

RFR (SOFR) Market Model For MBS

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1.0 Overview

Bloomberg's shifted-lognormal LIBOR Market Model (LMM) and LIBOR based mortgage rate projections have been the basis of our MBS risk analytics for the past decade. In preparation for the cessation of LIBOR, Bloomberg has enhanced its interest rate derivatives, yield curves, and volatility structures to support Risk Free Rates (RFR). For USD, the RFR is the Secured Overnight Financing Rate (SOFR). The Bloomberg LIBOR Market Model has been extended to support RFR rates and price RFR derivatives. Building on this, the Bloomberg Structured Products team has redeveloped its mortgage rate and interest rate forward projection models to support RFR.

On 3/18/2022, we will release our US RFR Market Model on OAS1 <Go> and Core Mortgage Premium API (CMP).¹ The LIBOR Market Model will remain the default for the time being but this release will enable clients the option to calculate SOFR based OAS risk analytics for US Agency MBS/CMO bonds, and to compare results to the existing LIBOR based analytics.

2.0 RFR Risk Analytics Framework

Major components for our RFR risk analytics framework include:

1. RFR Swap Curve

The LIBOR Swap curve, USD S23(30/360, S/A vs. 3M LIBOR), used in the LMM model is constructed with LIBOR spot rates, LIBOR based futures contracts and Swaps. To build an RFR Swap curve for USD, Bloomberg used overnight SOFR rates and Swaps that use daily compounded overnight SOFR for the floating leg. The resulting curve is the USD S490 SOFR curve, which has been backfilled to 1/1/2007. SOFR based futures contracts are also currently available but are not available for the entire backfill period. Because historical "as of" analysis is an important feature of Bloomberg's mortgage analytics platform, the version of the S490 SOFR curve used to value US Agency MBS/CMOs excludes SOFR based

¹ RFR Market Model selection was released to clients for Japanese MBS (KIKO/KOKO bonds) on 1/4/2022.

futures. This preserves the full historical “as of” capabilities of the platform in the new RFR environment. The RFR curve used to value Japanese MBS is the S195 JPY OIS curve.²

2. RFR Volatility Cube

Volatility Cubes, for compounded overnight Risk-Free Rates in USD and JPY, were created which utilize RFR market quotes in the major currencies (i.e., SOFR caps in USD and SONIA caps in GBP) or implied RFR volatility by converting LIBOR Swaption volatility. The USD and JPY RFR BVOL Cubes were released on 12/8/2021 with limited backfill. For historical analysis, when the RFR data is unavailable, the RFR BVOL cubes will fallback to use LIBOR volatility quotes. For JPY, the RFR cube has been the default cube since 1/3/2022.³

3. RFR Market Model

Bloomberg’s shifted-lognormal Market Model framework has been adapted to support RFR based interest rate derivatives in addition to legacy LIBOR based derivatives. The RFR are typically daily compounded overnight rates. An arbitrage-free approach based on the Werpachowski condition is developed to simulate such daily compounding rates at any point of time with non-zero shifts. Hence, the original LIBOR market observables and the new RFR observables can be generated together consistently. This RFR market model framework allows the same 256 rate simulation paths for OAS risk analytics and utilizes very similar curve and volatility data structures as LMM. The output of the RFR market model can include daily rates, setting-in-arrears term rates, and zero coupon bond rates, to support MBS predictive models and any new RFR reference rates embedded in MBS/CMO bonds or underlying collateral.⁴

4. USD SOFR Mortgage Rate forward projection model

The Bloomberg mortgage rate model decomposes mortgage rates into

² For more information about Bloomberg RFR Swap curves, see ICVS <Go> on the Bloomberg terminal.

³ For more information on Bloomberg RFR BVOL cube, see DOCS 2098153 <Go> on the Bloomberg terminal.

⁴ For more details on Bloomberg RFR Market Model, see DOCS 2098246 <Go> on the Bloomberg terminal.

the sum of a par coupon rate and primary-secondary spread (i.e. the spread between the primary market mortgage rate available to borrowers and the secondary market par coupon rate on MBS). The primary-secondary spread is modeled as a path dependent function of the par coupon rate, so all of the LIBOR dependence in the mortgage rate model sits inside the par coupon rate projection. At each node along each interest rate path in an OAS simulation, the par coupon rate is calculated as the coupon that produces a par priced MBS using the term structure of spot rates at that node, a prepayment assumption, a base spread assumption and an option cost assumption. The prepayment and option cost assumptions are also functions of the term structure of rates at the given node. To remove the model's LIBOR dependence, we used backfilled S490 SOFR curves along with historical S23 LIBOR curves to translate the curve dependent parameters of the model from LIBOR to SOFR. We then recalibrated the base spread to align the average levels of the SOFR and LIBOR based par coupon models over the historical sample period. This produced a SOFR based mortgage rate model that aligns very closely with the LIBOR based model over historical periods while still being operational after the cessation of LIBOR. The SOFR based mortgage rate model was released to clients on 3/11/2022 through BAM v1.43.1.

5. RFR curves/rates based forward rate projection models for interest rate indices.

The transition from LIBOR based reference interest rate index projections to RFR was available at the end of 2021. The RFR based index forward projection is the current default method for single path conventional analytics on YT/SYT. For multi-path risk analytics, users can select the RFR market model (OAS1 <GO> Figures 3&4 below) to use RFR based interest rate projections.

3.0 RFR Risk Analytics on OAS1

As an illustration of the impact of LIBOR to SOFR transition, we use the OAS1 <Go> terminal function to examine OAS analytics for the FNCL 3 4/22 TBA. We break the analysis into several components: the impact of changing the discount curve from LIBOR to SOFR, the impact of changing the market model IBOR to RFR,

and the impact of changing the mortgage rate model from LIBOR to SOFR based mortgage rate projections (BAM v1.43 to v1.43.1).

Figure 1: OAS1 - IBOR Market Model and S23 Discounting

The screenshot shows the Bloomberg OAS interface for FNCL 3 4/22 Mtge. The 'Settings' tab is selected, showing a 'Rate Env' of v1.43. The 'Discount Curve' dropdown is highlighted with a yellow circle and set to 'Default (S23)'. The 'Market Model' dropdown is also set to 'Default (S23)'. The 'Analytics' section displays various OAS and ZV metrics, and the 'Market Environment' section shows prepay projections and advanced durations. The bottom status bar indicates the current date and time.

Figure 2: OAS1 - IBOR Market Model and S490 Discounting

The screenshot shows the Bloomberg OAS interface for FNCL 3 4/22 Mtge. The 'Settings' tab is selected, showing a 'Rate Env' of v1.43. The 'Discount Curve' dropdown is highlighted with a yellow circle and set to 'SOFR (S490)'. The 'Market Model' dropdown is also set to 'Default (S490)'. The 'Analytics' section displays various OAS and ZV metrics, and the 'Market Environment' section shows prepay projections and advanced durations. The bottom status bar indicates the current date and time.

Figure 3: OAS1 - RFR Market Model and S490 Discounting

FNCL 3 4/22 Mtge Settings Option-Adjusted Spread Analysis

100% FNCL 3.0 3.741(358)1 CUSIP 01F030645 Pool Level Factor Date 03/2022

D Quote 99-19+ Price Prepay 100 BAM *Production Rate Env NY 4PM Close 03/11/2022

v1.43 Settle Date 03/11/2022

Discount Curve SOFR (S490)

Market Model RFR (S490)

Security Info		Collateral Info		Analytics		Market Environment		Model Fits		Projects	
Basic		Additional		OAS Analytics		ZV Analytics		KR Durations		9	
Coupon	3.000	Coll Type	CL	OAS	57.9	Spread	119.3	6M	-0.08		
WAC	3.741			OAD	4.94	Duration	6.55	1Y	0.15		
WAM	358	Loan Size		OAC	-1.88	Convexity	-3.22	2Y	0.32		
WALA	1	AOLS	346,999	OASD	5.44	Sprd Dur	6.37	3Y	0.54		
SATO	39	WAOLS	403,834	OASC	0.55	Yield	3.049	5Y	0.79		
Credit Score	725	MAXOLS	1,500,000	Opt Cost	61.4	WAL	7.57	7Y	0.75		
Orig Date	01/2022	ALS	346,302	+25bp Px	98.320	+25bp Px	97.877	10Y	1.39		
LTV (%)		Occupancy (%)		-25bp Px	100.781	-25bp Px	101.141	20Y	1.02		
WAOLTV	77	Owner Occupied	92					30Y	0.06		
WAOLTV-HPI	77	Second Home	4								
Min OLTV	9	Investment Pro.	4								
Max OLTV	97										
Property Type (%)		Loan Purpose (%)									
Single Family	97	Purchase	44								
2-4 Family	3	Refinance	56								
		Loss Mitigation	--								

Static Analytics Prepay Projections Advanced Durations

Price 99.609 1Y CPR 5.1 Mtge Rate -0.96

Yield 3.051 3Y CPR 8.2 Cur Cpn -0.89

WAL 7.11 LT CPR 10.4 30Y Cur Cpn -0.87

Mod Dur 5.97 ZV 1Y CPR 4.7 15Y Cur Cpn -0.02

Yield Sprd 128.9 ZV 3Y CPR 7.5 Prepay 0.0043

Cashflow Sprd 121.6 ZV LT CPR 9.5

Australia 61 2 9777 8600 Brazil 5511 2395 9000 Europe 44 20 7330 7500 Germany 49 69 9204 1210 Hong Kong 852 2977 6000
Japan 81 3 4565 8900 Singapore 65 6212 1000 U.S. 1 212 318 2000 Copyright 2022 Bloomberg Finance L.P.
SN 572579 G274-42-169 14-Mar-22 0:04:32 EDT GMT-4:00

Figure 4: OAS1 - RFR MM, S490 Disc., BAM v1.43.1/SOFR Par Coupon

FNCL 3 4/22 Mtge Settings Option-Adjusted Spread Analysis

100% FNCL 3.0 3.741(358)1 CUSIP 01F030645 Pool Level Factor Date 03/2022

D Quote 99-19+ Price Prepay 100 BAM *Research v1.43.1 Rate Env NY 4PM Close 03/11/2022

Settle Date 03/11/2022

Discount Curve SOFR (S490)

Market Model RFR (S490)

Security Info		Collateral Info		Analytics		Market Environment		Model Fits		Projects	
Basic		Additional		OAS Analytics		ZV Analytics		KR Durations		9	
Coupon	3.000	Coll Type	CL	OAS	58.2	Spread	119.3	6M	-0.08		
WAC	3.741			OAD	4.95	Duration	6.59	1Y	0.15		
WAM	358	Loan Size		OAC	-1.88	Convexity	-3.15	2Y	0.31		
WALA	1	AOLS	346,999	OASD	5.47	Sprd Dur	6.41	3Y	0.53		
SATO	39	WAOLS	403,834	OASC	0.55	Yield	3.049	5Y	0.79		
Credit Score	725	MAXOLS	1,500,000	Opt Cost	61.1	WAL	7.63	7Y	0.75		
Orig Date	01/2022	ALS	346,302	+25bp Px	98.317	+25bp Px	97.869	10Y	1.40		
LTV (%)		Occupancy (%)		-25bp Px	100.785	-25bp Px	101.154	20Y	1.03		
WAOLTV	77	Owner Occupied	92					30Y	0.07		
WAOLTV-HPI	77	Second Home	4								
Min OLTV	9	Investment Pro.	4								
Max OLTV	97										
Property Type (%)		Loan Purpose (%)									
Single Family	97	Purchase	44								
2-4 Family	3	Refinance	56								
		Loss Mitigation	--								

Static Analytics Prepay Projections Advanced Durations

Price 99.609 1Y CPR 5.1 Mtge Rate -0.98

Yield 3.051 3Y CPR 8.2 Cur Cpn -0.91

WAL 7.11 LT CPR 10.4 30Y Cur Cpn -0.89

Mod Dur 5.97 ZV 1Y CPR 4.6 15Y Cur Cpn -0.02

Yield Sprd 128.9 ZV 3Y CPR 7.4 Prepay 0.0043

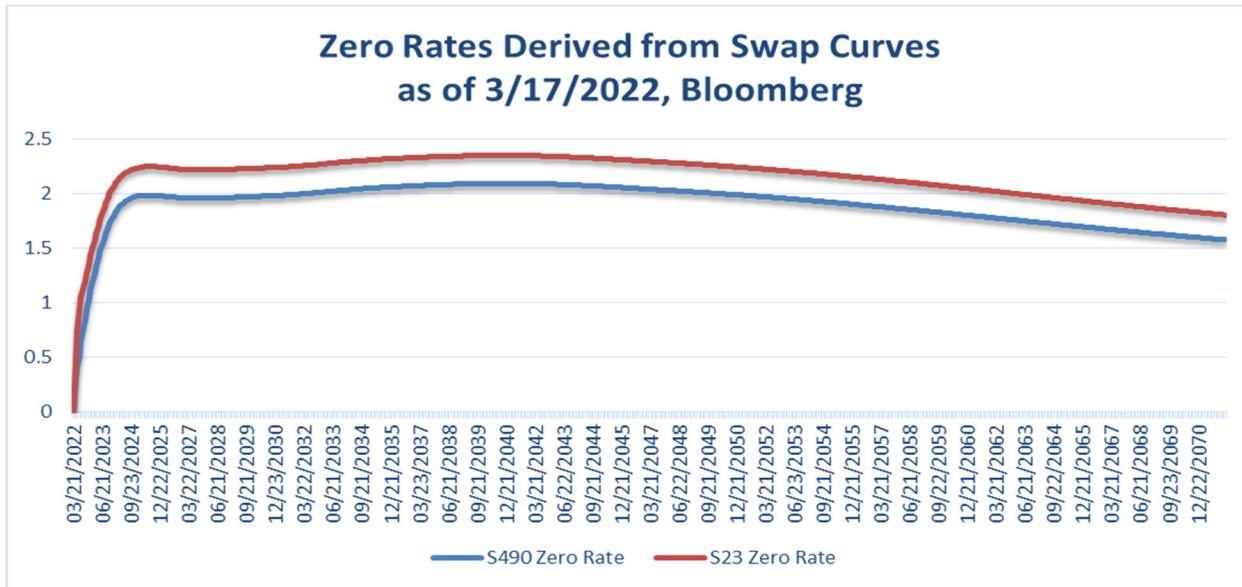
Cashflow Sprd 121.6 ZV LT CPR 9.4

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Japan 81 3 4565 8900 Singapore 65 6212 1000 U.S. 1 212 318 2000 Copyright 2022 Bloomberg Finance L.P.
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From the OAS1 Figures above, one can see the following:

(a) Changing from LIBOR to SOFR discounting (Figures 1 & 2) has a large impact on OAS (25.9 bp) and minimal or no impact on OAD and OAC, as the market model does not change. The OAS increase of roughly 26 basis points is in line with the spread between the S490 and S23 curves (see Figure 5 below).

Figure 5: USD SOFR vs LIBOR Swap Curves



- b) Changing from the IBOR to RFR market model leads to an incremental increase in OAS (4.5bp), has minimal impact on OAD (0.09) and produces a small reduction in OAC (-0.12) (Figures 2 & 3).
- c) Finally, changing from the LIBOR to SOFR based mortgage rate model has minimal to no impact on OAS, OAD or OAC (Figures 3 & 4). As described above in Section 2.4, this is because the new SOFR based mortgage rate model is a LIBOR to SOFR translation of the existing model, designed to maximize historical alignment while removing LIBOR dependence.

4.0 RFR Risk Analytics Changes on Selected Sectors

Following the same approach as above, we extend the analysis to include a variety of Agency related securities including Generics, Pools, CMO's, and CMO derivatives. We summarize the impact on OAS risk analytics in Table 1 below.

The sample bonds include:

- 1) 1500 generics, randomly selected
- 2) 2000 Fixed Rate pools, randomly selected
- 3) 1000 ARM pools, randomly selected
- 4) 500 CMO bonds, randomly selected
- 5) 100 Strip IO/PO CMO bonds

(The numbers of bonds are nominal. The actual numbers depend on prices and running results.)

The risk analytics scenarios are as follows:

- I. 100BAM + IBOR MM + S23 discounting
- II. 100BAM + IBOR MM + S490 discounting
- III. 100BAM + RFR MM + S490 discounting
- IV. 100BAM + RFR MM + S490 disc + SOFR/S490 par coupon model

Subtracting Scenario(I) from Scenario(II) gives the effect of changing the discount curve on OAS/OAD/OAC/ZvOAS. Similarly, Scenario(III) - Scenario(II) gives the impact of the IBOR to RFR Market Model change. Finally, Scenario(IV) - Scenario(III) gives the impact of the LIBOR to SOFR par coupon model change.

Table 1: LIBOR to RFR Risk Analytics Changes

Prepayment: 100BAM As of 2/28/2022		Discounting Effect				Market Model Effect				SOFR/S490 Par Coupon Model Effect			
		IBOR_MM_S490 - IBOR_MM_S23				RFR_MM_S490 - IBOR_MM_S490				RFR_MM_S490_S490 - RFR_MM_S490			
Sector	Difference	OAS	OAD	OAC	ZvOAS	OAS	OAD	OAC	ZvOAS	OAS	OAD	OAC	ZvOAS
Generics	avg(x - y)	24.3806	0.0023	-0.0008	24.3923	1.2326	0.0097	0.0027	0.0000	-0.0134	0.0096	0.0021	0.0032
Fixed Pools	avg(x - y)	24.2286	0.0024	-0.0008	24.2399	1.3474	0.0108	0.0017	0.0000	-0.0113	-0.0001	-0.0001	0.0031
ARM Pools	avg(x - y)	24.2607	0.0030	0.0002	24.2562	0.0358	-0.0284	0.0141	0.0000	0.0219	-0.0003	-0.0011	0.0164
CMO Bonds	avg(x - y)	23.5706	0.0024	-0.0004	23.5762	1.0544	0.0043	0.0033	0.0000	0.0039	-0.0005	-0.0009	0.0182
Strip/IOPC Bonds	avg(x - y)	24.5836	0.0024	-0.0007	24.5848	2.6775	0.0060	-0.0861	0.0000	0.1475	-0.0042	-0.0007	0.1041

Similar to what we saw in the OAS1 screens above, the largest impact is the increase in OAS that results from changing the discount curve from S23 LIBOR to S490 SOFR. This is because of the large, almost parallel spread between the S23 and S490 curves. The impact from the RFR/SOFR market model and the SOFR par coupon model changes are less significant and not always in the same direction across the sectors. While the above analysis suggests a generally minor impact on OAS analytics of the transition from LIBOR to SOFR, it is important to keep in mind that the results represent a snapshot in time that can change along with changes in the relationship between the LIBOR and SOFR based discount curves and volatility surfaces used to derive them.

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