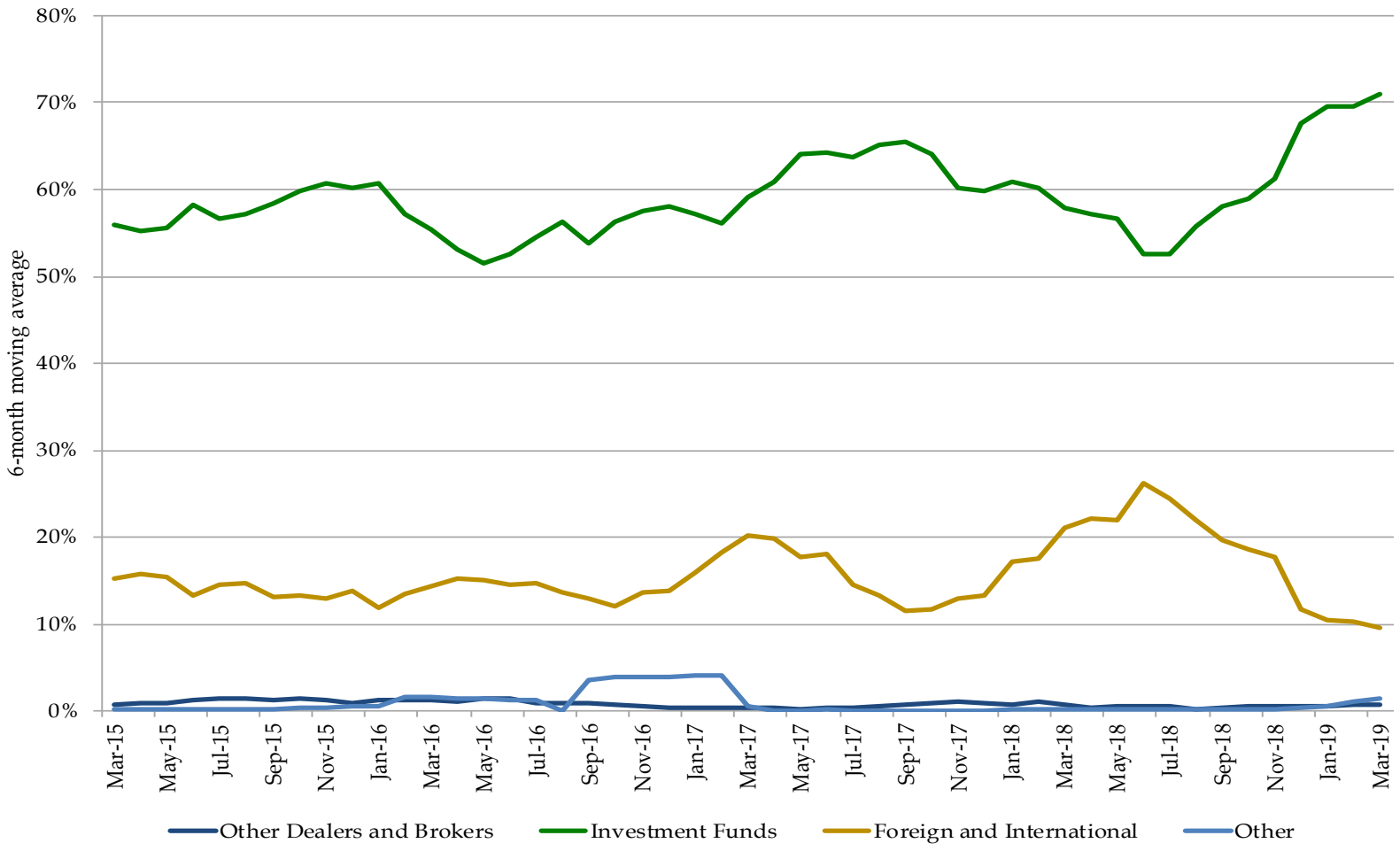
Excludes SOMA add-ons. The "Other" category includes categories that are each less than 5%, which include Depository Institutions, Individuals, Pension and Insurance.

Percent Awarded in 7-, 10-, 30-Year Nominal Security Auctions by Investor Class (6-Month Moving Average)



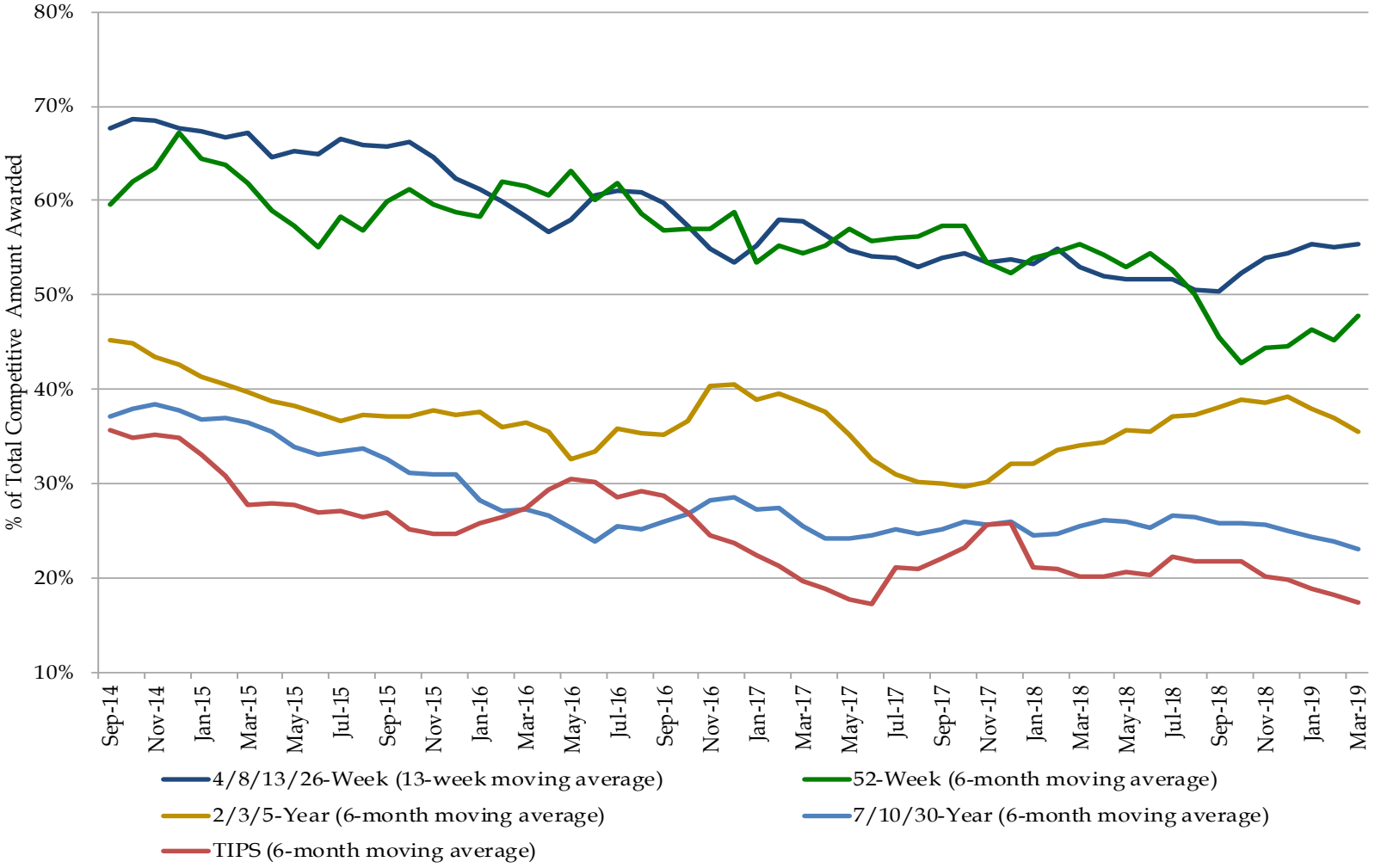
Excludes SOMA add-ons. The "Other" category includes categories that are each less than 5%, which include Depository Institutions, Individuals, Pension and Insurance.

Percent Awarded in TIPS Auctions by Investor Class (6-Month Moving Average)



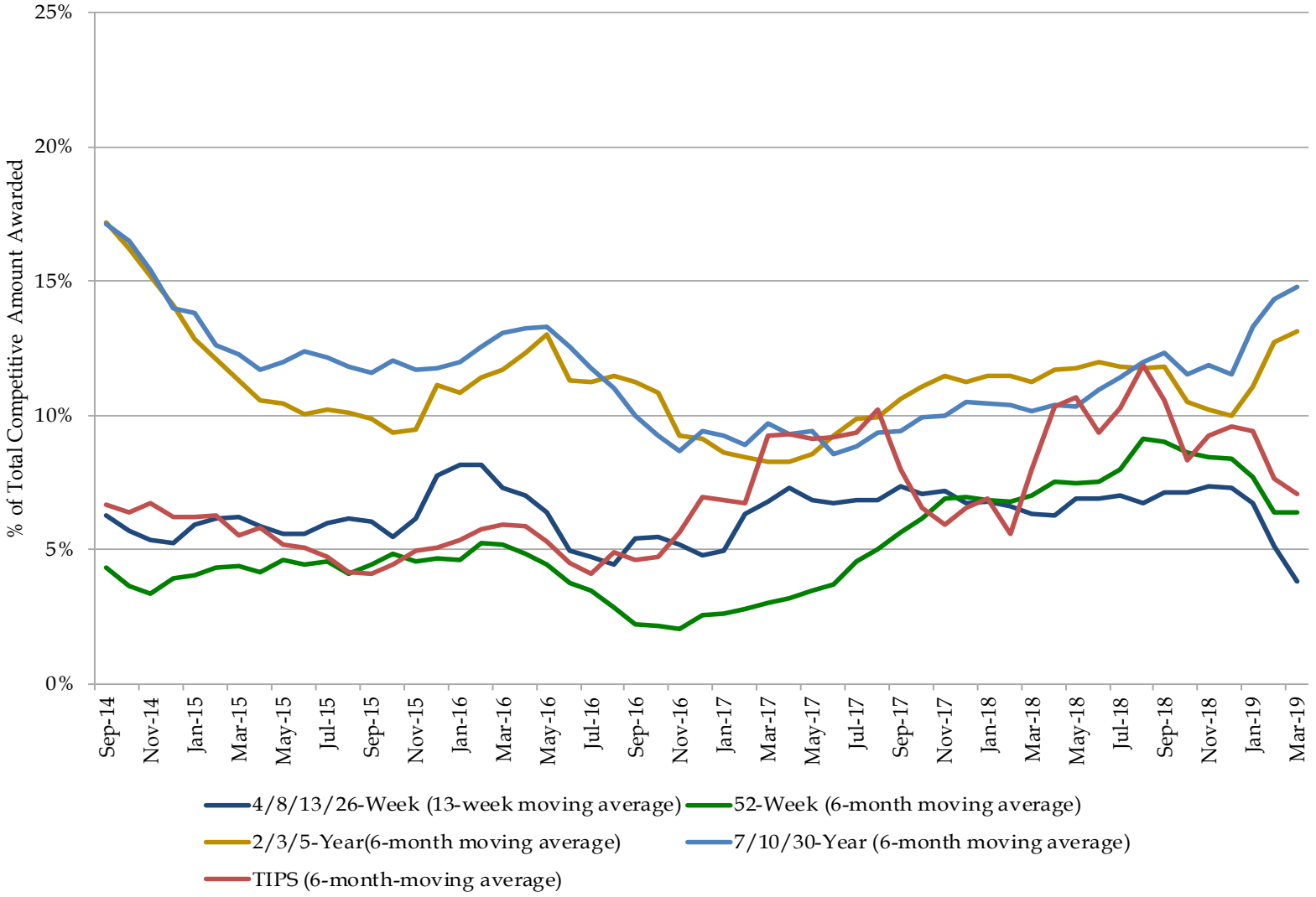
Excludes SOMA add-ons. The "Other" category includes categories that are each less than 5%, which include Depository Institutions, Individuals, Pension and Insurance.

Primary Dealer Awards at Auction



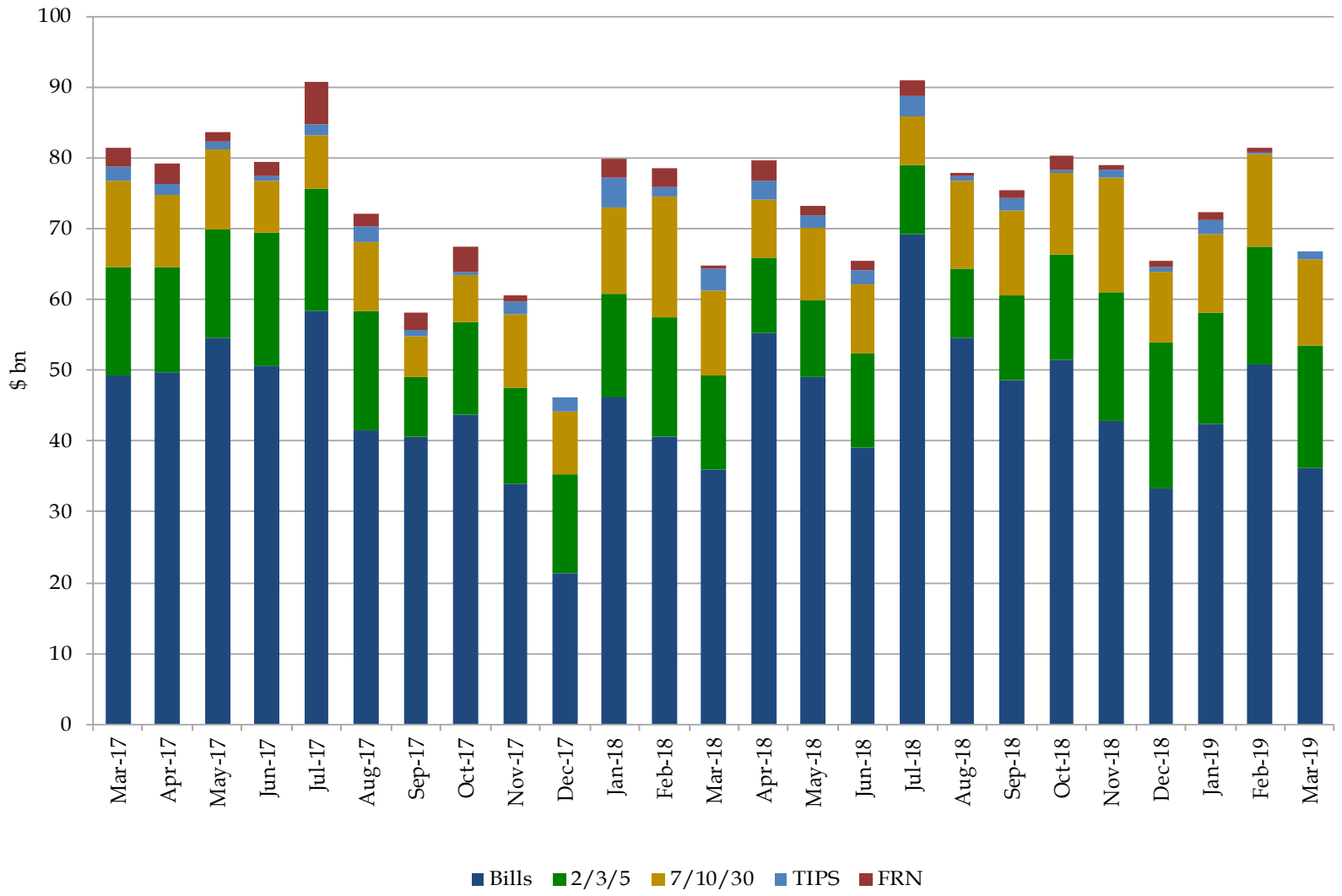
Excludes SOMA add-ons.

Direct Bidder Awards at Auction



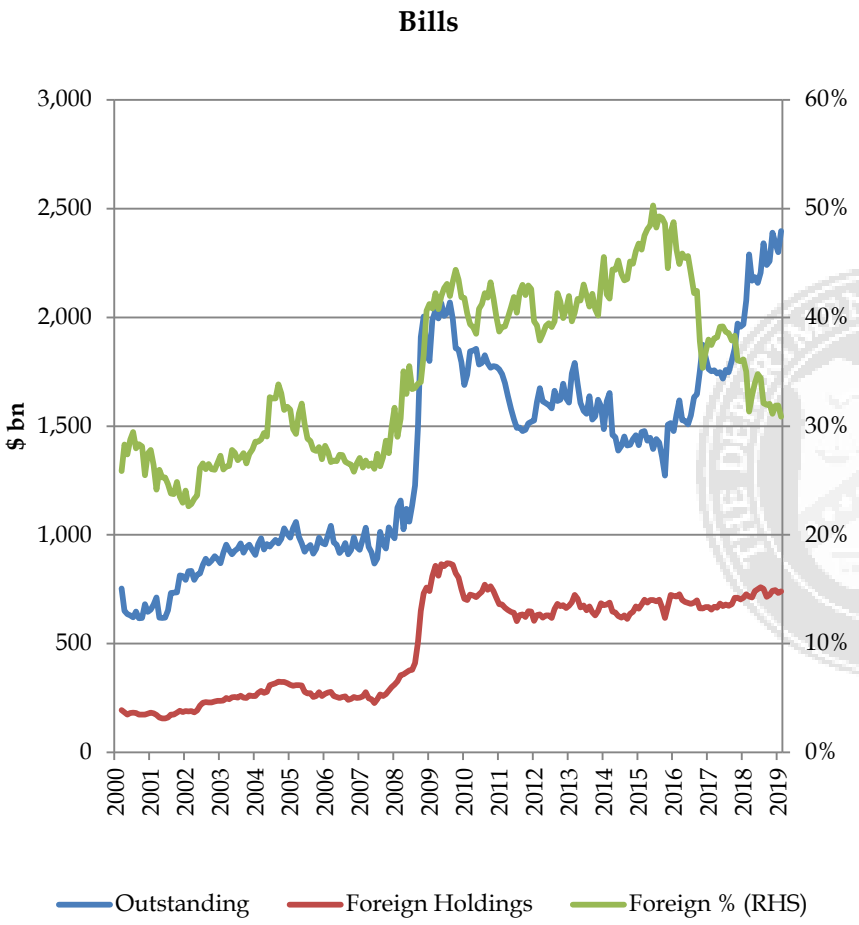
Excludes SOMA add-ons.

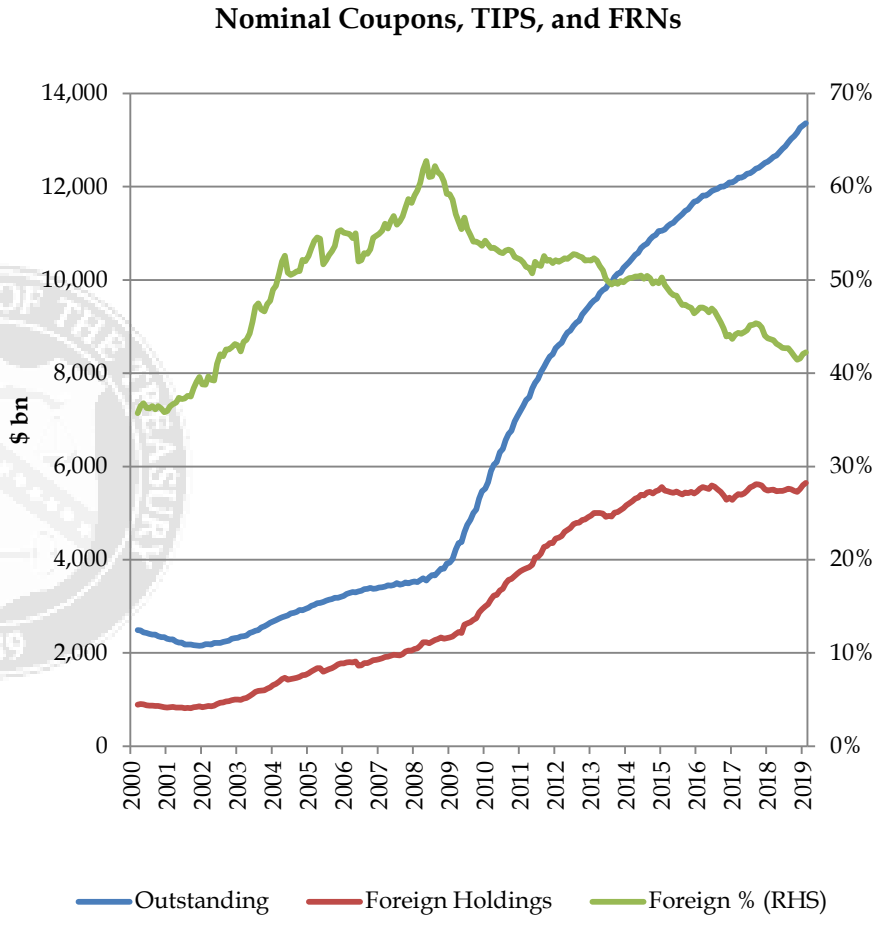
Total Foreign Awards of Treasuries at Auction, $ billions



Foreign includes both private sector and official institutions.

Total Foreign Holdings





Source: Treasury International Capital (TIC) System.
For more information on foreign participation data, including more details about the TIC data shown here, please refer to Treasury Presentation to TBAC "Brief Overview of Key Data Sources on Foreign Participation in the U.S. Treasury Securities Market" at the Treasury February 2019 Refunding.

Appendix

Historical Net Marketable Borrowing and Projected Net Borrowing Assuming Future Issuance Remains Constant, $ billions

Fiscal Year	Bills	2/3/5	7/10/30	TIPS	FRN	Historical/Projected Net Borrowing Capacity	OMB's FY 2020 Budget of the U.S. Government	CBO's "The Budget and Economic Outlook: 2019 to 2029"	Primary Dealer Survey
2014	(119)	(92)	669	88	123	669			
2015	(53)	(282)	641	88	164	558			
2016	289	(82)	477	64	47	795			
2017	155	9	292	55	9	519			
2018	438	209	316	51	26	1,040			
2019	240	517	255	49	55	1,117	1,168	885	938
2020	0	461	366	45	34	907	1,168	965	1,097
2021	0	237	348	20	0	605	1,136	1,025	1,135
2022	0	117	374	10	(0)	502	1,112	1,169	
2023	0	142	262	11	5	419	970	1,181	
2024	0	(10)	328	23	(1)	341	761	1,136	
2025	0	(46)	313	(58)	(0)	209	692	1,260	
2026	0	(41)	295	(46)	(3)	204	634	1,253	
2027	0	4	243	(33)	(2)	212	568	1,241	
2028	0	(15)	247	(63)	3	173	563	1,472	
2029	0	(7)	205	(64)	0	135	250	1,401	

Net borrowing capacity reflects a reduction in SOMA's monthly Treasury redemption cap from $30 billion to $15 billion beginning in May 2019 and an end date for SOMA capped redemptions at the end of September 2019, according to the FOMC's "Balance Sheet Normalization Principles and Plans" published on March 20, 2019.
Treasury's latest primary dealer survey estimates can be found on page 11. OMB's projections of the change in debt held by the public are from Table S-10 of "A Budget for a Better America, Fiscal Year 2020," March 2019. CBO's baseline budget projections of the change in debt held by the public are from Table 1-1 of CBO's "The Budget and Economic Outlook: 2019 to 2029," January 2019.

Bills										
Issue	Settle Date	Stop Out Rate (%)*	Bid-to-Cover Ratio*	Competitive Awards ($bn)	% Primary Dealer*	% Direct*	% Indirect*	Non-Competitive Awards ($bn)	SOMA "Add Ons" ($bn)	10-Year Equivalent ($bn)*
4-Week	1/8/2019	2.390	2.81	38.8	67.6	9.9	22.4	1.2	0.0	0.4
4-Week	1/15/2019	2.380	3.07	38.6	59.2	10.7	30.0	1.4	0.0	0.4
4-Week	1/22/2019	2.370	3.05	38.8	59.4	8.5	32.1	1.2	0.0	0.4
4-Week	1/29/2019	2.355	2.78	43.6	59.5	1.9	38.6	1.4	0.0	0.4
4-Week	2/5/2019	2.390	2.65	48.7	63.3	3.0	33.7	1.3	0.0	0.5
4-Week	2/12/2019	2.390	2.79	48.6	61.1	3.6	35.3	1.4	0.0	0.5
4-Week	2/19/2019	2.395	2.85	47.8	44.4	2.1	53.5	2.2	0.0	0.5
4-Week	2/26/2019	2.390	2.83	48.2	62.5	2.1	35.5	1.8	0.0	0.4
4-Week	3/5/2019	2.410	2.78	58.7	50.9	1.2	47.9	1.3	0.0	0.5
4-Week	3/12/2019	2.405	2.88	58.6	49.4	1.8	48.8	1.4	0.0	0.5
4-Week	3/19/2019	2.420	2.43	58.3	78.0	2.1	19.9	1.7	0.0	0.5
4-Week	3/26/2019	2.470	2.30	57.9	66.7	1.8	31.5	2.1	0.0	0.5
4-Week	4/2/2019	2.400	3.01	48.7	35.8	3.0	61.2	1.3	0.0	0.4
8-Week	1/8/2019	2.375	3.14	29.8	56.9	7.2	35.8	0.2	0.0	0.5
8-Week	1/15/2019	2.390	3.25	29.7	67.6	7.0	25.4	0.3	0.0	0.5
8-Week	1/22/2019	2.365	3.47	29.8	70.2	7.8	21.9	0.2	0.0	0.5
8-Week	1/29/2019	2.370	2.74	34.7	71.7	2.0	26.3	0.3	0.0	0.6
8-Week	2/5/2019	2.400	2.69	34.7	73.1	2.2	24.8	0.3	0.0	0.6
8-Week	2/12/2019	2.385	3.21	34.8	56.9	3.0	40.0	0.2	0.0	0.6
8-Week	2/19/2019	2.400	2.95	34.6	53.5	2.8	43.6	0.4	0.0	0.6
8-Week	2/26/2019	2.400	3.17	34.7	50.1	1.9	48.1	0.3	0.0	0.6
8-Week	3/5/2019	2.410	3.02	33.8	59.7	2.1	38.2	1.2	0.0	0.6
8-Week	3/12/2019	2.400	3.54	34.7	45.4	2.9	51.6	0.3	0.0	0.6
8-Week	3/19/2019	2.400	3.09	34.7	52.7	2.6	44.7	0.3	0.0	0.6
8-Week	3/26/2019	2.420	2.89	34.8	48.9	1.4	49.6	0.2	0.0	0.6
8-Week	4/2/2019	2.395	3.11	34.4	51.6	3.8	44.6	0.6	0.0	0.6

*Weighted averages of competitive awards.
**Approximated using prices at settlement and includes both competitive and non-competitive awards.

Bills										
Issue	Settle Date	Stop Out Rate (%)*	Bid-to-Cover Ratio*	Competitive Awards ($bn)	% Primary Dealer*	% Direct*	% Indirect*	Non-Competitive Awards ($bn)	SOMA "Add Ons" ($bn)	10-Year Equivalent ($bn)*
13-Week	1/10/2019	2.410	3.06	37.6	52.9	9.4	37.7	1.4	0.0	1.1
13-Week	1/17/2019	2.405	2.90	37.7	62.2	7.6	30.2	1.3	0.0	1.2
13-Week	1/24/2019	2.390	3.02	40.9	60.1	6.8	33.1	1.1	0.0	1.2
13-Week	1/31/2019	2.375	3.27	40.8	54.7	4.1	41.2	1.2	0.0	1.2
13-Week	2/7/2019	2.385	3.03	43.6	49.5	3.8	46.7	1.4	0.0	1.3
13-Week	2/14/2019	2.400	2.96	43.4	46.9	2.9	50.3	1.6	0.0	1.3
13-Week	2/21/2019	2.395	2.99	43.7	51.6	3.0	45.4	1.3	0.0	1.3
13-Week	2/28/2019	2.405	2.97	46.0	46.8	2.2	51.0	2.0	0.0	1.4
13-Week	3/7/2019	2.410	2.76	46.9	53.0	2.5	44.5	1.1	0.0	1.4
13-Week	3/14/2019	2.405	3.02	46.8	44.8	2.2	52.9	1.2	0.0	1.4
13-Week	3/21/2019	2.410	2.70	46.8	46.0	3.3	50.7	1.2	0.0	1.4
13-Week	3/28/2019	2.410	2.87	45.9	42.2	2.8	54.9	2.1	0.0	1.4
26-Week	1/10/2019	2.470	2.98	34.9	58.9	4.8	36.3	1.1	0.0	2.1
26-Week	1/17/2019	2.460	3.22	33.9	50.5	4.1	45.3	2.1	0.0	2.1
26-Week	1/24/2019	2.450	3.10	37.0	46.7	4.4	48.9	2.0	0.0	2.3
26-Week	1/31/2019	2.450	3.09	37.1	44.5	11.0	44.4	1.9	0.0	2.3
26-Week	2/7/2019	2.440	2.66	37.8	66.0	3.5	30.5	1.2	0.0	2.3
26-Week	2/14/2019	2.450	2.95	37.5	55.6	2.3	42.1	1.5	0.0	2.3
26-Week	2/21/2019	2.455	3.08	37.6	55.6	3.1	41.3	1.4	0.0	2.2
26-Week	3/7/2019	2.460	3.03	37.9	52.6	3.1	44.3	1.1	0.0	2.2
26-Week	3/14/2019	2.455	3.09	37.7	52.1	4.0	43.9	1.3	0.0	2.2
26-Week	3/21/2019	2.450	2.86	37.8	60.3	2.8	36.9	1.2	0.0	2.2
26-Week	3/28/2019	2.415	2.88	37.1	60.2	1.7	38.1	1.9	0.0	2.2
52-Week	1/31/2019	2.515	3.16	24.8	58.0	5.5	36.5	1.2	0.0	3.1
52-Week	2/28/2019	2.470	3.60	25.0	44.5	5.1	50.5	1.0	0.0	2.9
52-Week	3/28/2019	2.360	3.69	25.3	48.6	7.3	44.1	0.7	0.0	3.0
CMB	2/11/2019	2.395	3.00	50.0	51.1	2.4	46.5	0.0	0.0	0.3
CMB	3/1/2019	2.400	3.34	23.0	55.2	2.8	42.0	0.0	0.0	0.3
CMB	3/7/2019	2.410	3.06	30.0	56.7	2.8	40.4	0.0	0.0	0.4

*Weighted averages of competitive awards.
**Approximated using prices at settlement and includes both competitive and non-competitive awards.

Nominal Coupons										
Issue	Settle Date	Stop Out Rate (%)*	Bid-to-Cover Ratio*	Competitive Awards ($bn)	% Primary Dealer*	% Direct*	% Indirect*	Non-Competitive Awards ($bn)	SOMA "Add Ons" ($bn)	10-Year Equivalent ($bn)*
2-Year	1/31/2019	2.600	2.56	39.6	27.5	19.1	53.4	0.4	0.0	9.3
2-Year	2/28/2019	2.503	2.50	39.5	38.8	22.6	38.6	0.5	1.9	9.4
2-Year	4/1/2019	2.261	2.60	39.5	30.7	13.3	56.0	0.5	0.0	9.0
3-Year	1/15/2019	2.559	2.44	37.8	40.4	17.7	41.9	0.2	0.0	12.9
3-Year	2/15/2019	2.502	2.55	37.8	35.9	18.5	45.7	0.2	9.2	16.2
3-Year	3/15/2019	2.448	2.56	37.8	41.1	9.4	49.5	0.2	0.0	12.6
5-Year	1/31/2019	2.576	2.41	41.0	24.6	15.2	60.2	0.0	0.0	22.9
5-Year	2/28/2019	2.489	2.40	41.0	19.8	22.5	57.7	0.0	2.0	23.1
5-Year	4/1/2019	2.172	2.35	41.0	23.8	17.2	59.0	0.0	0.0	22.3
7-Year	1/31/2019	2.625	2.54	32.0	16.8	24.9	58.3	0.0	0.0	24.3
7-Year	2/28/2019	2.538	2.60	32.0	16.4	28.4	55.2	0.0	1.5	24.6
7-Year	4/1/2019	2.281	2.54	32.0	14.8	20.7	64.5	0.0	0.0	23.8
10-Year	1/15/2019	2.728	2.51	24.0	22.3	20.8	56.9	0.0	0.0	23.9
10-Year	2/15/2019	2.689	2.35	27.0	28.4	12.2	59.5	0.0	6.5	35.0
10-Year	3/15/2019	2.615	2.59	24.0	21.5	9.1	69.4	0.0	0.0	24.0
30-Year	1/15/2019	3.035	2.19	16.0	26.7	15.9	57.3	0.0	0.0	36.1
30-Year	2/15/2019	3.022	2.27	19.0	26.6	17.0	56.4	0.0	4.6	55.5
30-Year	3/15/2019	3.014	2.25	16.0	28.1	14.1	57.8	0.0	0.0	36.2
2-Year FRN	1/31/2019	0.115	2.89	20.0	52.1	0.3	47.7	0.0	0.0	0.0
2-Year FRN	2/22/2019	0.149	2.70	18.0	47.9	0.4	51.6	0.0	0.0	0.0
2-Year FRN	3/29/2019	0.180	3.78	18.0	46.0	0.6	53.5	0.0	0.0	0.0

TIPS										
Issue	Settle Date	Stop Out Rate (%)*	Bid-to-Cover Ratio*	Competitive Awards ($bn)	% Primary Dealer*	% Direct*	% Indirect*	Non-Competitive Awards ($bn)	SOMA "Add Ons" ($bn)	10-Year Equivalent ($bn)*
10-Year TIPS	1/31/2019	0.919	2.42	13.0	16.6	14.3	69.1	0.0	0.0	14.7
10-Year TIPS	3/29/2019	0.578	2.43	11.0	17.4	5.6	77.0	0.0	0.0	11.9
30-Year TIPS	2/28/2019	1.093	2.46	8.0	15.0	3.0	82.0	0.0	0.4	24.8

*Weighted averages of competitive awards. FRNs are reported on discount margin basis.
**Approximated using prices at settlement and includes both competitive and non-competitive awards. For TIPS' 10-Year equivalent, a constant auction BEI is used as the inflation assumption.

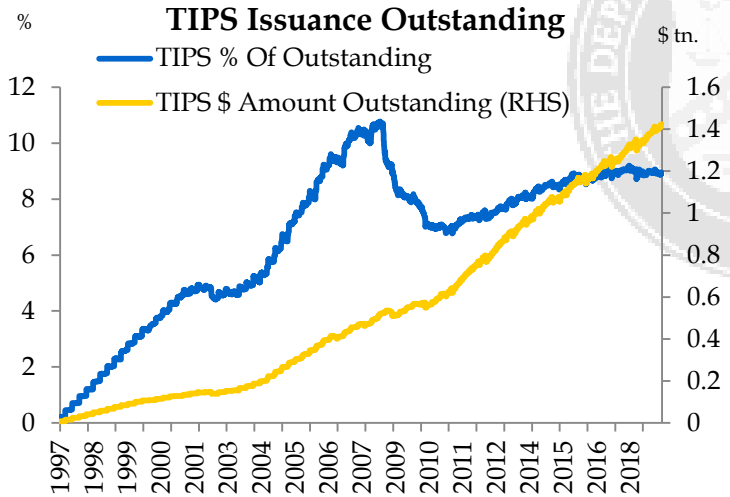
Office of Debt Management

TIPS Program Update

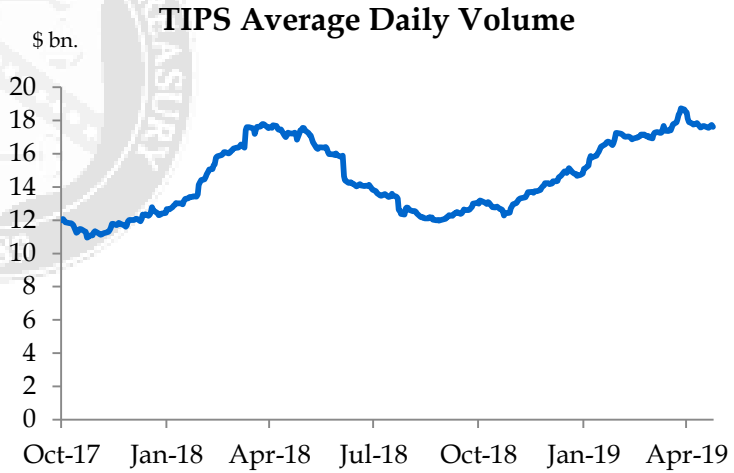
April 2019

TIPS Issuance Review

- TIPS represent over $1.4 trillion in inflation adjusted principal or just under 9 percent of marketable borrowing outstanding
- TIPS daily trading volume averages around $15 billion
- The TIPS program has saved the taxpayer money over the life of the program



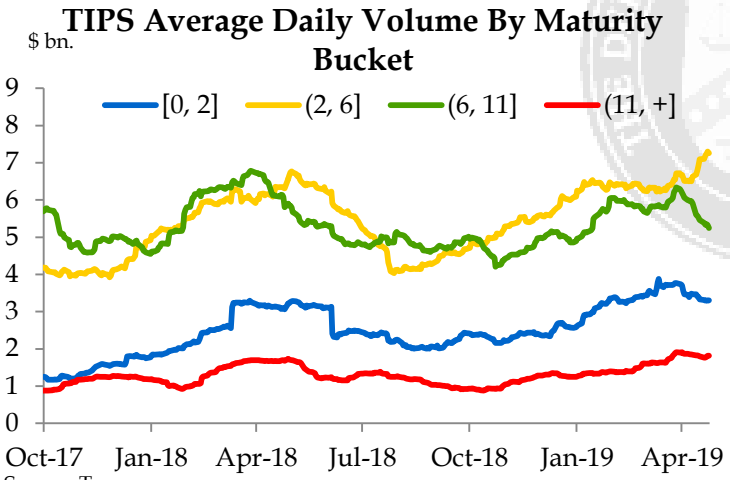
Source: Treasury
Note: TIPS % is in par value terms; $ amount inclues CPI accual



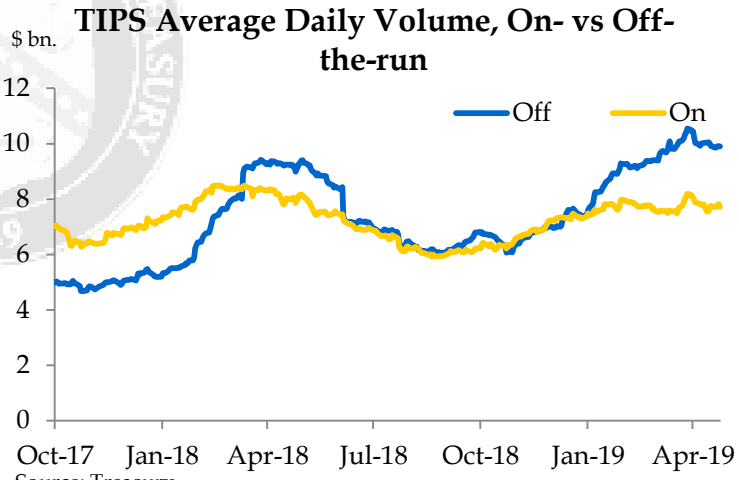
Source: Treasury
Note: 60-day MA; effective trading day is from 6pm- 6pm.

TIPS Liquidity

- Trading volumes in the five-year portion of the curve rival those in the 10-year
- Off-the-run trading volumes are similar to those in on-the-run, though with lower turnover



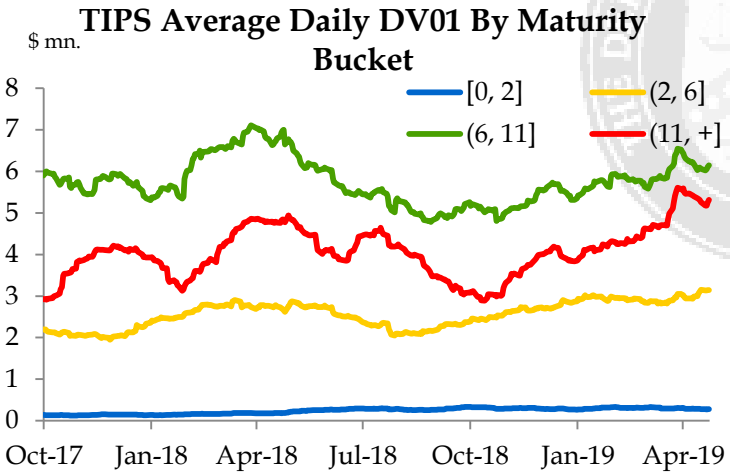
Source: Treasury
Note: 60-day MA; effective trading day is from 6pm- 6pm.



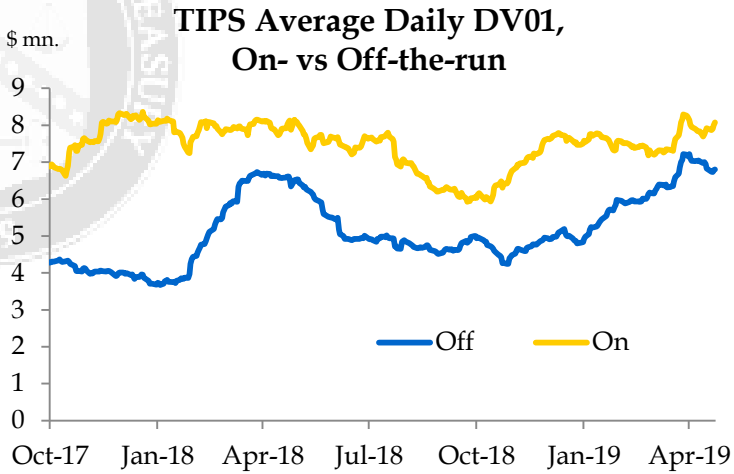
Source: Treasury
Note: 60-day MA; effective trading day is from 6pm- 6pm.

TIPS Ability to Move Risk

- Trading in DV01 terms has improved for longer-dated TIPS
- On-the-runs still dominate off-the-runs in daily DV01



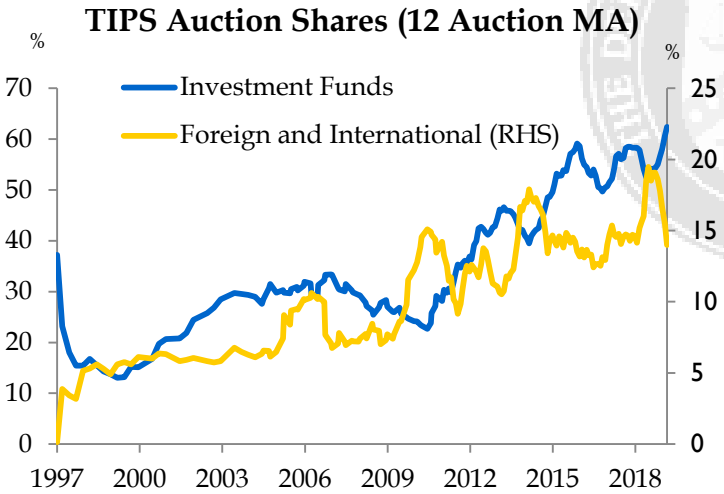
Source: Treasury
Note: 60-day MA; effective trading day is from 6pm- 6pm.



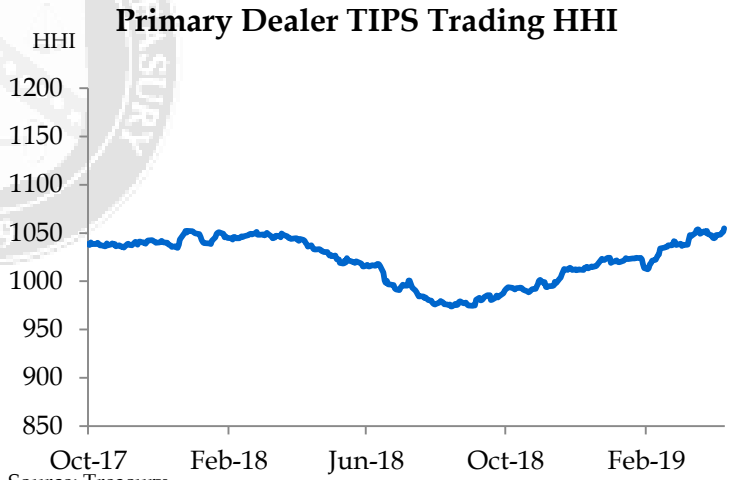
Source: Treasury
Note: 60-day MA; effective trading day is from 6pm- 6pm.

TIPS Investor Diversification

- Auction participation from investment funds and foreign investors has increased
- Concentration of liquidity providers has stabilized at a competitive level



Source: Treasury

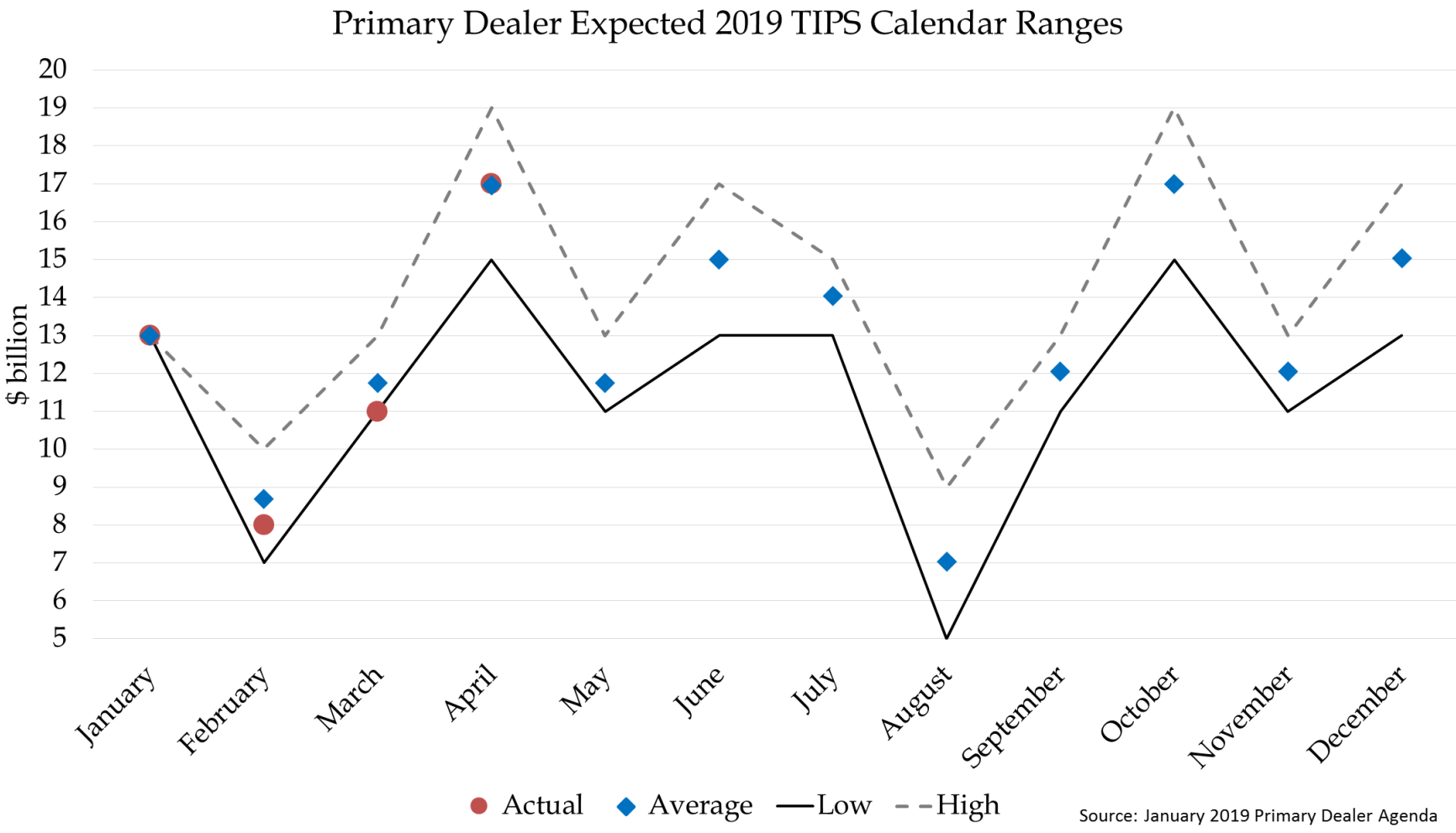


Source: Treasury
Note: 120-day MA; effective trading day is from 6pm- 6pm.

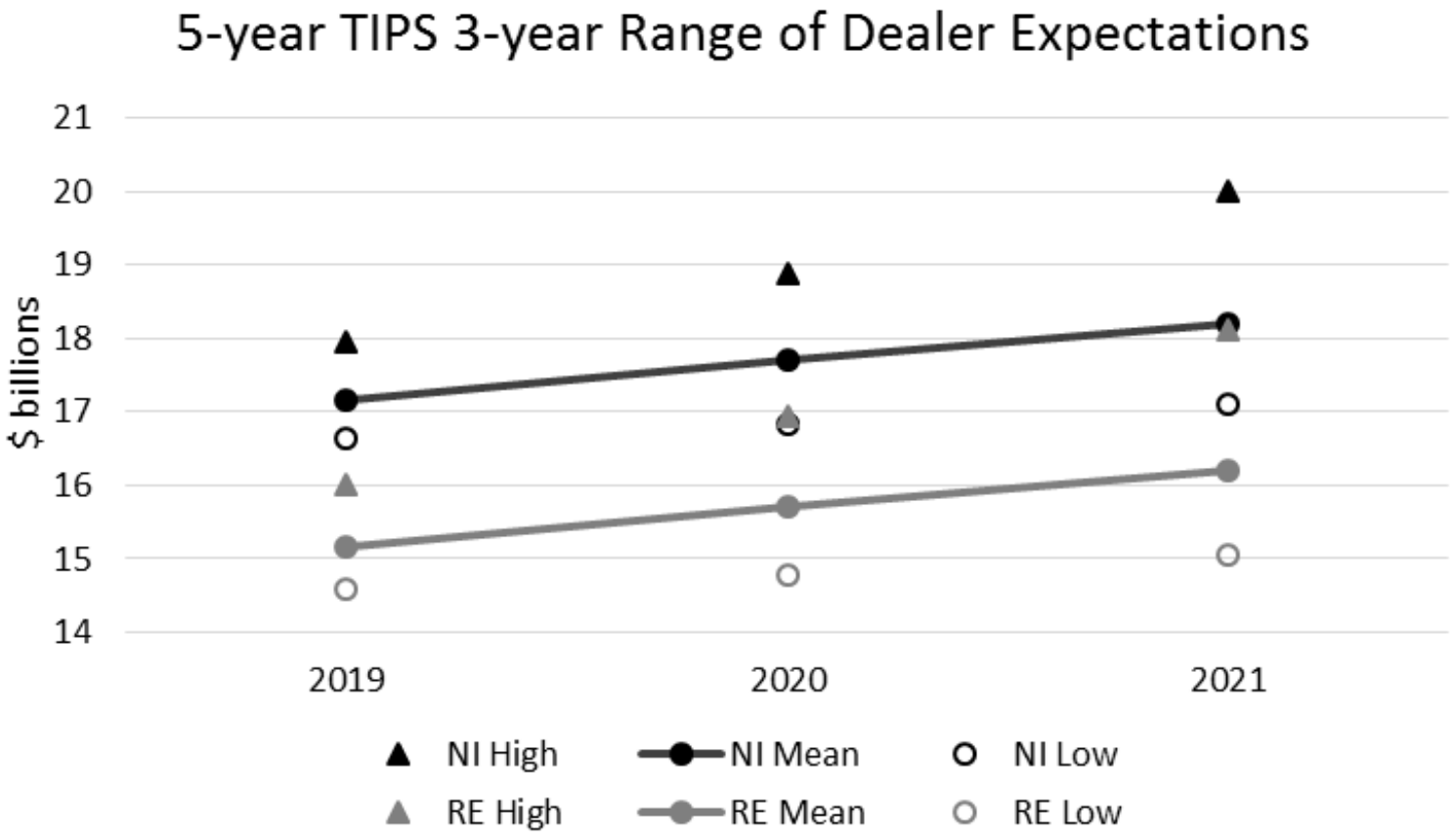
Announced TIPS Calendar Enhancements for 2019

- Introduced a second 5-year new issue in October and increased auction sizes in order to:
  - Reduce gaps in the TIPS yield curve
  - Improve liquidity and the pricing of inflation seasonality
  - Facilitate curve and breakeven positions
  - Reduce concentration of rebalancing needs
  - Meet structural demand for 5-year TIPS from
    - Fund flows into shorter-dated ETFs and mutual funds as well as target date funds
    - Investors with a preference for more pure inflation protection vs real yield duration
- Share of TIPS issuance will now be more balanced between 5-year and 10-year maturities and across calendar quarters
- The 30-year TIPS will now auction every 6 months with increased auction sizes to maintain a stable float
- TIPS auctions have been well received since the announced changes
- Overall TIPS issuance will increase to maintain proportion of outstanding

TIPS 2019 Auction Calendar Size Expectations

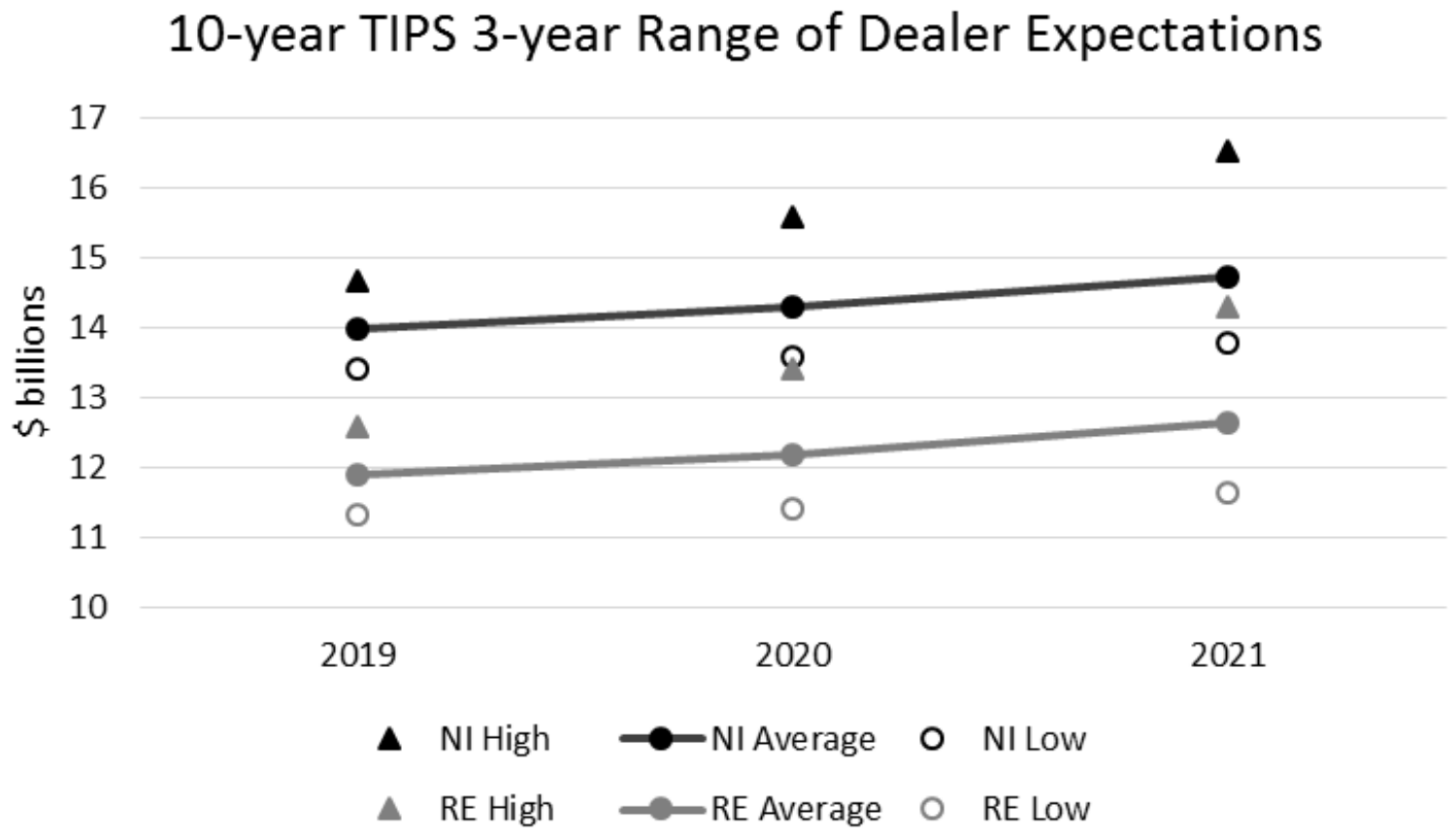


TIPS Auction Calendar Expectations 2019 - 2021



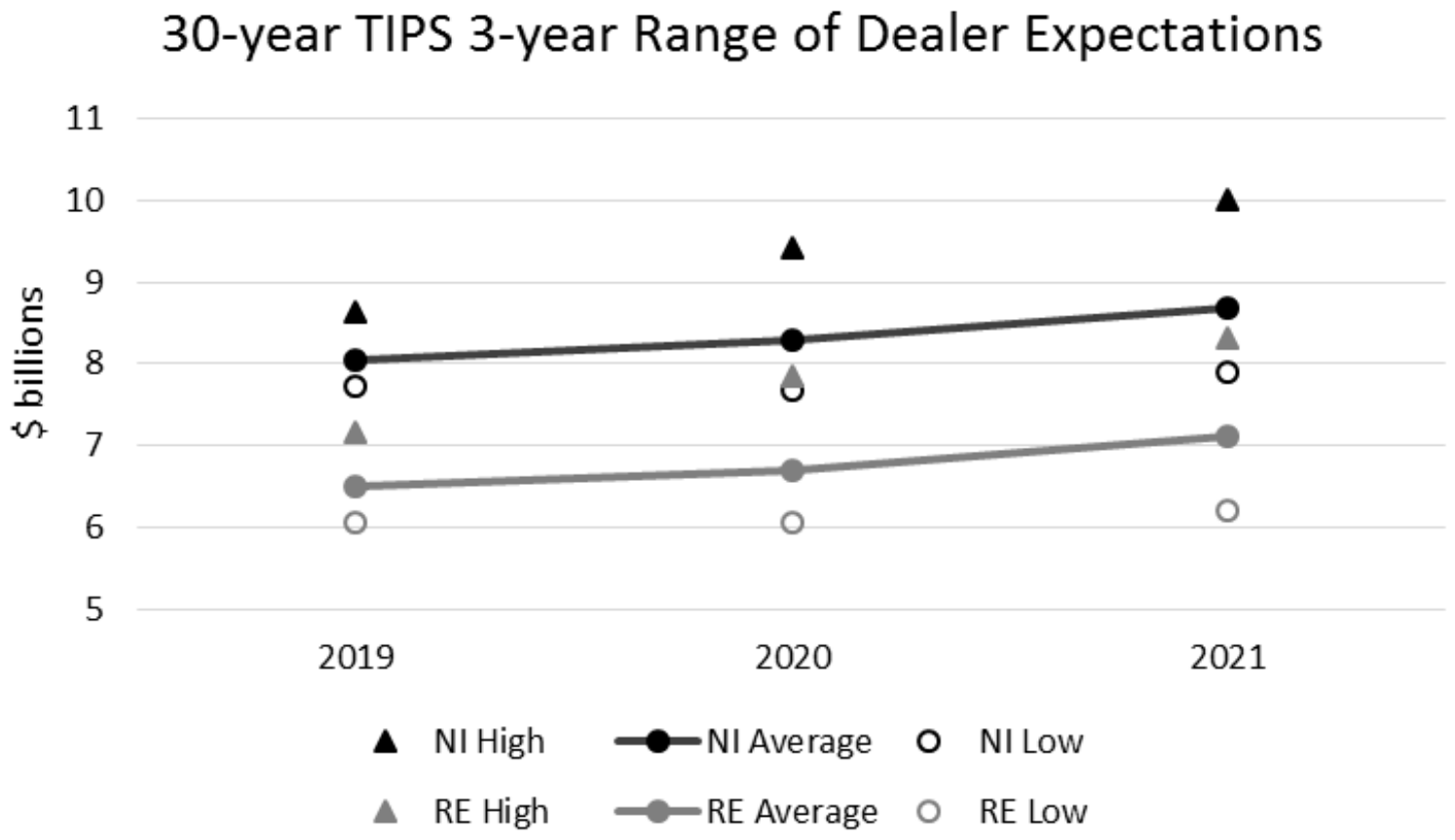
Source: April Primary Dealer Auction Size Survey

TIPS Auction Calendar Expectations 2019 - 2021



Source: April Primary Dealer Auction Size Survey

TIPS Auction Calendar Expectations 2019 - 2021



Source: April Primary Dealer Auction Size Survey

April 2019

TBAC – Charge One SOFR Pricing

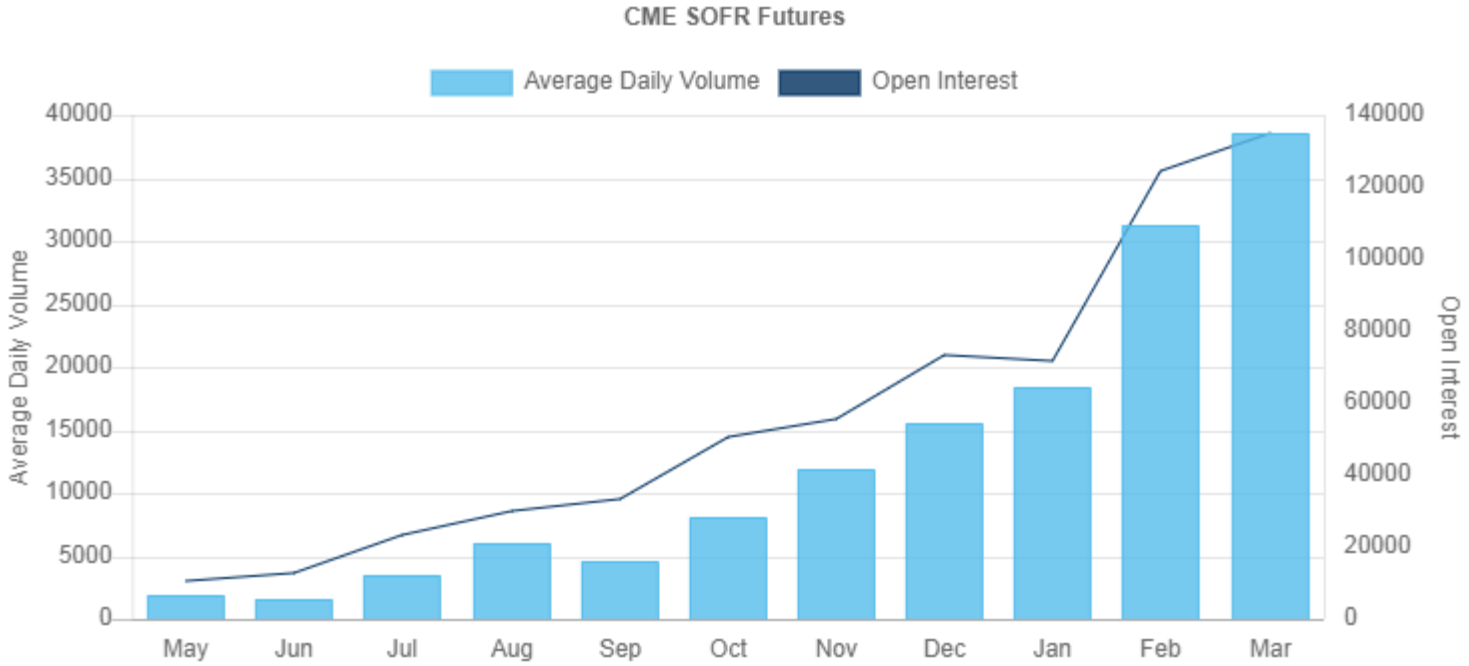
The Charge

Treasury continues to evaluate the possibility of issuing floating rate notes tied to SOFR; one important component of this evaluation pertains to market pricing. How should Treasury model expected interest costs for potential SOFR-linked issuance? How has existing SOFR-linked issuance by other issuers priced compared to expected 'fair value'? What factors have affected pricing of existing issuance and what factors do you expect to be most important going forward? Are there any lessons regarding product structure that Treasury can draw from SOFR-linked issuance to-date?

Executive Summary

- There has been a significant increase in SOFR FRN issuance recently
- We estimate current Treasury SOFR FRN pricing as low as
  - + 1 bps DM for 1-year FRN
  - + 3 bps DM for 2-year FRN
- Based on this estimate, and using current forward curves, it would NOT cost the Treasury more to issue SOFR FRN rather than T-bill FRN
- We expect greatest demand from 2a7 government only money market funds, focused on the 1-year maturity.
- We estimate the Treasury could (cumulatively) issue up to $250 billion 1-year SOFR FRN without cannibalizing demand from other Treasury securities.
- 2-year SOFR FRN could cannibalize demand from T-bill FRN due to 2A7 fund WAL constraints.

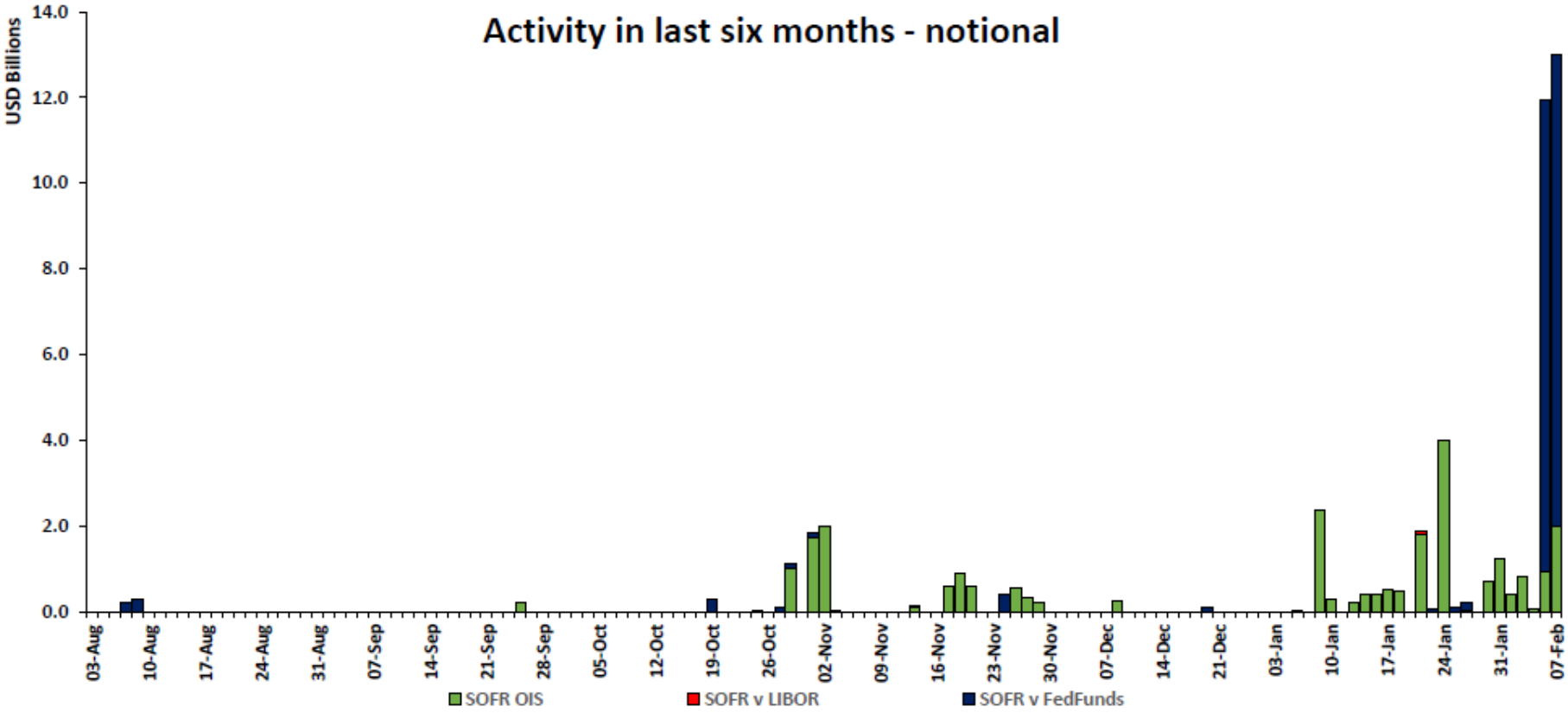
SOFR Futures Markets



- Source : CME

SOFR Swap Markets

Growth primarily in SOFR vs FF swaps



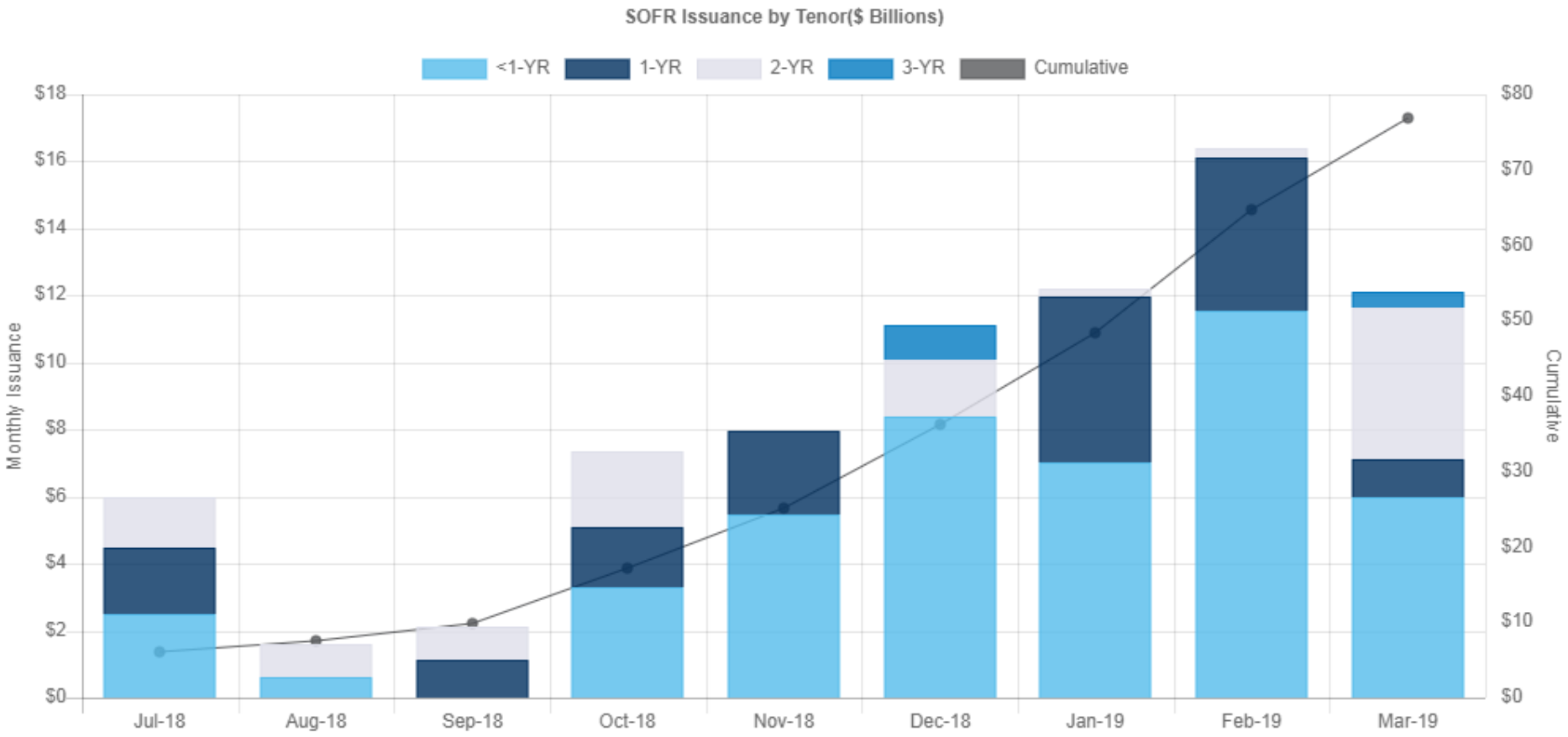
Total since inception		
Trade type	Notional	Trades
SOFR OIS	25,162,200,000	248
SOFR v LIBOR	210,000,000	4
SOFR v FedFunds	24,716,000,000	66

- Source : LCH

SOFR Cash Issuance

SOFR Issuance

23 institutions have issued a total of $77 billion notional in floating rate instruments tied to SOFR, including a monthly high of $16.4 billion in February 2019.



- Source : CME

Comparing SOFR FRN vs T-Bill FRN
Forward breakeven estimates using current futures and swaps markets

Estimate of 1-year Interest cost (0 DM)

US T-Bills	
3m	2.359
3m3m	2.384
6m3m	2.252
9m3m	2.338
12mo Price:	**2.333**

OIS	
3m	2.405
3m3m	2.339
6m3m	2.264
9m3m	2.201
12mo Price:	**2.302**

SOFR FUTURES	
SFRH9	2.455
SFRM9	2.395
SFRU9	2.315
SFRZ9	2.238
12mo Price:	**2.351**

Source: Bloomberg, (as of 4/25/19)

Estimate of 2-year Interest cost (0 DM)

US T-Bills	
3m	2.359
3m3m	2.384
6m3m	2.253
9m3m	2.337
12m3m	2.229
15m3m	2.212
18m3m	2.201
21m3m	2.104
2-year Price:	**2.260**

OIS	
3m	2.405
3m3m	2.339
6m3m	2.264
9m3m	2.201
12m3m	2.171
15m3m	1.950
18m3m	2.005
21m3m	1.980
2-year Price:	**2.164**

SOFR FUTURES	
SFRH9	2.455
SFRM9	2.395
SFRU9	2.315
SFRZ9	2.238
SFRH0	2.158
SFRM0	2.077
SFRU0	2.012
SFRZ0	1.977
2-year Price:	**2.203**

Source: Bloomberg, (as of 4/25/19)

Breakeven Rate: Discount Margin on 1-year SOFR Floater would need to be 2bps *less* than 3-month Bill Floater (using SOFR futures)

Breakeven Rate: Discount Margin on 2-year SOFR Floater could be 6bps *more* than 3-month Bill Floater (using SOFR futures)

Indicative DM on Treasury T-Bill Floating Rate Note (TF) as of 04/25/19

Floating Rate Notes			
31) TF 419	2.5 / 0.1	0.000	--
32) TF 719	2.5 / 0.6	0.000	+0.3
33) TF 019	2.7 / 0.8	0.000	-0.9
34) TF 120	3.1 / 1.5	0.000	-0.9
35) TF 420	3.7 / 2.2	0.000	-1.1
36) TF 720	4.6 / 3.0	0.000	-2.6
37) TF 020	10.6 / 9.4	0.000	+0.5
38) TF 121	12.1 / 10.6	0.000	-0.2
39) TF 421	14.3 / 13.3	0.000	--
40) WITF	/	0.000	-13.3

Source: Bloomberg.

- Current TF 04/20 (1-year) DM mid ~ 3.0 bps
- Current TF 04/21 (2-year) DM mid ~14 bps (though this is wide relative to long term average)
- Based on prior estimate of bills/SOFR spreads, current break even for Treasury SOFR FRNs are:
  - 1-year ~ 1 DM (3-2)
  - 2-year ~20 DM (14+6)

Treasury SOFR FRN pricing based on GSE SOFR FRN New Issue Levels

AGENCY Floating Rate Note Market as of 4/25/19					
			3ml Equivalent		
Tenor (Months)	Current SOFR DM	SOFR/LIBOR Basis	1mL	3mL	SOFR
6	1	16	-17	-16	-15
9	2	18	-17	-17	-16
12	4	20	-17	-17	-16
18	6	20	-14	-14	-15
24	6	20	-10	-11	-14

Source: Bloomberg

- Agency SOFR FRN new issue levels are fair to Libor FRN levels (after accounting for month-end and cost of LIBOR widening option)
- Using current Treasury – Agency spread of 3 bps, we estimate Treasury SOFR FRN pricing as low as:
  - 1-year DM ~+1 bps
  - 2-year DM ~+3 bps
- Hypothetical levels should move in line with market differentials (GSE new issue levels and Agency-Treasury spreads)
- GSE issuance >12 months has been limited and may not be reflective of investor demand or execution levels

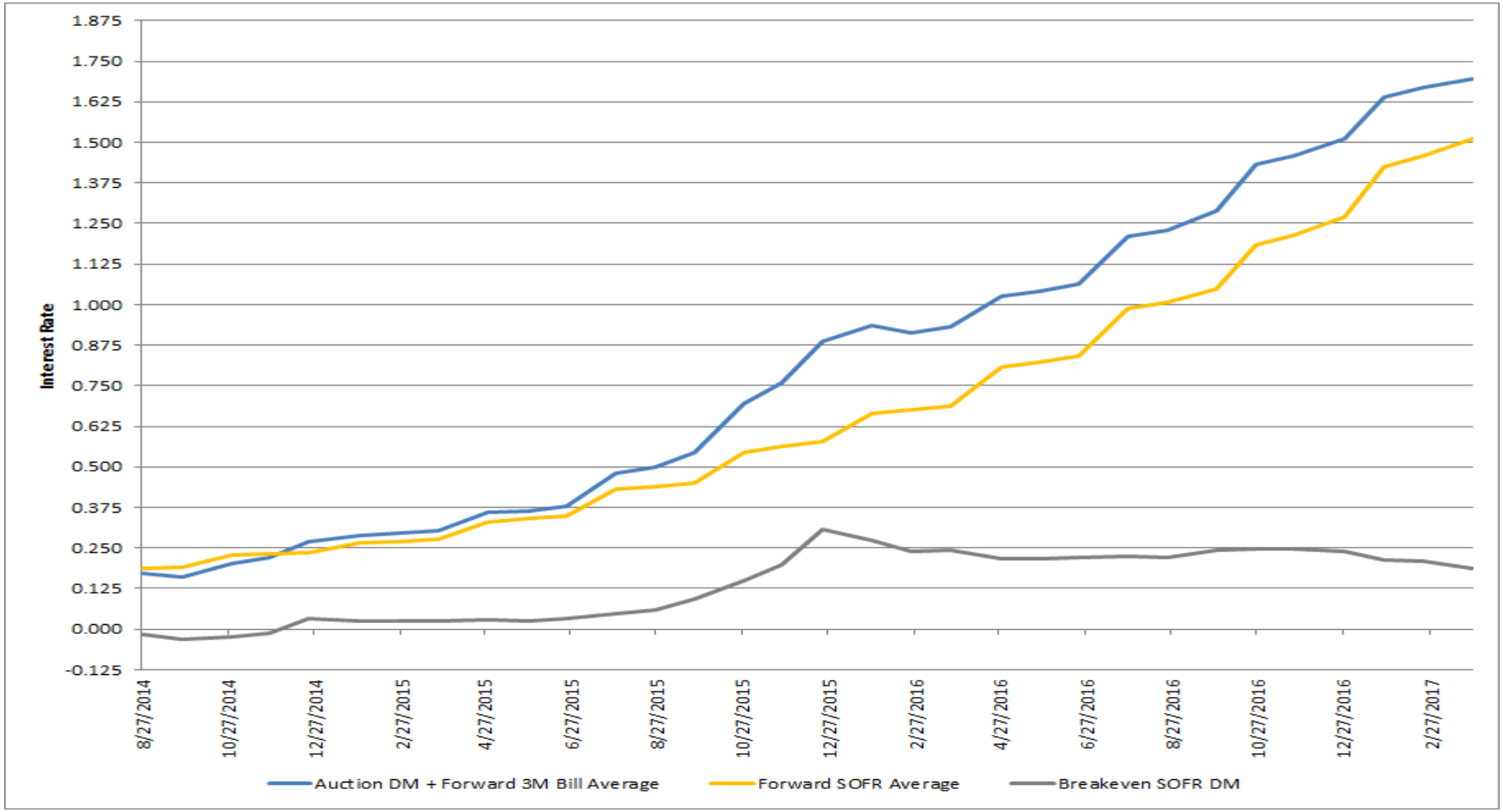
Given the breakeven estimates on previous slide which are based on current market levels, a SOFR FRN should not cost the Treasury more than a T-Bill FRN

Historical GSE FRN New Issue Levels

Date	Ticker	Size ($Bn)	Tenor (Month	Spread
1/9/2019	FHLMC	0.55	6	1
1/10/2019	FHLMC	1.20	3	0
1/11/2019	FHLMC	0.34	6	1
1/17/2019	FHLB	1.00	12	5
1/17/2019	FHLB	1.75	6	2
1/17/2019	FHLMC	1.00	3	-1
1/24/2019	FHLB	1.50	18	7.5
1/25/2019	FHLMC	0.28	3	-2
1/30/2019	FNMA	2.00	18	6
2/5/2019	FHLMC	0.99	6	-1
2/6/2019	FHLMC	0.15	3	-2
2/8/2019	FHLMC	0.15	3	-2
2/13/2019	FHLB	1.50	9	1
2/13/2019	FHLB	1.00	3	-1
2/20/2019	FHLMC	1.32	3	-1
2/21/2019	FHLB	2.55	12	3.5
2/22/2019	FHLMC	0.95	3	-1
2/27/2019	FHLB	5.25	6	2
2/28/2019	FHLMC	1.00	12	2
3/5/2019	FHLMC	0.21	6	0.5
3/8/2019	FHLB	3.25	9	3
3/15/2019	FHLB	3.00	24	11.5
3/20/2019	FHLB	2.50	6	2.5
3/27/2019	FHLB	4.25	12	6.5
4/1/2019	FHLMC	0.54	6	3
4/5/2019	FHLMC	0.57	12	5.5
4/5/2019	FHLB	2.55	6	3
4/5/2019	FHLB	1.50	18	10.5

Comparing Actual Treasury T-Bill FRN to a hypothetical Treasury SOFR FRN (assumes 2-year Final Maturity)

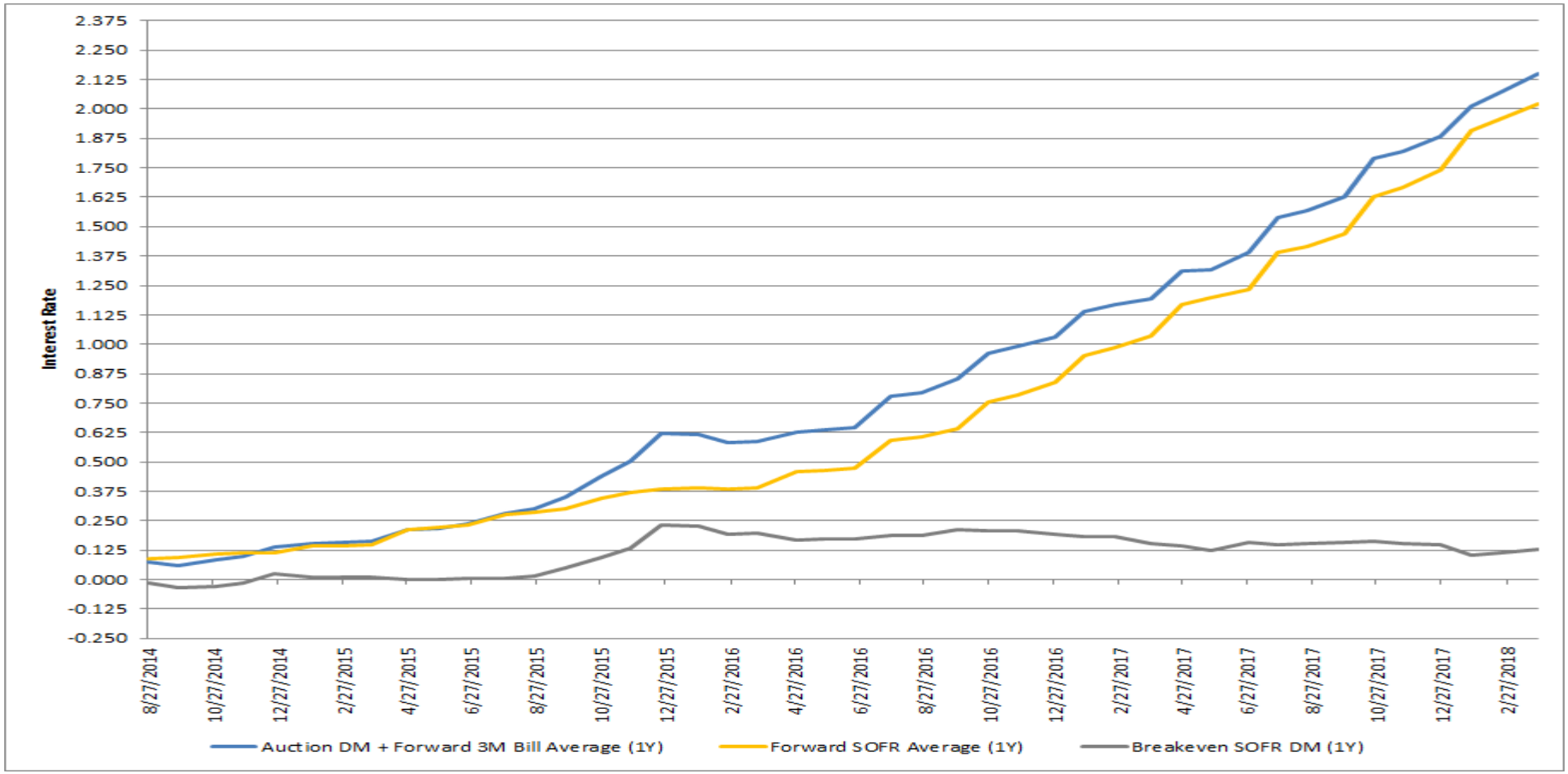
- The grey line shows the breakeven SOFR spread (discount margin) that would be needed at the time to compensate you for the difference in issuing a SOFR product versus actual Treasury T-Bill FRNs assuming 2-year final maturity



Source: Bloomberg

Comparing hypothetical Treasury T-Bill FRN to a hypothetical Treasury SOFR FRN (assumes 1-year Final Maturity)

- The grey line shows the breakeven SOFR spread (discount margin) that would be needed at the time to compensate you for the difference in issuing a SOFR product versus actual Treasury T-Bill FRNs assuming 1-year final maturity
- During a tightening cycle likely beneficial to issue SOFR Floaters (auction discount margin would like be lower than breakeven discount margin) and opposite likely true during easing cycle



Source: Bloomberg

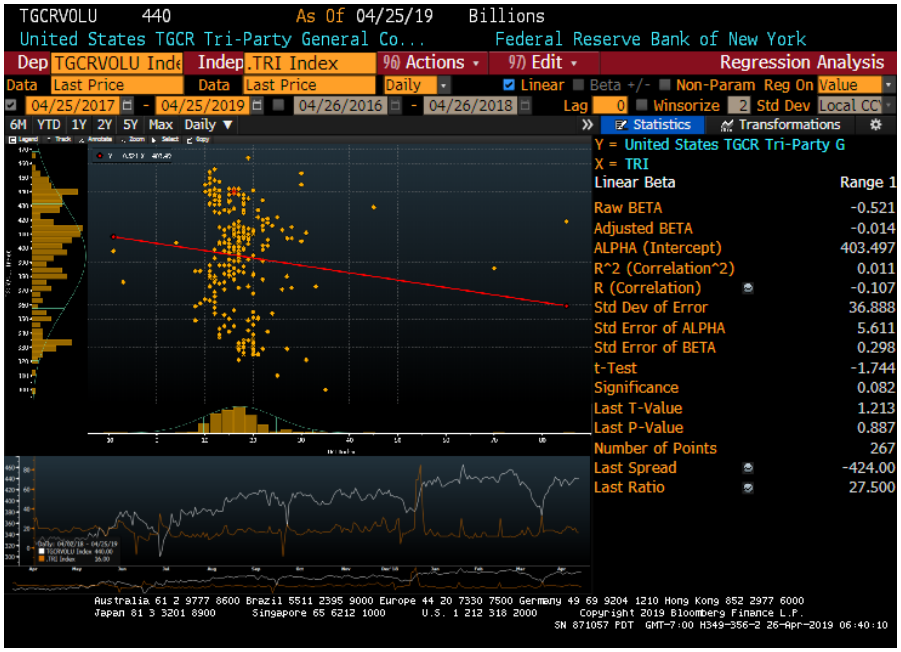
Estimating Month-/Quarter-/Year-end dynamics with SOFR: SOFR FRNs would yield an additional 0.25–0.50 bps per year

Year	Month	M/Q/Y	Avg 5d Before	End	Avg 5d After	Before Delta	After Delta	Average of Delta
2015	1	M	0.060	0.080	0.096	0.020	-0.016	0.002
2015	2	M	0.046	0.080	0.088	0.034	-0.008	0.013
2015	3	Q	0.110	0.200	0.130	0.090	0.070	0.080
2015	4	M	0.080	0.180	0.098	0.100	0.082	0.091
2015	5	M	0.070	0.130	0.118	0.060	0.012	0.036
2015	6	Q	0.088	0.170	0.106	0.082	0.064	0.073
2015	7	M	0.164	0.250	0.192	0.086	0.058	0.072
2015	8	M	0.148	0.220	0.152	0.072	0.068	0.070
2015	9	Q	0.104	0.230	0.102	0.126	0.128	0.127
2015	10	M	0.080	0.100	0.098	0.020	0.002	0.011
2015	11	M	0.076	0.170	0.130	0.094	0.040	0.067
2015	12	Y	0.350	0.450	0.362	0.100	0.088	0.094
2016	1	M	0.414	0.440	0.400	0.026	0.040	0.033
2016	2	M	0.350	0.400	0.352	0.050	0.048	0.049
2016	3	Q	0.354	0.420	0.362	0.066	0.058	0.062
2016	4	M	0.310	0.310	0.320	0.000	-0.010	-0.005
2016	5	M	0.276	0.350	0.346	0.074	0.004	0.039
2016	6	Q	0.532	0.630	0.410	0.098	0.220	0.159
2016	7	M	0.352	0.420	0.406	0.068	0.014	0.041
2016	8	M	0.370	0.460	0.394	0.090	0.066	0.078
2016	9	Q	0.548	0.890	0.468	0.342	0.422	0.382
2016	10	M	0.366	0.430	0.364	0.064	0.066	0.065
2016	11	M	0.260	0.270	0.260	0.010	0.010	0.010
2016	12	Y	0.506	0.480	0.526	-0.026	-0.046	-0.036
2017	1	M	0.532	0.600	0.536	0.068	0.064	0.066
2017	2	M	0.504	0.530	0.504	0.026	0.026	0.026
2017	3	Q	0.766	0.850	0.792	0.084	0.058	0.071
2017	4	M	0.798	0.900	0.798	0.102	0.102	0.102
2017	5	M	0.808	0.900	0.852	0.092	0.048	0.070
2017	6	Q	1.050	1.200	1.040	0.150	0.160	0.155
2017	7	M	1.040	1.080	1.014	0.040	0.066	0.053
2017	8	M	1.048	1.140	1.050	0.092	0.090	0.091
2017	9	Q	1.012	1.100	1.026	0.088	0.074	0.081
2017	10	M	1.058	1.100	1.088	0.042	0.012	0.027
2017	11	M	1.052	1.080	1.056	0.028	0.024	0.026
2017	12	Y	1.366	1.470	1.376	0.104	0.094	0.099
2018	1	M	1.340	1.380	1.300	0.040	0.080	0.060
2018	2	M	1.338	1.390	1.418	0.052	-0.028	0.012
2018	3	Q	1.704	1.800	1.774	0.096	0.026	0.061
2018	4	M	1.712	1.770	1.736	0.058	0.034	0.046
2018	5	M	1.716	1.810	1.760	0.094	0.050	0.072
2018	6	Q	1.912	2.120	1.966	0.208	0.154	0.181
2018	7	M	1.886	1.930	1.876	0.044	0.054	0.049
2018	8	M	1.942	1.970	1.944	0.028	0.026	0.027
2018	9	Q	2.176	2.250	2.192	0.074	0.058	0.066
2018	10	M	2.184	2.220	2.222	0.036	-0.002	0.017
2018	11	M	2.210	2.280	2.272	0.070	0.008	0.039
2018	12	Y	2.430	3.000	2.626	0.570	0.374	0.472
2019	1	M	2.398	2.580	2.406	0.182	0.174	0.178
2019	2	M	2.384	2.580	2.380	0.196	0.200	0.198
2019	3	Q	2.406	2.650	2.463	0.244	0.187	0.215

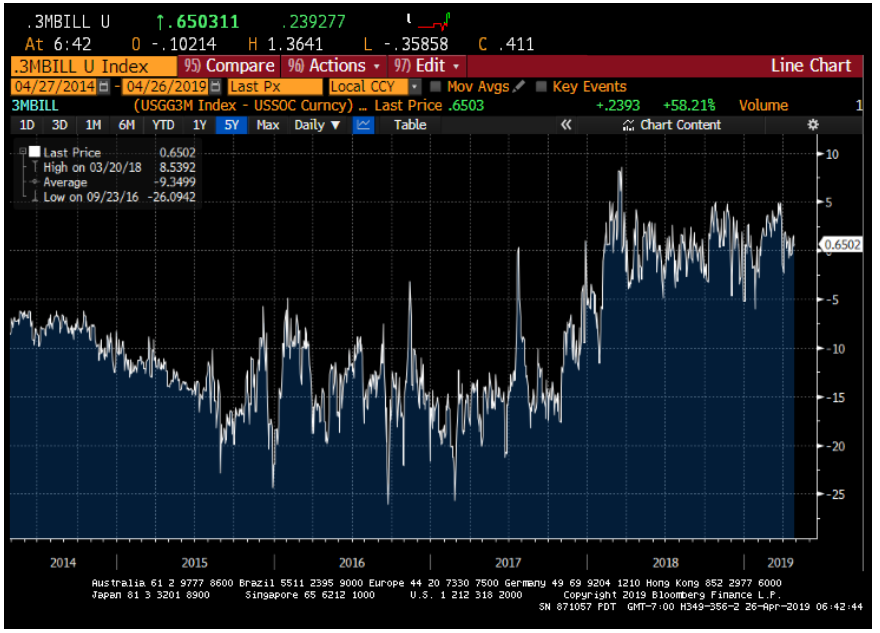
- Dealers look to reduce balance sheet at month-end increasing SOFR levels on month-end and most acutely at year-end
- On average SOFR has been higher on month-end than the average of the 5 trading days before and the 5 trading days after by:
  - Month-end Only: 5.4bps
  - Quarter-end: 13.2bps
  - Year-end: 15.7bps
- This spike would be approximately 0.25-0.5 bps of additional interest cost over the course of the year

Treasury Floater Introduction Did Not Materially Impact GC Repo Levels

- 2a7 Government Only Money Market Funds are the largest buyer of Treasury floaters
- Currently they hold approximately 50% of outstandings
- This had minimal impact on Treasury repo pricing when introduced
- Charts below shows a) almost no correlation between tri party repo volume and tri party repo rates vs FED RRP rate and b) no impact on T-Bill OIS spread after T-Bill FRN was introduced in Jan 2014
- We expect SOFR linked FRN introduction would also not have a significant impact on Treasury funding markets as there is currently un-met 2a7 demand for repo in bilateral markets



Source: Bloomberg



Source: Bloomberg

Estimating The Demand From 2a7 Government Money Market Funds

- 2a7 Funds could add a similar proportion of SOFR FRNs outstanding to their Bill FRN holdings by decreasing allocation to O/N Repo
- Assuming a 1-year final maturity, we estimate 2a7 funds could hold a large portion (>50%) without significantly impacting WAL
- Depending on size of SOFR program, a 2-year final maturity would see lower demand unless 2a7 Funds extend WAL above historical averages as WAL is typically below 100 days

WAL of 2a7 Govt Only Funds Assuming 1-year final maturity of SOFR FRN

% of Outstanding Held by Government MMF	SOFR FRN Total Outstanding ($Bn)							
	50	100	150	200	250	300	350	400
10%	85	86	86	87	87	87	88	88
20%	86	87	87	88	89	90	90	91
30%	86	87	88	90	91	92	93	94
40%	87	88	90	91	93	94	96	97
50%	87	89	91	93	95	96	98	100
60%	87	90	92	94	96	99	101	103
70%	88	90	93	96	98	101	104	106
80%	88	91	94	97	100	103	106	109
90%	88	92	95	99	102	106	109	113
100%	89	93	96	100	104	108	112	116

WAL of 2a7 Govt Only Funds Assuming 2-year final maturity of SOFR FRN

% of Outstanding Held by Government MMF	SOFR FRN Total Outstanding ($Bn)							
	50	100	150	200	250	300	350	400
10%	86	87	87	88	89	90	90	91
20%	87	88	90	91	93	94	96	97
30%	87	90	92	94	96	99	101	103
40%	88	91	94	97	100	103	106	110
50%	89	93	96	100	104	108	112	116
60%	90	94	99	103	108	113	117	122
70%	90	96	101	106	112	117	123	128
80%	91	97	103	110	116	122	128	134
90%	92	99	106	113	119	126	133	140
100%	93	100	108	116	123	131	139	146

Chart uses: CRANE GOVT INSTITUTIONAL Average WAL since 12/31/14: 85 days

Potential Repo Market Developments Could Affect The Pricing of SOFR-Linked Issuance

Mandate

1. Expansion of FICC Sponsored Repo
   - SOFR on last trading day of month-end / quarter-end would trade at a level closer to previous trading days. It would decrease volatility on last trading day and lower spikes in level.
   - SOFR would be marginally higher as increased volume by non-dealers in the bilateral repo market would be included in calculation
2. Implementation of the Basel proposal to report total leverage exposure as a daily average versus quarter-end snapshot
   - This would lower month-end spikes, however, SOFR would be permanently higher as dealers manage balance sheet on a daily basis.
3. Development of standing repo facility by the Federal Reserve (assumes 25bps above IOER)
   - The repo facility would cap the potential spike in SOFR at month-ends to whatever the rate on the facility was.

Mandate	Impact on Month-end Spikes	Overall Impact to SOFR level	Impact on Balance Sheet
1	Smaller spikes	Marginally higher	Increases
2	Smaller spikes	Higher	Lower
3	Smaller spikes	Unchanged	Marginally increases

Appendix

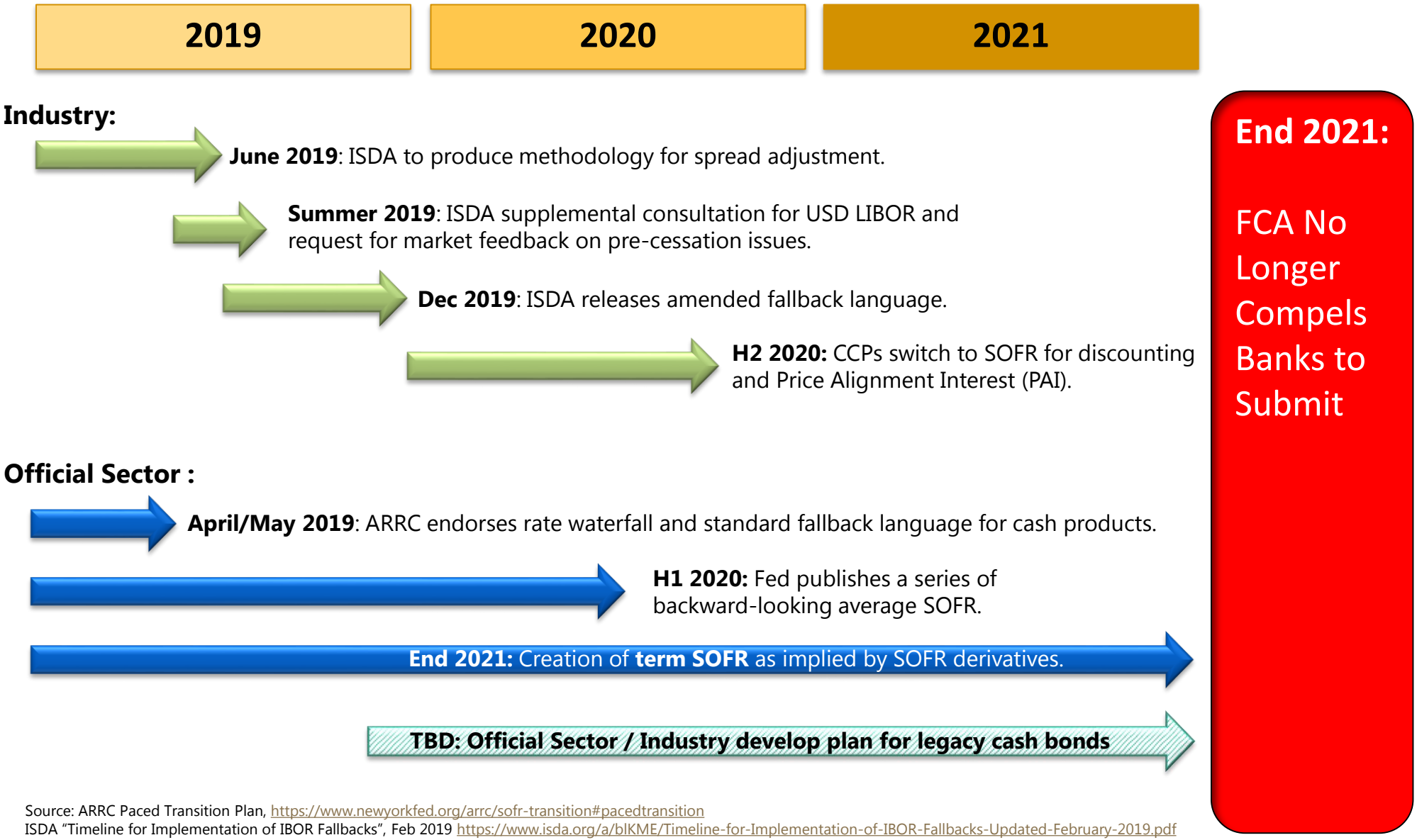
Progress on LIBOR transition since Nov 2018

Recent Developments in SOFR Transition

- Overall, while there has been increased focus on LIBOR transition, and some informative speeches from regulators, there has been limited realized progress in transitioning the US market.
- **Derivative Markets** – Continue to be the focus in order to foster familiarity, build liquidity and inform a forward looking term structure.
  - **Futures** market volumes and open interest at CME continue to grow.
    - Aggregate OI across 1m and 3m future exceeds 100k; OI has doubled since December 2018. Euro$ OI is 12.5mm, as reference.
  - **OIS Swaps** cleared in limited size (small DV01) with small number of total transactions.
  - **ISDA** published final results from their consultation on spread adjustment in December '18.
    - Overwhelming support for compounded setting in arrears with mean/median approach.
    - **Next deliverable is for ISDA to produce description of methodology this summer**. This will likely be followed by a public comment period. There will also be consultations for pre-cessation triggers and additional currencies.
  - CCPs (LCH, CME) announced they will **switch to SOFR discounting** and PAI (price alignment interest) from Fed Funds in 2nd half 2020. Intend to use 'big bang' approach with compensation.
- **Cash Markets** – Issuance ($77bln) primarily from agencies with limited secondary market liquidity.
  - ARRC endorsed fallback language for new issuance is expected to be published late April 2019.
  - Fed minutes noted staff work to **publish backward looking average SOFR**. Fed published staff working paper on methodology for forward looking term rate (infer from derivatives).
  - No progress in efforts to address legacy paper – amendment or legislative solution.

Source : CME, LCH, ISDA, ARRC

Timeline for LIBOR Transition



Source: ARRC Paced Transition Plan, https://www.newyorkfed.org/arrc/sofr-transition#pacedtransition
ISDA "Timeline for Implementation of IBOR Fallbacks", Feb 2019 https://www.isda.org/a/blKME/Timeline-for-Implementation-of-IBOR-Fallbacks-Updated-February-2019.pdf

ARRC Working Group Fallback Language for New Issues

- ARRC has tasked product focused working groups (FRN, Loans, Securitized, Consumer) with proposing fallback language that may be used in new LIBOR issuance.
- Enhanced fallback language will **provide greater certainty to investors** on what to expect if LIBOR were to be discontinued, and allow for continued performance of floating rate securities.
- The substantive elements of the fallback language are **(i) what triggers moving away from LIBOR and (ii) how the replacement rate is defined**.
- The working groups contemplated certain "pre-cessation" triggers, with some divergence between products.
  - The pre-cessation triggers are intended to provide a mechanism to move to a more appropriate rate for securities that are not otherwise easily amended.
  - ISDA had earlier decided **not to include** pre-cessation triggers but will be launching a follow-up consultation.
  - ARRC is focused on achieving alignment among all products and derivatives.
- **ARRC Triggers (**"pre-cessation" in blue, not currently in ISDA proposal**):**
  1. Public statement by administrator that it has ceased or will cease to provide LIBOR.
  2. Public statement by regulatory supervisor that administrator will cease to provide LIBOR.
  3. Public statement by regulatory supervisor that the benchmark is no longer representative.
  4. For securitized products only, underlying collateral in a deal moves to the alternative rate.

Source: ARRC "A User's Guide to SOFR" April 2019. https://www.newyorkfed.org/medialibrary/Microsites/arrc/files/2019/Users_Guide_to_SOFR.pdf
ARRC recommendations for More Robust Fallback language for New Issuance of LIBOR Floating Rate Notes and Syndicated loans, April 2019.
https://www.newyorkfed.org/medialibrary/Microsites/arrc/files/2019/FRN_Fallback_Language.pdf
https://www.newyorkfed.org/medialibrary/Microsites/arrc/files/2019/Syndicated_Loan_Fallback_Language.pdf

ARRC Working Group Fallback Language – Waterfall to Fallback Rates

- **Waterfall of Fallback Rates:**
  1. **Term SOFR** recommended by Relevant Governmental Body + Spread
  2. **Compound SOFR** + Spread
  3. Replacement rate recommended by Relevant Governmental Body + Spread
     - To address a scenario where SOFR has been discontinued, fallback to a rate selected by the Relevant Governmental Body (ARRC or similar) as a replacement for a SOFR-based rate.
  4. Replacement rate in ISDA Definitions + Spread
     - To address a scenario where SOFR has been discontinued and the relevant governmental body has not recommended a replacement , fallback to rate waterfall embedded in ISDA standard definitions at the time.
     - The ISDA Fallback Rate embedded in the current ISDA definition :
       1. Relevant Governmental Body recommended replacement for SOFR (#3 above)
       2. Overnight Bank Funding Rate ("OBFR")
       3. FOMC Target Rate
  5. Replacement rate determined by issuer or its designee + Spread
- **"Replacement Floating-Rate Spread**" means, in respect of any interest reset date:
  1. Spread recommended by Relevant Governmental Body.
  2. ONLY if benchmark rate matches selected ISDA rate, then Spread in fallbacks for derivatives in ISDA definitions.
  3. Spread determined by issuer or its designee.

Source: ARRC "A User's Guide to SOFR" April 2019. https://www.newyorkfed.org/medialibrary/Microsites/arrc/files/2019/Users_Guide_to_SOFR.pdf
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Considerations for Cash Products referencing SOFR – Compounding vs Simple Averaging

- While recent issuance has utilized a simple average methodology, there has been consideration for utilizing a compounded average approach for calculating SOFR interest over a term.
  - For compounding:
    - To provide economic equivalence with the interest applicable for a deposit held in a bank account for the same period and rolled daily in overnight markets.
    - Aligns with established market practice for SOFR-referencing derivatives, including OIS market. This is **preferable for hedging purposes.**
    - May reduced risk of international liquidity fragmentation as SONIA-referencing products generally use a compounded average approach.
    - If the **Fed publishes a compounded rate**, that rate may be used as a reference across markets providing both consistency and reducing operational issues.
  - For simple averaging:
    - The formula is less complex and may be easier to include in interest calculation systems. This concern is reduced once the Fed publishes a compounded rate.
    - Some degree of market familiarity with simple average given recent issuance utilizing this approach in US markets.

Source: ARRC "A User's Guide to SOFR" April 2019. https://www.newyorkfed.org/medialibrary/Microsites/arrc/files/2019/Users_Guide_to_SOFR.pdf

Recap of Important Recent Speeches

- **Financial Stability Board (FSB) letter to ISDA** – March 12, 2019
  - FSB provided feedback on the transition process while escalating/encouraging a consultation to add an additional trigger for derivatives.
  - The trigger being contemplated is one in which the **regulatory authority (FCA in case of LIBOR) would decide that LIBOR is no longer a representative rate** and should not be used for new contracts.
  - The letter acknowledges that a critical benchmark could continue if its discontinuation creates disruption in existing contracts. However, if such a determination is made then EU supervised entities would not be able to use the benchmark for **new** derivative trades or securities.
- **Michael Held (NY Fed) speech at SIFMA lunch** – February 26, 2019
  - Escalated that firms should be assessing potential vulnerabilities if LIBOR ceased to be published.
- **Megan Butler (FCA) speech to Investment Association** – February 21, 2019
  - Escalated potential risk exposures for **asset managers**, including transition of derivatives as liquidity moves to risk free rates and 'uncertainty premium' impacting value of bonds linked to LIBOR.
- **Edwin Schooling Latter (FCA) speech at ISDA Legal Forum** – January 28, 2019
  - Suggests that the end-game for LIBOR may be an assessment by the FCA that the rate is no longer representative, which should be considered in derivative (ISDA) fallbacks.
  - Offers solution to address potential disruption in cash markets **by allowing continued publication of LIBOR** for use in legacy instruments which do not have mechanism to remove that dependency. This suggests regulators are differentiating between cash and derivatives in assessing risk.

Source: "FSB letter to ISDA about derivative contract robustness to risks of interest rate benchmark discontinuation", March 2019 http://www.fsb.org/wp-content/uploads/P150319.pdf
"Michael Held: SOFR and the transition from LIBOR", March 2019 https://www.bis.org/review/r190318f.pdf
"Ending reliance on LIBOR: Overview of progress made on transition to overnight risk-free rates and what remains to be done" Megan Butler, Feb 2019
https://www.fca.org.uk/news/speeches/ending-reliance-libor-overview-progress-made-transition-overnight-risk-free-rates-and-what-remains
"LIBOR transition and contractual fallbacks" Edwin Schooling Latter, Jan 2019 https://www.fca.org.uk/news/speeches/libor-transition-and-contractual-fallbacks

Summary of ISDA Final Report on Benchmark Fallbacks Consultation (1 of 2)

- 147 unique entities provided responses with overwhelming support for 2 of the 9 possible combinations for term adjustment and spread approach.
  - The other possible approaches received support from only 7 or fewer respondents.
- **The majority of respondents, 60% or 86 of 142, favored compounded setting in arrears with historical mean/median approach**.
- The next most favored approach is the compounded setting in arrears with forward approach with 41 votes of support (29%).
- Taking the term adjustment and spread approach separately, 90% of respondents preferred compounded setting in arrears for term adjustment and 70% preferred historical mean/median for spread adjustment.
  - **Noted benefits of historical mean/median approach include (i) it is robust and simple, (ii) it would reduce the potential for manipulation and (iii) resistant to market distortions**.
  - Respondents commented on valuation and operational complexities associated with the forward approach.
- In total, the responses most commonly represented bank/broker entities (38% of entities responded), pension funds (19%) and asset managers (13%).
- Although the historical mean/median was the preferred approach there were some concerns expressed regarding additional complexity introduced by the 1-year transition period as proposed by ISDA in the consultation (transitioning from current forwards to historical mean over the course of 1 year).

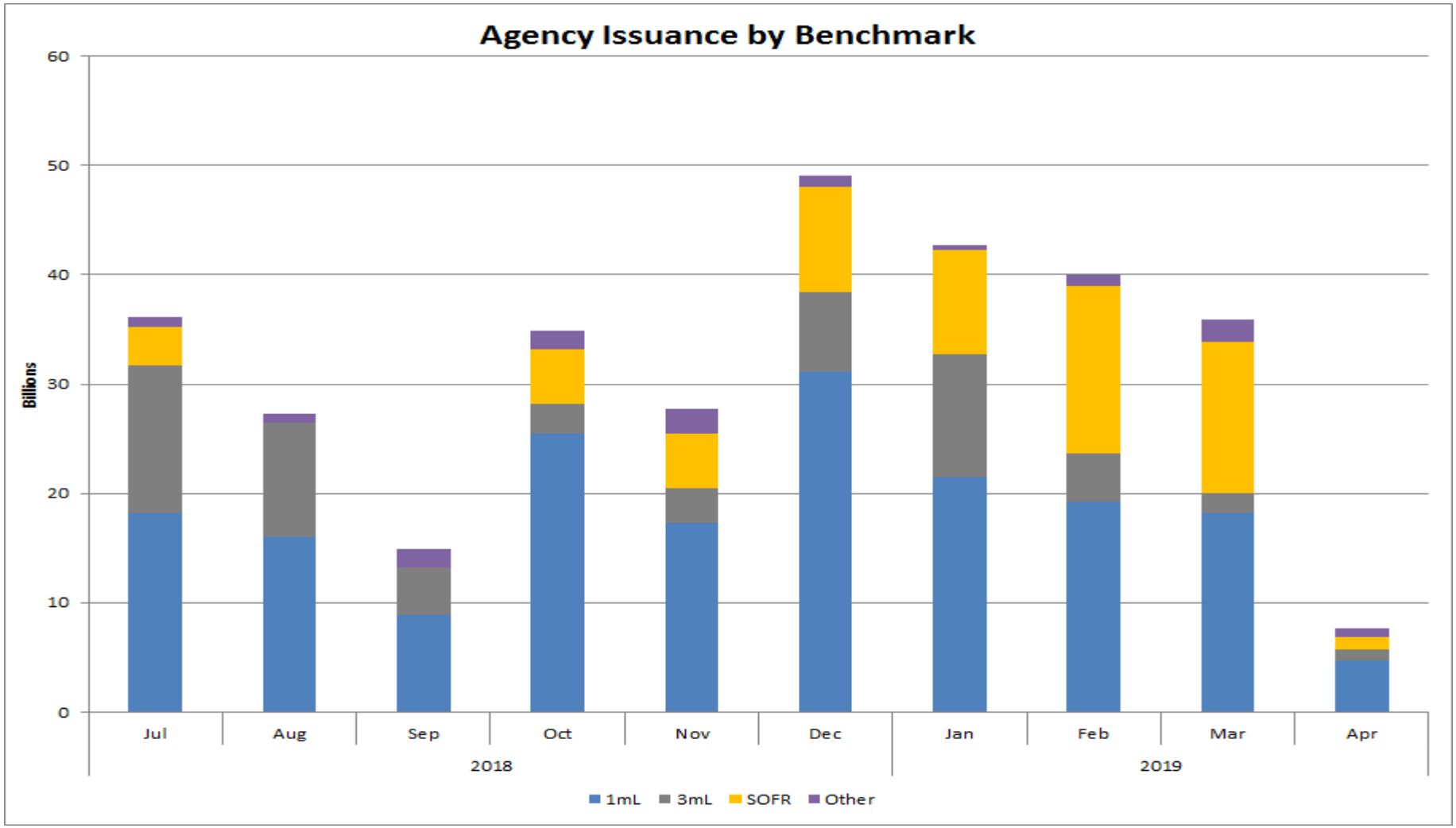
Source: Anonymized Narrative Summary of Responses to the ISDA Consultation on Term Fixings and Spread Adjustment Methodologies, Dec 2018
http://assets.isda.org/media/04d213b6/db0b0fd7-pdf/

Summary of ISDA Final Report on Benchmark Fallbacks Consultation (2 of 2) – Specification of historical mean/median approach

- The report notes that ISDA will continue to work with its independent advisors on the specification including performing sensitivity analysis on the range of potential parameters and expects to solicit additional feedback from market participants on a calculation method.
- Historical Mean/Median Approach:
  - **49% of respondents preferred the median** while 19% preferred the mean. The report states that ISDA considers these percentages informative but not dispositive.
  - One bank noted that the median provides greater certainty on the eventual outcome sooner which could increase the changes of successful adoption and a smooth transition process.
  - A European pension fund preferred a trimmed mean to address the issue of potential outliers.
  - In terms of the look back period, **50% of respondents selected a 5-year lookback, 20% selected 10-year** with the remaining selecting neither.
  - One dealer suggested a dynamic lookback period that is unknown to the market in order to introduce additional uncertainty and encourage voluntary transition in advance of a fallback trigger.
  - Another dealer suggested applying a time decay function (exponential weighting) to give more weight to recent periods.
  - Others suggested a blend of longer and shorter lookback periods and setting a fixed starting date rather than a fixed-length window.
- The **majority of respondents (78%) preferred using the same methodology across all benchmarks**. Operational concerns were cited as the major reason for supporting a consistent methodology (cross currency swaps etc).
- Other concerns regarding the fallback include the pricing of FRAs for a compounded in arrears term rate as well as the fact that the alternative rates are generally not known until T+1 and payments would need to be delayed to account for the day lag.

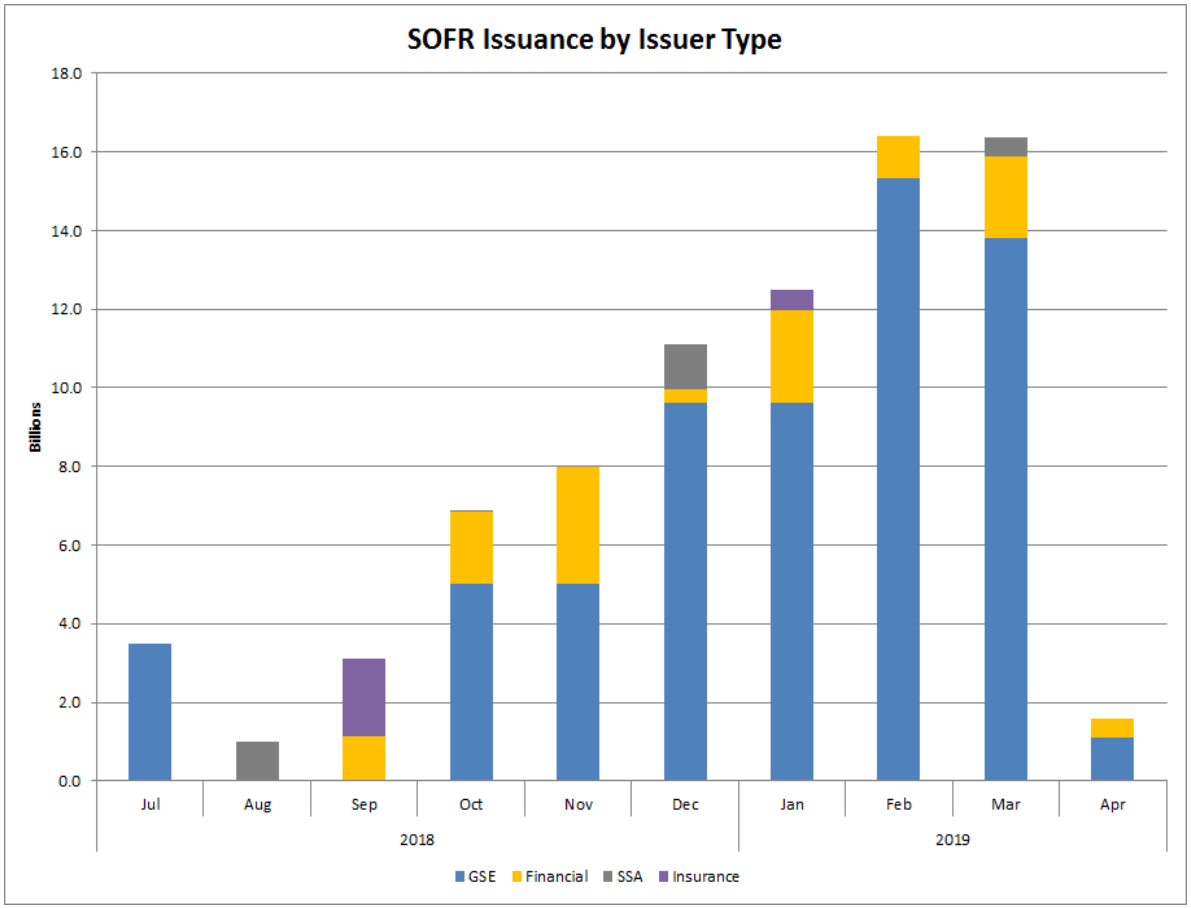
Source: Anonymized Narrative Summary of Responses to the ISDA Consultation on Term Fixings and Spread Adjustment Methodologies, Dec 2018
http://assets.isda.org/media/04d213b6/db0b0fd7-pdf/

Agency Issuance By Benchmark

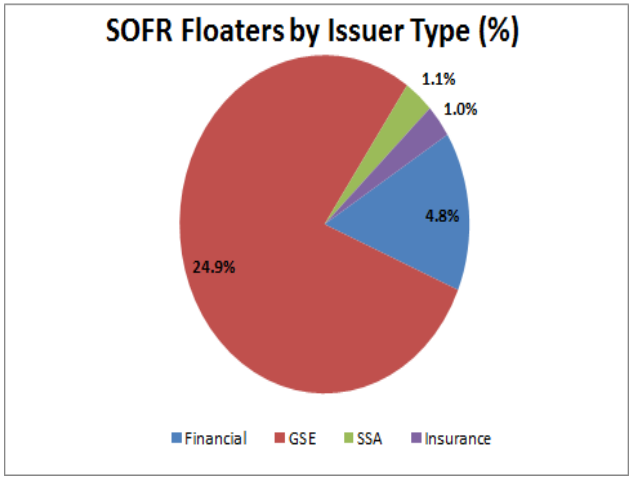


Source: Bloomberg

SOFR Issuance By Issuer Type



Source: Bloomberg



Source: Bloomberg

Fixed vs. Floating Rate Treasury Securities

April 30, 2019

Charge question

April 30, 2019

- Please comment on the optimal funding mix of fixed versus floating rate securities including the primary relevant factors to consider.

Executive summary

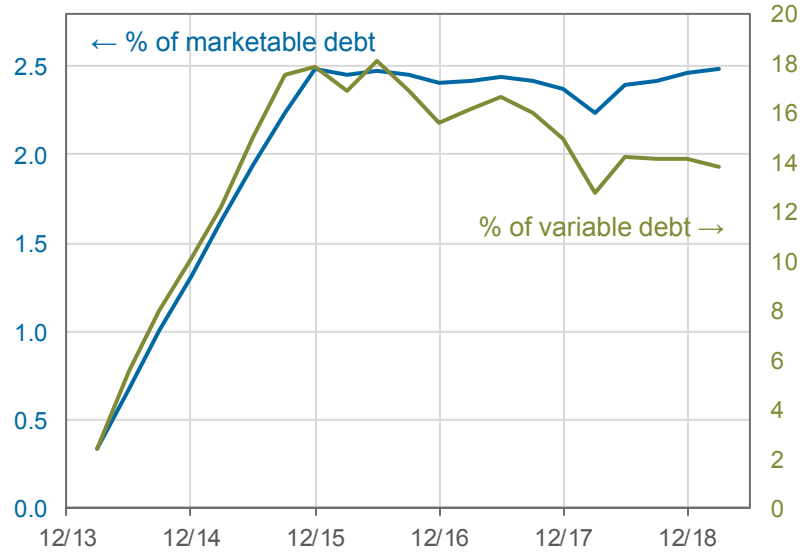
- FRNs are attractive to a broad set of investors and allow the Treasury to diversify its investor base
  - Treasury auction statistics show stronger end user demand for this product than Treasury bills; FRNs are also priced attractively relative to 2-year nominal Treasuries on an asset swap basis
- In considering the optimal funding mix of floating rate versus fixed rate debt, we highlight recent work by TBAC on debt optimization
  - Across a broad set of inputs/assumptions, TBAC's debt optimization model generally highlights **a favorable risk/return tradeoff from reducing the allocation to variable rate debt** (bills and FRNs) and increasing the allocation to short/intermediate fixed rate debt; in large part, this reflects the current negative term premium in the yield curve
  - Beyond the debt optimization model, we also note that Treasury's allocation to variable rate debt is quite high in comparison to all other DM issuers
- We also consider the optimal funding mix between bills and FRNs comparing the tradeoffs between the higher cost of FRNs and the reduced rollover risk compared to bills; while this work highlights the benefits of FRNs, on balance, **it does not strongly support increased issuance at the current time. Instead, for a broad range of risk parameters, the model favors TIPS and intermediates as better tools to reduce rollover risk**
  - In assessing the optimal funding mix between bills and FRNs, we improve on our existing debt optimization model by explicitly introducing a measure of rollover risk into the model
  - With no constraints on rollover risk, the model generally favors bills over FRNs reflecting the higher cost of FRNs. As rollover risk constraints are tightened to moderate levels, the model generally finds TIPS and short/intermediate fixed rate debt a more attractive way to reduce rollover risk than FRNs
  - At high enough levels of risk aversion, however, the optimal debt mix does include a significant allocation to FRNs; in these cases moreover, the cost/risk tradeoffs highlight benefits to lengthening the maturity of FRNs to as long as 5 years
- The improvements to our model highlight some important shortcomings of WAM as a measure of rollover risk; to better assess the operational risks of debt rollover, **we recommend Treasury rely more heavily on expected rollover as a risk metric rather than WAM**

Agenda

Overview of Treasury FRN market

- Treasury first introduced a 2-year FRN in January 2014 with coupons indexed to the 3-month bill
  - The interest rate is set daily based on the most recently auctioned 3-month bill plus a spread (discount margin) that is set at the initial FRN auction
- Current issuance of FRNs totals $56 bn per quarter ($20 bn new issue plus two $18 bn monthly reopenings); this compares to $120 bn quarterly issuance of 2-year notes
- Total outstanding FRNs has grown to $400 bn representing 2.5% of total marketable debt and 14% of all variable rate (Bills and FRNs) debt
- FRNs are much less actively traded in the secondary market than other Treasury securities; daily volumes average $3 bn/day or 0.9% of outstanding debt

FRN debt outstanding as % of total and variable rate debt; %



Source: US Treasury

Average daily volume by security type; 4/18-4/19

	Avg. daily volume	
	$bn	% of outstandings
Coupons	413.9	3.8
Bills	121.0	5.6
TIPs	16.5	1.3
FRNs	3.1	0.9

Source: FRBNY

Investor demand for FRNs

- Auction stats for FRNs suggest a similar investor profile to Treasury bills with slightly stronger end user demand for FRNs than bills
- Investment fund demand for FRNs has grown as short term rates have normalized increasing from 12% of demand in 2014-2015 to 27% in 2018 and 37% in 2019
- Significant participation in FRN auctions by non-traditional ("other") investors; may reflect use of FRNs by CCPs and FCMs as investments held against cash collateral for derivatives margining
- Bid to cover ratios for FRNs are similar to bills and generally higher than 2-year notes

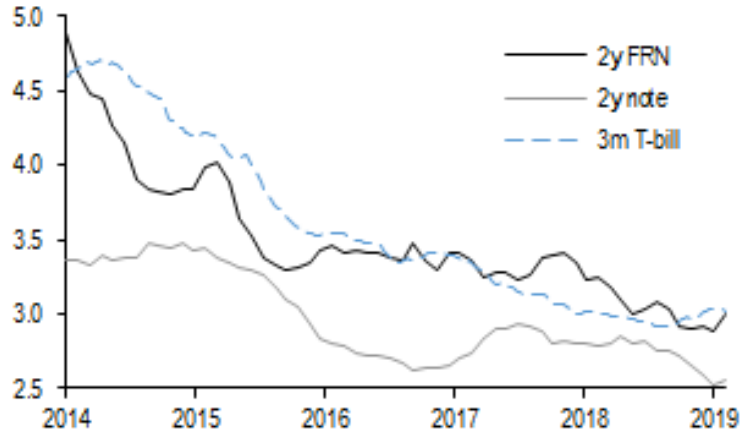
Treasury auction demand statistics

2014-2019 avg	Depository institutions	Individuals	Dealers and brokers	Pension and Retirement funds and Ins. Co.	Investment funds	Foreign and international	Other
Bills	0.2%	1.5%	64.7%	0.2%	24.4%	8.7%	0.3%
FRNs	0.5%	0.1%	52.8%	0.2%	19.7%	15.6%	11.2%
Nominals	0.2%	0.2%	35.5%	0.1%	47.0%	16.5%	0.5%
TIPS	0.0%	0.2%	25.5%	0.6%	58.5%	15.1%	0.2%
Total	**0.2%**	**1.2%**	**57.3%**	**0.2%**	**29.9%**	**10.7%**	**0.5%**

2018	Depository institutions	Individuals	Dealers and brokers	Pension and Retirement funds and Ins. Co.	Investment funds	Foreign and international	Other
Bills	0.1%	1.9%	60.1%	0.1%	30.5%	7.2%	0.2%
FRNs	0.4%	0.1%	49.7%	0.4%	27.0%	9.1%	13.3%
Nominals	0.0%	0.3%	34.9%	0.1%	49.2%	14.9%	0.5%
TIPS	0.0%	0.2%	20.1%	0.3%	62.2%	17.1%	0.0%
Total	**0.1%**	**1.5%**	**54.1%**	**0.1%**	**34.7%**	**9.0%**	**0.5%**

Source: US Treasury

Bid-to-cover ratios for 2-year FRN, 2-year note and 3-month T-bill, 6-month moving averages; %



Global comparisons

- FRNs have been issued by Italy, Japan, and the US
- Italy issues 6-year FRNs indexed to 6-month EURIBOR; the Italian Treasury expects to issue two new benchmark securities in 2019 with a maturity in the 5-to-7-year range*; Japan had a 15-year FRN program indexed to the 10-year JGB auction rate that it discontinued in 2008.
- US debt outstanding is more heavily weighted to variable rate debt (17.5%) than international peers; the heavy weighting to bills results in the US having the lowest WAM and highest 2019 redemptions as a % of outstanding debt compared to any DM issuer

Government debt outstanding by security type as of 12/18; %

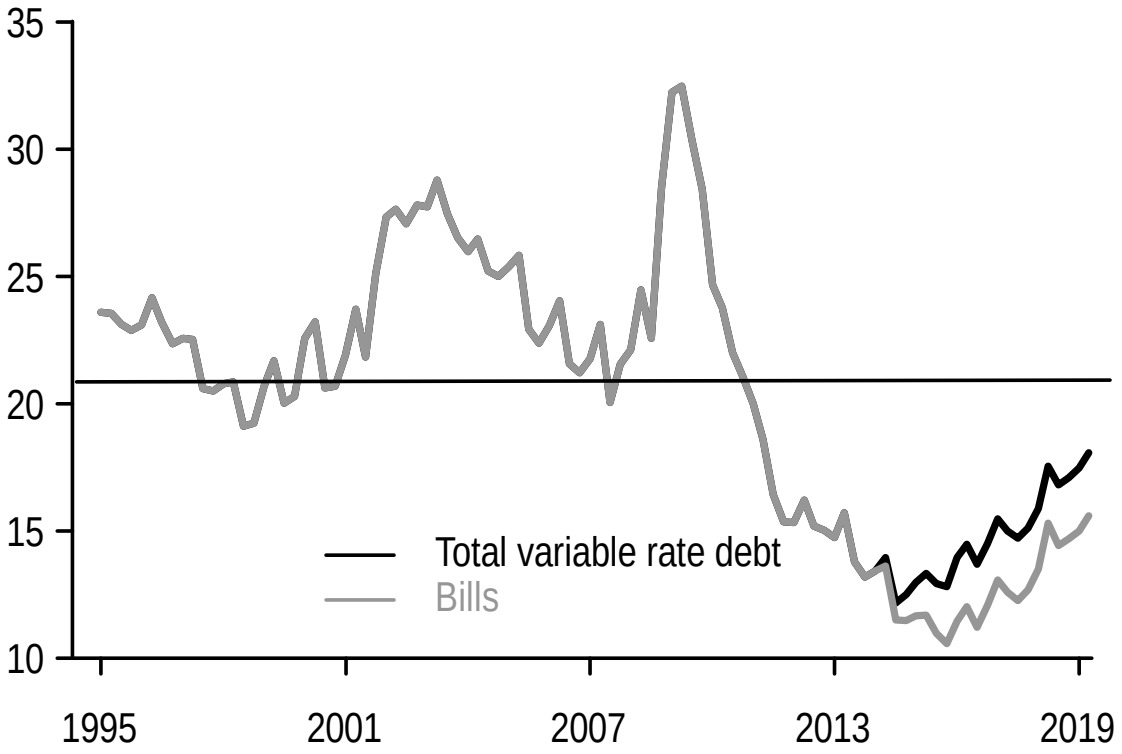
							2019 projected rollover	
	Bills	FRNs	Bills + FRNs	Linkers	All other LT	WAM (years)	% of debt stock	% of GDP
Austria	1.0%	0.0%	1.0%	0%	99%	10.3	12%	6%
Belgium	5.0%	0.0%	5.0%	0%	95%	9.9	6%	5%
Finland	0.0%	0.0%	0.0%	0%	100%	7.1	9%	4%
France	5.0%	0.0%	5.0%	12%	83%	8	8%	5%
Germany	1.0%	0.0%	1.0%	6%	93%	6.9	13%	4%
Ireland	1.0%	0.0%	1.0%	0%	99%	7.3	10%	4%
Italy	5.0%	6.7%	11.7%	12%	76%	6.7	11%	11%
Netherlands	4.0%	0.0%	4.0%	0%	96%	7.4	10%	4%
Portugal	8.0%	0.0%	8.0%	0%	92%	6.4	6%	4%
Spain	6.0%	0.0%	6.0%	6%	88%	7.5	10%	7%
UK	4.0%	0.0%	4.0%	27%	69%	15.3	7%	5%
Japan	9.5%	1.0%	10.5%	1%	89%	8.1	20%	36%
US	**15.0%**	**2.5%**	**17.5%**	**9%**	**74%**	**5.8**	**28%**	**19%**
Unwtd avg	5.0%	0.8%	5.7%	6%	89%	8.2	11%	9%

*2019 Guidelines for public debt management, Dipartimento del Tesoro

Variable rate debt outstanding as a % of marketable debt

- The proportion of outstanding debt that is variable rate has increased recently but remains below its long run average

Bills and total variable rate debt as a % of marketable debt

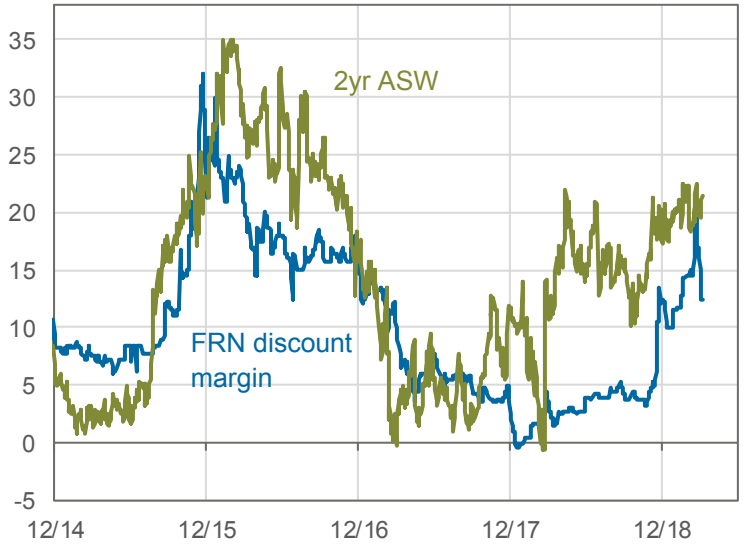


Source: US Treasury

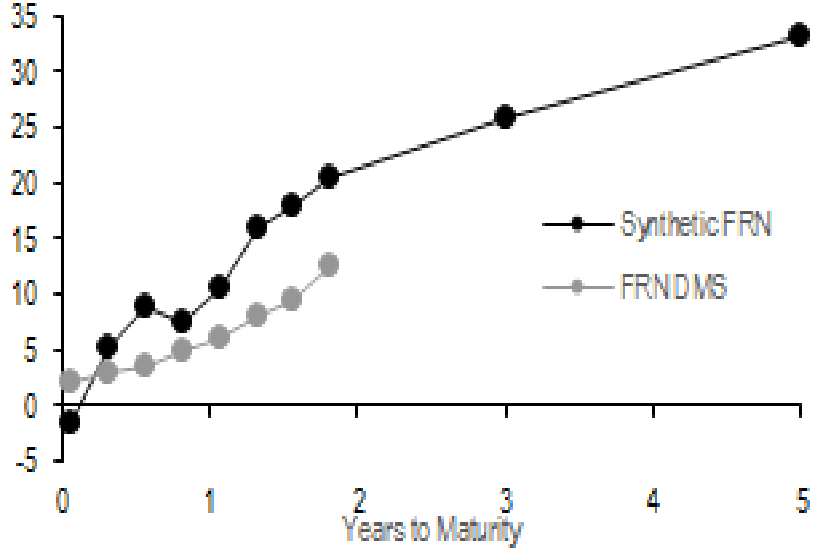
Pricing of FRNs

- Both FRNs and 2-year Treasury asset swaps (synthetic FRN) have traded cheap to Treasury bills reflecting the compensation required by investors to provide term funding to Treasury
  - FRNs have averaged 10 bp cheap to bills and 2 bp rich to 2-year Treasury asset swaps
  - Spreads are derived from the Libor/bill basis market; some caution is warranted in interpreting these spreads given the illiquidity in this market
- The term structure of FRN spreads is similar to nominal Treasury asset swap spreads with the nominal asset swap spread curve slightly steeper than FRNs

2-year FRN discount margin vs. 2-year UST asset swaps[1]; spread to bills; bp



Term structure of FRN and Treasury asset swap spreads; spread to bills; bp



1. 2-year Treasury asset swap converted to spread to 3-month bills using Libor/bill basis market

Agenda

Choosing between fixed and floating rate Treasury securities

In optimizing the funding mix between fixed-rate Treasury securities and FRNs, it is useful for Treasury to separately consider two decisions:

- An **interest rate risk** decision that involves determining the optimal funding mix between fixed and variable rate instruments including FRNs and Treasury Bills
  - Primarily involves assessing tradeoffs between cost and volatility of alternative funding strategies
  - Recent modelling of debt optimization by TBAC provides useful insights on these tradeoffs

- An **operational risk / rollover risk** assessment across variable rate funding alternatives that involves determining the optimal mix of bills and FRNs
  - Primarily involves assessing the tradeoff between the higher cost of FRNs, and the benefit to the Treasury from reduced rollover risk of FRNs vs. bills
  - Rollover risk in this context primarily reflects the operational risk of large auctions and/or the risk of large supply concessions associated with large auctions; it is also correlated with the volatility of debt servicing costs which is one of the risk measures we consider in our work on optimization
  - The work below improves on TBAC's earlier work on debt optimization by explicitly introducing a rollover risk constraint in order to assess the optimal mix of bills and FRNs
  - Other considerations in choosing an optimal bill/FRN mix that we don't incorporate into the model include reduced financial stability risks from greater bill supply that reduces the private sector's need to create "near money" (see Greenwood, Hanson, and Stein, "A Comparative-Advantage Approach to Government Debt Maturities," The Journal of Finance, August 2015)

Insights from debt optimization on optimal fixed/floating funding mix

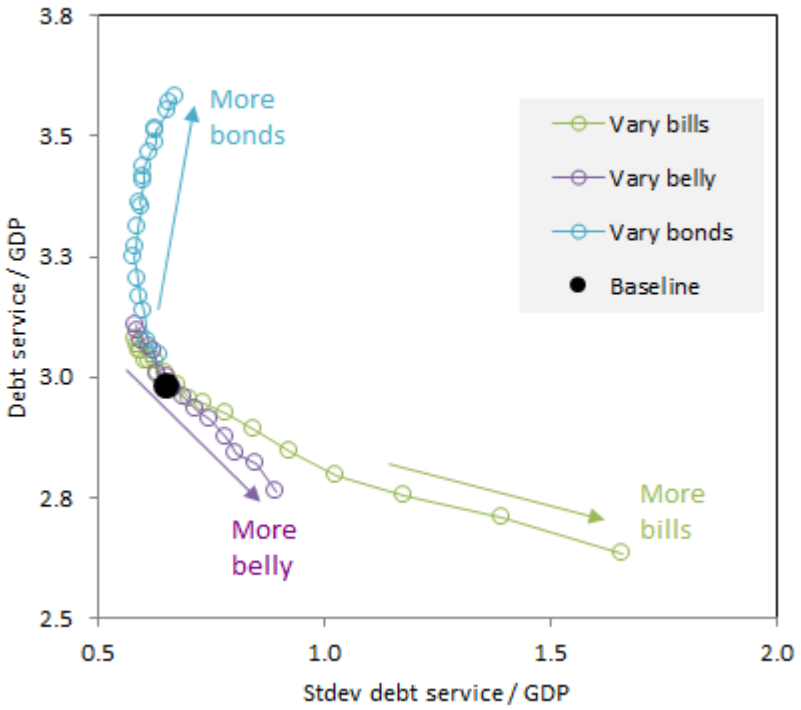
Previous work by TBAC on debt optimization provides a number of useful insights around the optimal mix of variable rate and fixed rate funding. By way of review, the model developed by TBAC contains a number of key components including:

- A simulation module consisting of:
  - A macroeconomic model for the unemployment gap, core PCE inflation, CPI, the Fed Funds target rate, the rate of change of real GDP, the potential rate of change of real GDP, and the equilibrium real rate of interest
  - A model for the Treasury yield curve using expected Fed policy and term premium
  - A model for the TIPS yield curve, which involves a decomposition of term premium into inflation, real rate, and liquidity components
  - A fiscal model for the primary budget deficit
- A debt dynamics module that projects current and future debt issuance
- An optimization module that identifies low cost strategies given risk appetite and constraints and can generate both static optimization (issuance fractions never change) and dynamic optimization solutions where issuance depends on macro variables

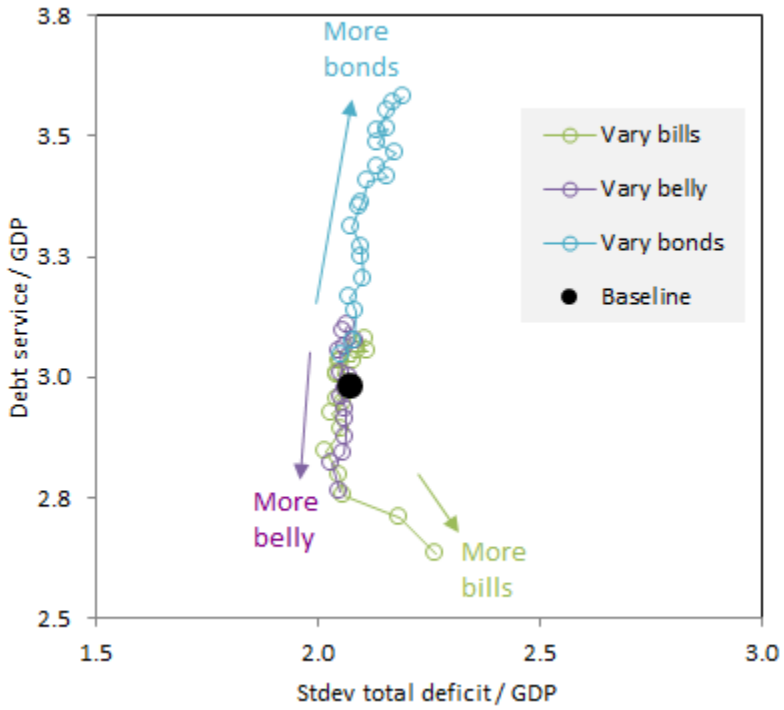
Optimal funding mix between fixed and variable rate (including bills) securities

- Previous work on debt optimization highlights that the optimal amount of floating rate debt depends on both the degree of risk aversion of the debt manager and whether risk is better measured by the volatility of debt servicing costs or the volatility of deficits
  - When risk is measured by the volatility of debt servicing costs, increased allocation to bills at the expense of 2-, 3- and 5-year fixed rate notes is not especially attractive as it generates only modest cost savings with significant increases in risk
  - When risk is measured by the volatility of deficits, a heavier allocation to floating rate debt is appropriate as the strategy benefits from the correlation between rates and the primary deficit

Debt cost / variability tradeoff under alternative issuance strategies



Debt cost / variability tradeoff under alternative issuance strategies

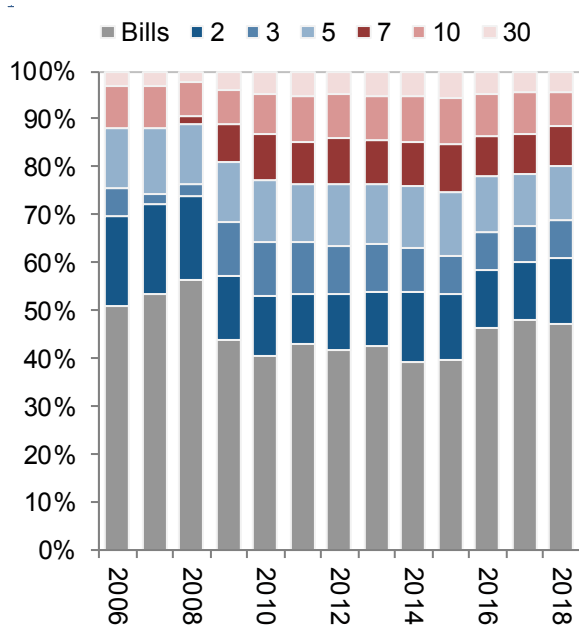


Source: Belton, Dawsey, Greenlaw, Li, Ramaswamy, and Sack, "Optimizing the maturity structure of U.S. Treasury debt: A model-based framework", The Hutchings Center on Fiscal and Monetary Policy, Brookings Institution (October 2018). https://www.brookings.edu/research/optimizing-the-maturity-structure-of-u-s-treasury-debt/

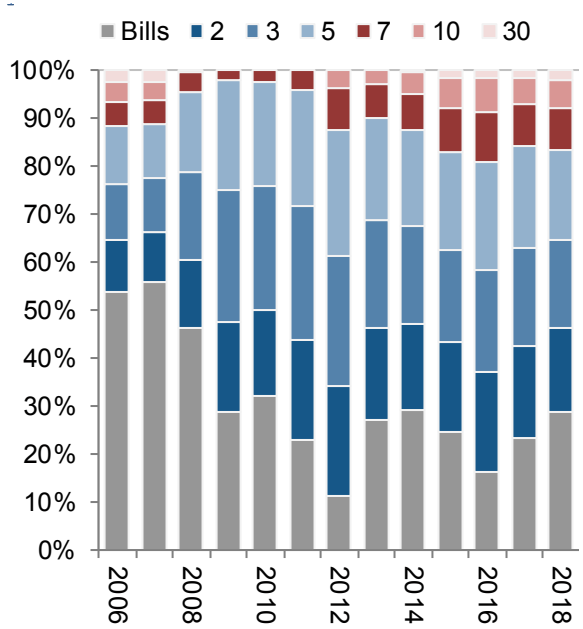
The model's optimal allocation to variable rate debt has generally favored less variable rate issuance and more issuance in intermediates than historical patterns

- The model's optimal issuance varies over time but has generally favored larger issuance at intermediate maturities and smaller issuance in bills/FRNs relative to actual Treasury issuance
- The difference between the model and actual issuance patterns has been most pronounced in recent years as the combination of low term premium and low front end rates implies significant benefit from reducing bill and FRN issuance in favor of intermediates

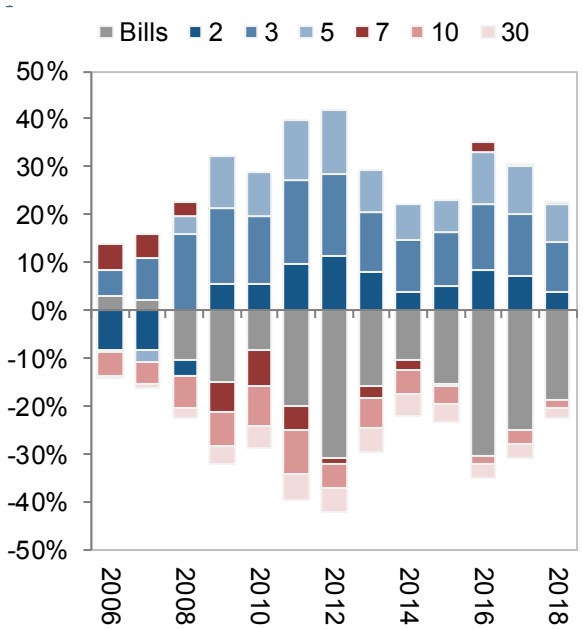
Actual historical issuance mix[1]



Optimal issuance mix[1]



Optimal - Actual issuance mix



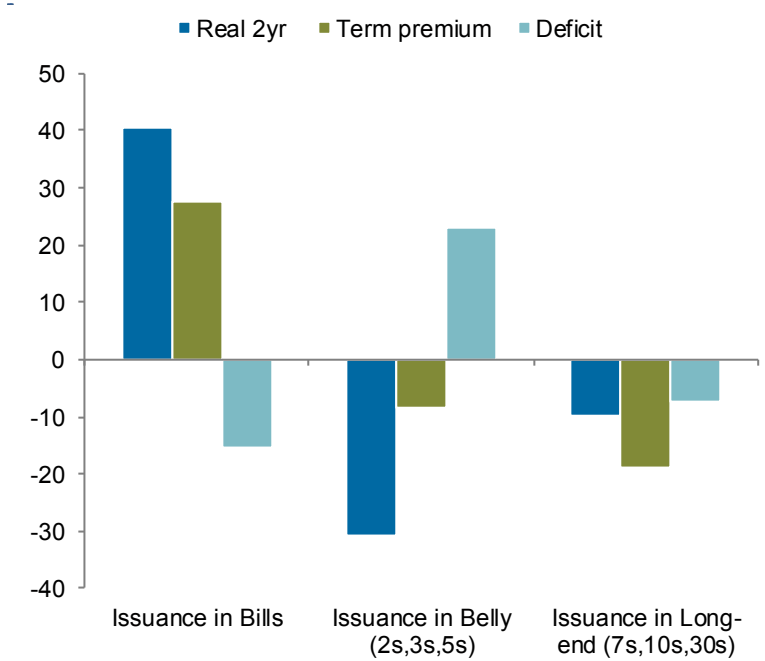
1. Bill issuance across varying tenors are all scaled to 1-year (52-week) tenor; i.e. 100B of 26-week Bills scales to $50B of 1-year equivalent bills

Source: TBAC and Belton, Dawsey, Greenlaw, Li, Ramaswamy, and Sack, "Optimizing the maturity structure of U.S. Treasury debt: A model-based framework", The Hutchings Center on Fiscal and Monetary Policy, Brookings Institution (October 2018). https://www.brookings.edu/research/optimizing-the-maturity-structure-of-u-s-treasury-debt/

Term premium and the level of real yields have a large influence on the optimal mix of fixed and floating rate debt

- Increases in term premium and/or real front end rates can imply significant benefits to increasing variable rate issuance at the expense of fixed rate debt
  - The Chart below shows the sensitivity of the optimal funding mix relative to our baseline optimization from a one sigma increase in each of the macro variables; the sensitivities shown are in $bn of annual issuance and reflect zero sum reallocations across the curve
  - A one sigma increase in 10-year term premium (equal to 80 bp) implies a $25 bn reallocation from coupons to floating rate issuance; a one sigma increase in real 2-year rates (equal to 190 bp) implies an even larger reallocation from fixed to floating rate debt issuance
- The normalization of term premium and real 2-year rates to their steady state levels over time would be expected to increase the optimal proportion of variable rate debt issuance to ~40%; however, even in this more normalized macro environment, the model favors a lower allocation to variable rate debt than what the Treasury is currently issuing (~50% floating; see prior slide)

Optimal response of issuance to changes in the macroeconomic variables; $bn



Optimal issuance under static and dynamic reaction function

	Dynamic Response Function		
Gross Issuance	4Q18 MEVs	Long run MEVs	Static
Bills/FRNs	29%	39%	25%
2s	17%	16%	19%
3s	18%	20%	22%
5s	19%	18%	21%
7s	8%	5%	7%
10s	6%	2%	4%
30s	2%	0%	2%

Source: TBAC and Belton, Dawsey, Greenlaw, Li, Ramaswamy, and Sack, "Optimizing the maturity structure of U.S. Treasury debt: A model-based framework", The Hutchings Center on Fiscal and Monetary Policy, Brookings Institution (October 2018)

Agenda

Term Premium Decomposition

We extend the TBAC model to include funding risk premium, the compensation for term funding

- In previous work[1,2] we decomposed Treasury yields into two components, the first accounting for interest rate expectations, and the second, a risk premium required by investors. The risk premium component varies with maturity and is referred to as the term premium (TP).
- We decomposed Nominal and Real TPs into real (RRP), inflation (IRP), and liquidity (LRP) components, and estimated the IRP, RRP, and LRP historically using an affine term structure model fit to excess returns, yields, and a TIPS liquidity index.
- Here we recognize that investors also require a risk premium for providing term funding (FRP), and as shown on slide 7 it is typically an increasing function of maturity. We use the spread of 2-year FRNs over T-bills to approximate the 2-year FRP, and use the term structure of Nominal asset swap spreads to T-bills to project the FRP for maturities longer than 2-year.
- We update the model to include the FRP as an additional component of the term premium for all Treasury securities, and decompose Nominal, TIPS, and FRN risk premia as

$$\begin{aligned} TP^{Nominal} &= FRP + RRP + IRP \\ TP^{Real} &= FRP + RRP + LRP \\ TP^{FRN} &= FRP \end{aligned}$$

- Following our previous work[1,2], in the simulation module, for each maturity we model the Nominal TP as an affine function of the unemployment gap, the IRP as an affine function of the spread of expected real rates over r_t^*, and the TIPS LRP as a constant equal to the historical average. However, we now include the FRP, as an additional constant equal to the historical average.
- We define the RRP in our simulation block to be TP – IRP – LRP – FRP. In the table below you can see the steady state risk premia decomposition used in the simulation.

	Maturity	FRP	RRP	IRP	LRP	TP
FRNs	2	10				10
	5	26				26
	30	52				52
TIPS	5	26	-61		32	-3
	10	36	44		24	16
	30	52	7		19	77
Nominals	1	0	0	0		0
	2	10	-74	60		-4
	3	15	-69	60		6
	5	26	-61	60		24
	7	35	-58	60		37
	10	36	-44	60		51
	30	52	7	48		108

Source: TBAC

[1] https://home.treasury.gov/system/files/276/TBACCharge14thqtr2018.pdf

[2] Belton, Dawsey, Greenlaw, Li, Ramaswamy, and Sack, "Optimizing the maturity structure of U.S. Treasury debt: A model-based framework", The Hutchings Center on Fiscal and Monetary Policy, Brookings Institution (October 2018). https://www.brookings.edu/research/optimizing-the-maturity-structure-of-u-s-treasury-debt/

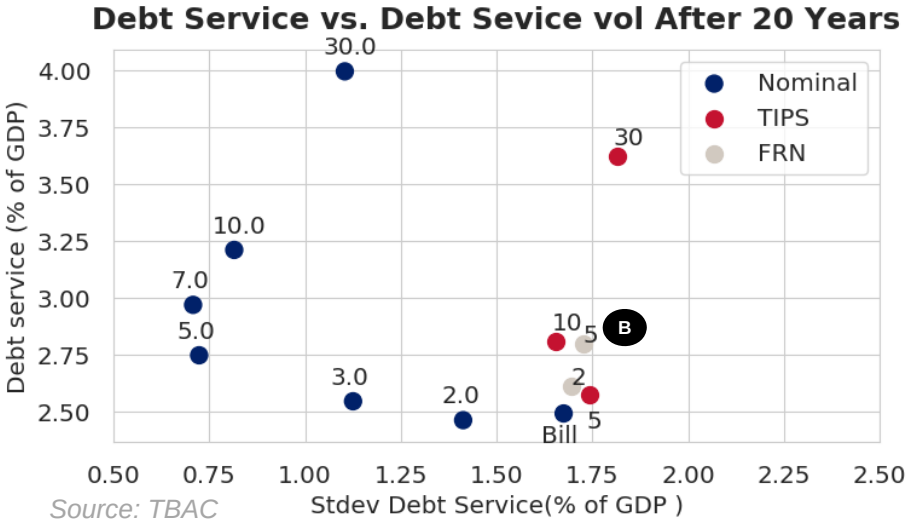
Single Security Issuance Results Including FRNs

Results show average debt service cost in year 20 vs two different measures of risk

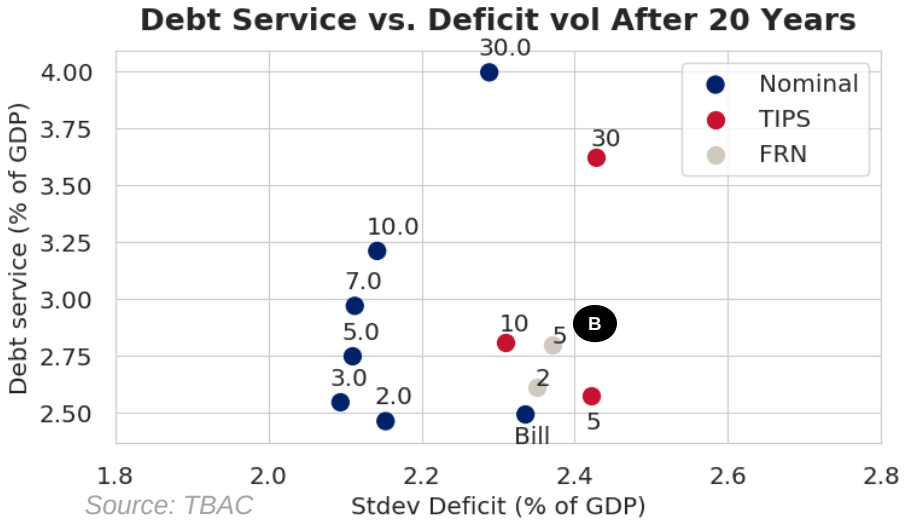
- The scatterplots below compare average debt service cost as a fraction of GDP to the standard deviation of debt service (left) and deficits (right) at year 20 (computed over 2000 simulated paths). Cash needs are met every quarter entirely by issuance of a single security. We include a 2-year FRN and a hypothetical 5-year FRN.

A FRNs have slightly higher costs than Bills due to their FRP, and as a result of their increased funding requirements they also exhibit a slightly higher risk to Bills under both metrics.

B FRNs lie well within the suboptimal portion of the cost / interest rate risk feasible region.



Source: TBAC



Source: TBAC

	2yF	5yF	Bill	2yN	3yN	5yN	7yN	10yN	30yN	5yT	10yT	30yT
Average issuance rate	3.09	3.24	2.99	2.96	3.02	3.15	3.29	3.44	4.01	1.07	1.21	1.79
Average debt service/GDP	2.62	2.80	2.49	2.46	2.55	2.75	2.97	3.21	4.00	2.58	2.81	3.62
Standard deviation debt service/GDP	1.70	1.73	1.67	1.41	1.13	0.72	0.71	0.82	1.10	1.74	1.65	1.81
Standard deviation total deficit(%GDP)	2.35	2.37	2.34	2.15	2.09	2.11	2.11	2.14	2.29	2.42	2.31	2.43
Correlation funding cost, primary deficit (%GDP)	(0.15)	(0.14)	(0.15)	(0.18)	(0.11)	0.13	0.14	0.11	0.10	(0.12)	(0.16)	(0.14)

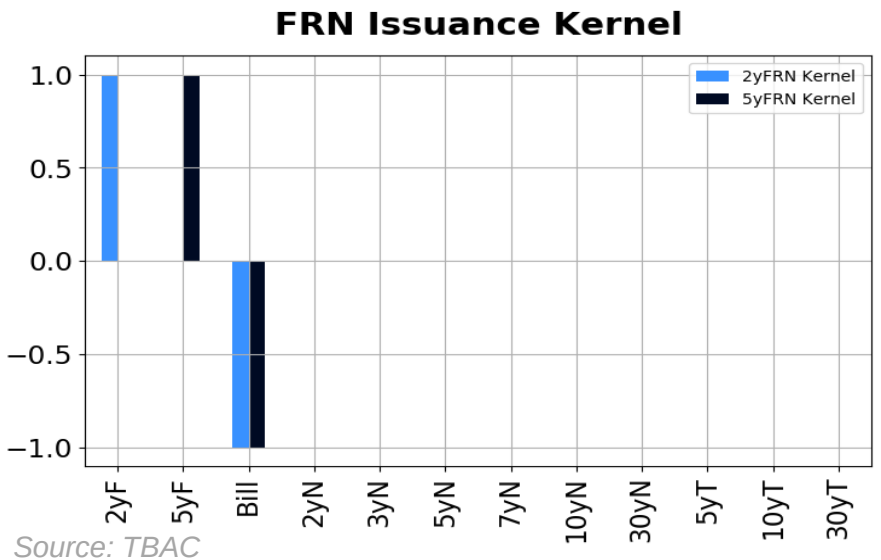
Source: TBAC

A

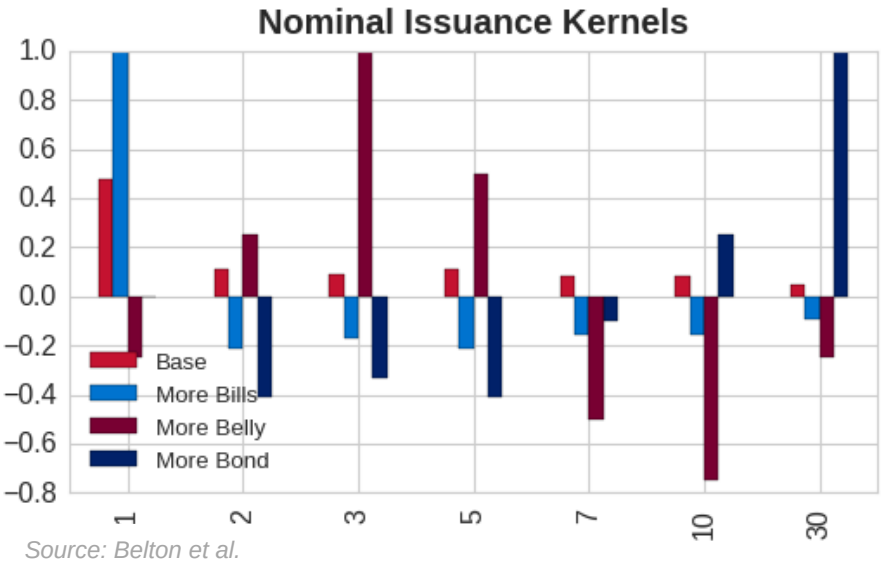
Issuance Kernels and Static Optimization Results

Static optimization over Nominal, TIPS, and FRN kernels results in no FRN allocation

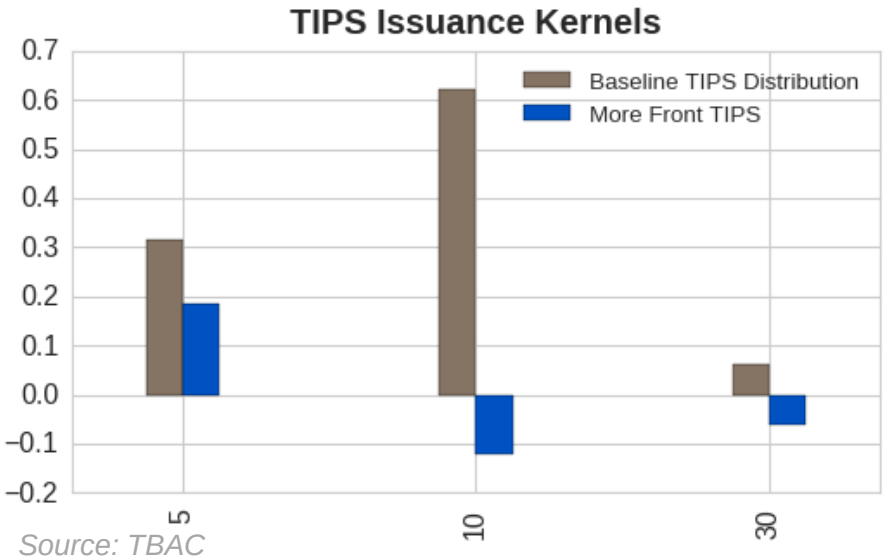
- We introduce a kernel to switch out of Bills into 2-year FRNs, and run a static optimization.
- The optimal solution does not place any weight on 2-year FRNs.
- Similar analysis allowing switching out of Bills into 5-year FRN also results in no weight on the 5-year FRN.



Source: TBAC



Source: Belton et al.



Source: TBAC

Introducing Rollover

Treasury refinancing as a fraction of GDP

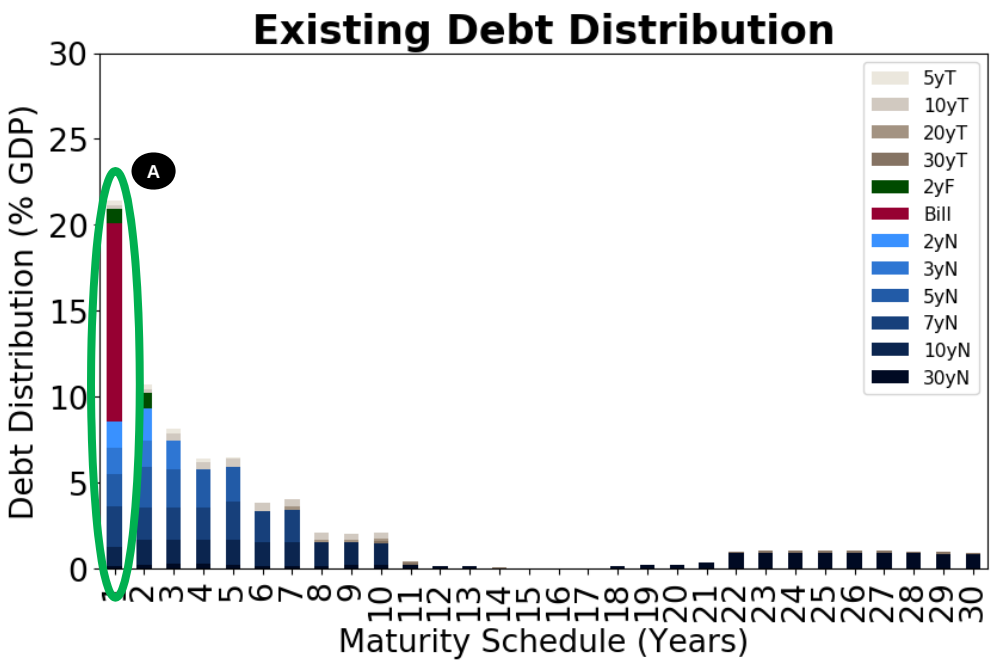
- Below left we show the maturity distribution of the Q2 2018 stock of Treasury debt, expressed as a percentage of GDP.

- A We measure rollover as 1-year principal redemptions (excluding Bills) plus Bills outstanding, and normalize it as a fraction of GDP. The expected normalized rollover is simply the first bar in the graph below left. The concept of controlling rollover primarily reflects the operational risk of large auctions and/or the risk of large supply concessions associated with large auctions. Rollover is also correlated with the volatility of debt servicing costs which is one of the risk measures we consider in our work on optimization.

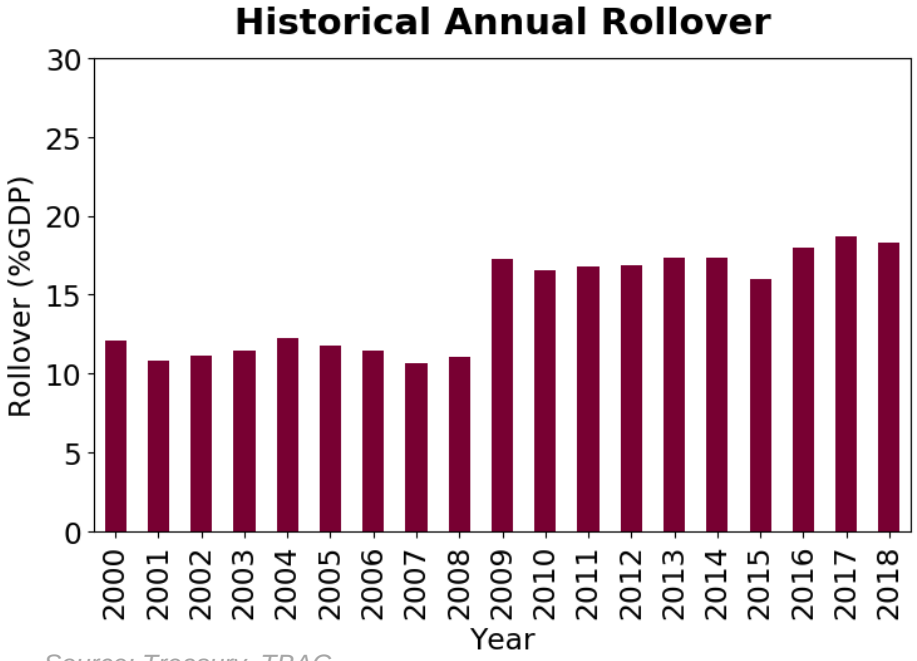
- The choice of GDP as denominator allows for natural growth of the debt stock (and the resulting principal redemption) with the economy, and sets refinancing in the context of domestic economic activity in total.

- An alternative choice of denominator is the size of the existing debt stock. We chose not to use this definition after considering states of the world in which economic conditions require fiscal stimulus, but the existing debt stock is small compared to GDP. In these states, a debt increase which is large compared to the existing debt stock could be easily absorbed, but would result in a high rollover value. In our simulations these alternatives do not differ greatly, as debt-to-GDP is fairly stable.

- At lower right we show how Treasury's annual rollover has evolved over time.



Source: Treasury, TBAC



Source: Treasury, TBAC

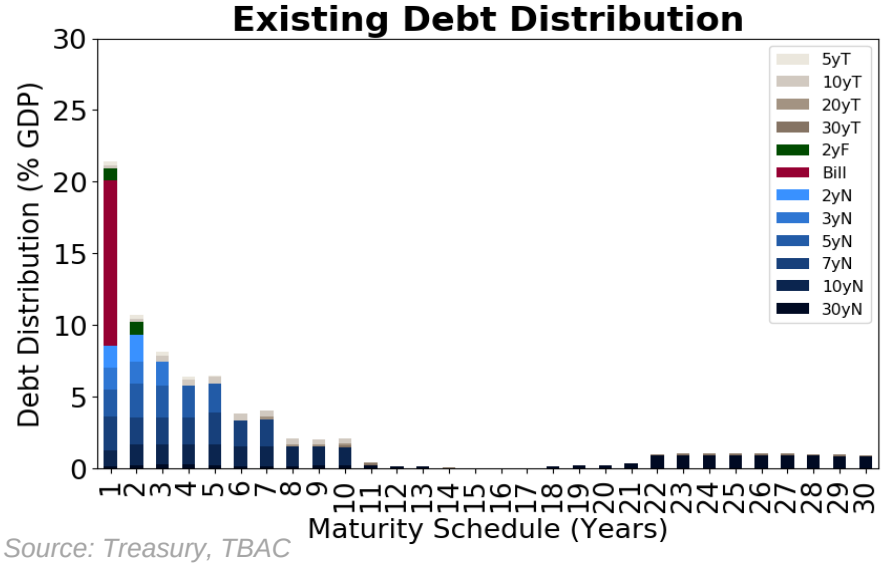
Adding a Rollover / GDP Penalty to the Optimization

Penalizing rollover / GDP above a threshold effectively controls rollover but increases cost

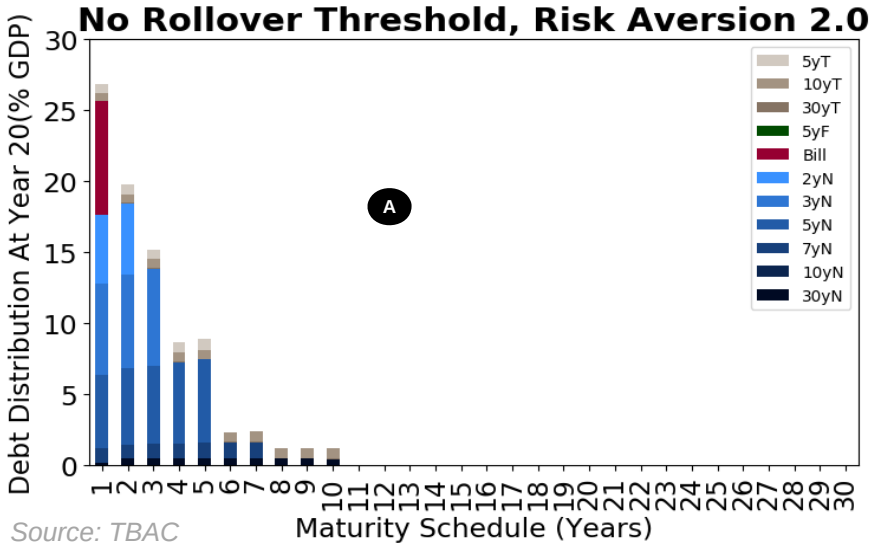
- We add a new term to the objective function which penalizes outcomes above a certain threshold of rollover/GDP (see appendix for details).

A We re-run our static optimizations with and without a rollover threshold (set to 10%), using hypothetical 5-year FRNs; and display the resulting maturity distributions averaged across paths at year 20 of our simulation, comparing them to the existing debt distribution.

B Introducing a rollover penalty shifts the efficient frontier up in cost. The red shaded segment of the frontier indicates when FRNs are included.



Source: Treasury, TBAC



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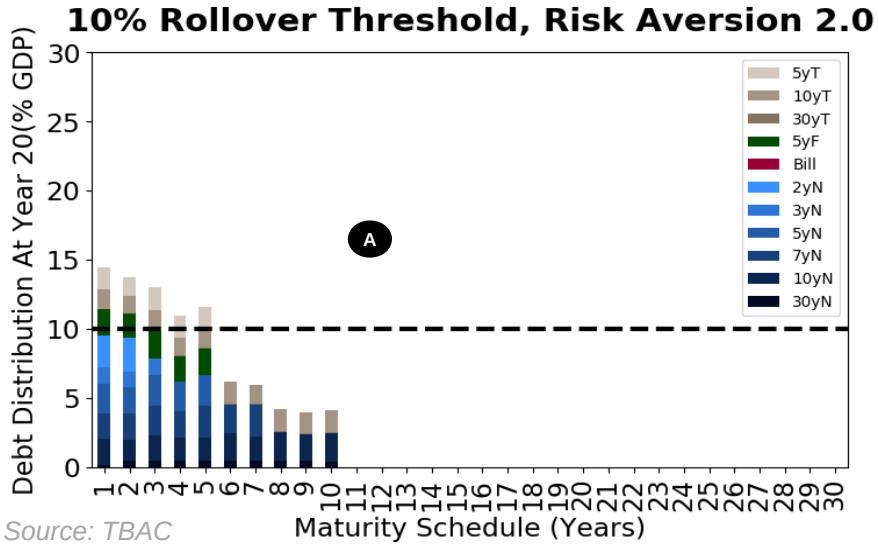
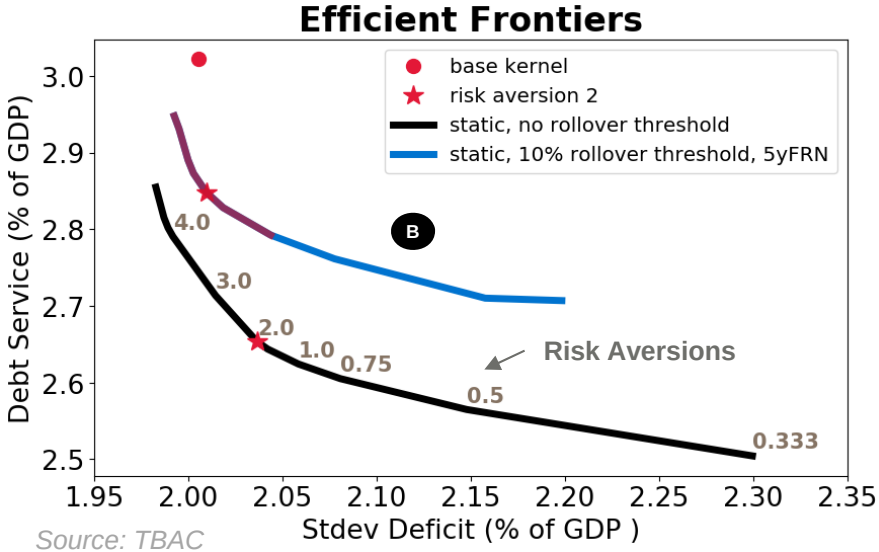


Source: TBAC

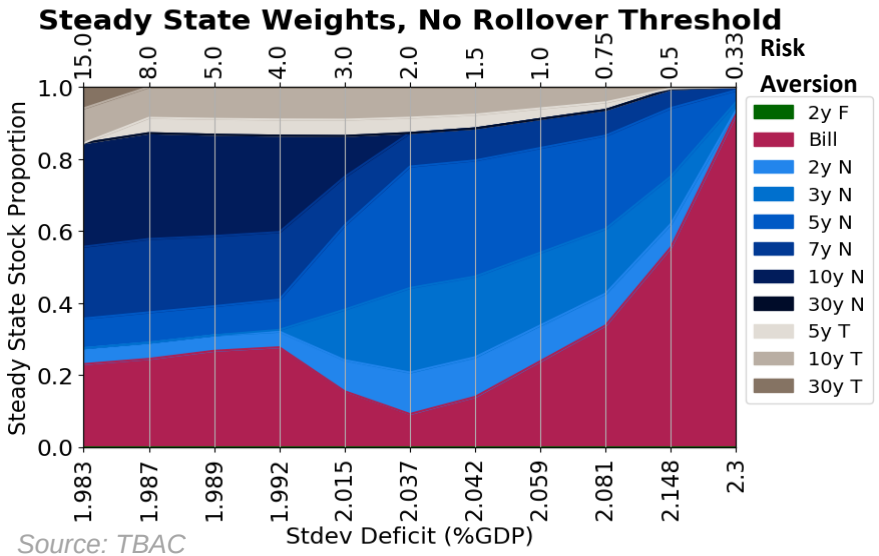


Source: TBAC

Results For 2-year FRNs Including a Rollover Threshold

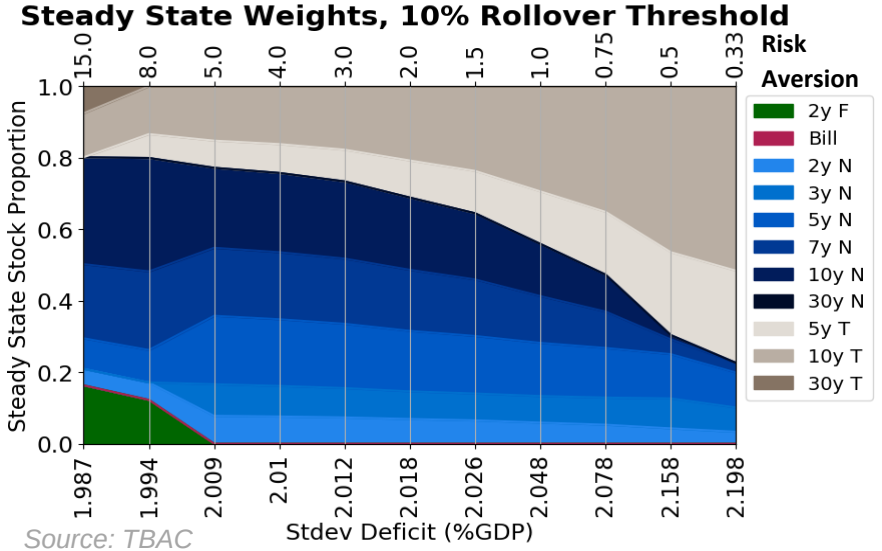
With a rollover / GDP threshold penalty, the model favors intermediate issues and TIPS over Bills and 2-year FRNs

With no rollover / GDP penalty, Bills and belly are a large fraction of the optimal debt stock at all but highest risk aversion



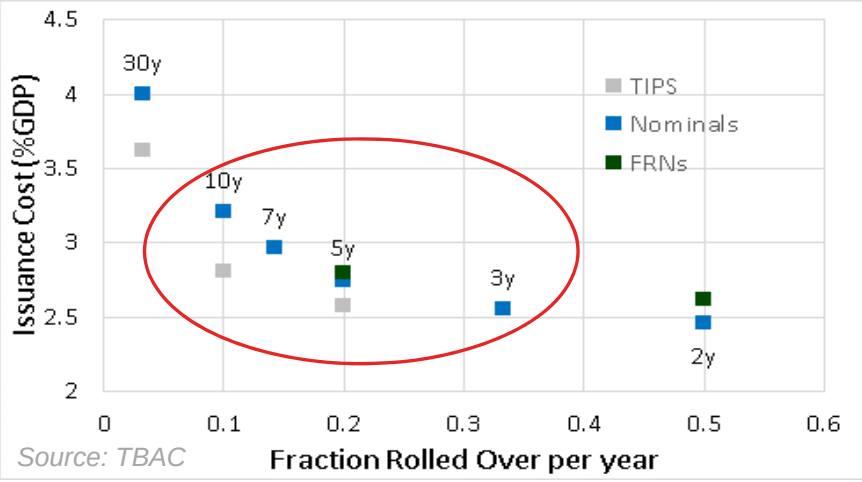
Source: TBAC

Penalizing rollover / GDP > 10%, allocations to TIPS increase vs Bills for low risk aversion, while Notes and FRNs emerge for high risk aversion



Source: TBAC

Intermediate maturities exhibit an attractive rollover / cost tradeoff



Source: TBAC

Nominals have the lowest stand alone risk (A). While FRNs and TIPS, provide a diversification benefit (B).

	2yF	2yN	3yN	5yN	7yN	10yN	5yT	10yT	30yT
Average yield	3.09	2.96	3.02	3.15	3.29	3.44	1.07	1.21	1.79
Average debt svce (% GDP)	2.62	2.46	2.55	2.75	2.97	3.21	2.58	2.81	3.62
Stdev debt svce (% GDP)	1.70	1.41	1.13	0.72	0.71	0.82	1.74	1.65	1.81
Stdev total deficit(% GDP)	2.35	2.15	2.09	2.11	2.11	2.14	2.42	2.31	2.43
Correl(debt svce, PRI)	(0.15)	(0.18)	(0.11)	0.13	0.14	0.11	(0.12)	(0.16)	(0.14)

(A) (B) (B)

Source: TBAC

Results for 5-year FRNs With a 10% Rollover / GDP Threshold Penalty

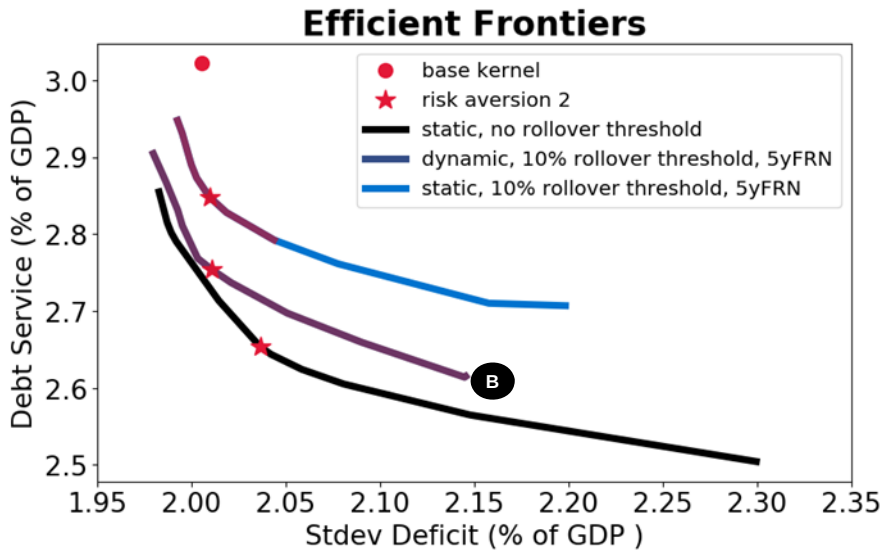
5-year FRNs are preferred to 2-year FRNs, but fixed is preferred to floating at current levels of term premium

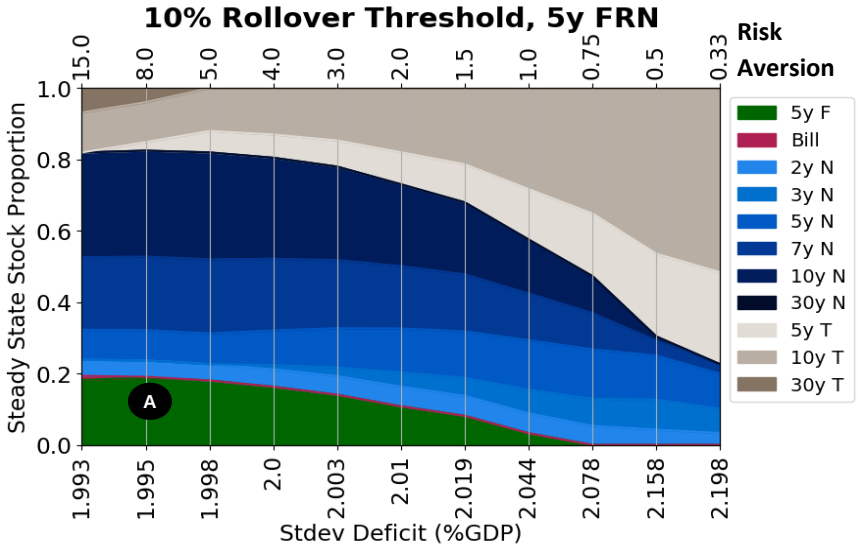
A For high risk aversion the model allocates 60% / 20% / 20% between longer maturity Nominals / 5-year FRNs / TIPS.

- Following our previous work[1,2], we examine the effect of including 5-year FRNs and a rollover threshold in a dynamic debt optimization model.

B In the upper right chart, we see that dynamic issuance lowers the efficient frontier considerably (middle line) compared to the static case with the same rollover threshold (top line).

C We back-test the optimal response function using historical levels of 10-year Term Premium and 10-year Inflation Risk Premium. It shows that the current environment does not favor issuance of FRNs, since low Term Premium advantages intermediate Nominals at their expense.





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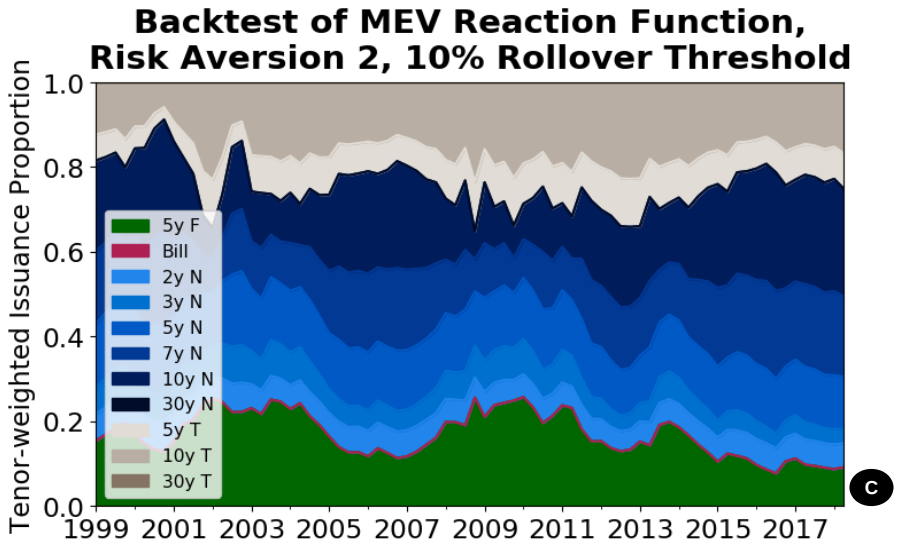


Source: TBAC

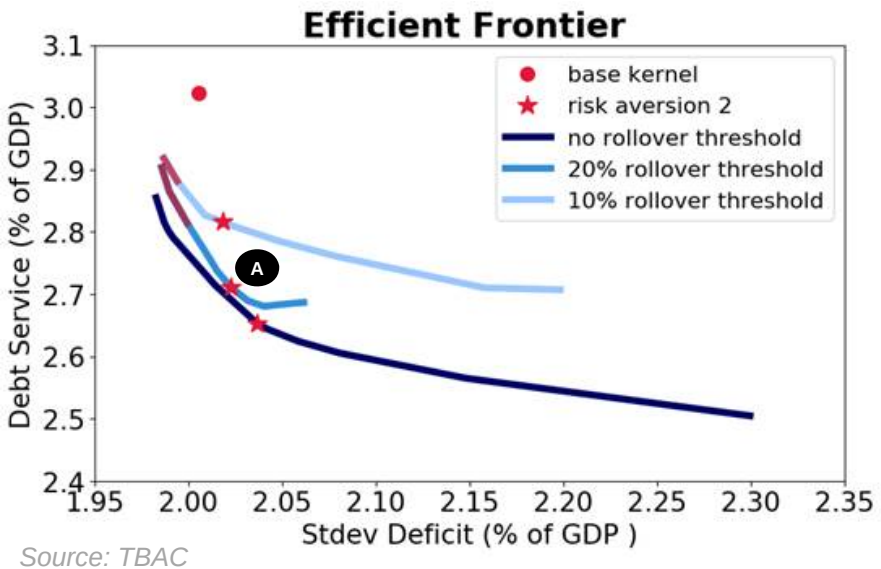
[1] https://home.treasury.gov/system/files/276/TBACCharge14thqtr2018.pdf

[2] Belton, Dawsey, Greenlaw, Li, Ramaswamy, and Sack, "Optimizing the maturity structure of U.S. Treasury debt: A model-based framework", The Hutchings Center on Fiscal and Monetary Policy, Brookings Institution (October 2018). https://www.brookings.edu/research/optimizing-the-maturity-structure-of-u-s-treasury-debt/

Optimizing the Trade-Off Between Cost, Risk, and Rollover

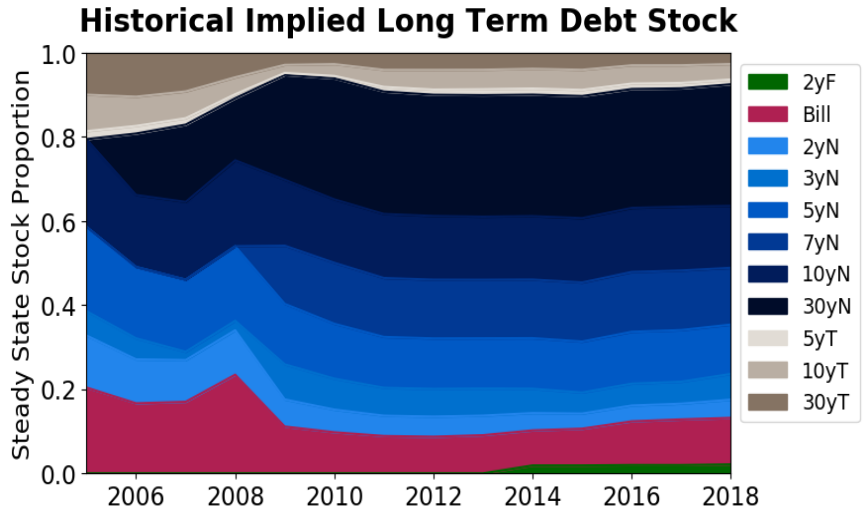
Comparison between model outputs and historical issuance

A A threshold of 20% of GDP constrains rollover to be close to current levels, and risk aversion of 2 lies close to the unconstrained frontier



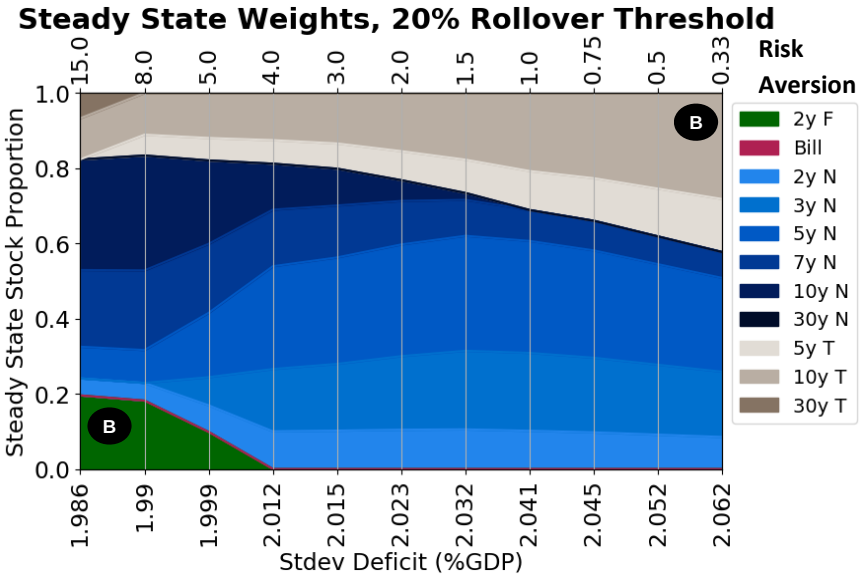
Source: TBAC

Historical issuance show much more weight in Bonds and Bills than what is favored by the model



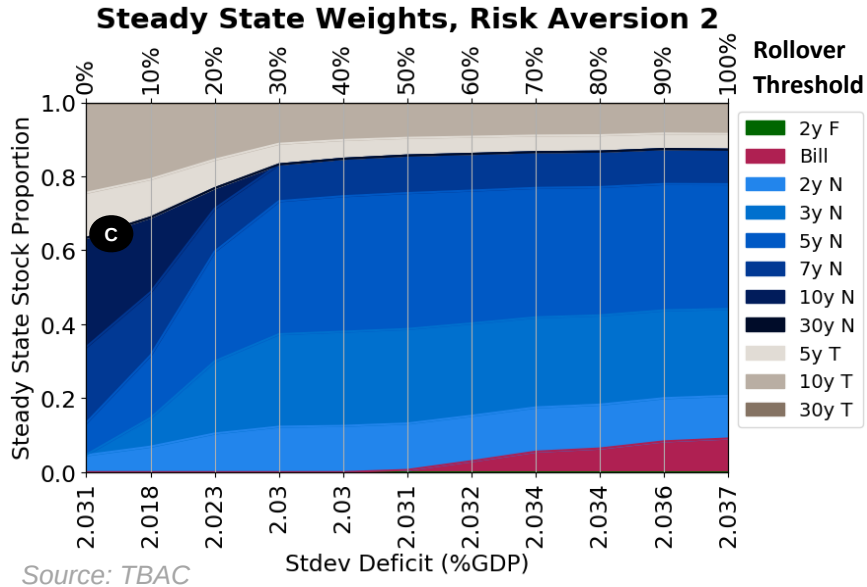
Source: TBAC

B Weights along the 20% rollover threshold efficient frontier highlight the allocation to 2-year FRNs at left, and to TIPS at right



Source: TBAC

C With risk aversion of 2, 2-year FRNs receive no allocation. Low rollover thresholds bring in 10-year Notes and TIPS.

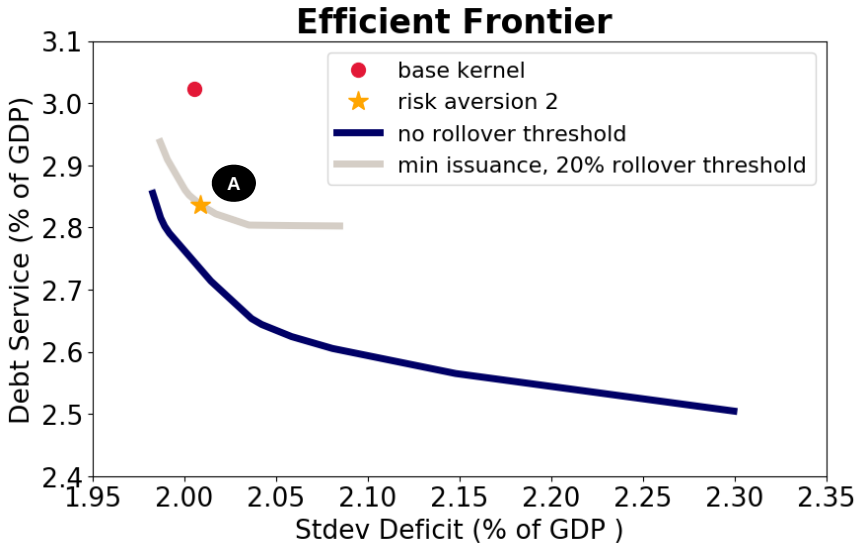


Source: TBAC

Minimum Issuance Size Constraints

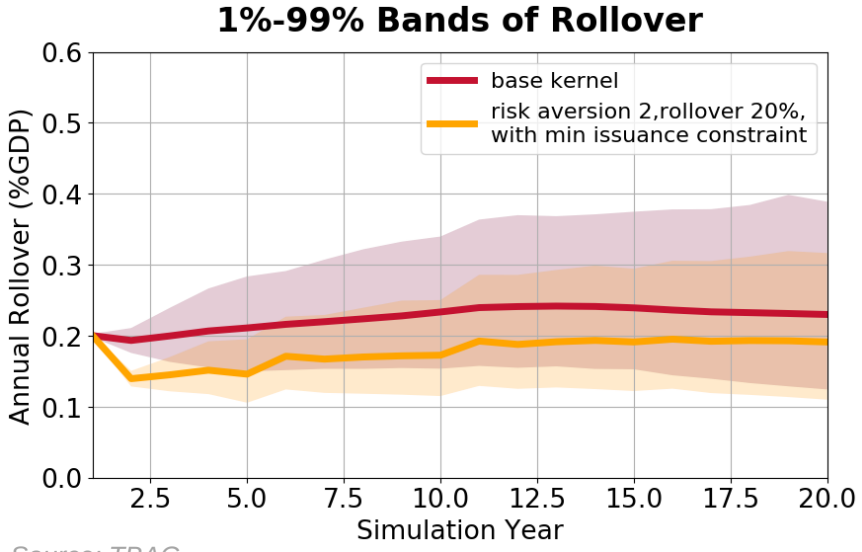
Minimum issuance constraints do not alter the model's preferred allocations significantly

A Constraining issuance weights to be no less than half of 2018 weights in any security shifts the frontier up



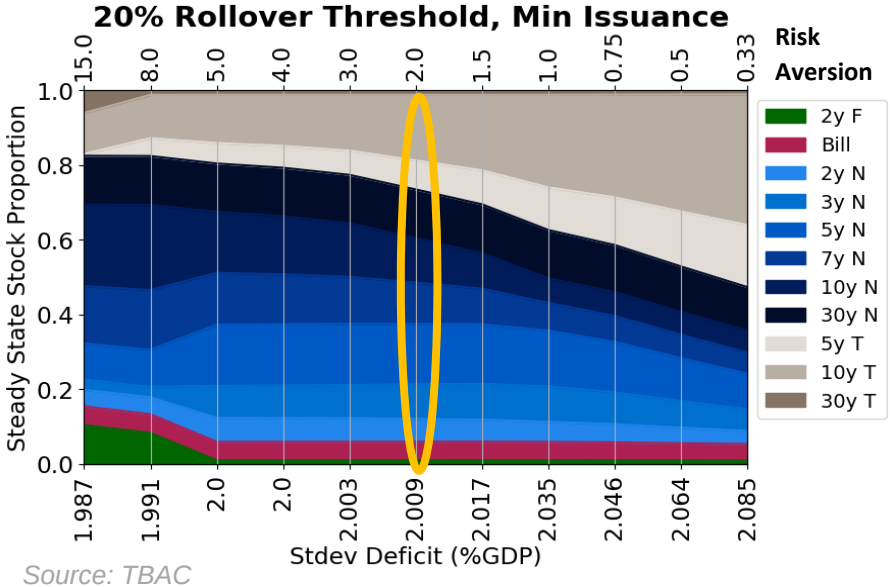
Source: TBAC

The constrained rollover distribution is centered just below 20%, and its 99th percentile is considerably lower than that of base



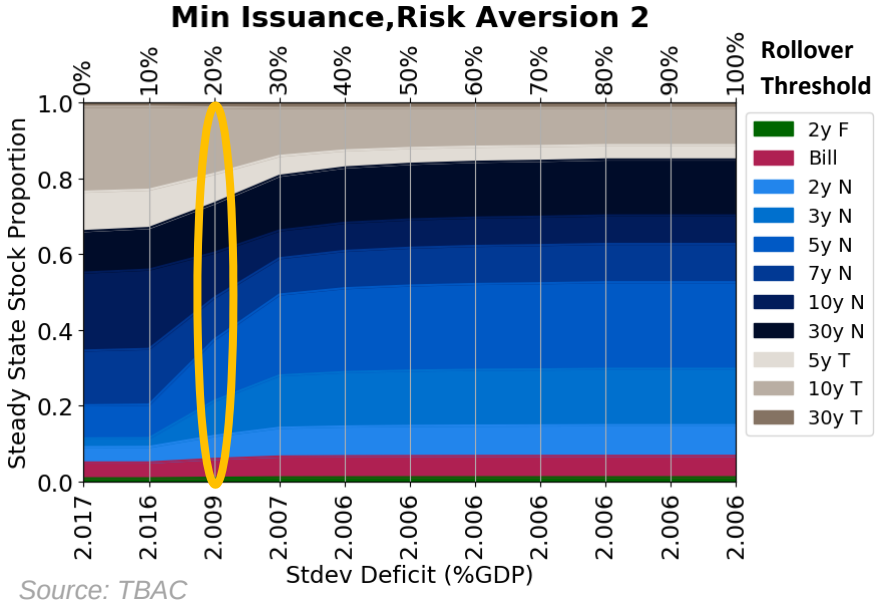
Source: TBAC

Allocations on the constrained frontier continue to favor intermediates and TIPS



Source: TBAC

The rollover threshold remains most consequential below 30% when minimum issuance constraints are included



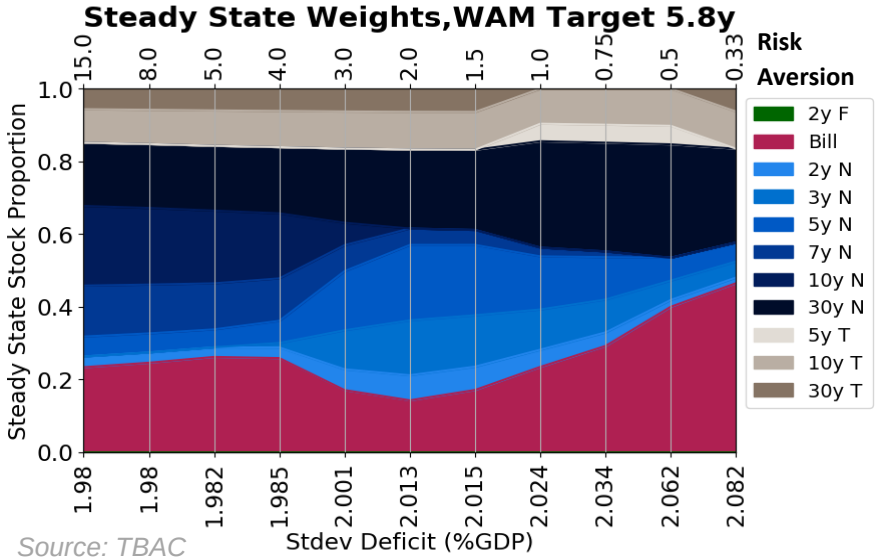
Source: TBAC

Comparing WAM Targeting to Rollover Targeting

Targeting WAM leads to high rollover strategies

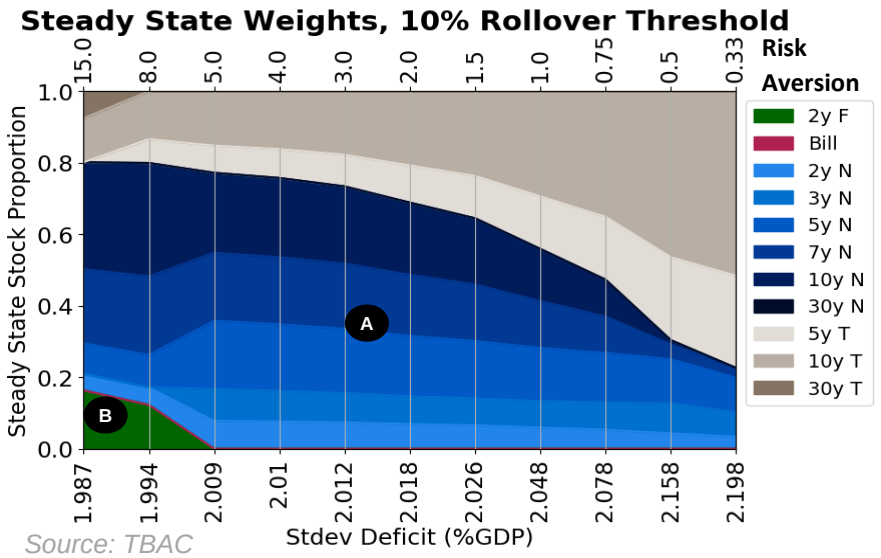
We introduce a WAM target of 5.8 years into our objective function and re-optimize (see appendix for details).

Optimization with a WAM target generically results in a barbell strategy of Bills versus Bonds and 30-year TIPS



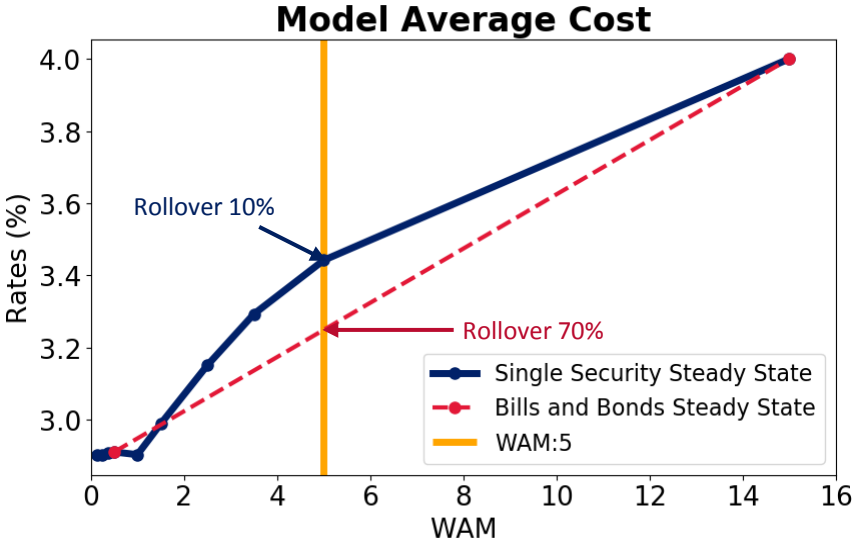
Source: TBAC

A Optimization with a rollover target chooses intermediate maturity instruments, B and FRNs only for high levels of risk aversion



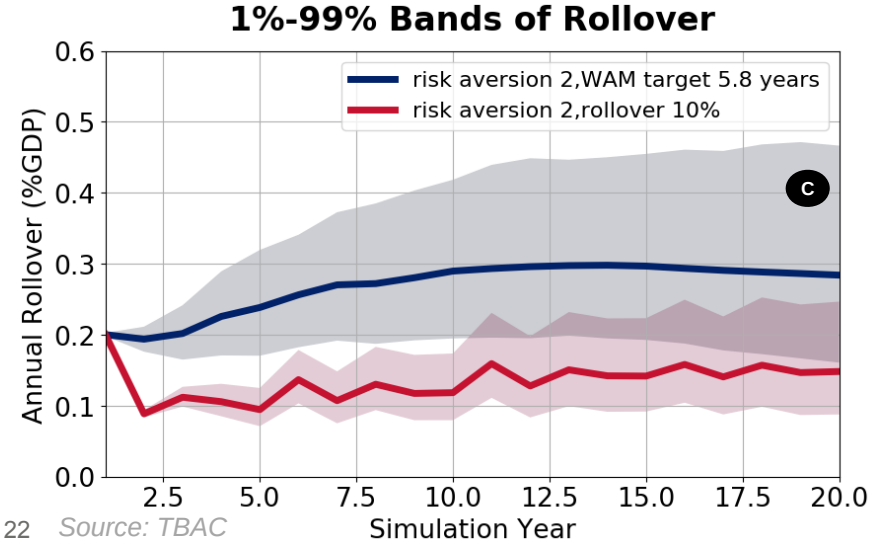
Source: TBAC

The Bills / Bonds barbell has lower average cost than a rollover - minimizing single security issuance pattern



Source: TBAC

C Distributions for 2000 simulated paths show the effect of WAM versus rollover targeting. WAM targeting leads to high rollover.



Source: TBAC

Limitations

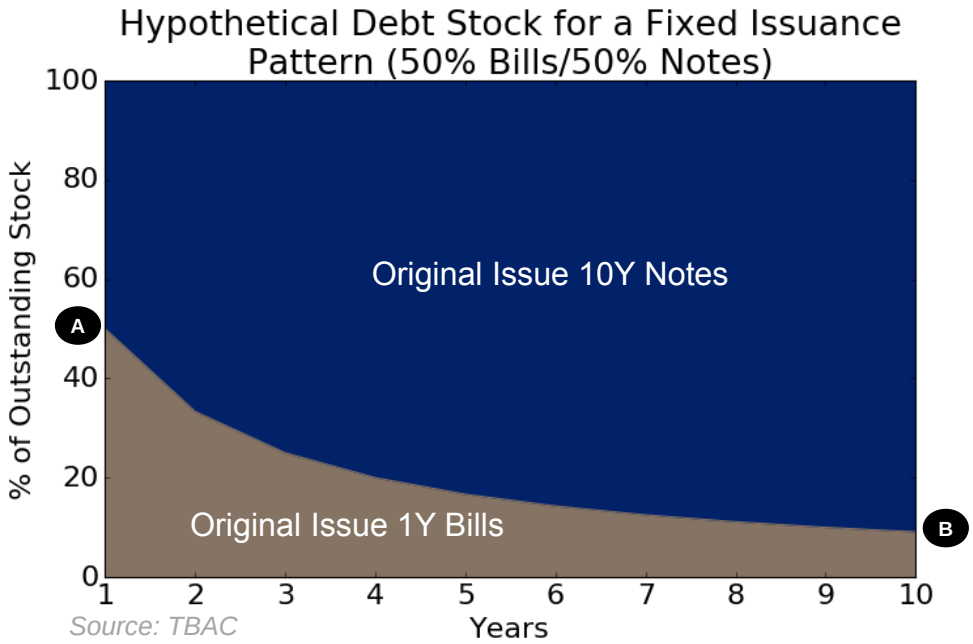
- This work represents one model with results that depend critically on model assumptions. TBAC does not drive recommendations off of one model, but instead takes into account a wide range of inputs on investor demand and market pricing.
- Results depend critically on the choice of risk measure (standard deviation of deficit versus debt service), and on the model implied cross correlations between interest rates, inflation, and primary deficits.
- Results depend heavily on the ex-ante assessment of term premium and its decomposition into funding, inflation, liquidity, and real risk premia.
- Results depend on specific choice of issuance kernels.
- Results would also be sensitive to supply effects, which are not modeled in this presentation.
- The model assumes the debt manager's utility function is of a specific form, which may not fully reflect all real world considerations, e.g., the maintenance of minimum issue sizes to foster liquidity. Also, results depend heavily on debt manager aversion to interest rate and rollover risk.

Agenda

Maturity Weighted Issuance

We focus on maturity weighted issuance because it aligns more closely with steady state portfolio metrics

- **A** Consider a hypothetical issuance split 50% : 50% between 1-year Bills and 10-year Notes.
- In steady state, 100% of the outstanding stock of Bills turns over every year, but only 10% of the stock of 10-year Notes would be redeemed.
- **B** The 50% : 50% issuance split leads to a 9% : 91% Bills / Notes steady state distribution.
- The weighted average maturity of the steady state debt distribution is 4.6 years, which is more than ½ the WAM of a 1-year + the WAM of a 10-year (2.75 years).



Source: TBAC

- Suppose Treasury can issue securities with maturities $\{\tau_1, \ldots, \tau_M\}$. Denote by w_m the fraction of each years debt issued in the m-th maturity with $\sum_{m=1}^{M} w_m = 1$.
- Assume that quarterly issuance is a constant one unit, and that the issuance fractions never change. Then after a long time, the total amount of outstanding debt which is an original-issue τ_m- maturity security is simply $\tau_m w_m$, because it takes τ_m years for each w_m of debt issued to mature. The total stock of debt is simply $D = \sum_{m=1}^{M} \tau_m w_m$.
- We can define the *steady-state debt stock fractions*

$$\bar{s}_m = \frac{\tau_m w_m}{\sum_{n=1}^{M} \tau_n w_n},$$

which also sum to 1. The relationship can also be inverted: given a desired set of $\bar{s}_m$, the required yearly issuance fractions are

$$w_m = \frac{(\bar{s}_m/\tau_m)}{\sum_{n=1}^{M}(\bar{s}_n/\tau_n)}.$$

- Given these elements, the weighted average maturity (WAM), measured mid-year, of the steady-state debt stock can be computed as $\bar{W} = \frac{1}{2}\sum_{m=1}^{M} \bar{s}_m \tau_m$.
- In the steady state, the annual principal redemption as a fraction of the debt stock can be computed as $\bar{\mathcal{R}} = \sum_{m=1}^{M} \bar{s}_m/\tau_m$.

Rollover and WAM Targets

- We define normalized rollover as the annualized principal redemption $R_{t,p}$ in the simulation at each time on each path, as a percentage of GDP:

$$rollover_{t,p} = 100 * {R_{t,p}}/{GDP_{t,p}}$$

- To target normalized rollover, we augment the objective function with a penalty term given by

$$\eta \sqrt{\frac{1}{TP} \sum_{t,p} \left[\left(rollover_{t,p} - threshold \right)^{+} \right]^2},$$

  where η is a new risk aversion parameter which we set equal to 0.05

- Using the formulae from the previous slide, the steady-state weighted average maturity (WAM) of the securities issued at each time-step on each path is defined as

$$\bar{W}_{t,p} = \frac{1}{2} \sum_{m=1}^{M} \bar{s}_{m,t,p} \tau_m = \frac{1}{2} \frac{\sum_{m=1}^{M} w_{m,t,p} \tau_m^2}{\sum_{n=1}^{M} w_{n,t,p} \tau_n}$$

  where $w_{m,t,p}$ is the issuance fraction of security m at time t on path p , τ_m is the time to maturity of security m, and the sums are over all issued securities.

- To target WAM, we augment the objective function with a penalty term given by

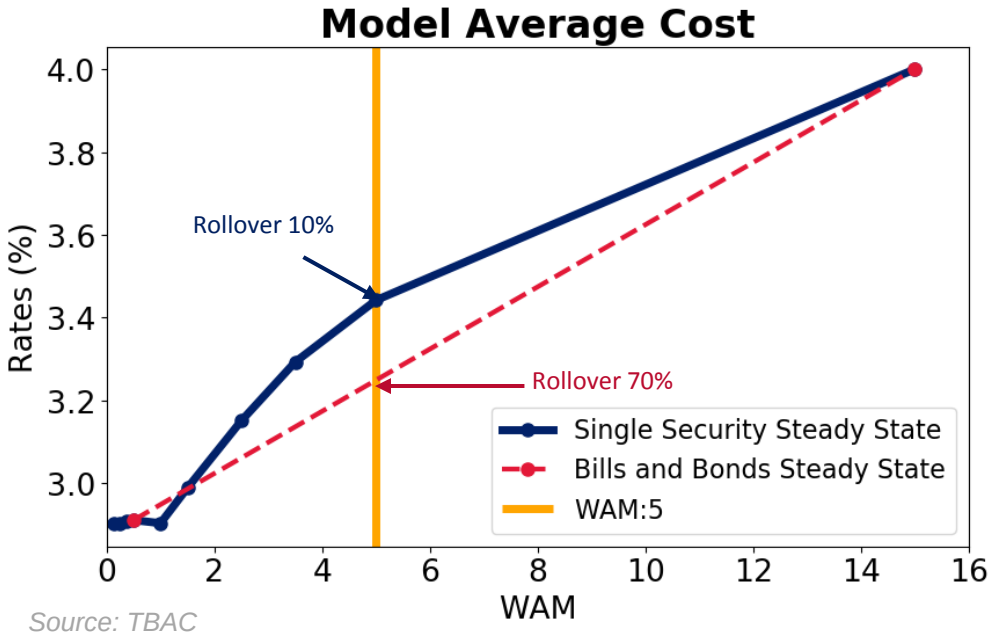
$$\frac{1}{TP} \sum_{t,p} \left(\bar{W}_{t,p} - target \right)^2 .$$

WAM Versus Rollover In More Detail

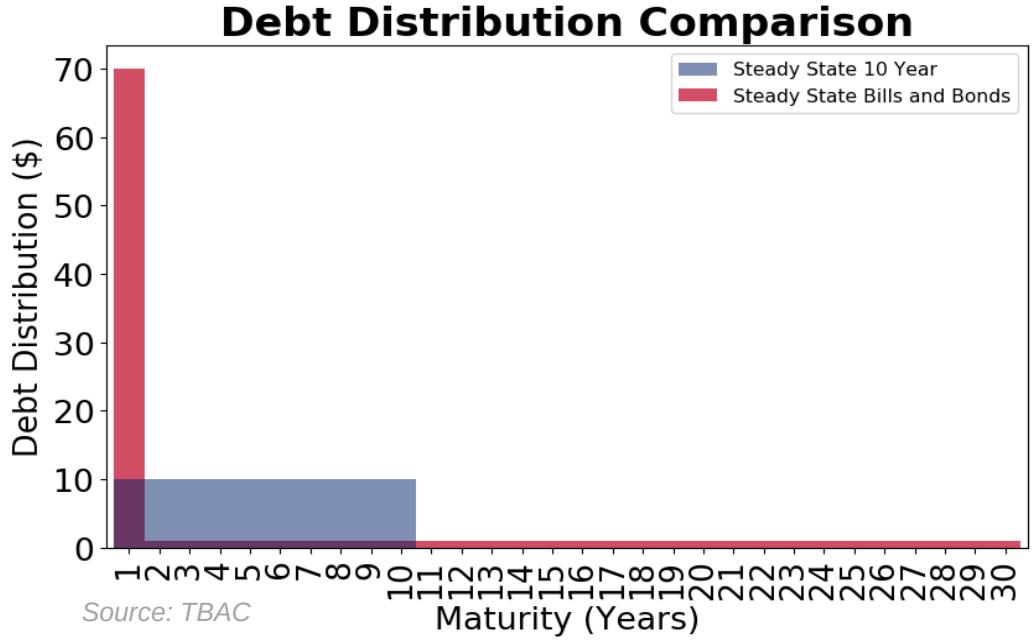
- To give further intuition for the difference between WAM targeting and rollover targeting, suppose we want to create a stock of debt with total outstanding principal of $100, and a desired WAM target of 5 years. We will ignore interest payments for clarity of exposition.
- One way to achieve our goal is to issue $10 each of 1-, 2-, …, 10-year Notes. The WAM of the outstanding debt is 5 years, and in each year, 10% of the debt stock matures and can be replaced by issuing $10 worth of new 10-year Notes. This is a steady-state debt distribution, since 10% of the debt stock is refinanced every year, exactly the same way.
- Another way to achieve our goal is to issue 98.522% Bills and 1.478% Bonds every year, starting with $100 in year one. After a long time doing this, the debt distribution consists of $68.96 Bills and $31.04 original-issue Bonds, maturing annually out to 30 years. Each year, 1/30th ($1.03) of the original issue Bonds, as well as the $68.96 worth of Bills, must be refinanced, for a total of almost 70% of the debt stock. This is also a steady-state distribution.
- For the given WAM goal, the first distribution has minimal rollover (10%), and the second strategy has maximal rollover (70%).
- However, the first distribution is more costly. The average cost in our model is 3.44% (the average 10-year note yield), whereas the average cost of the second strategy is

$$(0.6896 * 2.91\% + 0.3104 * 4.01\%) = 3.25\%$$

  due to the preponderance of Bills and the fact that the yield curve is (in expectation) concave.
- Therefore, an optimization which minimizes cost subject to a WAM target will choose the barbell distribution.



Source: TBAC



Source: TBAC

SUMMARY OF FRN STRUCTURE

Dated Date	Last calendar day of month
Issue Date	Original offerings on last calendar day of month or first business day thereafter; Reopening offerings on last Friday of month or first business day thereafter
Maturity Date	Last calendar day of month 2 years after Dated Date
Maturity Payment	Principal paid on Maturity Date or first business day thereafter
Interest Dates	Quarterly from Dated Date, to and including Maturity Date on the last calendar day of month
Interest Payments	Interest paid on each Interest Date or first business day thereafter
Index Rate	High rate from 13-week T-bill auction converted to simple-interest mmkt yield, ACT/360
Spread	Determined at initial auction, expressed in tenths of a basis point, set at the highest accepted Discount Margin at auction
Minimum Daily Interest Accrual	0.000 percent
Reset Frequency	Daily
Day Count Convention	ACT/360
Lock-Out Period	2 business days preceding FRN Dated Date or FRN Interest Date
Interest Accrual Period	From and including Dated Date or last Interest Payment date to but excluding next Interest Payment date or Maturity Date
Interest Accrual	For a calendar day, computed Index Rate from most recent auction that occurred on a day before accrual day + Spread divided by 360, subject to a minimum rate of zero A 13-week T-bill auction taking place in the 2-day Lock-Out Period prior to FRN Issue Date or FRN Interest Date will be ignored for calculating accrual for that day, instead using the Index Rate determined in the prior auction before the Lock-Out Period began
Issue Price	Determined at auction
Business Day	Any day other than Saturday, Sunday, or day on which the Federal Reserve Bank of New is closed
Auction Technique	Single price auction format in which each competitive bid specifies a Discount Margin (positive, zero, or negative expressed in tenths of a basis point) All noncompetitive bids up to $5mn per submitter accepted in full first then competitive bids accepted from lowest Discount Margin up to the highest until the public offering is filled Usual proration rules apply if amount of bids indicating highest accepted Discount Margin exceeds amount of public offering remaining Spread on reopening auction will be set in note's original issue auction