

Agency MBS Primer

A practitioner's toolkit

Primer

Key events have occurred since we last published our Agency MBS primer four years ago. We provide this updated version in guiding both newcomers and seasoned professionals, from the basics to developing an understanding of the ongoing changes the sector is beholden to. To this effect, we continue to orient this work to the active practitioner.

Expanded coverage in this update includes the following:

- The new MBS supply and demand technicals module delves into the drivers of gross and net supply, and factors affecting net demand from the key MBS investor groups: the Fed, domestic banks, overseas investors, and money managers.
- New trends in prepayments, including the growing role of FinTech, enabled by the GSEs, utilized by originators, all reshaping borrower and originator behavior.
- Expanded module on specified pools covering new collateral stories, hedging practices.
- GSE reform, finally taking shape, as well as other policy initiatives.
- New developments in pooling practices, UMBS.

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[Common Acronyms](#)

Introduction

We are pleased to present this updated primer on the Agency MBS sector. As with our October 2016 version, this piece is intended to serve as a handy reference for current and prospective investors looking to develop hands-on capabilities within the sector. The discussion in this primer continues to focus on loans and securities backed by single-family properties only, with multi-family collateral excluded.

Despite considerable amount of literature over the last few decades, as the sector has grown, structural changes continue to reshape drivers of performance. This necessitates this update.

Sponsorship transition is now under way as the Fed, currently the second largest holder of Agency MBS, reduces holdings acquired during post-crisis QE programs and private investors step in, each driven by their unique considerations. Favorable regulatory capital and liquidity treatment have resulted in captive holders amongst domestic banks, comprising the largest investor base in the sector. Overseas banks, both central and domestic, as well as life insurance companies, together the third largest holders, favor MBS liquidity to manage reserves and generate yields. Money managers, the fourth largest investor group, manage allocations opportunistically to outperform other index components, U.S. Treasuries and credit. Given these developments, we introduce a new module focusing on MBS technicals, teasing out drivers of MBS supply, and factors affecting net demand of the investor groups above.

Mortgage market fundamentals have also changed from 2016, reflected in this expanded coverage. Non-banks dominate origination and lead in adopting FinTech, aided by the government sponsored enterprises (GSEs). This has reshaped the profile of MBS cash flows, heralding a new era of streamlined refinancings, while also splitting borrowers into haves versus have nots, as the best credits benefit the most from automation.

As in the 2016 version, we begin our primer with a high level overview of the sector, followed by the basics of agency MBS securities, their underlying collateral, and the process of securitization. Next, we provide some review of the regulatory and historical context in the wake of the financial crisis. Building on that, we detail through more advanced topics including prepayments, valuation, hedging, and relative value, delving into prepayment drivers, negative convexity, carry and spread metrics, risk sensitivities, and strategies for managing risk. Throughout the piece, the aim is to develop intuition and practical understanding applicable to trading and managing MBS risk in today's market.

Away from the MBS basics, the primer breaks down into modular sections covering individual agency MBS subsectors, including their mechanics and operational aspects. We profile the to-be-announced (TBA) market, dollar rolls, deliverability risks, common trade constructs, and value drivers. We focus on 30-year fixed mortgages, and extend this coverage to intermediate duration sectors and ARMs. We expand the coverage on specified pools, agency CMOs, and mortgage derivatives as portfolio allocations have grown. We finish with a section on MBS technicals, described above. Again, we look to build intuition, context, and focus on the relevant drivers for each sector today.



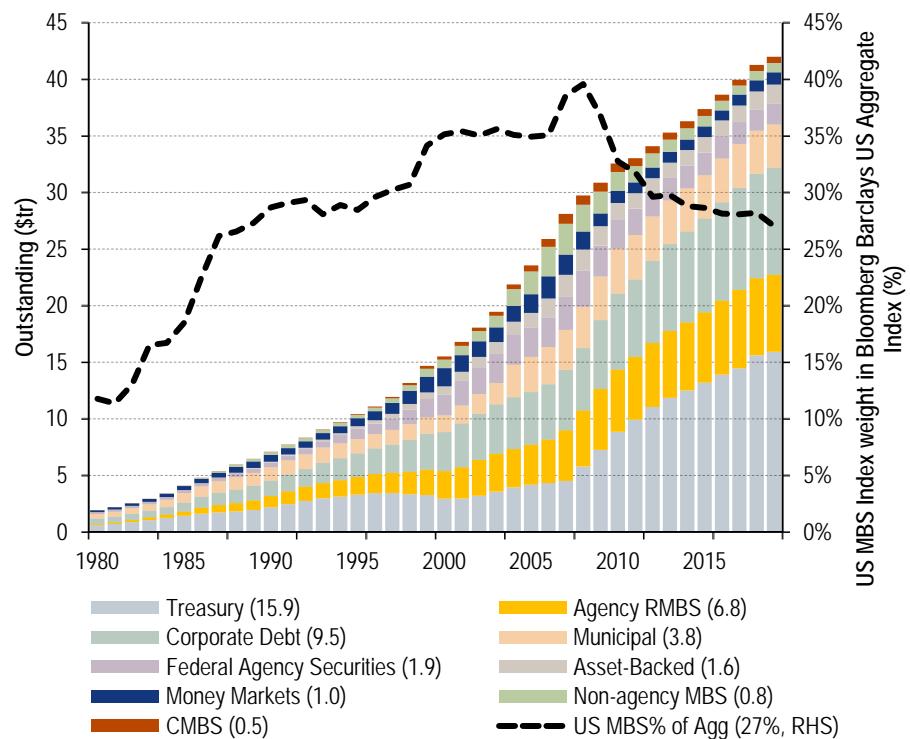
At a glance



Agency MBS market size and trading volumes

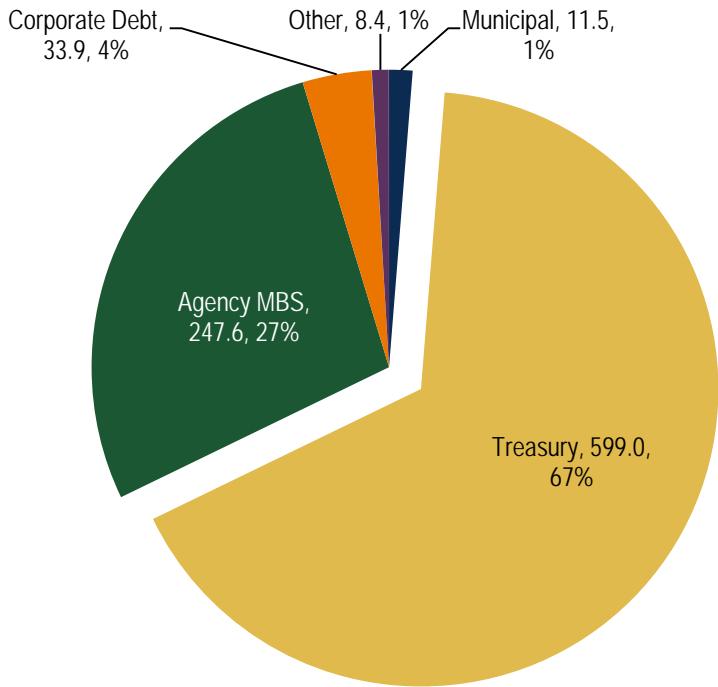
- Agency MBS comprises \$6.8tr of the \$42tr US bond market, the third largest sector after Treasuries and corporates.
- MBS has consistently comprised between 25% and 40% of the US aggregate index.
- The sector generated over 25% of US bond trading in 2019, second only to Treasuries.

Chart 1: Agency MBS is the third largest US bond sector (\$tr)



Source: SIFMA, BofA Global Research

Chart 2: Average daily trading volumes in 2019, by sector (\$bn)



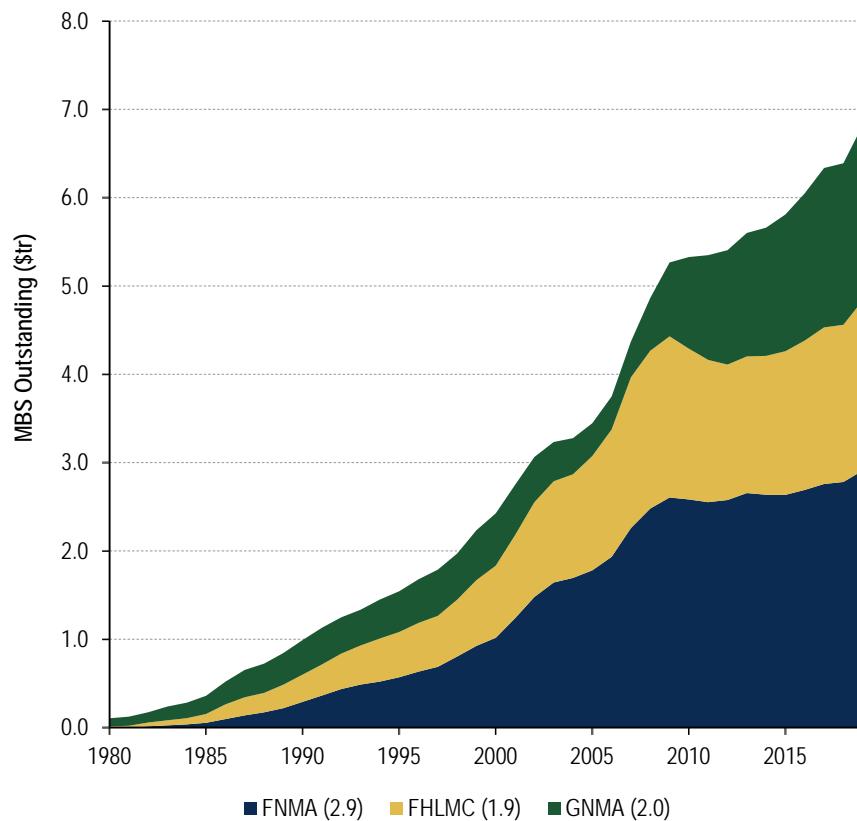
Source: SIFMA



Agency MBS issuers and liquidity

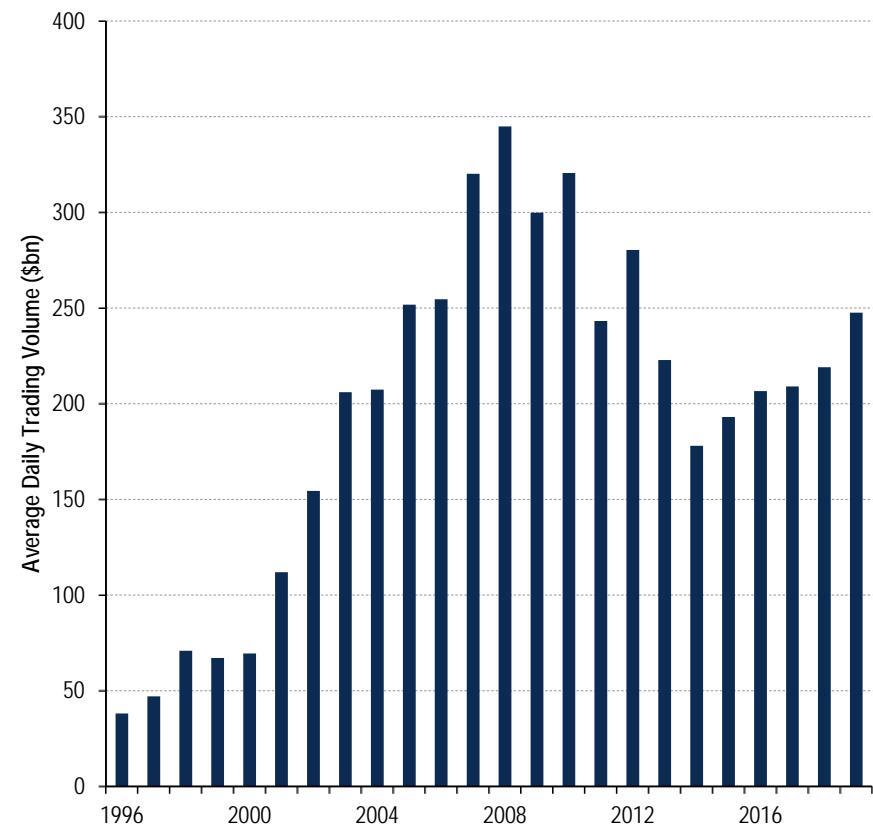
- Agency MBS are issued and guaranteed by three agencies: Fannie Mae, Freddie Mac, and Ginnie Mae. Fannie Mae has been the largest issuer historically. Ginnie Mae issuance has grown post-crisis, essentially expanding the government footprint.
- Trading volumes increased notably in the mid-2000s as the mortgage market expanded, peaking above \$300bn per day in 2008.
- The bulk of trading happens on a forward basis in the *To-Be-Announced (TBA)* market, similar to Treasury futures, where Fannie MBS and Freddie Mac MBS enjoy superior liquidity to Ginnie Mae MBS.

Chart 3: Agency MBS, outstanding by Agency



Source: SIFMA, BofA Global Research

Chart 4: Daily trading volume has ranged between \$200-250 bn over the last five years



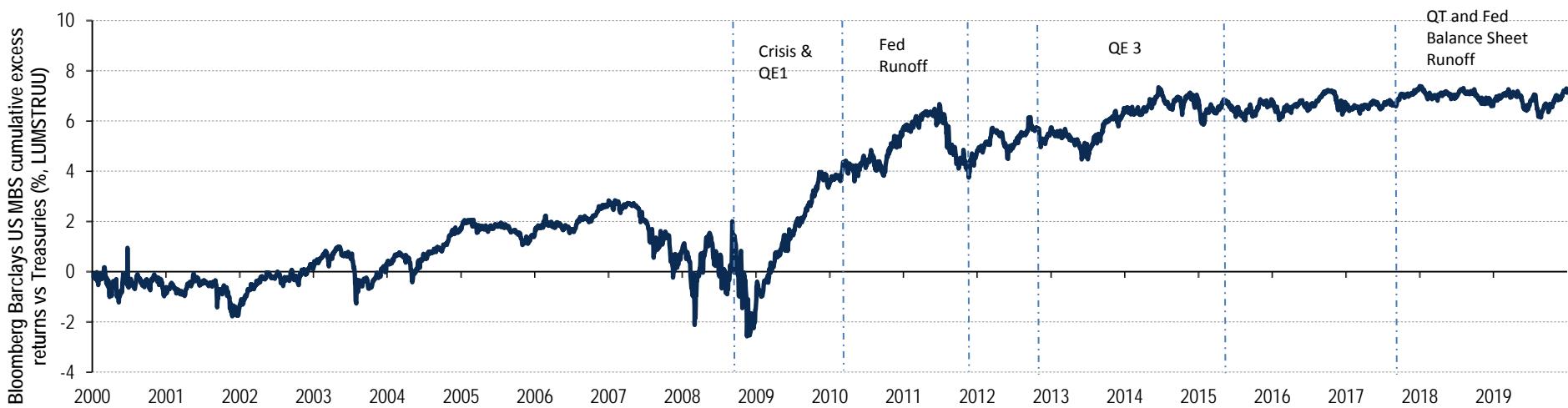
Source: SIFMA



Long-term MBS performance

- MBS typically trade at a positive spread to Treasury or swap benchmarks, offering spread compensation for the embedded risks.
- Realized annual Bloomberg Barclays US MBS Index excess returns since 2000 through end of 2019 are 36bps versus Treasuries. The years 2007 through 2010 are marked by unusual performance volatility due to the developments in the midst of the financial crisis.
- More stable performance has characterized the sector since, as market volatility has remained muted and MBS ownership has shifted into more stable hands. At the same time, MBS index annual excess returns versus Treasuries averaged a mere 6bps for the five years from 2014 to 2019.

Chart 5: Long-term MBS performance of Bloomberg Barclays US MBS Index (LUMSTRUU)



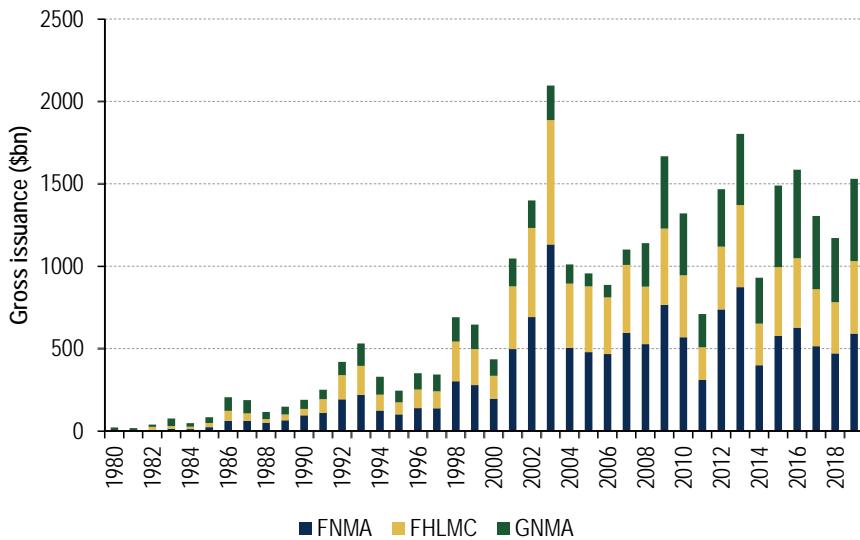
Source: Bloomberg, BofA Global Research



Historical gross and net issuance

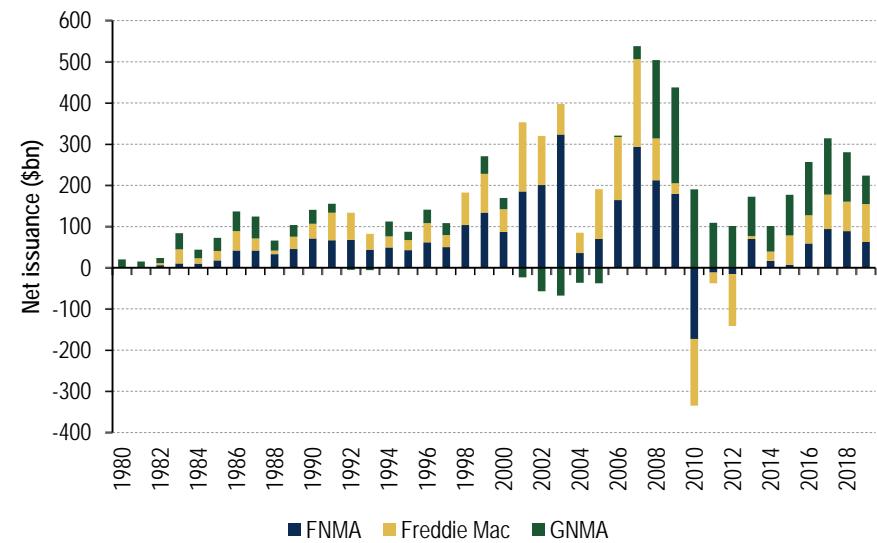
- Gross annual issuance averaged \$1.2tr since 2000, marking a peak of \$2.1tr in 2003.
- Net issuance peaked at \$538bn in 2007 and marked a low of -\$145bn in 2010. Net issuance has ranged between \$200-300bn over the past five years, post taper tantrums, as policy effects have largely stabilized.
- MBS issuance can vary considerably, driven by a number of macroeconomic and structural factors:
 - Paydowns, comprised of loan amortization and early payoffs
 - Pace of new and existing home sales
 - Home prices and home equity monetization by borrowers
 - Bank loan retention and origination pipeline growth
 - Agency loan retention and loan defaults
 - All-cash home sales and availability of mortgage credit away from the Agency MBS

Chart 6: Gross issuance has averaged \$1.2tr since 2000, peaking at \$2.1tr in 2003



Source: BofA Global Research

Chart 7: Net issuance varies considerably and can turn negative if amortization, prepayments, buyouts outpace new issuance



Source: BofA Global Research



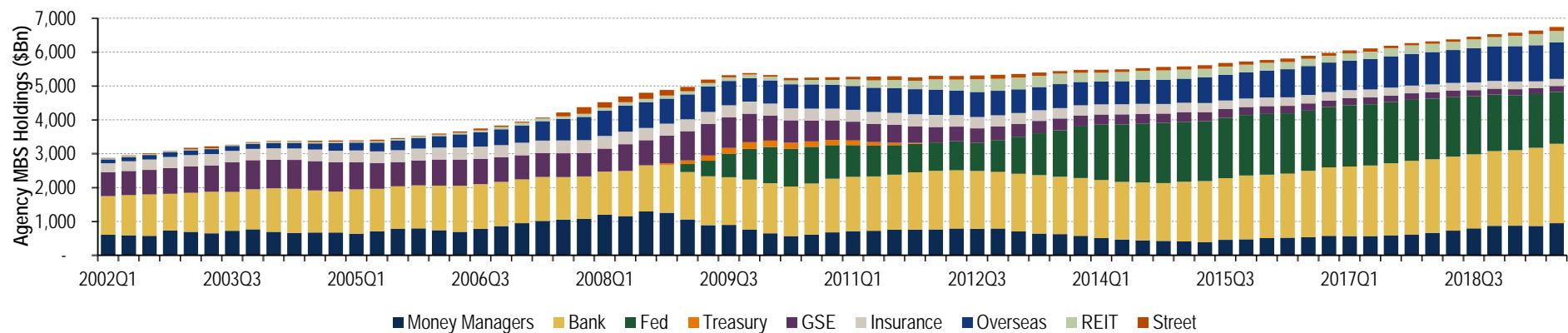
Holdings now dominated by buy-and-hold investors

Table 1: Agency MBS investor positioning, as of 3Q19

Investor group	Holdings (\$bn)	Driving factors for investor demand
Banks	2347	Agency MBS helps meet liquidity ratio requirements, offering incremental spread over Treasuries. MBS holdings trend up over time as bank assets grow with nominal GDP.
Fed	1529	Purchased through QE programs. Started balance sheet runoff in October 2017 with a monthly cap of \$20bn. Any paydowns in excess of the cap are reinvested. Coupon distribution closely matches issuance at the time of purchase.
Overseas buyers	1076	Yield-driven audience, investing dollar reserves and excess liquidity into MBS. Trade deficit, yields, and currency determine appetite.
Money managers	950	Includes index managers and relative value investors, such as hedge funds.
REITs	335	Leveraged relative value investors in MBS, generally seeking to maximize carry.
Insurance	208	Invest MBS for liquidity, spread, and liability management needs.
Fannie and Freddie (GSEs)	178	GSEs have wound down portfolio holdings since the financial crisis, no longer arbiters of relative value.
Street dealers	120	Carry inventory to provide liquidity for investors.

Source: BofA Global Research, Fed Z1

Chart 8: Holdings now dominated, by buy-and-hold investors



Source: BofA Global Research, Fed Z1



Historical demand displays regime shifts

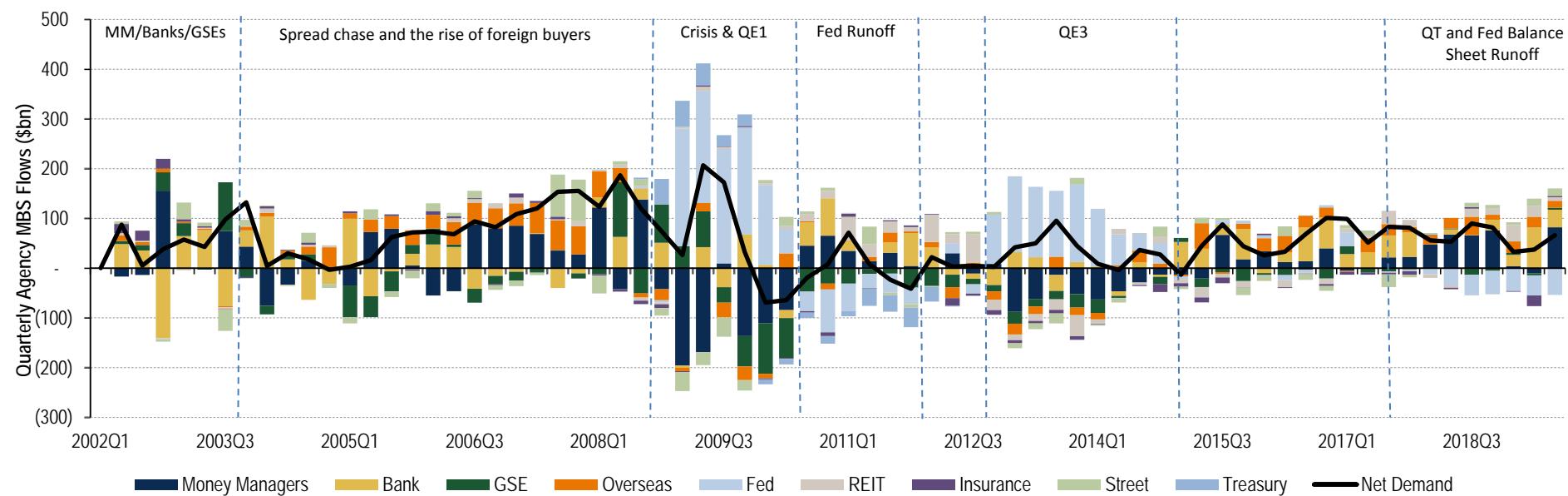
- Investor sponsorship and holdings have transformed the sector over the last two decades.

Table 2: Historical demand for MBS has been characterized by several regime shifts

Period	Dominant theme
Pre-2003	Trading is dominated by banks, money managers, and Fannie Mae and Freddie Mac.
2003-2008	Emergence of overseas buyers deploying forex reserves and spread product exposure through MBS. Money managers chase tighter spreads.
2008-2010	Crisis and QE1 lead to Fed emerging as the dominant buyer of MBS. Fannie and Freddie begin portfolio wind-down.
2010-2011	Fed's QE1 purchases wind down, REITs emerge as significant MBS buyers for the first time. Banks add to boost earnings.
2011-2014	QE3 leads to Fed re-emerging as the dominant buyer, with all others turning into net sellers.
2014-2017	Post-QE3 demand is primarily driven by banks on new regulations, overseas buyers, and money managers.
2017- today	Fed's balance sheet runoff forces money managers to absorb the incremental supply.

Source: BofA Global Research

Chart 9: Net MBS flows over time highlight distinct eras in the MBS market



Source: Fed Z1, TIC, S&P Global intelligence



From loans to pools



Agency origins and mandate: Fannie Mae and Freddie Mac

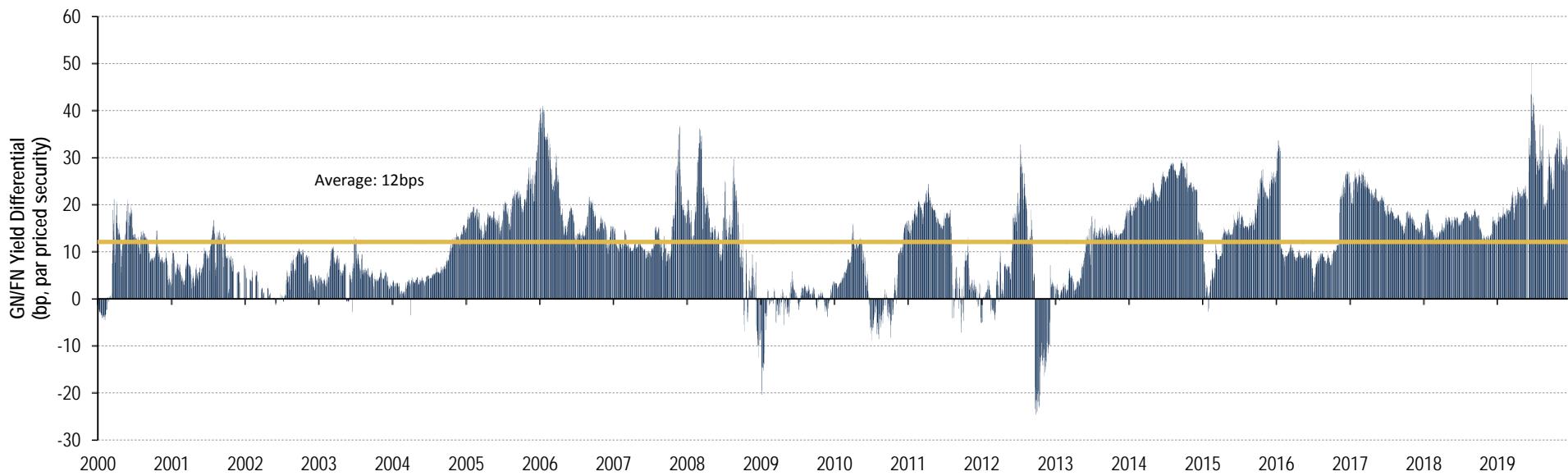
- The three agency issuers of MBS in the US are Fannie Mae, Freddie Mac, and Ginnie Mae.
- **Federal National Mortgage Association (FNMA, Fannie Mae):** Established in 1938 as part of the New Deal. Mandated to develop a liquid secondary mortgage market by securitizing residential mortgage loans. FNMA was privatized in 1968, becoming a publicly traded corporation.
- **Federal Home Loan Mortgage Corporation (FHLMC, Freddie Mac):** Established in 1970 with the same objectives as FNMA. Created to compete with the newly privatized FNMA.
- **Government Sponsored Enterprises (GSEs):** Collective reference to both, Fannie Mae and Freddie Mac. Federal Home Loan Banks (FHLBs) are also sometimes referred to as the GSEs – for the purpose of this primer, and in the context of the Agency MBS discussion, they are usually excluded.
- Fannie Mae and Freddie Mac MBS are the direct obligations of the GSEs, but not of the US government. MBS issued by the GSEs are often referred to as *Uniform MBS*, or UMBS.
- As Federally chartered institutions, the GSEs have access to a limited credit line with the US government, enjoying favorable funding based on their perception as “too big to fail.” These constitute the basis for the implicit US Government guarantee of GSE MBS securities. GSEs are also exempt from state and local income taxes.
- The “too big to fail” assumption was challenged only once during the mortgage crisis in 2008, causing Fannie and Freddie mortgage spreads to widen. This precipitated a government bailout of both entities, placing them under conservatorship of the Federal Housing Finance Administration (FHFA).
- Under the conservatorship, GSEs have operated with very limited capital, ultimately relying on the US Government as a credit backstop. All profits have been passed to the US Treasury per the Senior Preferred Stock Purchase Agreement (PSPA) signed August 2012, subsequently revised to allow limited capital to build up at the GSEs.
- The mechanics of the PSPA extend to the credit lines being available through the transition period from conservatorship to the final exit from conservatorship.



Agency origins and mandate: GNMA

- **Government National Mortgage Association (GNMA, Ginnie Mae)**: Split off from FNMA in 1968, retained as a public institution. It is part of the Department of Housing and Urban Development (HUD), a cabinet-level agency created in 1965.
- GNMA seeks to provide liquidity and capital market access for the loans guaranteed by the Federal Housing Administration (FHA), Department of Veteran's Affairs (VA), US Department of Agriculture Rural Housing Service (USDA RHS), and HUD's office of Public Indian Housing (PIH).
- MBS are issued under two main programs, Ginnie Mae I and Ginnie Mae II. Ginnie Mae II, or G2s, is the dominant program today, offering more liquidity and pooling flexibility to issuers.
- GNMA MBS are backed by the full faith and credit of the US government, enjoying the same regulatory capital and liquidity treatment as US Treasuries. As a result, GNMA yields on average are historically lower than on GSE-issued MBS.

Chart 10: Historical GN/FN yield differentials show Ginnie MBS trade at 12bps premium



Source: BofA Global Research

Agency MBS pooling

- All three agencies wrap single-family mortgage loans with a credit guarantee in exchange for a *guarantee fee* (*G-fee*), and securitize the remaining cashflows, net of servicing fees, into MBS pools. Lenders have the option of exchanging their loans for pools backed by that specific collateral, or for a pro rata share of a multi-lender pool. Loan originators can also sell the loans directly for cash to the GSE *cash window*, which will subsequently securitize the loans into MBS.
- GSE G-fees are lender-specific, and are the key driver with respect to the relative attractiveness of Agency execution versus Private Label Securitization (PLS).
- Agencies set their own underwriting, servicing, and pooling standards, published in their respective selling and servicing guides. Loans underwritten to these guidelines are exempt from QM/QRM requirements under the Dodd-Frank Act of 2010. This QM *patch* is scheduled to expire in 2021 for the GSEs, and changes to the QM rule have been proposed by CFPB that would ensure a seamless transition.
- Agencies act as trustees for the MBS securities, responsible for the distribution of cashflows as well as monthly data reporting, with paydowns reported on the fourth business day of the month.
- All MBS issued by Fannie Mae and Freddie Mac are referred to as Uniform MBS (UMBS). Legacy MBS issued by the GSEs prior to June 3rd, 2019 are referred to as Fannies and Golds.
- MBS cashflows are distributed monthly to investors with a payment delay, typically of 55 days for UMBS, and 50 days for G2s. Payment delay is defined relative to the due date, first of the month, assuming a 30/360 convention. Thus, UMBS pay on the 25th of the next month after the due date, and G2s on the 20th. Since US borrowers pay 30 days in arrears, the payment corresponds to the month preceding the due date. Example: September payment is due October 1, paid to UMBS investor on November 25.

Table 3: Agencies, at a glance

	GNMA	FNMA	FHLMC
MBS outstanding	\$2.0t	\$2.9t	\$1.9t
Ownership	Government-owned	Private entities, currently in conservatorship	
Government backing	Explicit sovereign guarantee	Implicit guarantee	
Programs	Federally-insured (FHA, VA, RHS)	Conventional loans	
LCR	Level 1A (no haircut)	Level 2A (15% haircut, 40% cap on HQLA)	
Capital Treatment	0% risk weight	20% risk weight	

Source: BofA Global Research



Pool characteristics and common terms

- Agencies issue MBS pools daily and subsequent balances are reported monthly.
- Pools are typically identified by a unique pool number as well as a Committee on Uniform Securities Identification Procedures (CUSIP) number. Each pool gets a prefix, which identifies the program type, i.e., 30yr, 15yr, special program, etc. Prefixes comprising similar collateral are often grouped into tickers, i.e. FNCL indicates 30yr UMBS.
- Special pools are sometimes created that contain other pools instead of loans. These are termed Supers for UMBS and Platinums for Ginnies. The underlying pools in a Super or a Platinum pool must have matching coupon and maturity. Within Supers, Fannie and Freddie UMBS are interchangeable and can be commingled.
- Supers are created to improve liquidity and ease of position management, typically by creating a large pool out of a number of smaller ones. Legacy Supers issued prior to June 3rd, 2019 are called Megas and Giants for Fannie and Freddie, respectively.
- Common terms used to describe features of MBS pools are shown in the table below.

Table 4: Definitions of basic pool characteristics and common terms

Terms	Description
Net coupon	Coupon passed through to the MBS investor after stripping servicing fee, G-fee from the loans. Applied using 30/360 convention.
Pool factor	Ratio of current bond balance to the original balance, released on the fourth business day of every month.
WAC, GWAC	Weighted Average Coupon, or Gross Weighted Average Coupon – weighted average gross interest rate, or note rate, paid by the borrower, in percentage.
WAM	Weighted Average Maturity, in months.
WALA	Weighted Average Loan Age, in months.
FICO	Stands for Fair, Isaac, and Company, and is a consumer credit score metric - it ranges from 300 to 850, with 850 reflecting perfect credit.
LTV, CLTV	LTV stands for loan to value, a ratio of loan balance to property value. Combined loan to value takes into account all loans secured by a property.
ALS, AOLS, WALS, WAOLS	Average Current Loan Size (ALS) and Average Original Loan Size (AOLS). WALS and WAOLS are weighted by balance.

Source: BofA Global Research



MBS pool on Bloomberg

- Extensive pool information is available on Bloomberg, updated monthly from the Agency data tapes.
- Example below: UMBS pool number BC2848.

Chart 11: FN BC2848 MTGE <GO> DES screen provides a high-level pool description

FN BC2848	102-027 ₈	102-017 ₈ /102-037 ₈	Yield	2.642/2.632	Coupon	3.000%	BVAL
As of 18 Dec	Prepay 162PSA	Fannie Mae Pool	BAM TOAS	30.8			
FN BC2848 Mtge	Export		Page 1/2 Security Description				
FNCL 3 M	3.605(314)40 CUSIP 3140EXEW9	Pool Level			90 Buy	90 Sell	
i Summary j Comments							
Pool FN BC2848		10) Seasoning	FNCL 3 M		As Of	12/2019	
Type (CL) UMBS Conventional Conv 30 years Level pay		11) Vintage	FNCL 3 2016		Issue Date	09/01/2016	
Traits 30/360					Maturity Date	09/01/2046	
11) Seller Wells Fargo Bank, N.A.		Issuer FNMA					
12) Pool Information			Balance				
Coupon 3.000 WAC	3.605 Orig WAC	3.612 Factor	0.75676239				
	WARM 314 Orig WAM	359 Orig Amt	2,053,136,711				
	WALA 40 Curr Amt	1,553,736,644					
13) Collateral Information		Prepay CPR PSA					
WAOLTV 78 AOLS*	312,286 Orig TPO	64.56 1 Month	9.2 153				
WAOLTV-HPI*	66 WAOLS*	336,622 Curr TPO	65.26 3 Month	10.8 179			
WAOCLT	79 MAXLS	1,061,000	6 Month	11.1 184			
WAOCSCS	764 WAOLT	359	1 Year	9.2 154			
	WAODTI*	34	Life	6.3 160			
14) # Loans 5,433 Delay 54 (24)		10) States California		%UPB 22.4			
TRACE Eligible			Texas	7.4			
15) Paydown Information			Florida	5.0			
Prepay History	Dec19 Nov Oct Sep Aug Jul Jun May Apr Mar Feb Jan19						
1 Month CPR 9.2 12.3 10.7 11.3 12.4 10.3 10.4 9.2 8.4 5.4 4.5 5.8							
3 Month CPR 10.8 11.5 11.4 11.1 10.0 9.3 7.7 6.1 5.2 5.1 5.8							
6 Month CPR 11.1 11.3 10.7 10.3 9.4 8.1 7.3 6.4 5.9 5.1 5.5 6.2							
12 Month CPR 9.2 8.9 8.4 7.8 7.5 7.2 7.0 7.0 6.6 6.3 6.3 6.3							
Suggested Functions	BVAL Bloomberg Valuation		TRA Calculate total return for a security				

Source: Bloomberg

Chart 12: FN BC2848 MTGE <GO> CLC screen provides further collateral information

FN BC2848	102-027 ₈	102-017 ₈ /102-037 ₈	Yield	2.642/2.632	Coupon	3.000%	BVAL
As of 18 Dec	Prepay 162PSA	Fannie Mae Pool	BAM TOAS	30.8			
FN BC2848 Mtge	Video Tutorial						Collateral Composition
FNCL 3 M	3.605(314)40 CUSIP 3140EXEW9	Blended					
Composition	Overview	Show All	3) Clear				As of 12/2019
1) Overview				Curr %	Issue %		
2) Addl Info 1	Loan Purpose	12/2019	09/2016	Occupancy			
3) Modification	Purchase	66.0	65.5	Owner Occupied			
4) Custom	Refinance	25.0	34.5	Vacation			
5) Quartiles	Equity Take Out	9.0		Borrowers			
Distribution	Property Type				2 Borrowers		54.8
6) Origination Year	Single Family	53.3	99.3	1 Borrower			44.5
7) Geographics	Planned Unit Development	39.1		Mortgage Insurance			
8) Servicers	Condominium	7.1		No Data			68.3 61.3
9) Sellers	Co-op	0.5		30			15.6 0.0
10) Coupon	Manufactured Housing	0.1		25			12.9 0.0
11) Issuance LTV	First Time Home Buyer			Issuer Agency			
12) Amortized LTV	NO	76.1		FNM			100.0
13) Combined LTV	YES	23.9		Geographics			
14) Original LTV	Vintage			California			22.4 22.6
15) Credit Score	2016	100.0	100.0	Texas			7.4 7.3
16) Debt to Income	Service Name			Florida			5.0 5.1
17) Orig Loan Size	WELLS FARGO BANK, NATIONAL ...	100.0		Virginia			4.7 4.6
18) Age	Seller Name			Minnesota			
19) Remaining Term	WELLS FARGO BANK, NATIONAL ...	100.0		North Carolina			3.9 4.0
20) Original Term	Third Party Origination			Pennsylvania			3.8 3.5
21) Next Step Date	Correspondent	65.3	64.6	Georgia			3.6 3.8
22) Last Step Date	Retail	34.7	35.4	New Jersey			3.5 3.3
23) Terminal Coupon							
Suggested Functions	YT Price a security in multiple scenarios			RA Roll Analysis			

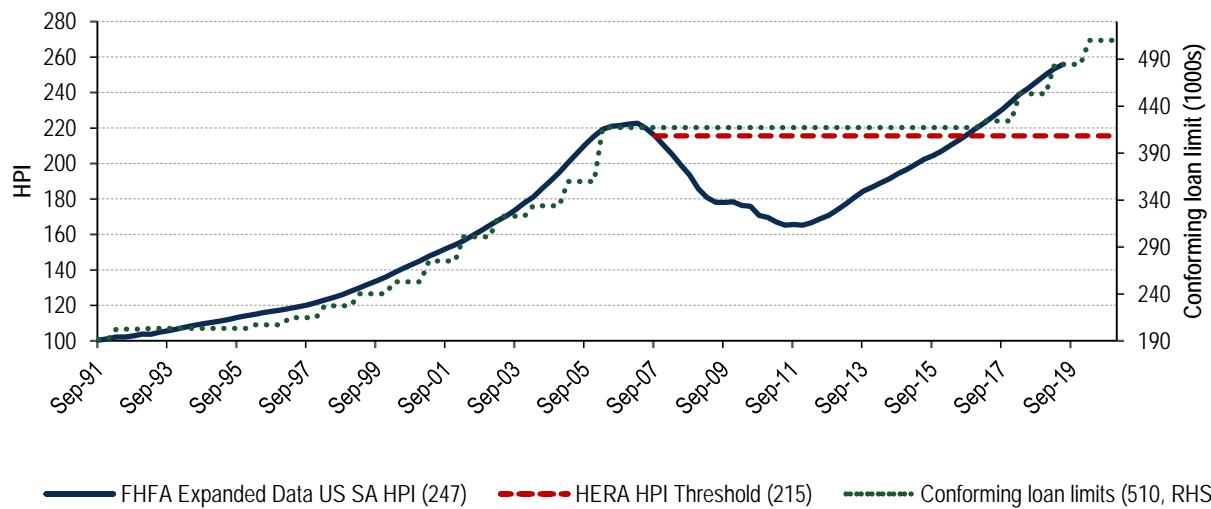
Source: Bloomberg



Conventional loans and the conforming loan limits

- The underlying loans to GSE MBS are typically referred to as *conventionals* or *conforming*.
- Loan balances are subject to the *conforming loan limit* for GSE pooling. This is now set by the formula defined in the Housing and Economic Recovery Act of 2008 (HERA).
- The limits are set to track the increases in the FHFA expanded data US seasonally adjusted home price index (HPI) once home prices exceed the prevailing level during 3Q07, the last reading before HERA took effect.
- Per HERA, conforming limits do not decline in the event home prices decrease, but do not resume increasing until the most recent HPI peak is revisited.
- The maximum single-family limit of \$510K, as of 2020, an increase from \$484k in 2019 within the contiguous states and DC. It is as high as \$765k in certain designated high cost areas. Limits for Alaska, Guam, Hawaii, and US Virgin Islands are also \$765k. Conventional loans with balances exceeding \$510k are referred to as *conforming jumbos*.

Chart 13: The conforming loan limits rise with HPA, but do not drop when HPA turns negative



Source: FHFA, BofA Global Research



Conforming loans – LTV limitations and PMI

- Conforming loan eligibility is also limited by LTV. Most loans today cannot exceed 97 LTV. However, there are exceptions, such as high LTV refinance programs aimed at underwater borrowers. Also, certain limitations are applicable for borrowers between 95 and 97 LTV.
- LTVs on cashout refinancings, when a new loan carrying a higher balance and LTV is used to pay off an existing loan, are limited to even lower values. The maximum is 80 LTV for the GSEs.
- Per the GSE charters, most borrowers with LTVs above 80 have to obtain *private mortgage insurance* (PMI or MI). PMI covers the first loss to the GSE in the event of a default, but is limited to a pre-determined coverage amount. Mortgage insurance premiums are set annually and paid monthly by the borrower. The premium amount is primarily determined by LTV, FICO and other characteristics of the loan. Example pricing grids are shown below.
- PMI is typically canceled once the loan amortizes below 80 LTV or the age of the loan reaches halfway through the term of the loan. If no delinquencies are incurred, then this happens automatically.

Table 5: Current MI pricing grid for a 30-year fixed loan (bps)

LTV	95-97	90-95	85-90	80-85
Standard Coverage	35%	30%	25%	12%
Cost in bps				
FICO				
760+	58	38	28	19
740-759	70	53	38	20
720-739	87	66	46	23
700-719	99	78	55	25
680-699	121	96	65	28
660-679	154	128	90	38
640-659	165	133	91	40
620-639	186	142	94	44

Source: Genworth Financial, as of Dec 2019

Table 6: Current MI pricing adjustments for 30-year fixed mortgage, by FICO (bps)

	MI Adjustments							
	760+	740-759	720-739	700-719	680-699	660-679	640-659	620-639
>= 2 Borrowers/97% LTV	-13	-13	-13	-13	-14	-15	-16	-18
Investment/3-4 Unit Property	34	38	38	47	50	57	65	75
Second Home	12	13	14	17	20	35	40	45
Manufactured Housing	18	2	20	25	30	50	55	60
Cash-Out Refinance	18	2	20	25	25	50	55	60
Relocation Loan	-2	-4	-4	-7	-7	-10	-12	-12
Declining Renewal (BPMI only)	2	3	3	4	4	5	7	7
Level Annual Refundable	-2	-3	-3	-4	-4	-5	-7	-7
Refundable Monthly	1	1	1	2	2	3	3	3
LPMI Monthly	4	6	8	11	13	19	21	23
DTI >45%/97% LTV	10	14	17	21	26	35	37	38
DTI >45%/95% LTV	9	11	14	18	23	27	29	31
Peak Portfolio/97% LTV*	-5	-6	-7	-8	-10	-13	-14	-16
Peak Portfolio/95% LTV*	-3	-5	-6	-7	-9	-12	-13	-14

Source: Genworth Financial, as of Dec 2019



Conventional loan pooling mechanics

- GSE pooling process generally involves packaging the loan into a pool after stripping the servicing fee and the G-fee owed to the GSEs.
- To improve liquidity, MBS pools are issued with coupons in multiples of 50bps, e.g. 3%, 3.5%, 4%, etc.
- The originator typically has the flexibility to deliver the same loan into a pool with a number of potential coupons. If the loan note rate, net of the G-fee and the minimum servicing fee, exceeds the expected pool coupon, the originator ends up retaining an *excess IO* cashflow. Excess IO cashflows can be retained, securitized and sold in the secondary market, or sold directly to the GSEs. The price quoted by the GSE for the excess IO is called the *buy-up multiple*, representing a price for a 100bps strip of excess IO backed by loans with a given note rate.
- Pools with higher coupon generally fetch higher prices. However, this decreases the excess IO, and potentially results in a *G-fee shortfall*, i.e., the loan interest proceeds are insufficient to pay servicing, G-fee, and the desired coupon to the investor. In this case, originator can pay an upfront amount of cash to the GSE to *buy down* the G-fee. The amount of upfront required is set by GSEs, termed the *buy-down multiple*, representing a price for 100bps of G-fee shortfall on loans with a given note rate.
- The buy-up/buy-down multiples tend to correlate to the general level of interest rates – higher at higher rates. For a given level of rates, they vary across borrower note rates with lower multiples offered for higher note rates. The buy-up multiples are usually lower than buy-down multiples, representative of the bid and the offer side for the excess IO, respectively.
- GSEs impose certain restrictions on pooling. For example, note rates on loans can't exceed the pool coupon by over 112.5bps. Also, the retained excess IO and the servicing fee can't exceed 50bps in total, with any excess mandated to be sold to the GSE at the buy-up multiple.

Table 7: Example of pooling 4.00% note rate loan into FN 3 with excess IO sold to the GSE

	FN 3
Mortgage Rate Payable by the Borrower	4.00
G-fee to the Agency	-0.44
Minimum Servicing Fee	-0.25
MBS Pool Coupon	-3.00
Excess IO	0.31
Buyup Amount (4.1x)	1.27
MBS pool price	101.22
Total proceeds from Sale	102.49

Source: BofA Global Research

Note: buyup multiple of 4.1 is illustrative, represents \$4.1 bid for 100bps of excess IO

Table 8: Example of pooling 4.00% note rate loan into FN 3.5 with G-fee buydown

	FN 3.5
Mortgage Rate Payable by the Borrower	4.00
G-fee to the Agency	-0.44
Minimum Servicing Fee	-0.25
MBS Pool Coupon	-3.50
Excess IO	-0.19
Buydown Amount (6.1x)	-1.16
MBS pool price	102.72
Total proceeds from Sale	101.56

Source: BofA Global Research

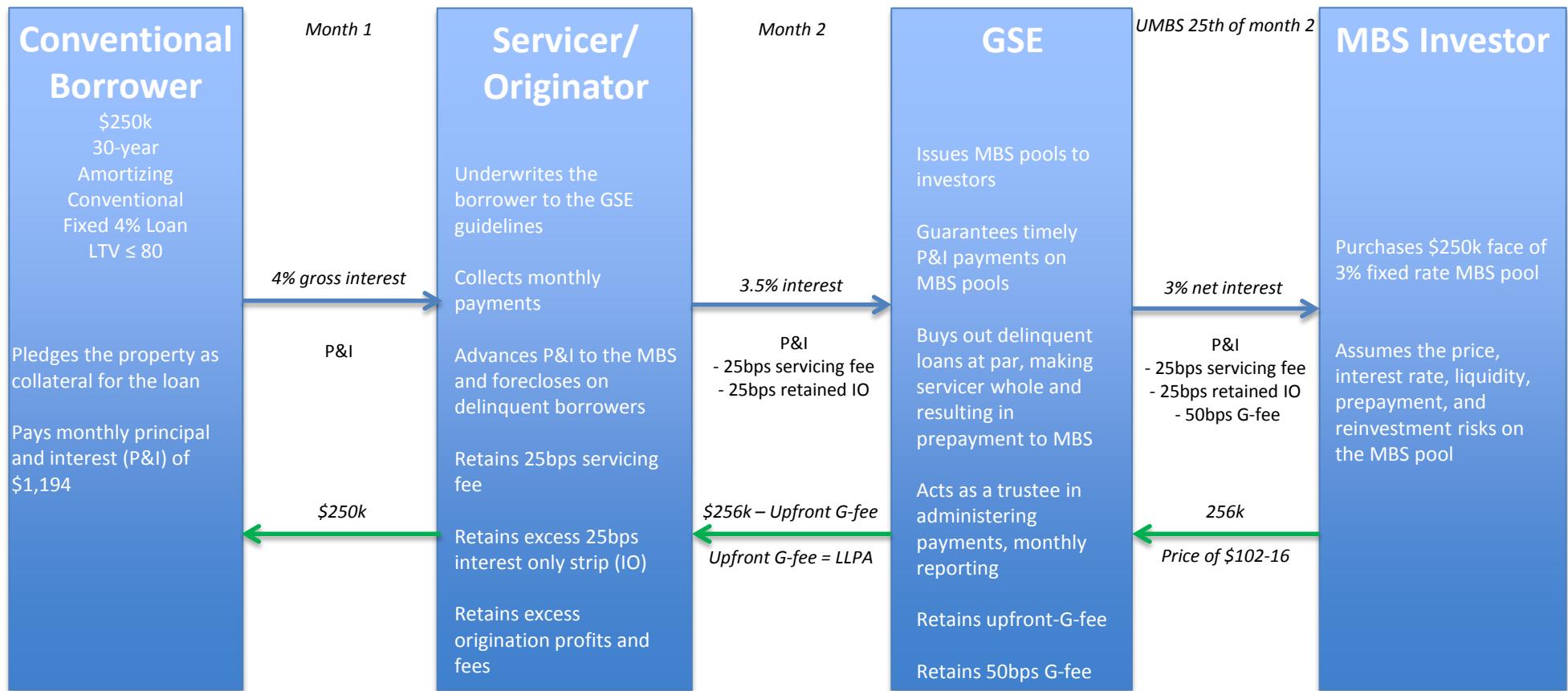
Note: buydown multiple of 6.1 is illustrative, represents \$6.1 offer to extinguish 100bps of G-fee shortfall



MBS cashflow basics – conventionals

- Servicer retains the minimum servicing fee of 25bps as well as any excess IO in exchange for collecting cashflows every month and advancing P&I on delinquent loans.
- GSEs collect and aggregate cashflows from servicers, report paydowns, and distribute MBS cashflows on the payment date, net of any retained G-fees.

Chart 14: Cashflows for conventional MBS



Source: BofA Global Research



GNMA collateral - FHA

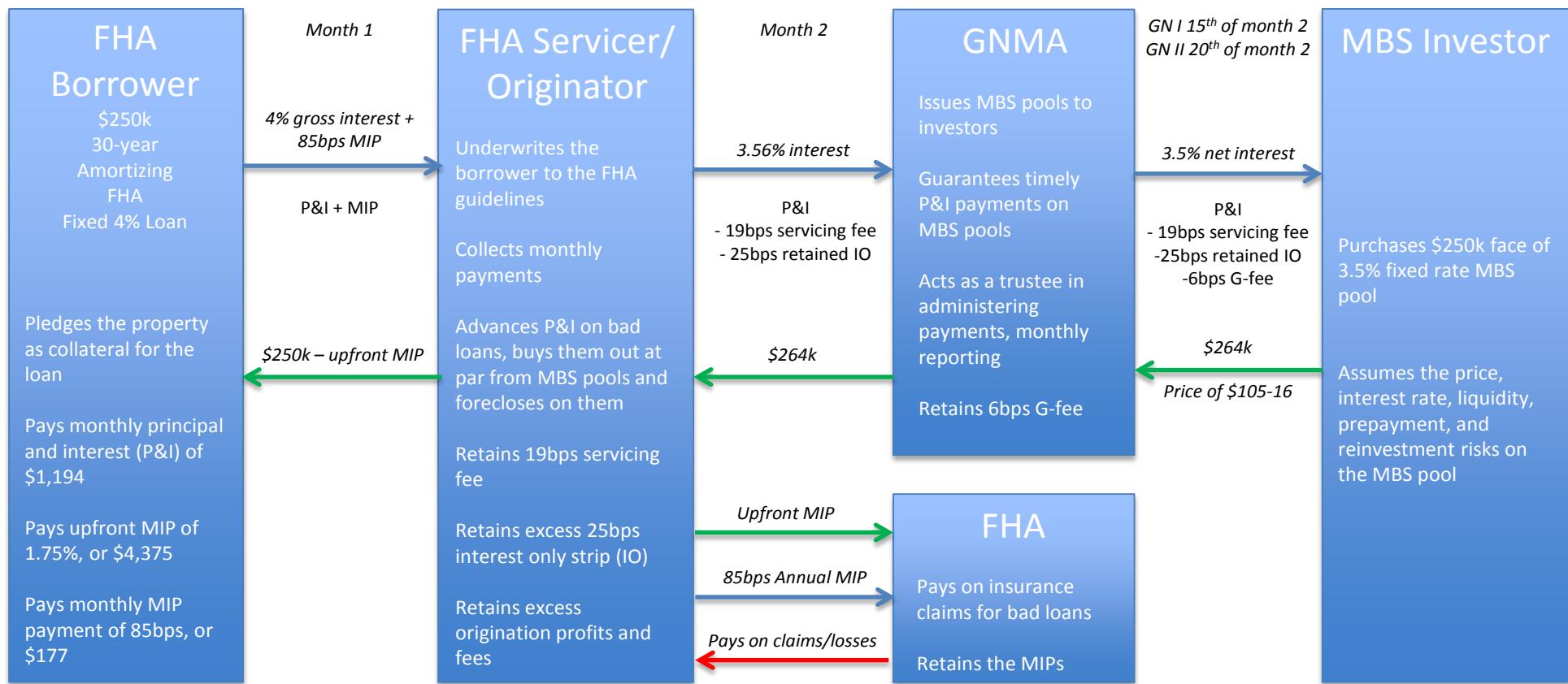
- Ginnie Mae securitizes government insured loans, typically aimed to provide access to or reduce the cost of credit to certain targeted groups of borrowers.
- The Federal Housing Authority (FHA) loans comprise around 55% of outstanding GNMA MBS. FHA seeks to make housing affordable, targeting lower income and first-time homebuyers.
- FHA's maximum loan size is determined annually for each geographical area, typically set at 115% of the median home price in the area. This limit itself is subject to a floor and a ceiling of 65% and 150% of the conforming loan limit respectively (currently \$510k and \$765k).
- FHA borrowers can obtain loans with LTVs of up to 97. Majority of the loans bear LTVs over 90.
- Effective September 1, 2019, maximum LTV for cashout refinances is lowered to 80, from 85 LTV.
- Similar to PMI in conventionals, borrowers with LTV above 80 pay a *mortgage insurance premium* (MIP) to the FHA. Unlike conventionals, nearly all FHA borrowers have high LTVs and must pay the MIP.
- The MIP has two components - upfront and annual premiums. The upfront MIP, currently set at 175bps, can be financed through the loan by adding the amount to the balance. The annual component is currently set at 85bps for loans above 97 LTV and 80bps for those below 97 LTV.
- For loans originated prior to June 3, 2013, the MIP automatically cancels once the loans amortize to 78 LTV and the MIP has been paid for at least five years. For all others, the MIP is set to last for the life of the loan.
- GNMA servicers are obligated to buy out the defaulted loans at par out of MBS pools. FHA provides a credit guarantee to the loan servicer in exchange for the MIP, covering the loan loss upon foreclosure. In the unlikely event that the servicer fails to advance, GNMA is required to pay the MBS investor.



GNMA MBS cashflow and pooling basics - FHA

- GNMA acts as a securitization arm for loans insured by the FHA, VA, USDA, and the Office of Public and Indian Housing (PIH).
- GNMA's minimum servicing fee is 19bps, for G2's, instead of 25bps on conventionals. The G-fee is 6bps, far lower than on conventionals since the bulk of the credit risk remains with the FHA.
- Unlike with the GSEs, no G-fee buydown is allowed, so excess IO is always retained or sold in the secondary market.

Chart 15: Cashflows for an FHA loan in GNMA MBS



Source: BofA Global Research



Borrower's choice: FHA versus conventional loans

- A borrowers' choice between an FHA versus conventional loan typically comes down to cost, comparing the conventional mortgage rate + MI versus FHA mortgage rate + MIP.
- The FHA mortgage rate is typically lower than the conventional rate. This is due to:
 - the fact that the GSE g-fee embedded in the rate is close to 50bps, compared to 6bps for GNMA
 - GNMAs trade at lower yield due to the explicit US sovereign guarantee.
 - Minimum servicing fee is lower, at 19bps for Ginnie Mae II versus 25bps for conventionals.
- The rate differential is typically less than the MIP, so qualified borrowers with LTVs below or close to 80 will generally prefer conventional loans, as MI is either not required or will be automatically canceled soon.
- Those with high credit scores, where MI costs are lower, prefer a conventional loan. This can happen even at MI slightly above 85bps to avoid the upfront MIP and qualify for the eventual automatic MI cancellation.
- Private MI costs for lower FICO, higher LTV credits far exceed the MIP. Those borrowers will generally choose an FHA loan. Occasionally, however, even those with high FICOs and low LTVs may choose an FHA loan when other loan characteristics raise the cost of MI, such as high debt-to-income ratio (DTI).
- This adverse selection results in considerably worse credit characteristics of FHA borrowers, observed via lower FICOs and higher LTVs versus conventionals.

Table 9: MI cost grid; highlighted better credit borrowers will most likely prefer conventional loan with MI to an FHA loan with MIP

LTV	Required Coverage	Pricing in bps							
		760+	740-759	720-739	700-719	680-699	660-679	640-659	620-639
95-97	35%	58	70	87	99	121	154	165	186
90-95	30%	38	53	66	78	96	128	133	142
85-90	25%	28	38	46	55	65	90	91	94
80-85	12%	19	20	23	25	28	38	40	44
<80	0%	0	0	0	0	0	0	0	0

Source: Genworth Financial, BofA Global Research



GNMA collateral – Veterans Affairs

- Department of Veterans Affairs (VA) extends its home loan guarantee to eligible members of the armed forces, veterans, reservists, national guard members and their surviving spouses.
- VA comprises about 40% of outstanding GNMA MBS, and about 45% of 2019 issuance.
- VA does not impose a maximum loan amount; however, the VA guarantee is limited to the lower of 25% of the county loan limit (currently set at the FHFA conforming loan limit) or 25% of the loan amount.
- Ginnie Mae requires that the borrower's down payment combined with the amount of government agency guarantee be equal to at least 25% of the home value. Hence, the VA's 25% guarantee fully covers this requirement in most cases, and most VA borrowers under the conforming limit in their area can have LTVs of up to 100 (or higher, if closing costs are included in the loan).
- Away from VA, GNMA imposes a separate limitation on LTV for VA cashout refinance loans effective November 2019. VA cashouts with LTVs above 90 are ineligible for inclusion into the Ginnie Mae II Multiple Issuer Pools and Ginnie Mae I Single Issuer Pools.
- Similar to the FHA's upfront MIP, VA collects an upfront *funding fee* from the borrower to help offset the cost of providing the guarantee. This fee can be funded through the loan and varies by the type of loan, military type, number of uses, down payment, and disability status of the borrower. The fee can range from zero to 3.3%, with 50bps on refinancings.
- Lenders are allowed to cover some closing costs on behalf of borrowers in exchange for higher borrower note rates. This is limited to 4% of the loan amount.
- Similar to FHA, VA rates are typically lower than those on conventional loans. Thus, without the annual MIP requirement, most qualified borrowers will choose a VA loan. As a result, VA borrowers tend to have better credit than the adversely selected FHA borrowers. LTVs tend to be similar or higher than FHA.



GNMA collateral – Rural Housing

- The US Department of Agriculture's (USDA) Rural Housing Service (RHS) guarantees home loans under Section 502 to certain qualified rural borrowers. Borrowers are low- to moderate-income families earning below 115% of the median, and must be unable to qualify for a conventional loan.
- RHS loans comprise about 5% of outstanding GNMA MBS, and about 3% of 2019 issuance.
- Similar to VA, no down payment is required on the loans, so LTVs can exceed 100 with closing costs. RHS guarantees 100% of the loss on the first 35% of the loan and 85% of the loss on the remaining 65%. The maximum loss to RHS cannot exceed 90% of the loan.
- RHS charges a one-time upfront fee of 1% and the annual fee of 35bps to help offset the losses on the loans. The upfront fee can be financed through the loan, just like the upfront MIP.
- These borrowers cannot qualify for a conventional loan, and the fees are below the FHA's MIP. Thus, borrowers will choose an RHS loan over the FHA. As a result, these borrowers typically have similar credit profile to FHA. They also typically have smaller loan balances.



Agency MBS collateral features

- Conventionals have the strongest credit profile, encompassing most “prime” borrowers.
- FHA tends to have the weakest credit profile, due to the adverse selection versus conventionals.
- VA borrowers have a prime credit profile as most veterans are incented to take advantage of the program over the GSEs. VA loans tend to have larger loan sizes due to low down payment requirements and higher affordability absent the annual MIP.
- RHS loans tend to be smaller balances located in rural areas, aimed at lower income families. They are not eligible for GSE loans and have weaker credit profiles.

Table 10: Snapshot of 30yr fixed MBS collateral features – 2019 issuance

Agency	WAC	FICO	Loan Size	LTV	Purchase share	First-time homebuyers (% of purchases)
GSEs	4.32	747	\$323k	78	58%	44%
FHA	4.33	668	\$267k	94	69%	77%
VA	3.97	712	\$342k	95	55%	50%
RHS	4.22	696	\$179k	99	94%	82%

Source: BofA Global Research, Fannie Mae, Freddie Mac, Ginnie Mae

Note: as of Nov 2019 issuance

Table 11: % of total agency 2019 issuance by FICO/LTV, 30-year conventionals shown

FICO/LTV	<80	80-85	85-90	90-95	95-97	>97	Total
760+	21%	12%	3%	5%	6%	2%	47%
740-759	6%	3%	1%	2%	2%	1%	15%
720-739	5%	3%	1%	1%	2%	1%	13%
<620	10%	5%	1%	2%	4%	2%	25%
Total	41%	23%	6%	10%	14%	6%	100%

Source: BofA Global Research, Fannie Mae, Freddie Mac

Note: as of Nov 2019 issuance



Creation of an MBS pool, best execution

- Mortgage originators deliver loans to the agencies, which in turn sell the pools in the secondary market. Pools are sometimes referred to as *passthroughs*. Sales are conducted on a forward basis, allowing time for a loan to close, the period from application to final approval and funding.
- Coupon selection of the new MBS security is determined by *best execution*, one generating the highest profit for the originator. Best liquidity is usually achieved in selling coupons that trade in multiples of 50bps, an industry standard.
- GNMA execution generates larger gains on sale, as 38bps lower G-fee is not usually fully passed through to the borrower in the form of lower mortgage rates, and pools trade at higher prices due to the explicit backing of the US government. This is partially offset by higher origination costs.

Table 12: Sample pooling of a 4.00% conventional loan and 3.9% FHA loan – best execution is pointing to 3s in both Fannies and Ginnies in this example

	Conforming Execution			FHA execution		
	FN 3.0	FN 3.5	FN 4	G2 3.0	G2 3.5	G2 4
Mortgage Rate Payable by the Borrower	4.00	4.00	4.00	3.90	3.90	3.90
G-fee to the Agency	-0.44	-0.44	-0.44	-0.06	-0.06	-0.06
Minimum Servicing Fee	-0.25	-0.25	-0.25	-0.19	-0.19	-0.19
Net Interest Available for MBS	3.31	3.31	3.31	3.65	3.65	3.65
MBS Pool Coupon	3.00	3.50	4.00	3.00	3.50	4.00
Excess Interest / Shortfall post-Securitization (XS IO)	0.31	-0.19	-0.69	0.65	0.15	-0.35**
MBS pool price (2-months forward)	101.22	102.72	103.97	102.50	102.94	
XS IO Price (4.1x/6.1x buyup/buydown)*	1.27	-1.16	-4.21	2.67	0.62	
Total proceeds from Sale	102.49	101.56	99.76	105.17	103.56	
Originator gain on sale	2.49	1.56	-0.24	5.17	3.55	

* buyup/buydown multiples are created for example only. If GSE bid for XS IO is 4.1x, i.e. GSE offering \$2.05 for 50bps of IO; G-fee buydown costs 6.1x coupon i.e. 50bps shortfall costs \$3.05 to extinguish

**No buydowns allowed

Source: BofA Global Research



GSE buy-up and buy-down multiple impact on execution

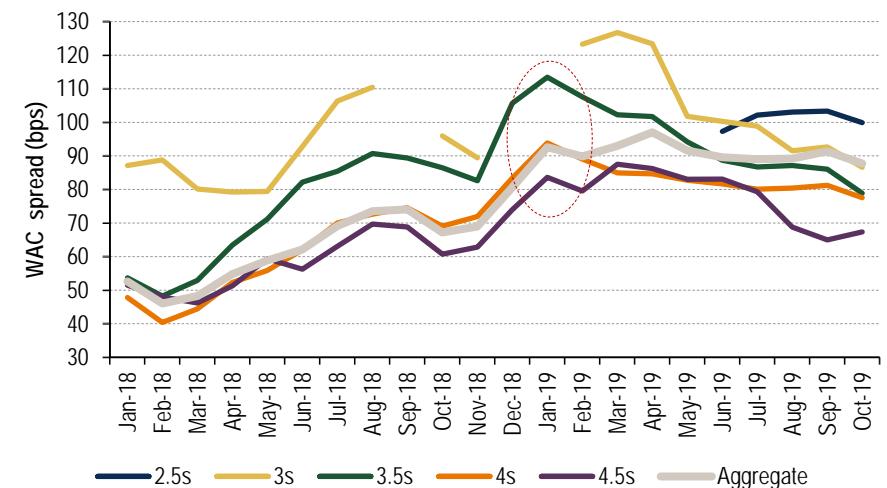
- When selecting the MBS coupon, the originator maximizes the combination of MBS price and buyup/buydown amounts. Therefore, GSEs' choice of buy-up and buy-down multiples influences best execution and originator profits. Higher buy-up multiple favors execution into lower coupons and the creation of excess IO, while lower buy-down multiples favor securitization into higher coupons, all else equal. Correspondingly, raising both multiples pushes securitization down in coupon, and lowering of both does the opposite.
- WAC spread*, the difference between the gross and net coupons of pools, is similarly influenced. Higher multiples encourage the creation of lower net coupons, raising the WAC spread.
- When best execution favors excess IO creation, lowering of the buy-up multiple eats into profit, and is equivalent to raising the G-fee. Alternatively, raising the buy-down multiple when best execution favors a buying down the G-fee does the same.
- While the originator has to buy down the G-fee in case of a shortfall, they technically don't need to sell their excess IO to the GSE and can choose to retain it. The latter can happen if the originator values the IO above the buy-up multiple. In practice, many originators don't have the necessary capital and funding to retain the excess IO. Furthermore, the 50bps limit on the combined servicing fee and excess IO limits the originator ability to retain, forcing lenders to buy-up.

Table 13: Pooling economics for 4.625% WAC at 3x vs. 5x multiples

A	WAC	4.625			
B	G-fee	-0.44			
C	Minimum servicing	-0.25			
D	Net WAC (=A-B-C)	3.935			
E	Pool price (2m Forward)	100.42	3.5 Execution	4 Execution	4/3.5 difference
F	Coupon	3.50		4.00	
G	Excess IO (=D-F)	0.435		-0.065	
Low multiple (3/3.5x)					
H	Buyup (=3 x G)	1.31		-	
I	Buydown (=3.5 x G)	-		-0.23	
J	Net Proceeds	101.72		102.03	0.31
High Multiple (5/5.5x)					
K	Buyup (=5.0 x G)	2.18		-	
L	Buydown (=5.5 x G)	-		-1.25	
M	Net Proceeds	102.59		101.01	-1.58

Source: BofA Global Research

Chart 16: WAC spreads peaked in early 2019 as GSEs marked their Bu/Bd multiples higher



Source: BofA Global Research



MBS pools come in a variety of shapes and sizes

Table 14: Examples of common pool types, from the GSEs and GNMA

Tickers	Description
FNCL	UMBS 30yr fixed
FNCI	UMBS 15yr fixed
FNCT	UMBS 20yr fixed
FNCN	UMBS 10yr fixed
G2SF	30yr Ginnie II
GNSF	30yr Ginnie I single-issuer pool
FNCK, FR3P	Fannie 30yr Jumbo, Freddie 30Yr Jumbo
G2JM	Ginnie II 30yr Jumbo
G2JO, GNJO	G2JO = Ginnie II 15yr, GNJO = Ginnie I 15yr
FNCZ	Fannie 40yr fixed
FGLMC	Gold 30yr fixed, legacy 45-day payment delay, not issued since June 2019
FGCI	Gold 15yr fixed, legacy 45-day payment delay, not issued since June 2019
FGTW	20yr Gold fixed, legacy 45-day payment delay, not issued since June 2019
FNRE, FR3L; FGRE	30yr relocation mortgage; Fannie/Freddie/Freddie legacy
FNRPR3, FRRP4I; FGRO	30yr reperforming non-modified loans; Fannie/Freddie/Freddie legacy
FNMDI4, FRMD4E; FGMA	40yr fixed rate modification; Fannie/Freddie/Freddie legacy
FNMSU3, FRMS4B; FGHB	30yr modified step-up rate; Fannie/Freddie/Freddie legacy
FNHLCO, FRHL3S; FGU6	30yr 105-125 LTV; Fannie/Freddie/Freddie legacy
FNHLCR, FRHL3V; FGU9	30yr 125+ LTV; Fannie/Freddie/Freddie legacy

Source: BofA Global Research



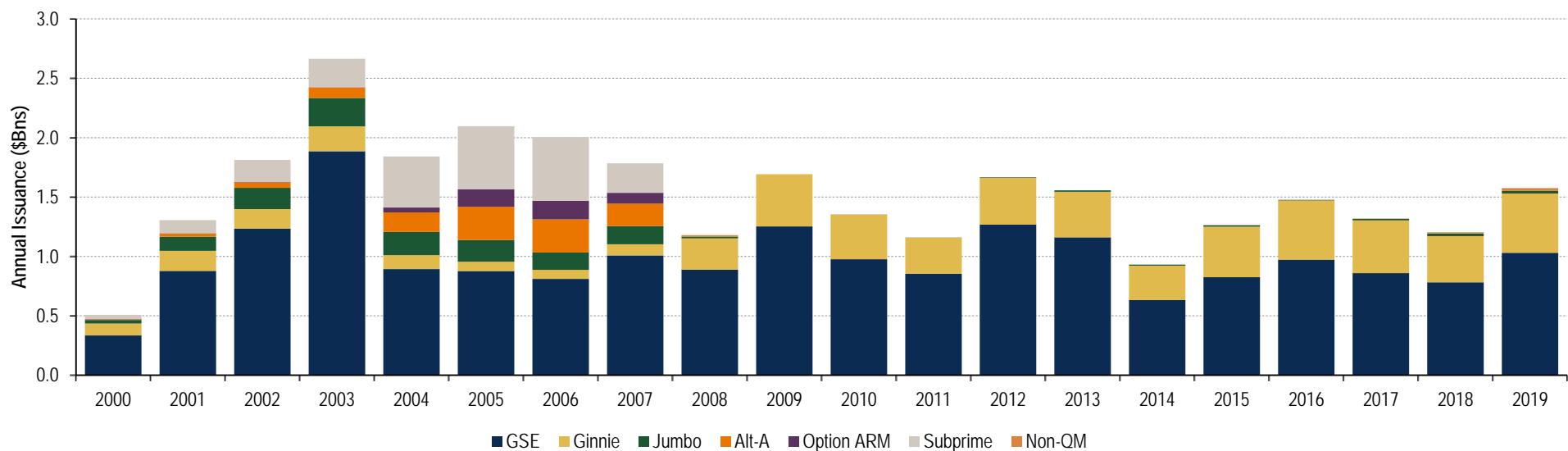
Financial crisis and regulatory response



The financial crisis, a catalyst for reform

- The financial crisis of 2008 exposed systemic weaknesses in the US housing system, ranging from a sync up of homeownership policy, affordable housing tax incentives, GSE leverage, and lack of industry regulation, to accounting standards, ratings and far reaching financial engineering across the credit spectrum.
- Loose lending standards and speculative borrowing were revealed following the sharp home price declines in 2007 and dramatically increased mortgage delinquencies and losses.
- Subsequently, the mortgage market has undergone profound changes, ranging from origination and servicing to the nature of key investors and risk profile of the assets.
- The agencies, including the GSEs and the FHA, came to dominate the securitized market for MBS, as the private market all but disappeared. Meanwhile, the agencies themselves remain subject to ongoing reform.

Chart 17: Post-crisis, the private label market has completely disappeared, while Ginnie issuance has grown



Source: BofA Global Research, Fannie Mae, Freddie Mac, Ginnie Mae

Impact on the mortgage market has been profound

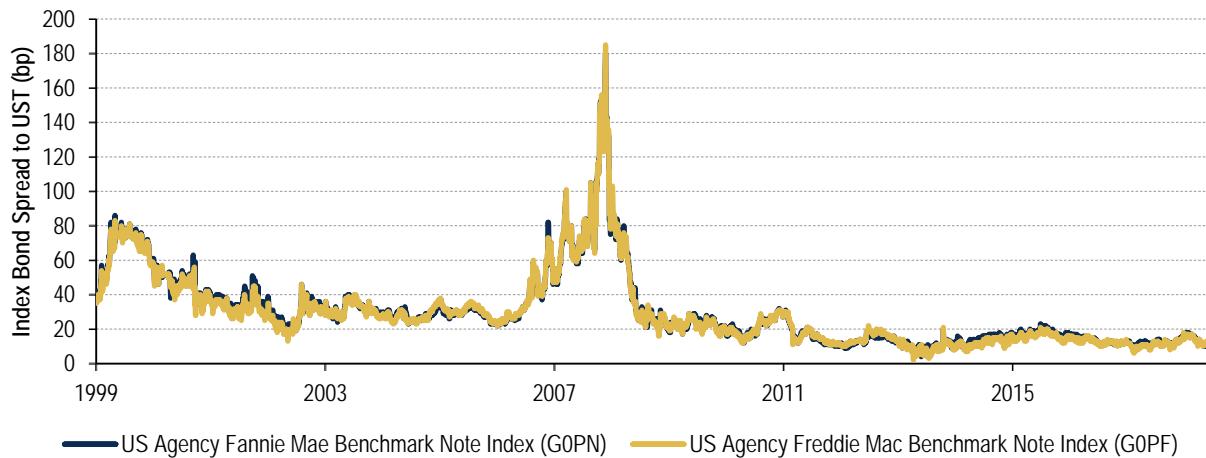
- **Affirmation of “too big to fail” and the bailout and conservatorship of Fannie Mae and Freddie Mac**
– GSE conservatorships were intended to be temporary, but have persisted since 2008. Throughout this period, the GSEs held little to no capital, with most profits relinquished to the US Treasury per the Senior PSPAs. Ongoing earnings and the limited credit line to the government constituted the buffers to absorb any losses. As the conservator of the GSEs, FHFA has exercised full control over the GSEs, overseeing the wind-down of the GSE MBS portfolios, increasing the level of G-fees, and influencing GSE credit standards and securitization practices. Mark Calabria, the Director of FHFA, since April 2019, has indicated a desire to end the conservatorships, culminating the Housing Reform Plan put forward by the US Treasury in September 2019. This multi-year undertaking still faces significant challenges, but the end-state envisions Agency MBS that is either explicitly or implicitly guaranteed by the US Government.
- **Mortgage market has gotten smaller** – as consumers deleveraged, MBS shrunk as % of GDP and share in the aggregate bond index fell.
- **Repricing of mortgage credit risk** – This, combined with the bank reforms, led to the virtual elimination of non-agency RMBS issuance. It has also led to higher G-fees and MIPs as well the introduction of Loan-Level Price Adjustments (LLPAs) by the GSEs.
- **Origination practices** – QM/QRM and Dodd-Frank, loan documentation requirements, rep and warrant related putback risk, expansion of FHA and Agency Jumbo lending, overall contraction of mortgage credit, freezing of conforming loan limits.
- **Housing activity stalled** – home sales, housing starts remain well below historical averages, and first time buyers are older, with higher incomes.
- **Servicing practices** – Introduction of loan modifications, extraordinary programs such as HARP, Basel III MSR balance sheet treatment and the rise of non-bank servicers.
- **Bank reforms – AOCI, SLR, LCR, NSFR** rules create new constraints as well as incentives for funding and ownership of Agency MBS, margining requirements. FAS 166/167 changes brought all securitizations on-balance sheet affecting issuers and buyouts.
- **New market dynamics of MBS** – Fed emerged as an important MBS investor, alignment of Fannie and Freddie practices and the single-security implementation, rise of Agency REITs, increased housing policy risk.



Too big to fail

- By the nature of the GSE guarantee, any MBS investor is exposed to the GSE's credit risk. GSEs, however, are unlike other private companies: they are exempt from state and local income taxes and enjoy a line of credit to the US Treasury. Given their size and systemic importance for the US housing finance system, investors are willing to lend to the GSEs at very tight credit spreads assuming they are "too big to fail." This assumption was tested and proved true during the 2008 financial crisis.
- By the middle of 2008, GSE capital was insufficient to absorb the looming credit losses, and spreads widened on GSE debt and MBS. The government had to intervene. In July 2008, a new regulator, the FHFA, was created with the power to advance funds to the GSEs, limited only by the federal debt ceiling. On September 8, 2008, the FHFA put both GSEs under conservatorship. At the same time, the US Treasury made an \$189.5bn capital investment into the GSEs. The US Treasury and the Fed began buying agency MBS as well as agency debt shortly after the conservatorship was announced. This eventually led to spread normalization.

Chart 18: GSE funding costs reflect minimum credit risk premium, despite companies having very little to no capital since 2008



Source: BofA Global Research



Timeline of the GSE crisis, bailout and major policy responses

Date	Description
September 2007	Credit spreads begin to widen on financial sector troubles.
December 2007	Loan Level Pricing Adjustments (LLPAs), Adverse market delivery charge (AMDC) added to G-fees.
July 2008	Housing and Economic Recovery Act of 2008 (HERA) passes. Establishes FHFA to oversee GSEs, authorizes Treasury financing of the GSEs in the amount only limited by the federal debt ceiling which was raised by \$800bn at the time.
September 2008	FHFA takes GSEs into conservatorship; US government purchases \$189.5bn of preferred equity and extends \$100bn credit lines to each. Government also takes effective control of 79.9% of each company and the power of board and management, eliminates dividends to common shares
January 2009	Making Home Affordable (MHA) passed, establishes Home Affordable Modification Program (HAMP) for loans in foreclosure.
March 2009	Home Affordable Refinance Program (HARP) implemented to aid in refinance of underwater mortgages. General streamline refinancing program is eliminated.
December 2011	Temporary Payroll Tax Cut Continuation Act mandates 10bp G-fee increase used to fund tax cuts, directly linking GSE and Government revenues. HARP 2.0 enacted, eliminates limits on LTV.
February 2012	FHFA's <i>Strategic Plan for Enterprise Conservatorships</i> sets the goal of contracting GSE operations by gradually raising G-fees in-line with the private market, establishing loss sharing agreements, and relying on private insurance; sets a the goal of building a common securitization platform (CSP).
April 2012	G-fees increased by 10bps.
August 2012	Treasury amends the GSE purchase agreement with a sweep of 100% of GSE earnings, just as GSEs are on the verge of becoming profitable.
July 2013	First Credit Risk Transfer (CRT) deal is priced, offsets first loss on quarterly GSE production onto the private market.
December 2013	Additional 10bps G-fee increase proposed and rescinded by the FHFA as leadership changes. Acting Director Ed DeMarco is replaced with Director Mel Watt as head of the FHFA. G-fee review is instituted by the FHFA.
May 2014	FHFA scorecard goal of <i>contracting</i> the GSEs officially changed to <i>reducing taxpayer risk through increasing the role of private capital in the mortgage market</i> . Director Mel Watt states that resolution of the conservatorship and GSE reform are not part of FHFA's statutory mandate.
April 2015	G-fee review is completed leaving them unchanged, AMDC dropped, minor adjustments to LLPAs.
August 2016	New high-LTV refinance program intended to replace HARP is announced, applicable to loans with LTVs above 97.
December 2018	HARP expires after 3.5mm borrowers take advantage since 2009. Replacement 97+ LTV program is applicable to loans from October 2017 onward, requires 15 months of seasoning and an appraisal.
June 2019	First Uniform Mortgage-Backed Security (UMBS) is issued. Common Securitization Platform is fully operational and utilized by both GSEs.
April 2019	Mark Calabria sworn in as the new Director of the FHFA, a proponent of reducing the government footprint in the mortgage market and ending the conservatorships.
September 2019	The US Treasury puts forth the Housing Reform Plan, which outlines recommended administrative and legislative steps for a GSE Reform. Government backstop and PSPAs set to remain in place even out of the conservatorships. FHFA allows the GSEs to build \$20 and \$25bn of capital for Fannie and Freddie respectively, from \$3bn via retained earnings.
November 2019	The original proposed 2018 Capital Rule for the GSEs is under review by the FHFA, set to be re-proposed sometime in 2020.

Source: BofA Global Research



A case for GSE reform

There are compelling reasons for GSE reform

- Political pressure to eliminate any future taxpayer exposure to the GSEs, lest 2008 repeat itself. Under the conservatorship, companies have passed the bulk of their profits to the Treasury, leaving them with only limited capital and quarterly earnings to absorb any losses. The US government would be on the hook once these are eroded.
- There is a lack of legal precedent for a permanent conservatorship per the FDIC Act. Remittances to the Treasury to-date stand at \$306bn, well exceeding the original investment of \$189.5bn. The legality of the earnings sweep is being challenged within the court system along with the open-ended conservatorship status.

There are reasons why progress has been difficult

- Risk of loss to the government is low. Private investors are already assuming most of the credit risk through credit risk-transfer deals, and the credit profile of the borrowers is considerably stronger than before the financial crisis.
- GSEs are profitable. Credit standards tightened post-crisis and losses to-date have been low even as G-fees increased. The government is increasingly relying on G-fees as part of the budget. For example, payroll tax cuts were funded by G-fee increases in 2011 as part of the Temporary Payroll Tax Cut Continuation Act.
- GSEs work. Mortgage credit is broadly available and MBS market remains highly liquid. There is a reluctance to “fix what isn’t broken.”
- Reform is predicated on resolving the legal claims of GSE common and preferred shareholders with respect to the earnings sweep.
- Political disagreement on what the replacement system should look like, including how to ensure continued access to affordable housing.
- Government control of the GSEs affords an effective policy lever to influence housing policy, access to and cost of credit.



The path forward

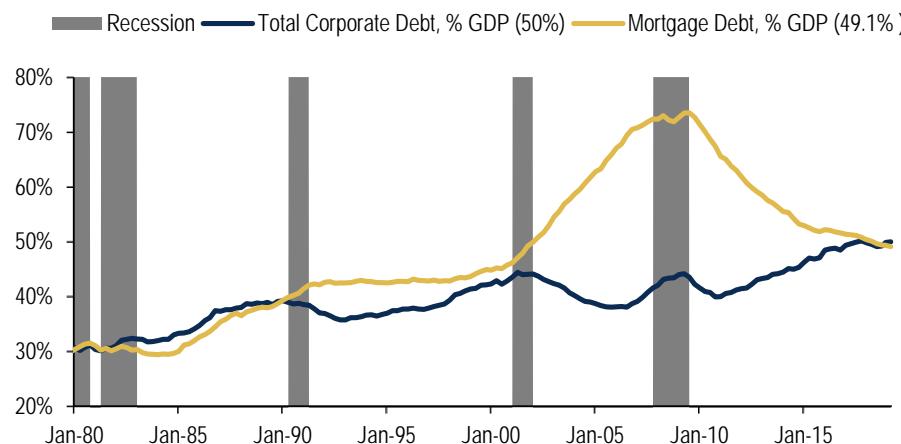
- Since the appointment of Mark Calabria as FHFA Director in 2019, the Administration's focus has been on recapitalizing and releasing the GSEs from the conservatorship.
- The Administration's vision has been laid out in the US Treasury's Housing Reform Plan released in September 2019, and outlines a set of specific recommendations, both administrative as well as legislative, to end the conservatorships and reform the US housing system.
- Most important for MBS investors, the plan explicitly acknowledges the continued need for a Government backstop for MBS, irrespective of the conservatorship status. The Treasury expects the PSPAs to remain in place, extending the credit line to the GSEs either indefinitely, or until such as time as Agency MBS obtain an explicit guarantee via legislation by the US Congress.
- The proposed Capital Rule, currently under the review by the FHFA and due in early 2020, will be key to determining the amount of capital the GSEs will need to raise, either via retained earnings or a series of IPOs. This can have direct implications on the timing of the GSE release from the conservatorships.
- Required return on that capital will factor in the pricing of mortgage credit and G-fees, and correspondingly the market share of the GSEs. This may also figure into which portions of the mortgage market the GSEs ultimately end up serving.
- Leveling the playing field between the GSEs and the banks is also a stated priority for the Administration, including the treatment of credit risk transfer deals for capital purposes. Ideally, money center banks and other SIFIs should not be at a significant disadvantage versus the GSEs under the new rule.
- One important item that will need to be addressed before capital can be raised externally is a potential settlement with the preferred and common shareholders of the GSEs, currently challenging the legality of the net profit sweep in the courts.



Mortgage market shrunk post-crisis

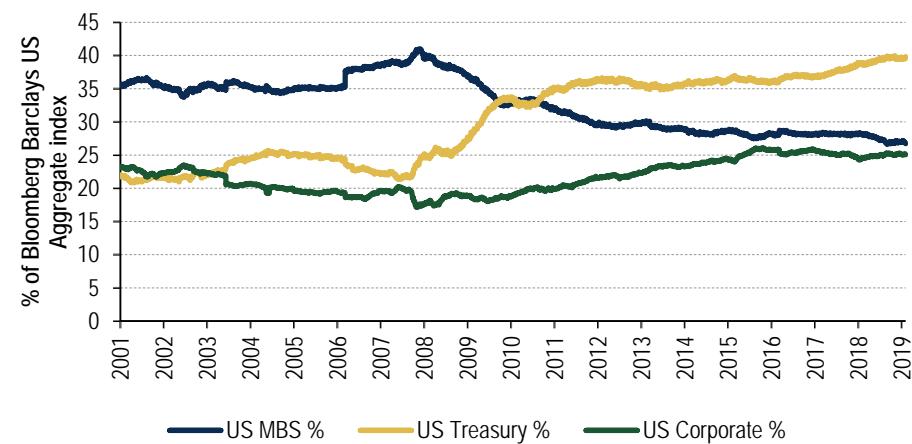
- As the 2008 financial crisis was mortgage-centric, the mortgage market has shrunk significantly post-crisis, with mortgage debt sliding to only 49% of GDP compared to a pre-crisis peak of over 70%. This completely erased the build-up since the 2000s after the dot-com bubble.
- Consumer deleveraging, and more conservative outlook for housing led to lower homeownership rates, from the pre-crisis high of 70% to 64% in 2019.
- MBS index weight slipped to 27% post-crisis from 35-40% pre-crisis in the Bloomberg Barclays US Aggregate Index. US Treasuries came to dominate the index on the back of record deficits.

Chart 19: Mortgage debt, as a % of GDP, has been declining post-crisis



Source: BofA Global Research, Federal Reserve, Preqin, National Bureau of Economic Research, Bureau of Economic Analysis, ICE Data Indices, LLC *Note: Data is through 1Q19

Chart 20: MBS index weight has declined to 27%, from 35-40% pre-crisis



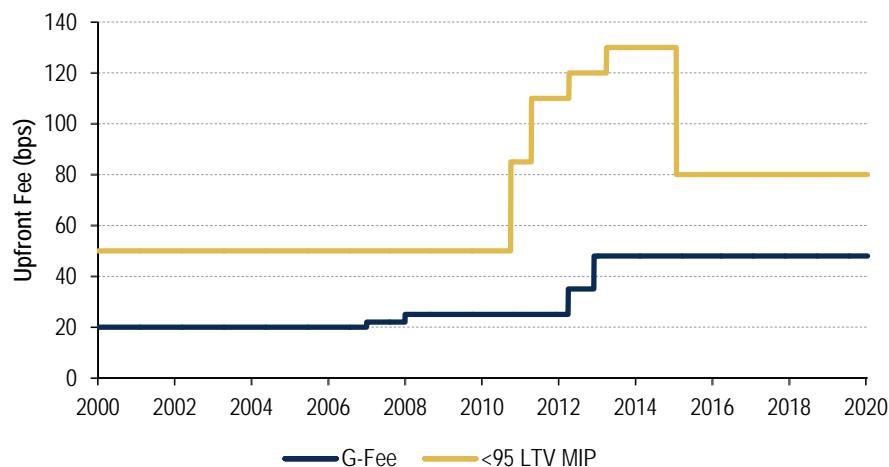
Source: BofA Global Research, Bloomberg



Repricing of the credit risk

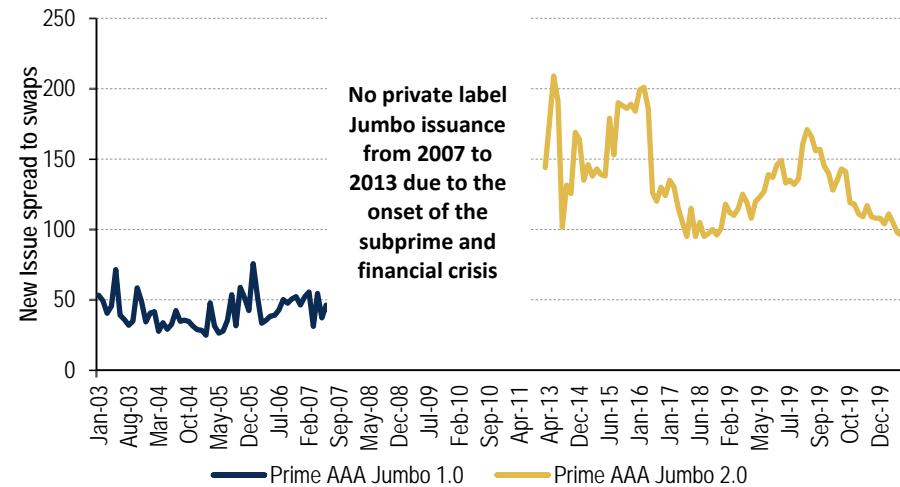
- Mortgage credit risk repriced higher post-crisis as default expectations were reset to the realized losses during the financial crisis.
- GSEs and the FHA increased G-fees and MIPs. LLPAs were introduced.
 - Higher G-fees and MIPs were meant to shore up the battered financials of the GSEs and the FHA.
 - LLPAs are effectively an additional G-fee, tiered by the individual credit features of the borrower.
 - G-fees were also raised with the aim of enticing the private capital, to contract the GSE footprint.
- Current pricing on risk transfer deals implies a “market” G-fee of 40-50bps, depending on assumptions.

Chart 21: G-fees and MIPs increased after 2008; MIPs were lowered in 2015



Source: BofA Global Research

Chart 22: Prime private label credit spreads widened permanently post-crisis



Source: BofA Global Research



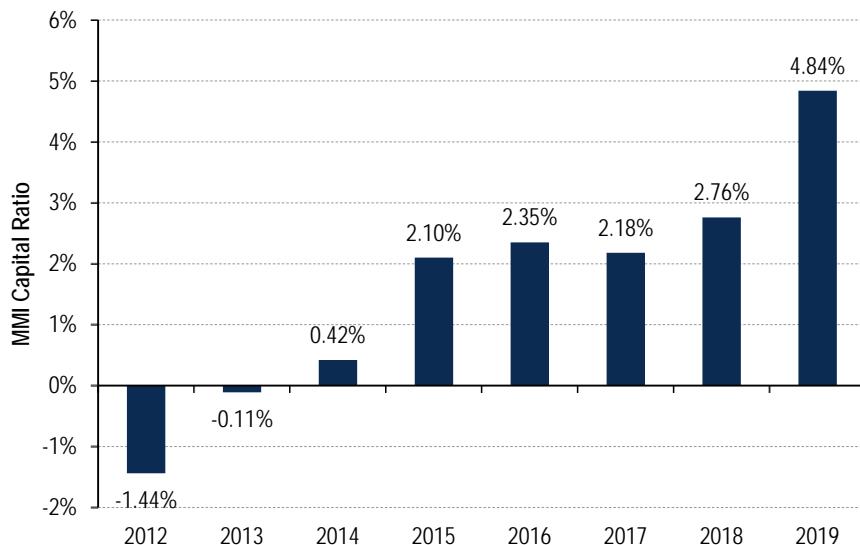
FHA MIPs tied to the FHA financials, policy

- FHA MIP increases were mandated to shore up the deteriorating financials of the FHA during the crisis. As the financials began to improve and losses declined on better underwriting, MIPs were cut by 50bps in January 2015.
- FHA losses are covered out of the Mortgage Market Insurance (MMI) fund, which was depleted during the housing crisis.
- The fund is financed through the collection of the MIP from borrowers and has a congressionally mandated 2% capital reserve ratio. This ratio is defined as:

$$(NPV \text{ of fund assets} + NPV \text{ of expected MIP inflows} - NPV \text{ of expected losses}) / \text{Insured Balance}$$

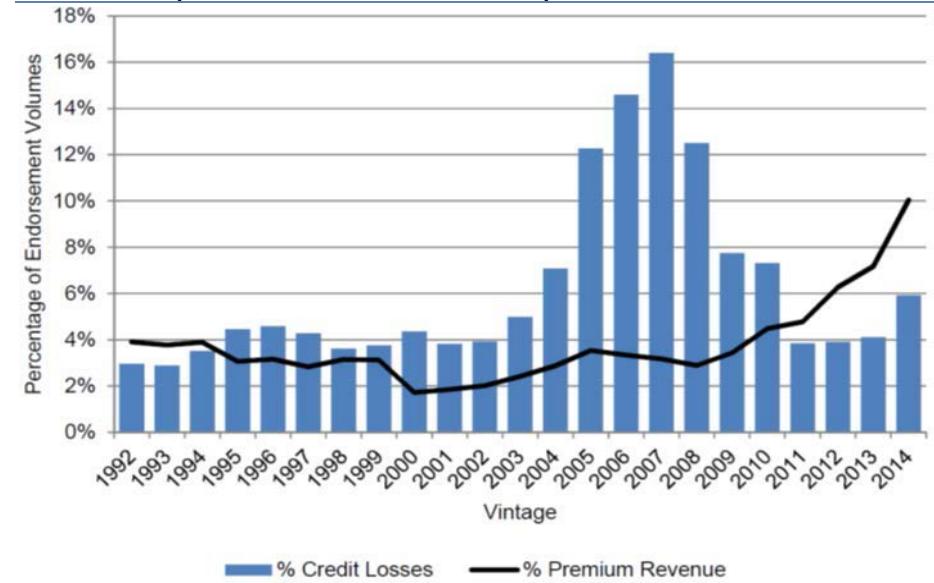
- The reserve ratio has recovered to 4.84% in 2019, from the lows of -1.44% in 2012. With the fund continuing to build up cushion, the door is open to future MIP cuts, subject to policy agendas and the economic outlook.

Chart 23: FHA reserve fund has largely recovered by 2019



Source: FHA

Chart 24: FHA expected losses on new loans declined to pre-crisis levels



Source: FHA



Tightening of the credit box

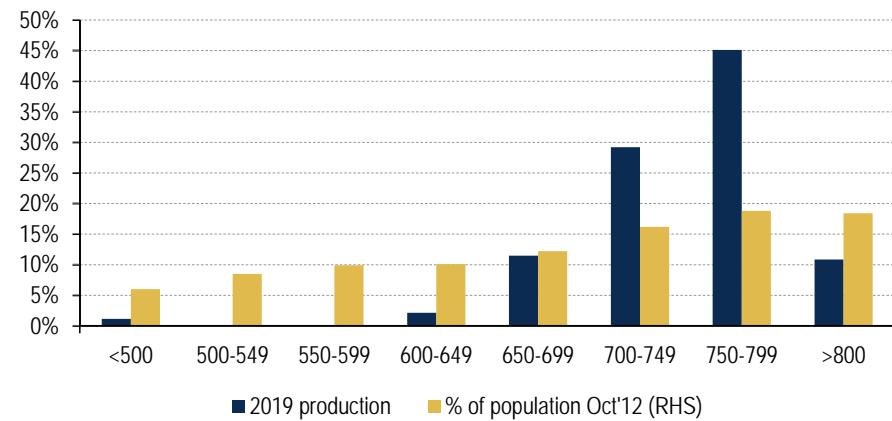
- Agencies are exempt from the new post-crisis Qualified Mortgage (QM) requirements of Dodd-Frank, which dictate borrower “ability to repay” rules based on income and documentation.
- Nevertheless, GSE lending today primarily focuses on good credits with full documentation as the credit standards tightened post-crisis, and they no longer compete with the private label RMBS market. Defaults have been minimal as a result. The tighter credit box has also constrained the supply of MBS.
- Loan documentation requirements have increased with respect to income, employment, and sources of funds. Legacy streamline refinancing program for loans already owned by the GSE that allowed for no income, employment, or asset verification was eliminated for new borrowers in March 2009.
- GSEs forced the banks to repurchase delinquent loans they originated based on the *representations and warranties (R&W)* breaches, causing tens of billions in losses. This *putback* risk led to the increased scrutiny on newly originated loans, limiting credit to only the best of borrowers. Banks exercise caution by further exceeding the minimum lending standards set by the GSEs, ie, placing *credit overlays*.

Chart 25: GSE purchase loan FICO scores rose from low 700s to mid to high 700s



Source: BofA Global Research

Chart 26: Almost 90% of GSE loans are 700+ FICO, the median credit score in the US



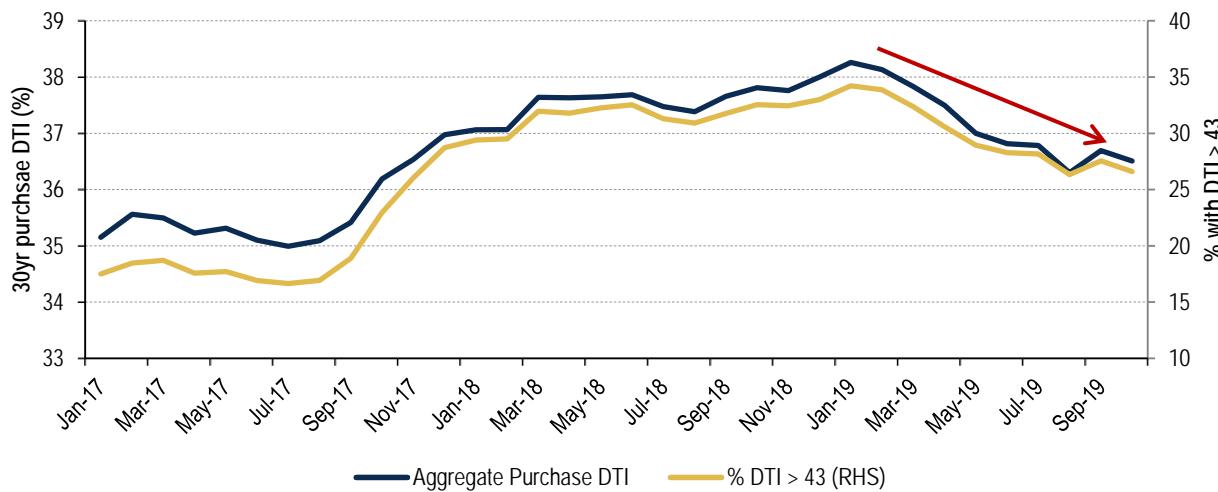
Source: BofA Global Research



DTI limit and the QM patch

- One way the credit box tightened post-crisis is with the introduction of QM rule as part of the Dodd-Frank Act of 2010 and its ability to pay requirement, predicated on the Debt-to-Income (DTI) ratio. The QM rule, defined by the Consumer Financial Protection Bureau's (CFPB), requires the borrower's DTI ratio to be less than 43%.
- GSEs are exempted from this requirement until January 2021 by law. This exemption is often referred to as the QM patch. Since about 25% of the GSE production is above 43% DTI currently, expiration would prove disruptive, forcing these borrowers into FHA, where costs are slightly higher, or simply into less expensive, more affordable homes.
- In anticipation of this, the QM rule is likely to be revised. CFPB has indicated in January 2020 that DTI constraints are likely to be dropped from the rule, in favor of limiting the mortgage rates that lenders are able to charge to the borrower. Under the proposal, QM patch would be extended until the new rule is finalized.
- Away from the CFPB, GSEs themselves have been experimenting with DTI in recent years, loosening the requirement in late 2017, and subsequently tightening it back in 2019 on concerns over layered risks.

Chart 27: DTI limits tightened in 2019, but >43 DTI still comprises over a quarter of GSEs purchase production



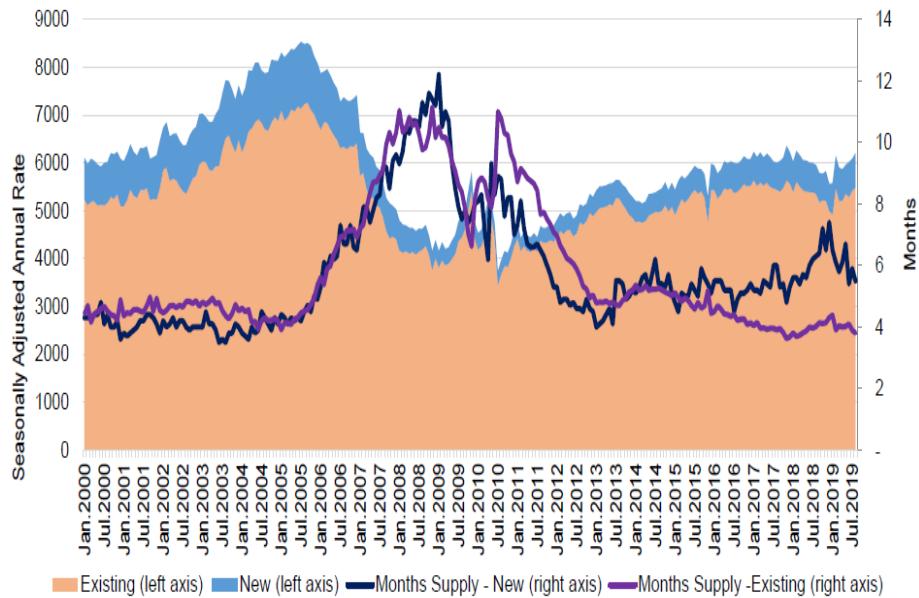
Source: BofA Global Research



Housing activity almost halved

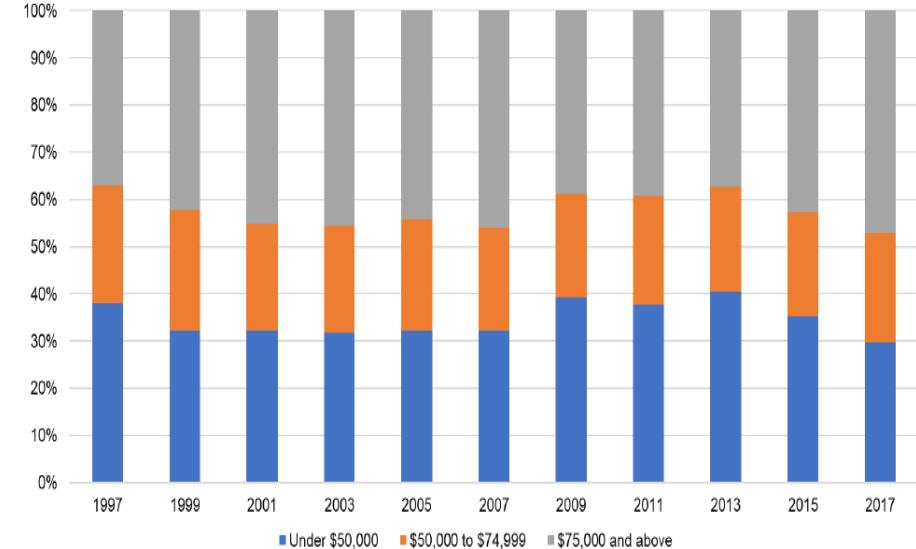
- In response to stalling home price growth and tighter credit, home sales, existing and new, almost halved compared to pre-crisis.
- Excess supply of houses pre-crisis kept new housing starts well below historical averages for a decade.
- Structurally, the composition of first time home buyers has also changed. Post-crisis, the share of lower income first time home buyers has been declining, as the underwriting standards tightened. The population of first time home buyers is now dominated by higher income buyers – 70% of the people have income higher than \$50,000 per year.

Chart 28: Slow growth in home sales and inventories post-crisis



Source: Census, National Association of Realtors

Chart 29: First time home buyers have shifted toward higher income buyers

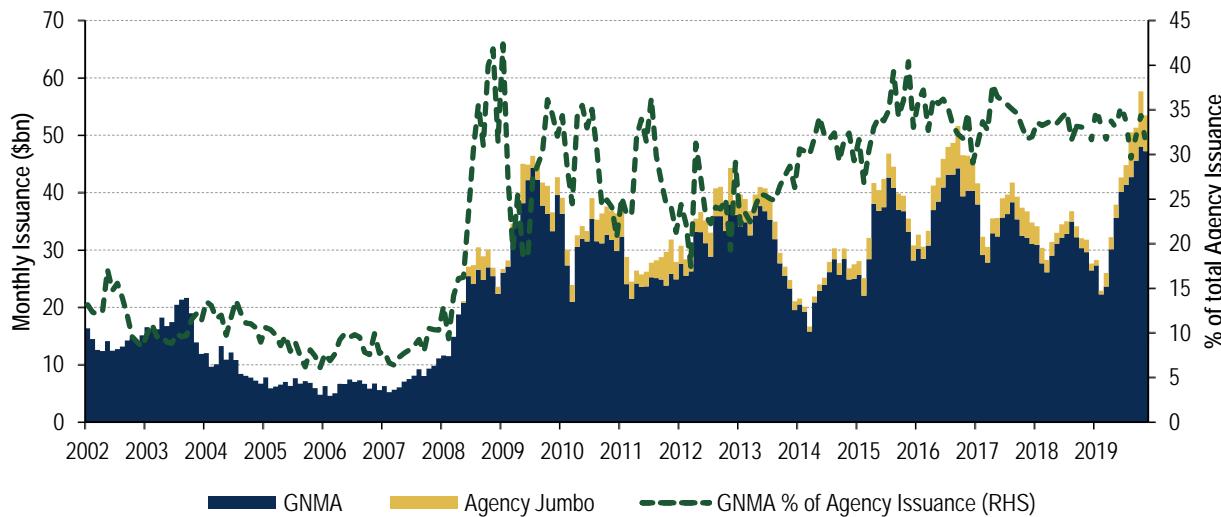


Source: Harvard Joint Center for Housing Studies

FHA picked up the slack created by the GSEs, non-agency RMBS

- With a virtual shutdown of the private non-agency RMBS market, GSE and FHA related lending picked up some of the slack in the flow of credit.
- With the introduction of HERA in 2008, conforming loan limits previously indexed to median home prices were not allowed to decline. This was done to maintain the flow of mortgage credit, preventing further escalation of the mortgage crisis. Moreover, high cost areas were established in which the GSEs could lend more than the national conforming loan limit, creating Agency jumbos.
- FHA lending, focused on weaker credit borrowers, grew significantly post crisis, as the subprime and Alt-A markets previously serving these borrowers shut down. GNMAAs comprise as much as 30% of agency issuance today compared to 10% in 2006. While the credit is weaker than the GSEs, the documentation standards remain rigid for FHA borrowers.

Chart 30: GNMA and Agency jumbos fill in the void left by the shutdown of the non-agency market



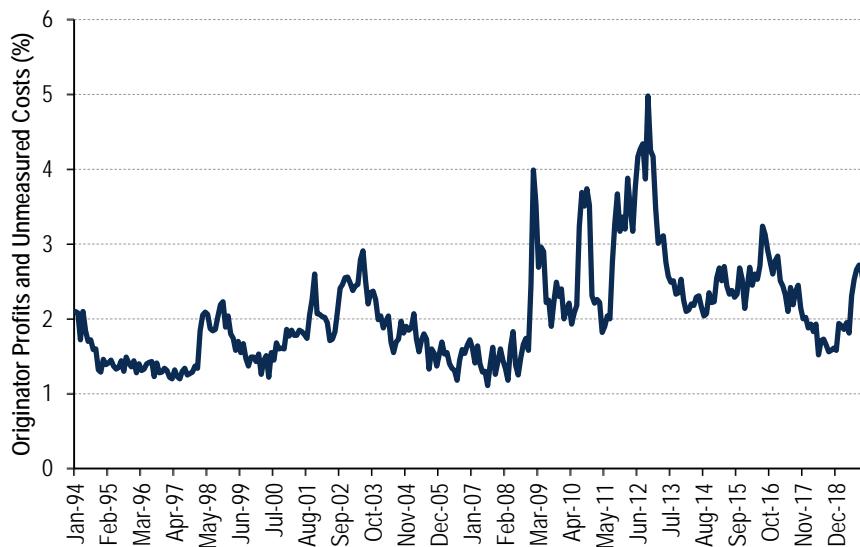
Source: BofA Global Research, Fannie Mae, Freddie Mac, Ginnie Mae



Putback risk raises costs, changed the servicing landscape

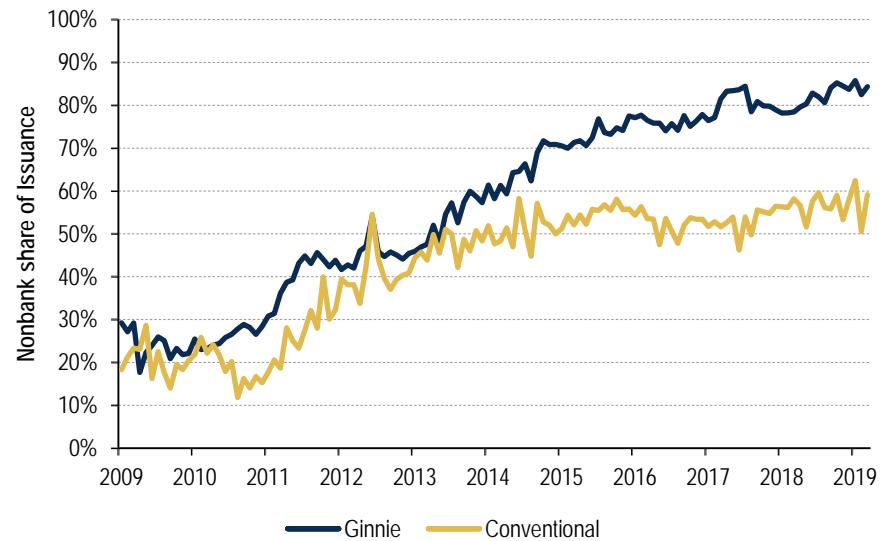
- Origination costs increased permanently post-crisis due to putback risk, increased compliance costs. This manifests through higher rates offered to borrowers.
- Balance sheet treatment of *mortgage servicing rights* (MSRs - fees charged for servicing the loans), was revised under Basel III as part of the regulatory overhaul, making them much more capital intensive. As a result, MSRs were actively sold to non-bank entities not subject to Basel rules.
- Diminishing bank appetite to take on putback risk or MSR assets shifted much of new origination to non-banks. This is particularly pronounced in GNMAAs where putback risk is greater due to weaker borrower credit profile as well as greater legal exposure. Under the False Claims Act, designed to protect the government from fraud, triple damages can be awarded. Thus, claims by the FHA or VA lead to higher potential liability than the non-government GSEs.

Chart 31: Originator revenue increased permanently post-crisis (per \$100 loan)



Source: Federal Reserve Bank of New York

Chart 32: Non-bank servicers have come to dominate origination post-crisis



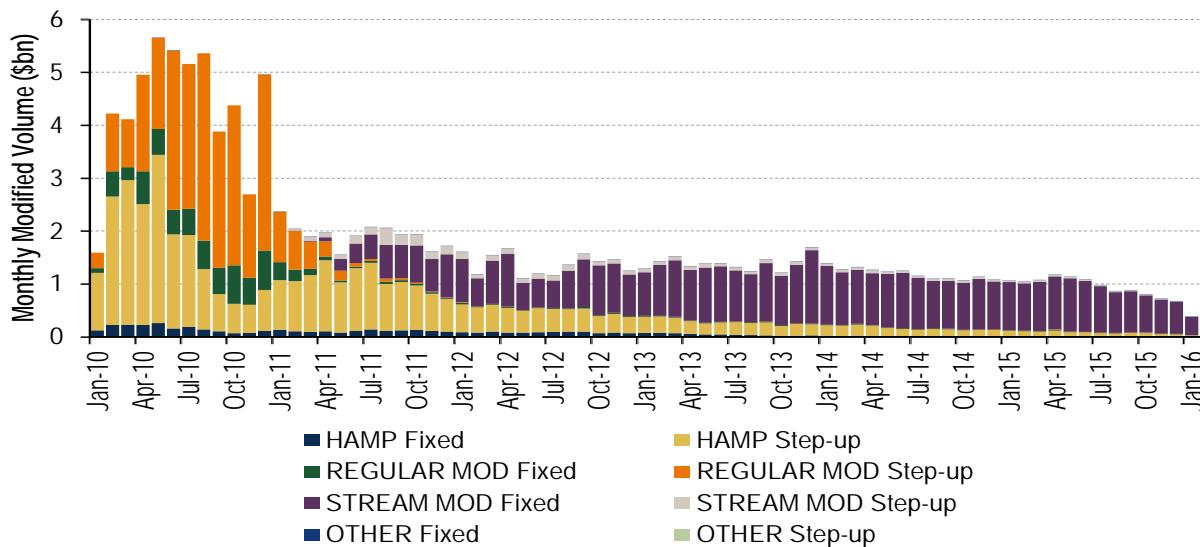
Source: BofA Global Research, Fannie Mae, Freddie Mac, Ginnie Mae



New servicer tasks: modification, special refinance programs

- Record high delinquencies and rising severities during the financial crisis precipitated new alternatives to foreclosure. Loan modification programs took off, seeking to lower payments through lower interest, term extensions, or forbearance. The US government created incentives through its own HAMP program, popular until 2012, before servicer streamline modifications were introduced. Upon curing, Agencies have been selling these loans through MBS securitization.
- Home Affordable Refinance Program (HARP) was created as part of the Making Homes Affordable (MHA) Act to allow underwater borrowers to refinance their existing agency loan after the crisis. HARP expired in December 2018 after over 3.5 million people participated. A new high LTV refinance program was put forth after its expiration to help future underwater borrowers.
- FHA and VA have broader streamline refinance programs in place, as well as the grandfathered MIP program for pre-June 2009 borrowers, eligible for 1bp upfront and 50bps annual MIP upon refi.

Chart 1: Modifications of Fannie Mae loans, soared post-crisis



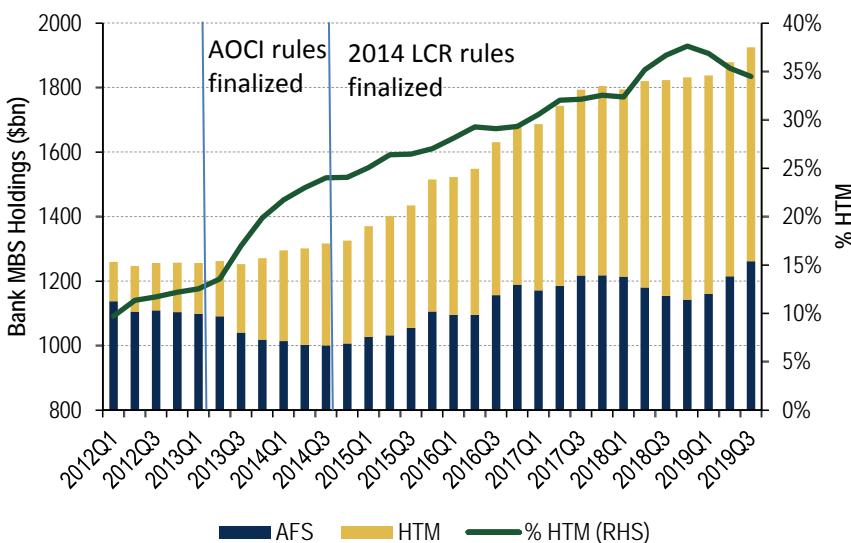
Source: BofA Global Research



Bank regulatory alphabet soup affects MBS demand

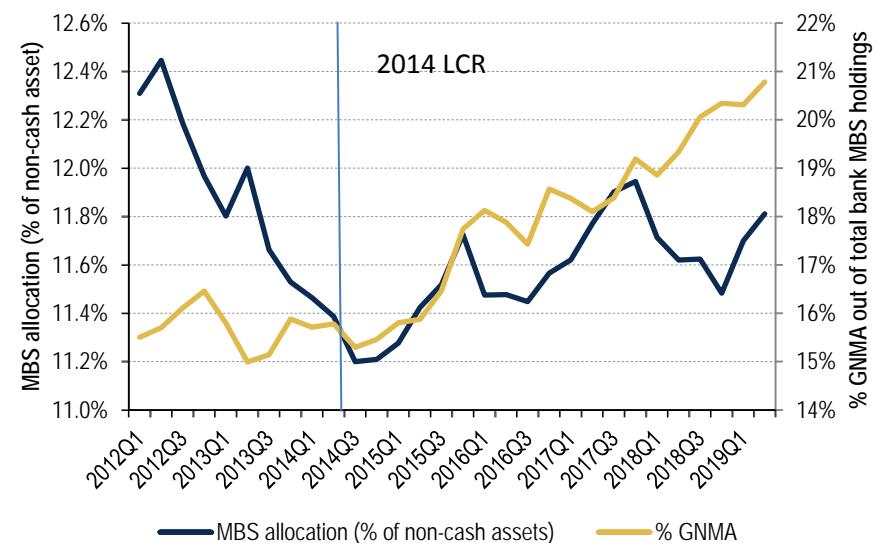
- Banks are historically the largest holders of MBS. Numerous post-crisis banking regulations have had a significant impact. Key regulations are highlighted below.
- All Other Comprehensive Income (AOCI)**, 2Q13 – P&L on *available for sale* (AFS) securities now passed through to capital. This forced a shift of longer duration MBS into *hold-to-maturity* (HTM). Unable to sell, banks become less price-sensitive. Reduces liquidity needs.
- Supplementary Leverage Ratio (SLR)**, 3Q14 – Leverage constraint on banks, regardless of risk weight. Absent risk weight, tighter spread assets such as MBS consume too much available leverage. SLR puts a cap on bank MBS demand as well as system-wide repo financing availability.
- Liquidity Coverage Ratio (LCR)**, 3Q14 – Minimum liquidity requirement forcing demand for high quality liquid assets (HQLA), i.e., Treasuries and MBS. GNMA are level 1A, same as Treasuries, and conventionals are level 2A for LCR purposes. LCR puts a floor on bank MBS demand as MBS offers incremental spread over Treasuries.

Chart 33: Introduction of AOCI drove bank MBS holdings into hold-to-maturity



Source: BofA Global Research, S&P Market Intelligence

Chart 34: Finalization of LCR rules in 2014 increased bank demand for MBS, particularly GNMA



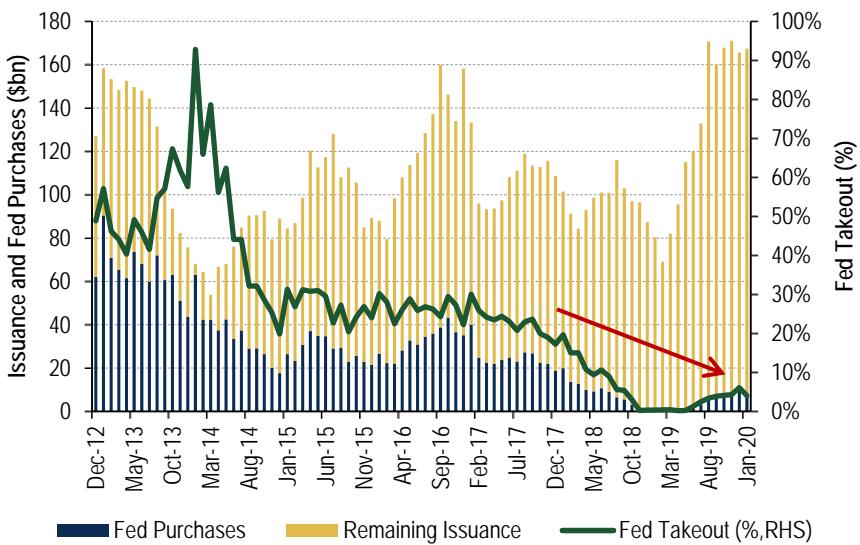
Source: BofA Global Research, S&P Market Intelligence, Fed H8



Fed policy dominated post-crisis valuations of MBS

- US Treasury MBS purchases in 2008 and the subsequent Fed purchases under QE1 and QE3 made the US Government the single largest holder of MBS. The US Treasury has since divested its holdings. The Fed owned \$1.8tr of the \$5.6tr universe of Agency MBS, or 32%, at its peak holdings. Since then, Fed balance sheet runoff, capped at \$20bn/month, has dropped its holdings to \$1.5tr, 22% of the \$6.8tn currently outstanding.
- Fed balance sheet policy is a key determinant of MBS valuations and the primary driver of MBS spreads. The Fed is a price-insensitive investor that absorbs a significant portion of the supply. Moreover, since the Fed has yet to sell MBS, it accumulates the riskiest, cheapest bonds over time, improving the overall quality of the *free float*, tradable MBS over time.

Chart 35: Fed used to own and purchase a majority of Agency MBS issuance, but this is no longer the case since the start of Fed balance sheet runoff in Oct 2017



Source: BofA Global Research

Chart 36: Most post-crisis MBS spread volatility was caused by the Fed's purchases



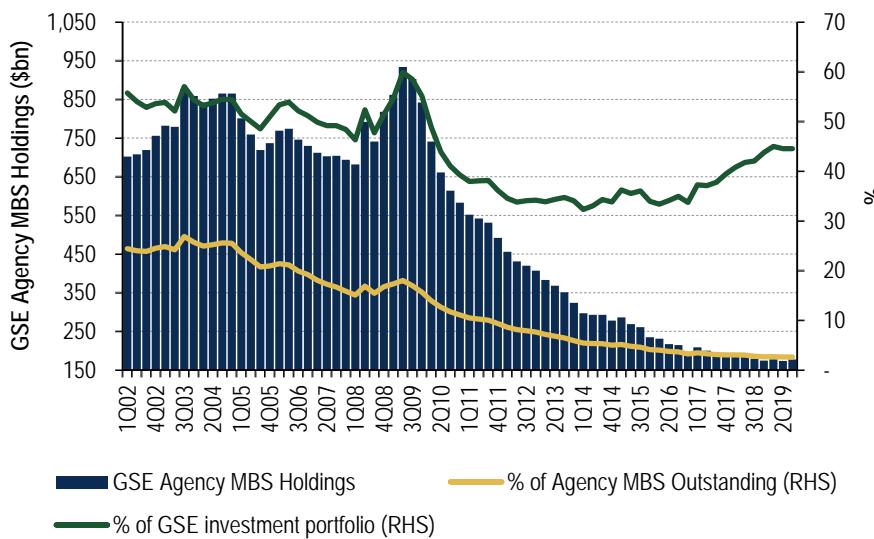
Source: BofA Global Research



Diminished influence of the GSEs

- Pre-crisis, Fannie Mae and Freddie Mac were the dominant Agency MBS investors, controlling over 25% of all Agency MBS outstanding by 2004.
- GSEs were active, relative value investors in the MBS market who tended to buy mortgages when spreads widened relative to their own cost of funds and sell when they tightened. Given their size, they were the primary value arbiters before the financial crisis and enforced a lasting OAS pricing regime driving convexity flows.
- GSE investment portfolios have been wound down under the FHFA conservatorship as part of the agreement with the government under the Senior PSPA. They are currently mandated to reduce their total investment portfolios to \$250bn each.
- Wind-down of the GSEs, replaced with the Fed, and increasing HTM holdings at banks all serve to reduce the share of relative value investors and liquidity needs in the market. This also increases correlations as policy and regulation drive demand in lieu of relative value.

Chart 37: GSEs, once reigning in the MBS market, are no longer dominant



Source: BofA Global Research, Fannie Mae, Freddie Mac

Chart 38: Relative value investors play a smaller role post-crisis, reducing structural liquidity and financing needs



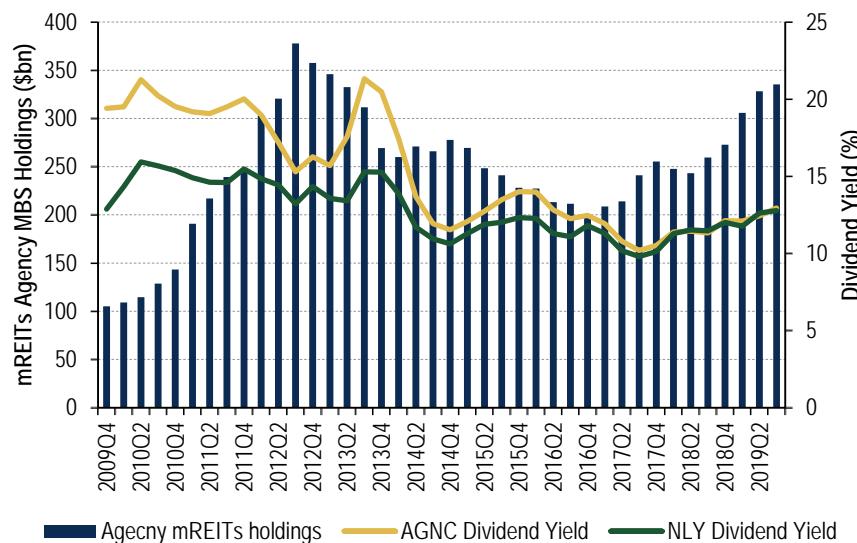
Note: GSE treated as RV prior to conservatorship – under conservatorship, they behave as HTM
Source: BofA Global Research, Fed Z1



Agency mREITs emerge as a new investor class

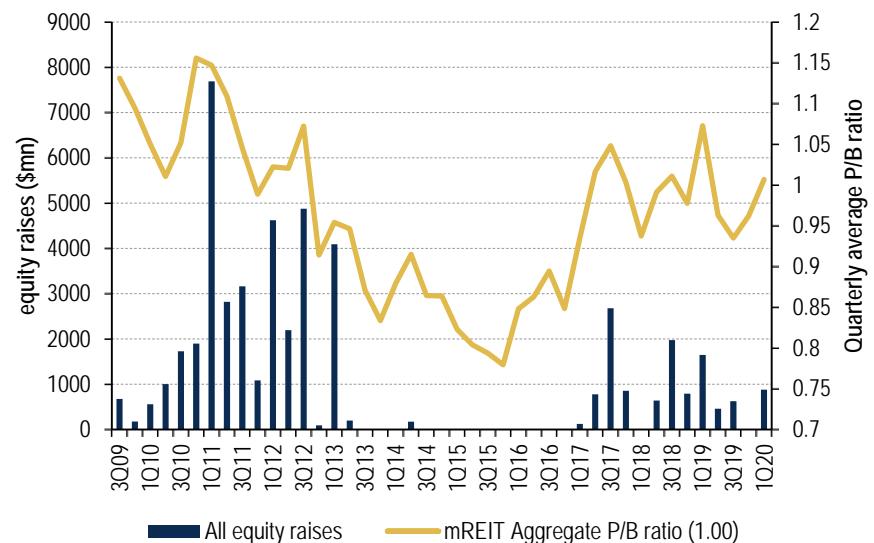
- Agency mREITs (mortgage Real Estate Investment Trusts) have emerged as a significant holder of Agency MBS post-crisis, effectively closing the gap as leveraged GSE portfolios shrunk.
- mREITs typically own MBS hedged with swaps, leveraged between 6x to 10x via repo. By leveraging up, Agency MBS excess returns they are able to sustain dividend yields in the teens, with minimal credit risk component.
- In the environment of lower rates and widening credit spreads, mREITs, backed by Agency MBS, were able to attract significant new capital between 2009 and 2013. With leverage, MBS holdings increased by \$250bn.
- Historically, mREITs equity raises are positively correlated with Price-to-Book ratios. P/B ratios higher than 1, imply equity is priced above the underlying MBS portfolio, making further raises economical.
- Post-QE3 taper tantrums resulted in losses for mREITs, forcing deleveraging, and deflating price-to-book ratios. Decline in repo financing in the wake of SLR further complicated the business model at the time. As a result, equity raises ceased between mid-2013 and 2017. 2016 rebound in equity valuations, and money market reform which improved funding conditions for Agency MBS, have caused mREITs to return to the Agency MBS sector in early 2017 via additional equity raises and higher leverage.

Chart 39: Dividends in excess of 10%, lack of credit risk, allowed for capital raises



Source: BofA Global Research, Bloomberg, Fed Z1

Chart 40: Historically, mREITs equity raises are positively correlated with P/B ratio



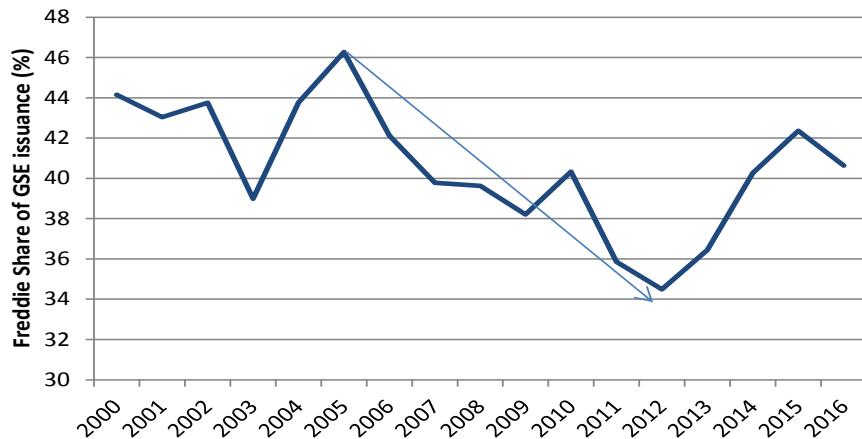
Source: BofA Global Research, Bloomberg



FHFA single security effort

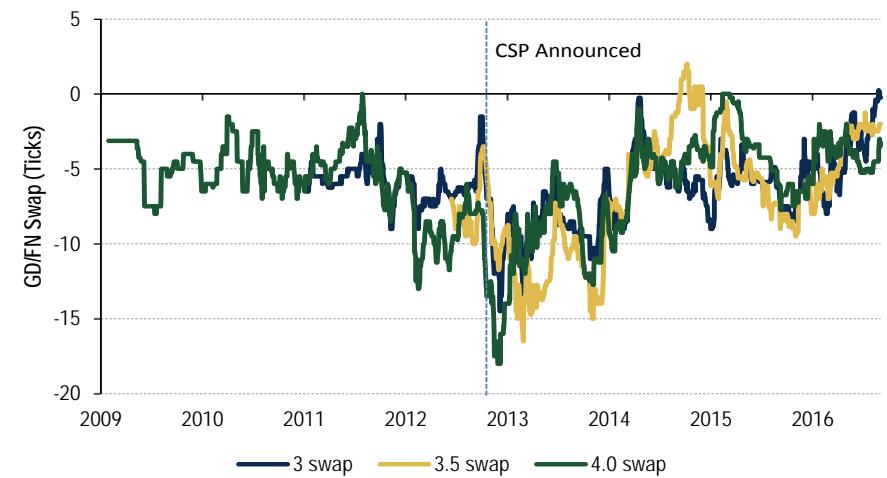
- Collateral, security features, and servicers varied historically between the two GSEs as they competed independently pre-crisis. Over time, pricing divergence has emerged between Fannie and Freddie MBS along with considerable differences in liquidity. Freddie Mac's bonds began to trade at a discount to Fannies.
- When Golds traded cheaper than Fannie MBS, best execution favored FNMs, requiring G-fee concessions from Freddie Mac. With the government effectively the sole equity holder of both GSEs during the conservatorship, these concessions had a direct impact on government revenues, effectively subsidized by the taxpayer.
- In late 2012, FHFA decided to merge the operational aspects of the two enterprises through the creation of the Common Securitization Platform (CSP). FHFA has subsequently announced its intention to create a single security for both GSEs, to boost liquidity of Golds and eliminate G-fee concessions.
- This effort was completed in June 2019, with the launch of UMBS. UMBS has the characteristics of legacy FNMA MBS, with 55-day payment delay. Legacy Freddie Gold pools are exchangeable into UMBS, with Freddie Mac compensating the holder for the 10-day extension in the payment delay.
- To ensure single-security success, FHFA enforces consistent underwriting criteria as well as security features between the two GSEs. Pooling differences still exist, however, between the GSEs and are likely to come under the FHFA's focus.

Chart 41: Gold market share declined post-crisis, creating a liquidity spiral



Source: BofA Global Research

Chart 42: Price concession on Golds narrowed as single-security became a reality



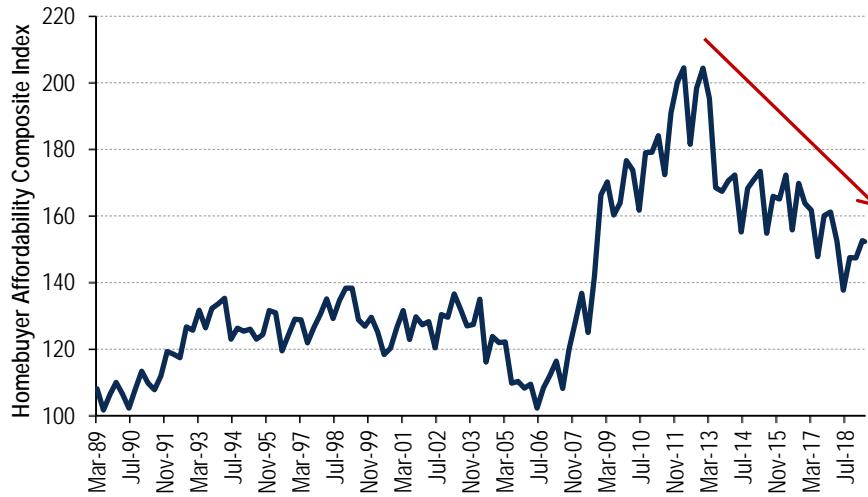
Source: BofA Global Research



Housing policy poses a new post-crisis risk in MBS

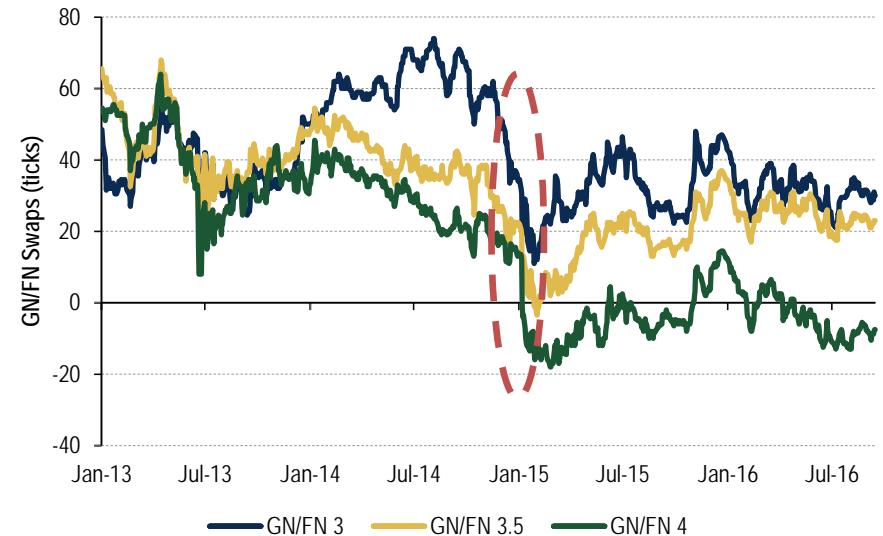
- With the US housing finance in control of all three agencies, the government is now in a position to exercise unprecedented control over the course of housing policy through the GSEs and HUD. Investor ability to push back on any changes is limited.
- This post-crisis regime creates new risks for MBS investors that are inherently difficult to model. Politically motivated policy decisions, rather than more predictable economics can alter cashflows on MBS securities, translating to changes in valuations and risk measures.
- Examples include expansion or contraction of the credit box, potential intervention addressing the declining housing affordability as incomes stagnate while home prices grow, repricing of G-fees and MIPs, expansion or extension of various refinancing programs, reintroduction of streamline refinancing for GSE borrowers, tweaks to single-security and pooling practices.

Chart 43: Low rates make homes affordable for now but that can change. Higher home prices, flat incomes reduced affordability after QE3



Source: Bloomberg

Chart 2: GNMA repriced sharply lower in early 2015 as MIPs were cut by 50bps



Source: BofA Global Research



Current reform snapshot and outlook

Table 15: FHFA, GSE reform snapshot

Topic	Description	Implications	Trend
Capital Rule	Outlining capital requirements for the GSEs, paving the way to end the conservatorships.	The amount of capital to be raised is a key determinant in how long the recapitalization, and ultimately the release from the conservatorships will take. The required returns on that capital will directly translate into pricing of mortgage credit via G-fees, and correspondingly the target market share of the GSEs.	↑
Legality of Net Worth Sweep	The legality of the net worth sweep was questioned. Temporary ending of the profit sweep started, and increased capital buffer limits for GSEs.	Building foundation towards possibly ending the conservatorship status of the GSEs.	↑
Release from Conservatorship under Consent Order	Uncertainty over whether Calabria can/will release the GSEs from conservatorship after a de minimis capital retention, but prior to Congressional action providing an explicit federal guaranty.	Status quo ante: TBA securities may be back to an "implicit" guaranty from the federal government.	↑
GSE pooling alignment	FHFA issued RFI on pooling, seeking input on whether more aligned pooling practices as proposed would improve UMBS liquidity.	Pooling methodologies between the GSEs needed to be more aligned to ensure the continued success of UMBS.	↑
Restoring captive insurers to FHLB	After being shut out in 2016, REITs will be able to regain access to FHLB funding via captive insurance companies.	Opening a new funding channel for an important investor group in Agency MBS.	↑

Source: BofA Global Research

Table 16: Current CFPB outlook

Topic	Description	Implications	Trend
QM patch expiring	QM/QRM exclusion slated to expire in 2021. CFPB slated to extend QM patch until DTI is eliminated from the rule, potentially replaced with a constraint on the mortgage rate.	Those otherwise prime borrowers would be relegated to FHA with higher costs or simply forced to buy less expensive houses. Industry has called for the elimination of the DTI limits.	↑

Source: BofA Global Research

Table 17: Other issues

Topic	Description	Implications	Trend
LIBOR transition	LIBOR may be phased out by the end of 2021.	Impacts on LIBOR-indexed hybrid ARM and floaters. GSEs adopt ARRC fallback language.	↑
VA churning	Addressing repeated refinancings of VA borrowers, abusive lending practices.	Impacts GNMA cashflow. After a burst of initiatives since 2016, GNMA is now taking a more "wait and see" approach.	↓
Constitutionality of Agency Structure	The Supreme Court has agreed to hear a case for the CFPB that challenges whether the President can remove the Director of an independent agency at will.	Any ruling on the CFPB case will likely apply to the FHFA, which could lead to GSE policy swings based on Presidential election cycles.	↑
Defect taxonomy	Rep and warrant framework for FHA.	Favorable outcomes could improve industry risk perception and likely result in expanded credit. FHA recently improved it, with lenders increasingly attracted back. Rep and warrant concerns remain but are being slowly addressed.	↑
HUD and DOJ agreement	Agreement signed on the appropriate use of the False Claims Act (FCA) for violations by FHA lenders. Until Congress acts, however, this is potentially reversible by another Administration.	Brings greater clarity to regulatory expectations within the FHA program. Make affordable FHA mortgages more accessible to qualified borrowers, and reduce risks within the FHA.	↑

Source: BofA Global Research



Prepayments



Refinancing risk is a unique attribute of MBS

- US mortgage lending terms allow borrowers to freely pay down any portion of the outstanding balance on their mortgage prior to maturity. The loan is paid off when the property is sold or when the borrower refinances into a new mortgage. Sometimes the borrowers want to shorten the maturity of the loan by paying more than the minimum payment. In most mortgages today, there is no *prepayment penalty* associated with the early payoff.
- This ability to prepay the loan creates uncertainty for MBS holders with respect to the *timing* of mortgage cashflows, resulting in *prepayment risk*. Prepayments are critical to the valuation of MBS, setting them apart from bullet Treasuries or corporates. The confluence of drivers that factor into prepayment risk are often referred to as *mortgage fundamentals*.
- Home sales and refinancing activity are rate-dependent, with prepayments increasing when rates drop. This creates *reinvestment risk*, as higher principal paydowns end up reinvested at lower rates. Conversely, principal paydowns slow when rates are higher, creating *extension risk*.
- As a result, a mortgage pool can be thought of as a callable bond, where the investor is short an option to the borrower. Unlike a corporate bond issuer motivated solely by the economics, MBS borrowers do not always exercise their options efficiently.
- Modeling the borrowers' behavior lies at the heart of projecting prepayments and mortgage valuations.



Measuring prepayments

$$\text{monthly prepaid balance} \over \text{scheduled balance}, \text{ or } \frac{\text{scheduled balance} - \text{current balance}}{\text{scheduled balance}}$$

- **Single monthly mortality (SMM)** = $\frac{\text{monthly prepaid balance}}{\text{scheduled balance}}$, or $\frac{\text{scheduled balance} - \text{current balance}}{\text{scheduled balance}}$
- SMM is the amount of unscheduled paydowns in any given month, expressed as a percent of the scheduled balance.
- **Conditional prepayment rate (CPR)** is the annualized SMM. CPR is the most commonly used metric for measuring prepayments. Generally:

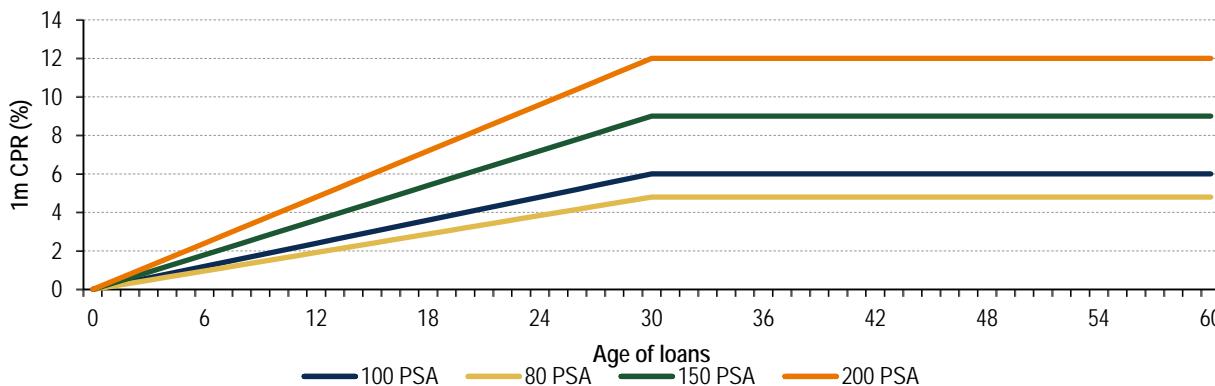
$$N\text{-month CPR} = 100 * \left\{ 1 - \left[\prod_{i=1}^N (1 - SMM_i) \right]^{\frac{12}{N}} \right\}$$

- Common metrics are 1m CPR, 3m CPR, 6m CPR, 12m CPR, and lifetime CPR. 1m CPR is most common:

$$1m \text{ CPR} = 100 * [1 - (1 - SMM)^{12}]$$

- **The Public Securities Association (PSA) model** of MBS has CPRs rising from 0 to 6 linearly by 0.2 per month over 30 months, 6 CPR thereafter. Speeds can be measured in % of this model, i.e., 100 or 150 PSA. Similar to CPR, 1m PSA, 3m PSA, 6m PSA, 12m PSA, and lifetime PSA are used. Examples: 3 CPR at 15 WALA = 100 PSA, 6 CPR at 30 WALA = 100 PSA

Chart 44: PSA model offers a simplified estimate for prepayment behavior over time



Source: BofA Global Research



SMM aggregation and generic cohorts

- Prepayment speeds are commonly aggregated into cohorts, typically defined using coupon and vintage, ie, FNCL 3.5 2018.
- Proper SMM aggregation across pools, or a group of loans, requires separate aggregations of prepaid balance and scheduled balance. Alternatively, SMMs can be weight-averaged by *scheduled balance*. CPR is then computed from the SMM.

Chart 45: Cohort prepayments on Bloomberg: FNCL 3.5 MTGE <GO> Paydown



Source: Bloomberg

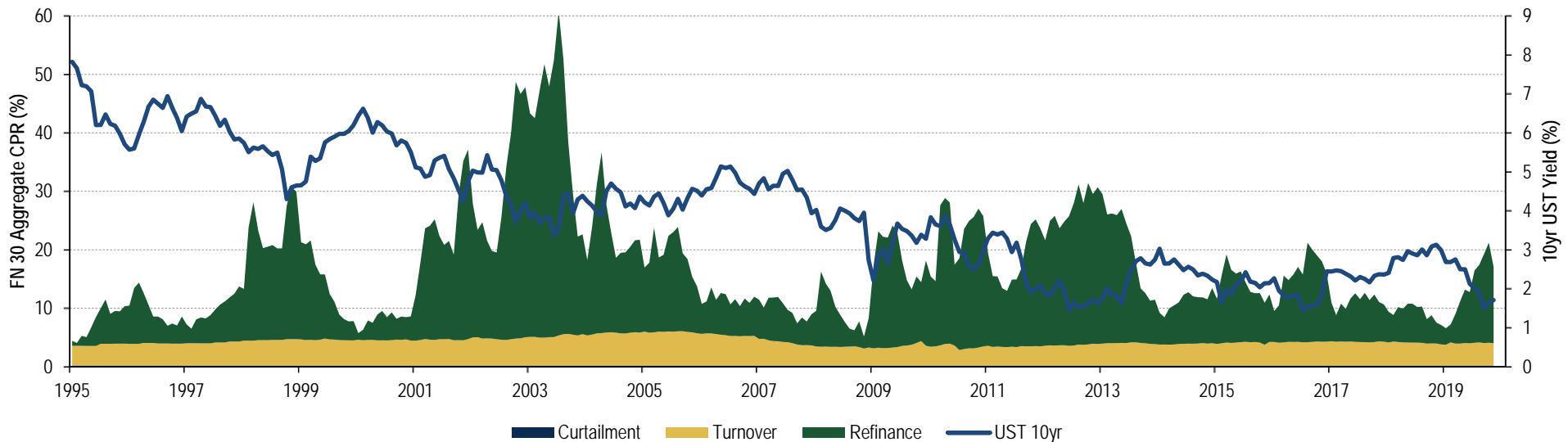


Drivers of prepayments and historical experience

Key drivers of borrower prepayments

- **Refinancing** – Borrowers refinance into lower mortgage rate loans to realize monthly payment savings when interest rates drop sufficiently.
- **Turnover** – Borrowers prepay their loans when the property is sold. Some of this is rate-independent – mortality, divorce, foreclosure, amount of home equity. Nevertheless, borrowers trade up and relocate less often when rates rise as the higher monthly payment on a new loan creates a disincentive.
- **Curtailment** – Certain borrowers attempt to pay down their mortgages more quickly, for example, in preparation for retirement. Their monthly payment exceeds the minimum, especially when nearing the end of the mortgage term. This is usually negligible except for the most seasoned mortgages.

Chart 46: Historical prepayment experience, by key drivers



Source: BofA Global Research

Key prepayment drivers

Chart 47: Key prepayment drivers

Refinancing

SMM =

Housing Turnover

Curtailments

- Loan Type – agency, term, purpose, coupon
- Lending regulations and standards
- Process/technology, appraisal waivers
- Rate incentive
 - Inclusive of fees, MI/MIP, fixed costs
 - Takes product transitions into account
 - Subject to varying lags, time to close
- Loan size
 - Larger loans have a higher dollar incentive
 - Loan size a proxy for other characteristics
- Loan age or seasoning
- Servicer – efficiency, incentives
- Media effect
 - Psychological impact of new lows in rates
 - Lender solicitation and appetite
- Credit profile
 - FICO, LTV, DTI, documentation, SATO
- Cashouts
 - HPA, equity, HELOC/2nd lien availability
- Occupancy – owner, investor
- Eligibility for any streamlined refi programs
- Geography – unique state rules/fees
- Burnout – foregone past opportunities
 - Creates path dependency in MBS
- Day count

- Loan Type – agency, term, purpose, coupon
- Lending regulations and standards
- MBS buyout practices and incentives
- Loan age or seasoning
- Seasonality
- Credit profile
 - FICO, LTV, DTI, documentation, SATO
 - Delinquency history / default likelihood
- Existing home sales rate:
 - Mortality, divorce
 - HPA – speculative home sales activity
 - Labor mobility
 - Demographic changes
 - Household formation
 - Incomes, affordability, and interest rates
- Rate incentive or lock-in effect
 - Inclusive of fees, MIPs, fixed costs
- Loan size
 - Larger loans have higher dollar lock-in
 - Starter, smaller homes trade-up more
 - Loan size a proxy for other characteristics
- Occupancy – owner, investor
- Geography – unique state rules/fees
- Day count

- Loan Type – agency, term, coupon
- Remaining maturity of the loan
- Credit Profile
 - FICO, LTV, DTI, documentation, SATO
- Macroeconomic factors:
 - Demographic changes
 - Incomes, inflation
- Rate incentive , ie, opportunity cost
- Loan Size
 - Smaller loans easier to pay off

Source: BofA Global Research



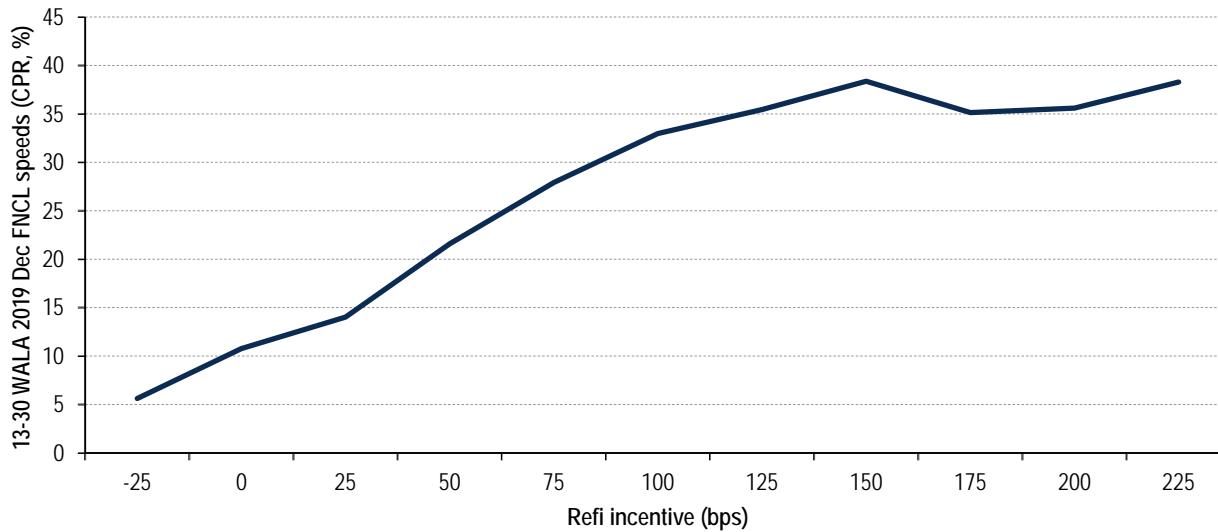
Refinancing incentive and the S-curve

- Prepayment speeds are predominantly driven by the economic incentive to refinance. The simplest definition is as follows, although can also be modeled as a ratio, or as dollar savings:

$$\text{Refi incentive} = \text{note rate on the existing mortgage} - \text{primary mortgage rate}$$

- Borrowing from option theory, refi incentive is known as *moneyness* and a borrower is said to be in-the-money when the refi incentive is positive and out-of-the-money when it's negative. MBS with a higher WAC spread faces higher refi incentive, all else equal.
- A plot of observed prepay speeds versus the refi incentive is known as the *S-curve*, for its shape, reminiscent of the letter S. CPRs are bounded by turnover when incentive is negative, while incremental incentive past a certain point fails to generate additional refis.
- Ultimately, dollar savings matter, as explicit and implicit costs to refi have increased. As borrowers take on the fixed refinancing costs of about \$2-3k, refis don't begin increasing until the point of inflection at 50-70bps of refi incentive for a typical 30yr mortgage. This defines the *refi elbow*.
- Borrowers close to the elbow are referenced as being on the *cusp*.
- Costs of MI, LLPA, MIPs can alter the economics of a refinance as well.

Chart 48: Prepayments exhibit an S-curve with respect to refi incentive



Source: BofA Global Research, FNMA



Measuring the refi incentive: primary mortgage rate

- The *primary mortgage rate* is the key determinant of a borrower's refi incentive.
- The industry benchmark mortgage rate is published by the Freddie Mac Primary Mortgage Market Survey (PMMS), sometimes simply referred to as the *survey rate*.
- Freddie Mac surveys a representative group of conventional lenders every Monday, collects the results by Wednesday, and publishes the rate on Thursday. A time series is available back to 1971 on Bloomberg: NMCMFUS Index and NMCM15US Index for 30- and 15-year rates, respectively.
- Borrowers sometimes buy down the rate, by paying an upfront amount to the lender, often capitalized in the loan itself. This is common when rates hit new, all-time lows. The amount paid, known as points, is also reported as part of the PMMS. Comparing rates from two different sources may require an adjustment for these points. This is typically done by computing a no-point equivalent rate, annualizing the points at some assumed multiple.
- Remaining term is important to the choice of the primary rate for the incentive calculation. Very seasoned 30yr borrowers are increasingly likely to do a *term refi*, ie, refinance into a 15- or 20-year mortgage, Thus, those rates should be used to estimate borrower savings.

Table 18: PMMS for December 19, 2019, adjusting for points

	30-Yr FRM	15-Yr FRM	5/1 - Yr ARM
Average Rates	3.73%	3.19%	3.37%
Fees & Points	0.7	0.7	0.4
No-point equivalent rate (4x multiple)	3.73+0.7/4 = 3.905%	3.19+0.7/4 = 3.365%	3.37+0.4/4 = 3.47%

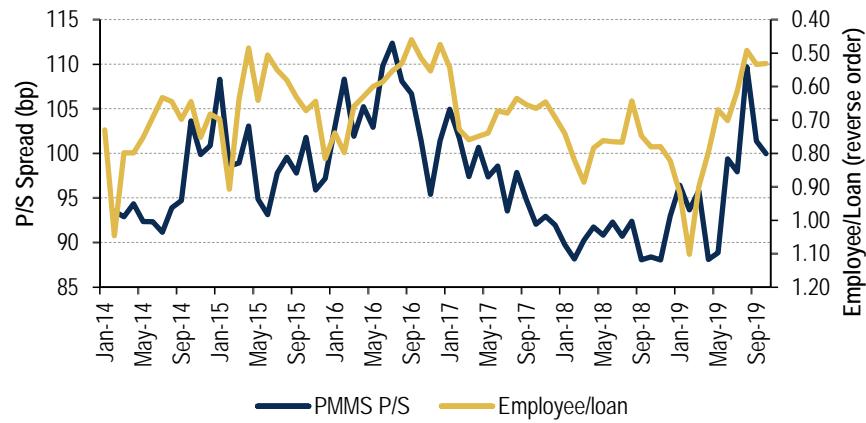
Source: Freddie Mac



Primary/secondary spreads and mortgage banking capacity

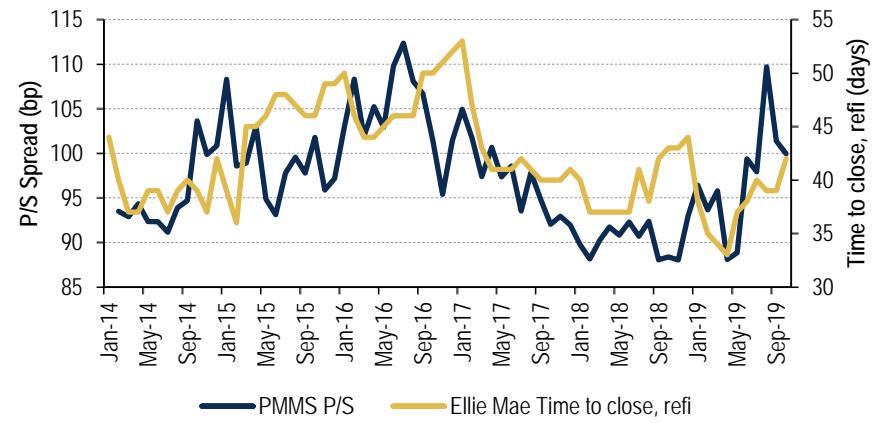
- Since originators sell mortgages in the secondary market, primary mortgage rates offered to borrowers are closely tethered to the par MBS yield, but not perfectly so.
- The *primary/secondary spread* is the difference between primary mortgage rate and the par MBS yield in the secondary market. After netting out the minimum servicing fee and the G-fee, primary/secondary spread is a proxy for originator profit. Primary/secondary spread widens when rates drop and origination capacity becomes constrained, effectively making mortgage rates sticky relative to changes in observable Treasury or MBS yields.
- The period of time between when a borrower locks the rate on the new mortgage and the time when that mortgage actually closes is known as the *processing lag*, or simply the lag. This time-to-close typically ranges 1 -2 months. Since the new loan is used to pay off the old one, the lag directly translates into the timing of prepayments. Similar to the primary/secondary spread, processing lags are mostly driven by capacity. When refinancing application volumes spike, it generally takes longer to close, pushing prepayments further out.

Chart 49: Capacity constraints drive pricing, making mortgage rates sticky



Source: BLS, BofA Global Research

Chart 50: Lags vary between 1-2 months, correlated to P/S spread



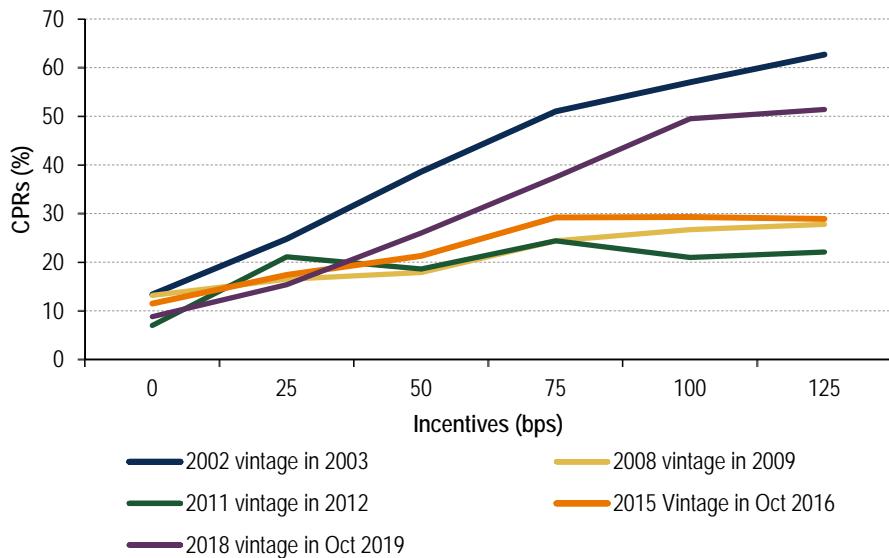
Source: Ellie Mae, BofA Global Research



Refi response changes over time: S-curve evolution

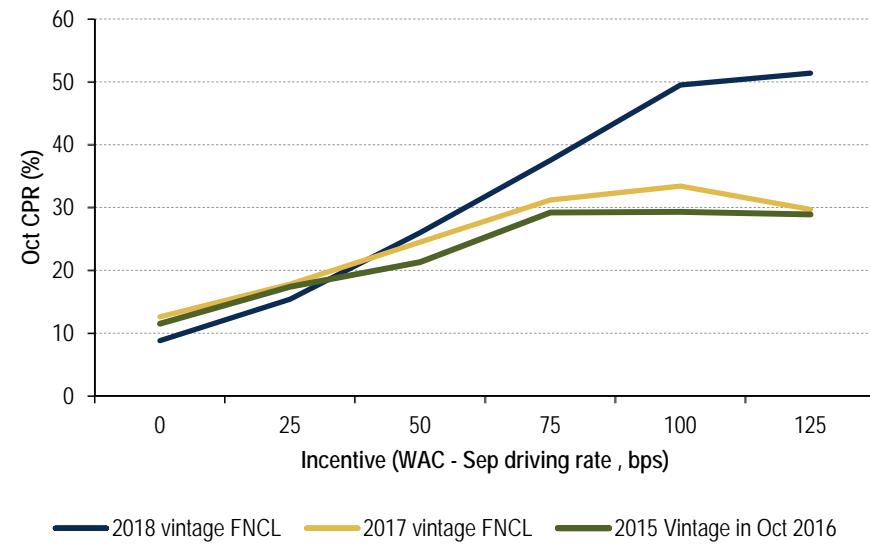
- Aggregate refinance sensitivity and S-curves have changed dramatically over time. These changes reflect the evolution of credit standards and industry practices, affecting the willingness and ability to refinance.
- Credit availability declined post-crisis and the GSE streamline refi programs were eliminated, flattening the S-curves.
- Post-crisis regulatory scrutiny and putback risk resulted in tighter underwriting and less aggressive servicing practices. After years of ongoing refinancing activity, the universe of borrowers still eligible for a refinancing has shrunk, limiting the servicer's reach.
- Most recently, technological and process advances in GSE mortgage underwriting have contributed to the steepening of the S-curve in 2019 for recently originated borrowers. This is heralding a new era of streamlining refinancings, thanks to advances in FinTech.

Chart 51: S-curves change dramatically over time, reflecting regime shifts in prepay behavior



Source: BofA Global Research

Chart 52: 2018 vintage borrowers behave very differently compared to the 2016 refi wave



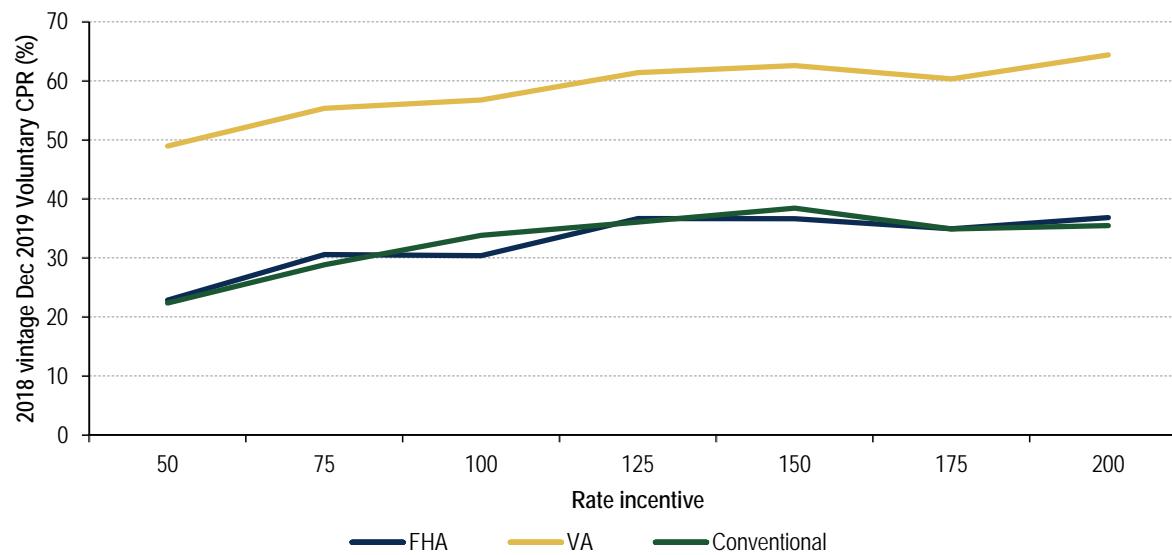
Source: BofA Global Research, FNMA



Refi response varies across the Agency programs

- The Agency and the type of loan are the key determinants of the S-curve.
- VA exhibits the steepest S-curve due to the ease of refinancing, lower funding fees on refinancing, aggressive servicing, and generally high credit quality of the collateral.
- FHA S-curve has traditionally been flatter than conventionals. In recent years, the FHA S-curve has steepened due to the ongoing changes in servicing practices and policy.
- Mortgage rates available to borrowers can vary significantly from PMMS – Jumbo, VA, FHA borrowers' rate incentives vary materially from conventionals. FHA/VA rate is usually lower, as G-fees are smaller and GNMA tend to trade at lower yields. MIPs also alter the refi incentive.

Chart 53: S-curve vary across the Agency programs



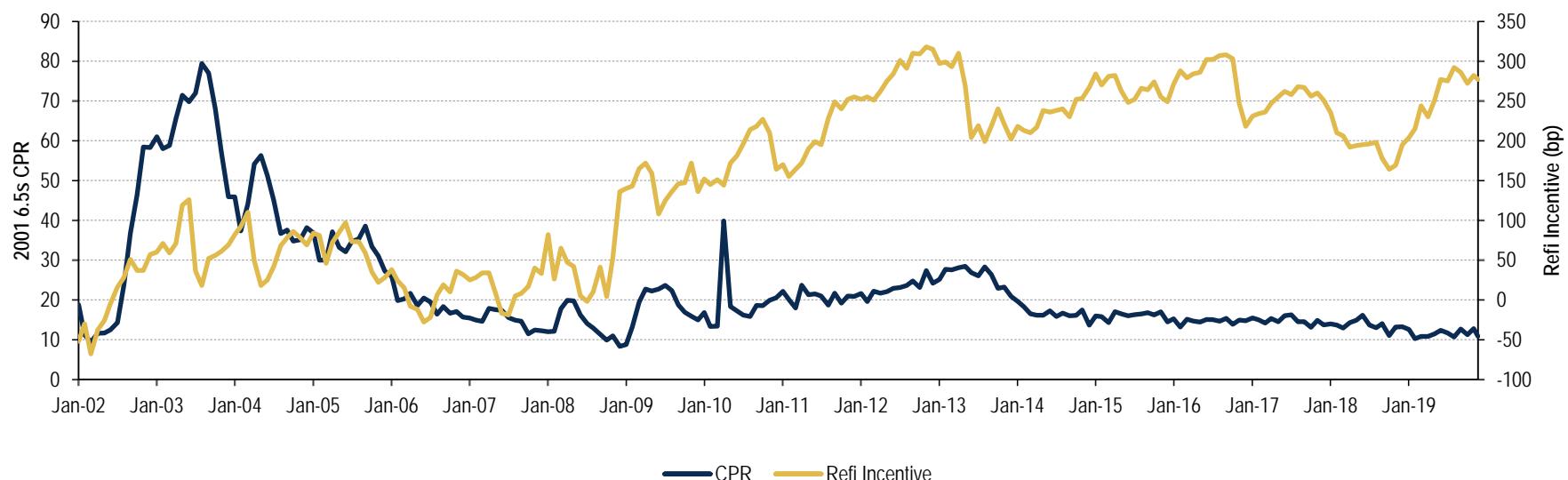
Source: BofA Global Research



Refi response dampens with age: burnout

- As borrowers are exposed to low rates and refinance incentives, the borrowers most attentive to rates and able to refinance will tend to prepay out of the pool, leaving the remainder of the pool “burned out.” The remaining loans will prepay at slower speeds subsequently and exhibit a flatter S-curve. This is known as the *burnout effect*.
- Burnout effect gives rise to the interest rate path dependence of MBS cashflows. Prepayments are not just driven by the spot level of rates but also by the realized path of interest rates and refinancing opportunities experienced to-date. This path dependence has significant modeling implications, often measured by the cumulative refi incentive since origination.

Chart 54: Over time refi response dampens due to burnout as the most attentive borrowers prepay out of a pool



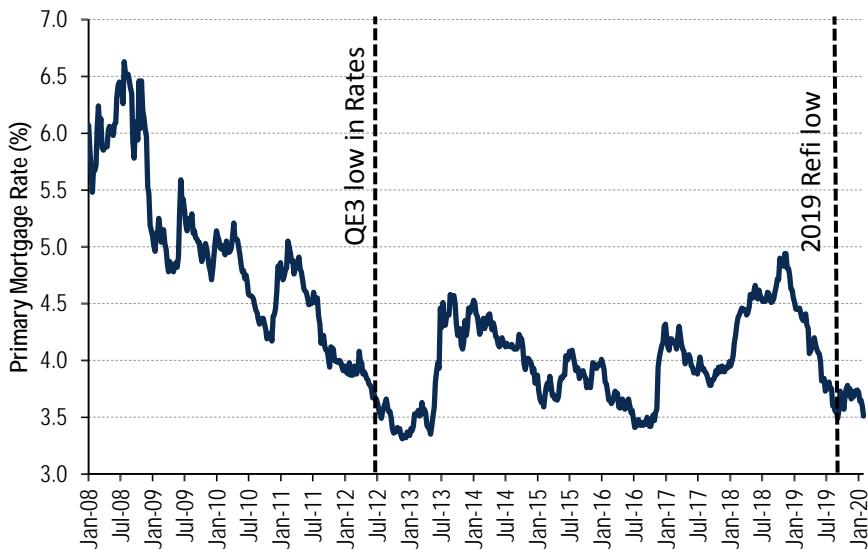
Source: BofA Global Research



Refi response triggered on new lows in rates: media effect

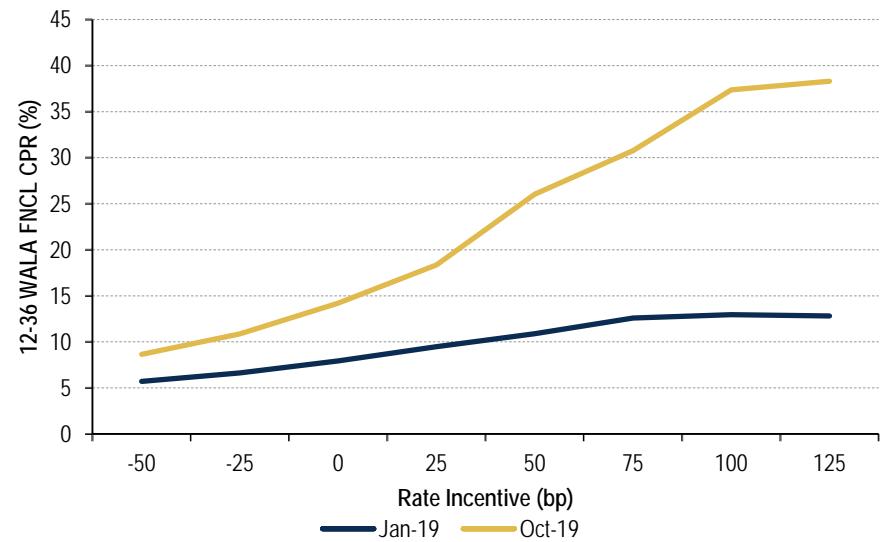
- S-curves tend to steepen out when new lows in rates are reached. This is known as the *media effect* as servicers begin to aggressively advertise the new rate lows and ramp up borrower solicitation to refinance.
- Media effect is another reason for the path dependence of MBS cashflows.
- Media effect is not constant and depends on the number of solicitable borrowers, origination margins, and available capacity. Media effect is often modeled as a ratio of the current primary rate over a historical longer term look back, such as three or five years, to establish effects of all-time or recent new lows.
- Loans bearing the lowest mortgages rate are impacted the most, compared to those already facing a significant refi incentive.

Chart 55: Rates rallied to historic lows following the QE3 announcement and recently in 2019



Source: Bloomberg, Freddie Mac

Chart 56: ... exacerbating a sharp steepening of S-curves due to the media effect



Source: Bloomberg, Freddie Mac



Refi response rises as home prices appreciate: cashouts

- Home equity, built-up as a result of amortization and *home price appreciation (HPA)*, can impact refinancings. Refinancing a loan with a new one carrying a higher balance and LTV is called *cashout refinancing*. Cashout refinancings can be used by borrowers to fund large items such as remodeling, cars, or college tuition at the rate of the secured mortgage. They can also be used to consolidate other higher interest debt, such as HELOCs or credit cards.
- Cashout refinancing was prevalent just prior to the financial crisis, as easy credit allowed borrowers to tap their home equity to fund consumption and investments. Freddie Mac estimates borrowers were cashing out over \$80bn of equity per quarter in 2006. Cashouts were skewing the observed refi behavior, occurring even on loans lacking refi incentive.
- Post crisis tightening of credit standards has brought cashout volumes to the levels of the early 2000s.
- Cashouts as % of refis, a commonly cited metric, can be misleading as it is subject to the mix of borrowers being refinanced. For example, in 2018 when rates were high, only the most seasoned, highest coupon MBS with built-up equity were in-the-money. In 2019, as rates rallied, refi composition changed to include most borrowers, driving cashout % lower. Through all this, cashout dollar volumes have remained relatively stable.

Chart 57: Cashout frequency as a % of refis

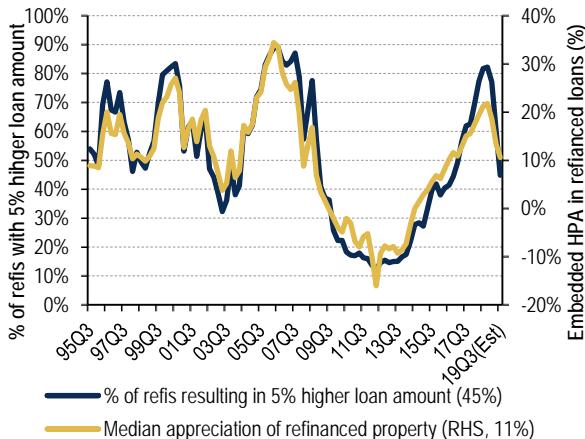


Chart 58: Cashed-out dollars (\$bn)

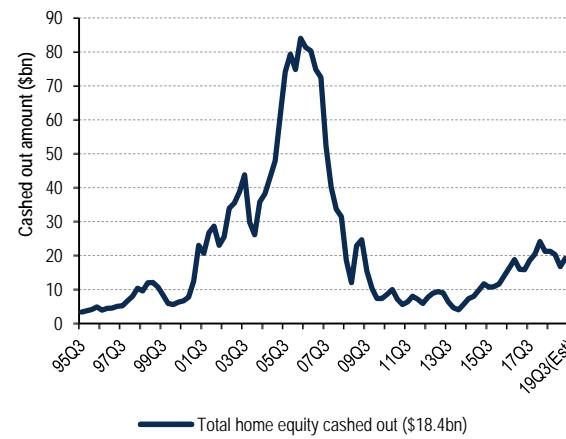
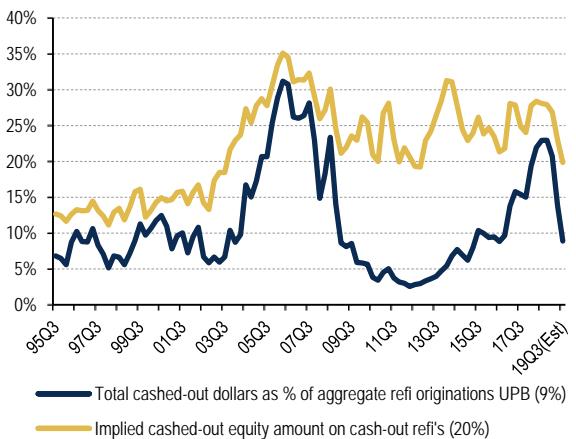


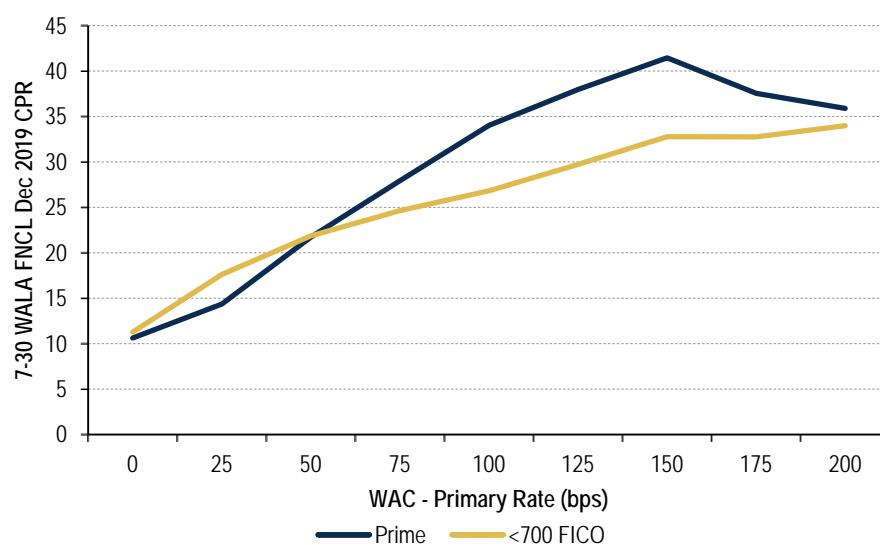
Chart 59: Typical cashout amount for a given refi



Refi eligibility is not guaranteed: credit box

- Pre-crisis, agency MBS prepayments exhibited little correlation to credit standards due to ease of access. This changed post crisis as the underwriting standards tightened.
- LLPAs associated with weaker credits effectively alter the refi incentive for borrowers. For example, 80 LTV, 650 FICO loan requires 325bps upfront. This is equivalent to 16bps higher mortgage rate when rolled into the balance of the loan. Alternatively, if the borrower is unable to roll the balance into the loan, for example because of LTV limitations, then the borrower may be able to finance this cost via points. At a multiple of 4, the same LLPA would equate to adding 81bps to the rate. The effective change in the amount of the refi incentive is known as an *elbow shift*.
- FICO, LTV, and DTI comprise the observable credit box. Unobservable variables, such as quality of documentation and borrower assets also affect the rate the borrower receives. They are often implied from *spread at origination* (SATO) - the difference between the note rate on the loan and the prevailing PMMS rate at origination.

Chart 60: Weaker credits prepay slower, facing greater frictions and costs



Source: BofA Global Research, Fannie Mae

Table 19: LLPA matrix below creates an elbow shift for weaker credits (upfront bps)

FICO \ LTV	<60	60-70	70-75	75-80	80-85	85-90	90-95	95-97	>97
>740	0	25	25	50	25	25	25	75	75
720-739	0	25	50	75	50	50	5	100	100
700-719	0	50	100	125	100	100	100	150	150
680-699	0	50	125	175	150	125	125	150	150
660-679	0	100	225	275	275	225	225	225	225
640-659	50	125	275	300	325	275	275	275	275
620-639	50	150	300	300	325	325	325	350	350
<620	50	150	300	300	325	325	325	375	375

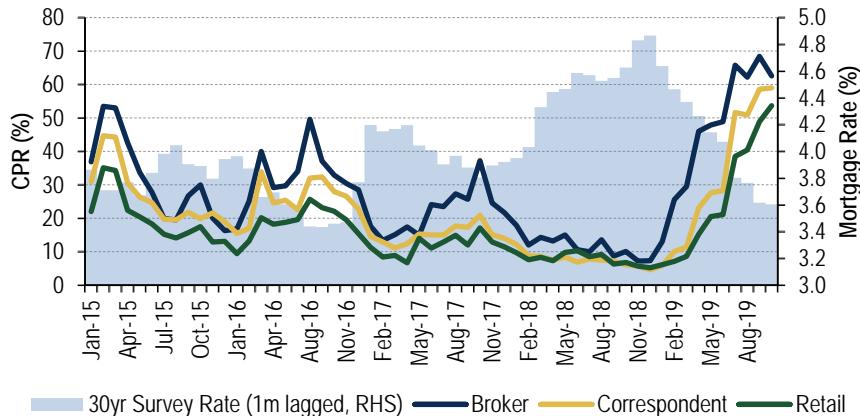
Source: Fannie Mae



Refis are fastest for brokers, slowest for retail

- Origination channel has a considerable impact on prepayment speeds. Historically, broker originated loans exhibit the fastest speeds and retail borrowers are the slowest, with correspondent originated speeds in between.
- Mortgage brokers – typically small entities who maintain direct client relationships and match them up with lenders - shepherding them through the process. Brokers work on commission and do not underwrite or fund the loans directly, and their revenues are driven by few considerations other than maximizing volume. As refis rise, brokers are quick to staff due to their small team size, and tend to be more adept at ensuring their customers benefit from the latest process and policy developments.
- Correspondents – originate and fund loans, but do not retain them on balance sheet or securitize directly, relying on short-term warehouse funding. Once produced, the loans are sold to the larger lender who will service and potentially securitize them. Underwriting is often done to the sponsor's specifications.
- Retail – loans originated directly with the customer without relying on brokers or correspondents. Retail originators will typically retain or securitize the loan, and service it for a fee.
- Growing market share of brokers has contributed to the steepening of the S-curve observed in 2019.

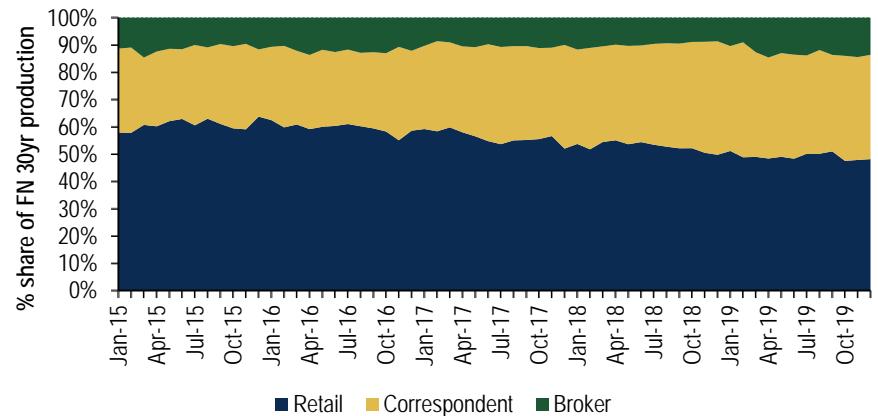
Chart 61: Broker loans are paying 20 CPR faster than retail in 2019



Source: BofA Global Research

Note: FN 30yr 4%, 6-12 WALA, >175k, ex-NY, <90 LTV, >700 FICO

Chart 62: Retail and correspondent channels dominate production volumes

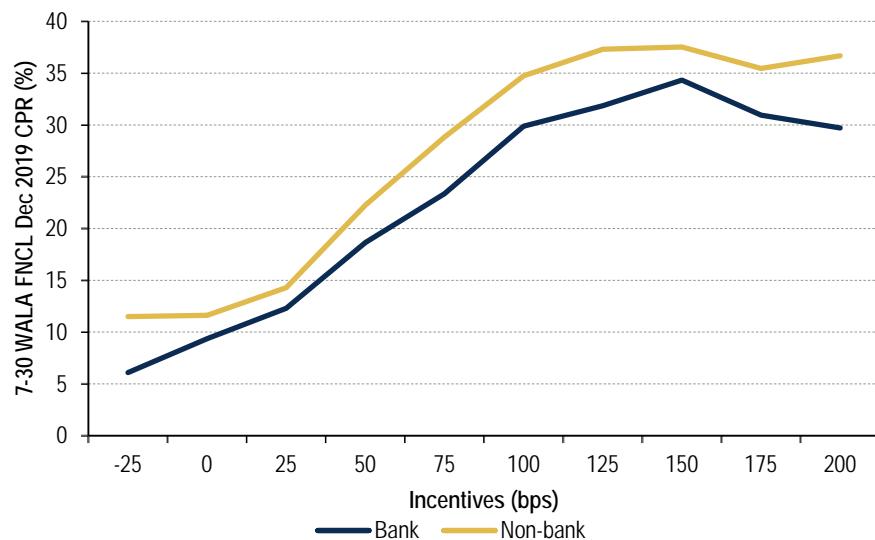


Source: BofA Global Research, Fannie Mae

Refis vary by lender: non-bank S-curves are steeper

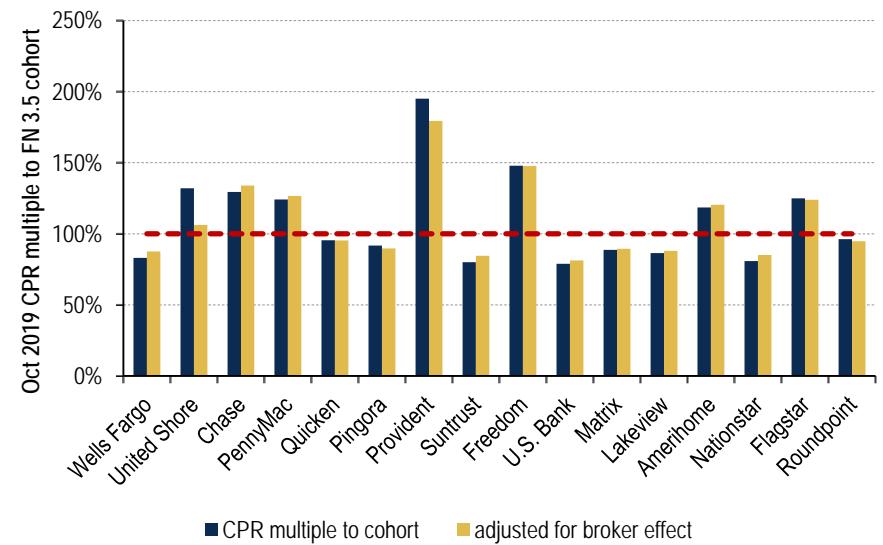
- Non-bank servicers exhibit substantially faster refinance speeds compared to their bank counterparts. Level, as well as the steepness of the S-curve, is both higher.
- Many operate with a more efficient footprint, focusing on online and other alternative channels, rather than traditional brick-and-mortar retail operations. This serves to shorten processing lags, increase prepayment sensitivity.
- The MSR book, comprising the sole tangible asset of many non-banks, is the primary driver of equity value. Non-banks are thus, highly incentivized to grow and protect their servicing book via aggressive refi solicitations. Unlike a bank, most don't hedge MSRs as the origination pipeline provides an implicit hedge, creating additional incentives to refi borrowers.
- Considerable variation of speeds exists between sellers/servicers, but needs to be evaluated in the context of collateral and origination channel differences.

Chart 63: Non-banks are significantly more efficient at refinancing their borrowers, leading to steeper S-curves



Source: BofA Global Research

Chart 64: 2018 vintage speeds by seller/servicer, before and after adjusting for the broker effect



Source: BofA Global Research

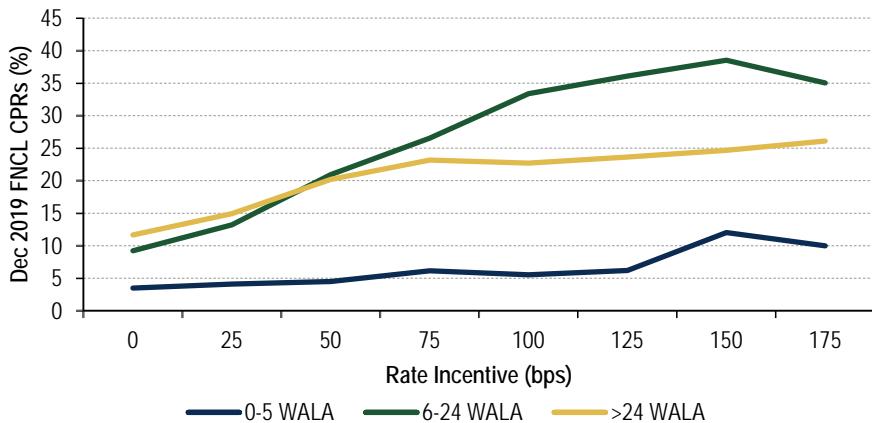
Note: 2018 vintage TBA FN 3.5 speeds as of October 2019, ex-NY, >225k loan size, <90 LTV, >700 FICO
Effectively, brokers prepaid 136% of cohort in 3.5s, we adjust for this aggregate broker effect here.



Refis change as loans age: seasoning

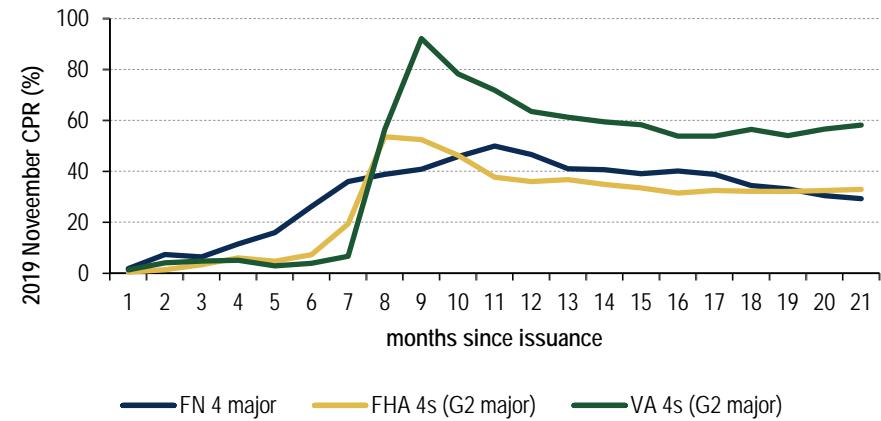
- Loan seasoning affects the pace of refinancing, typically flattening the S-curve during the first 4-6 months of the loan, steepening it subsequently, and flattening once more as the loan becomes seasoned. A plot of speeds versus age for a particular coupon is known as a *seasoning ramp*.
- Many loan officers are barred from soliciting refinances during the first 4-6 months since the closing of the original loan. This is designed to limit *churning*, preventing the repeated collection of origination commissions. Also, per the 2018 Economic Growth, Regulatory Relief, and Consumer Protection Act, GNMA cannot guarantee refinances of loans seasoned less than 210 days. As a result, S-curves tend to be very flat during the first few months of the loan.
- Once these incentives expire, however, borrowers become prime refinance targets if in-the-money. Their fresh documentation and recent property and credit appraisal allows for quicker and a less costly refi process. They are also more likely to fit the most recent underwriting guidelines. This steepens out the S-curve for a while, particularly among the more aggressive non-banks.
- As documentation begins to age, S-curves begin to flatten once more. This is true even independent of the burnout effect.

Chart 65: S-curves ramp up over the first 6 months, and flatten after 24 WALA



Source: BofA Global Research

Chart 66: Seasoning ramps differ between conventional, FHA, VA

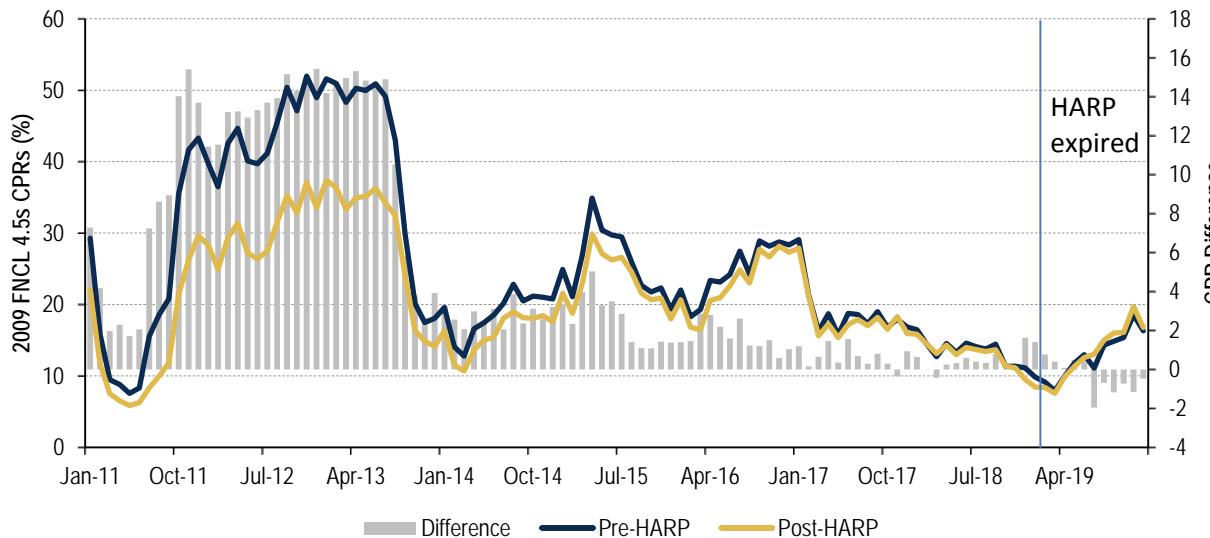


Source: BofA Global Research, Fannie Mae, Ginnie Mae

Refi programs: HARP and high LTV refi option (HLRO)

- Special post-crisis refinancing programs aimed at underwater borrowers have altered the prepayment profile of eligible borrowers and MBS.
- The largest program to-date was HARP, as part of the Making Home Affordable Act (MHA), which lasted from March 2009 to December 2018. Streamline refinancing features of HARP were available to performing, pre-May 2009 borrowers resulting in faster speeds, all else equal. Peak response was observed from 2011 to 2013, before burning out.
- High LTV refi option (HLRO), intended to provide a refi outlet similar to HARP for a future downturn, was implemented in 2018. Minimum LTV is 97.01 and the program shares many of the same features as HARP. For example, the original loan needs to be performing and there are no restrictions on LTV, credit, income, or assets. However, there are some notable differences. Unlike HARP, which could only be availed of once, HLRO is intended to be usable multiple times. Also, the loans need to be at least 15 months seasoned and only loans originated after October 2017 are eligible. Finally, borrowers still need to go through the normal appraisal process under HLRO, which was not the case under HARP.
- Given the normal GSE production capped at 97 LTV, and positive home price growth since 2017, the usage of HLRO has been limited to-date as few eligible loans are currently underwater.

Chart 67: HARP had a substantial prepayment impact, boosting speeds by 5-15 CPR

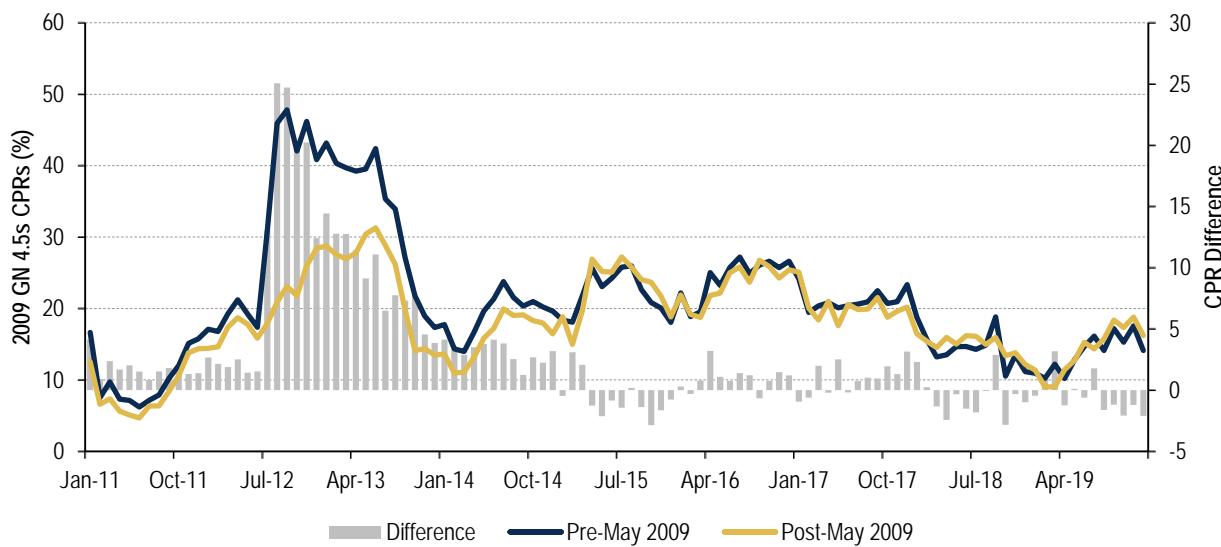


Source: BofA Global Research, Fannie Mae

Refi programs: FHA and VA streamline refis

- FHA and VA streamline refinance programs allow for refinancing without an appraisal, income, asset, or credit verification. It is available to all borrowers, as long as they are current and no cash is taken out. VA loans that go through this are dubbed *Interest Rate Reduction Refinance Loans (IRRRLs)*.
- Since 2012, pre-May 2009 FHA borrowers are eligible for a one-time “grandfathered” MIP refinancing with 1bp upfront and 55bps annual MIP, considerably cheaper than the prevailing MIPs of 175bp upfront and 85bp annual.
- Ability to grandfather the MIP effectively increases the refi incentive for pre-May 2009 borrowers, compared to their June 2009 and later counterparts who would face the higher MIPs on their new loans. This is equivalent to an elbow shift, increasing refis.
- Similar to HARP, pre-May 2009 speeds remained elevated for a time, but that population of borrowers is now more burned out as a result.

Chart 68: FHA's streamline caused a 25CPR boost at its peak



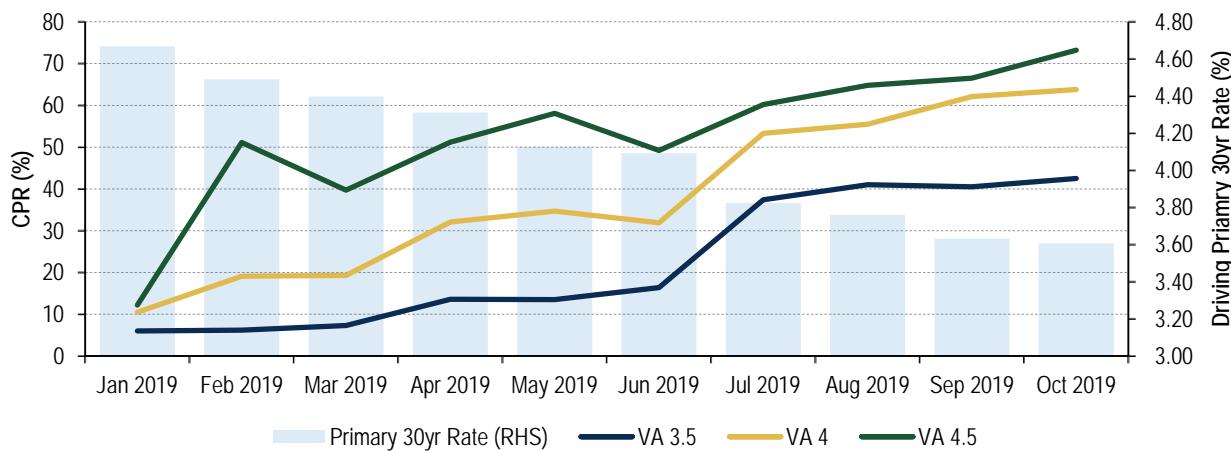
Source: BofA Global Research, Ginnie Mae



Recent trends: VA Net Tangible Benefit (NTB) test

- Streamline FHA refis and all VA refinances are required to pass a Net Tangible Benefit test (NTB). NTB test was first introduced for FHA streamline refinancing in 2011, but was implemented only in 2018 for VA following the passage of the Economic Growth, Regulatory Relief, and Consumer Protection Act.
- The FHA NTB test requires that borrowers must meet the minimum 50bps interest rate savings requirement, inclusive of the MIP, in order to qualify for a refi.
- VA borrowers also have to realize 50bps in savings, and recoup all costs within 36 months. Some exemptions exist for cashout refis, which are subject to less stringent requirements.
- NTBs result in a binary nature to applications and speeds in G2's. Thus, G2s display a more step-laddered response to rates.
- NTB tests also amplify the sensitivity to the mortgage rate for loans that are on the cusp of refinancing. With no commonly accepted benchmark FHA and VA mortgage rate, prepayments on such collateral have become highly uncertain.

Chart 69: VA 12 WALA speeds jumped on 4.5s in Feb 2019, and in 3.5s and 4s in July 2019 as borrowers passed NTB tests

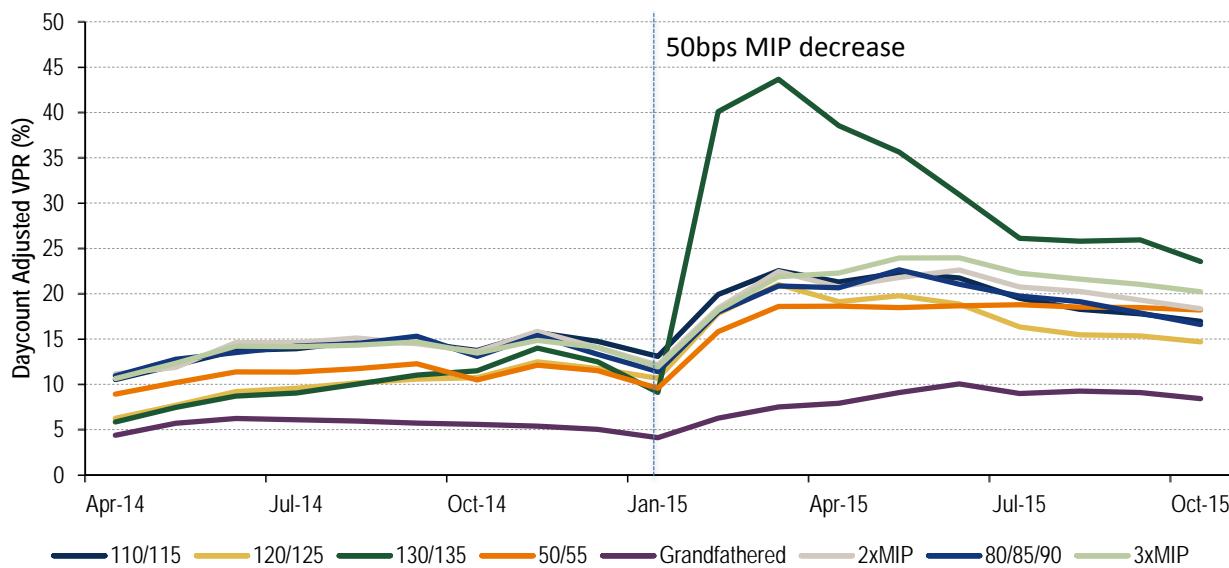


Source: BofA Global Research, GNMA

Refi policy watch: impact of G-fee and MIP changes

- Any changes to the MIPs or G-fees could have a material and lasting impact on refinancings.
- Lowering of G-fees or MIPs increases the refi incentive for existing borrowers, introducing an elbow shift equal to the amount of the decrease, all else equal. The reverse is also true, as raising of G-fees or MIPs would decrease refis.
- Moreover, as FHA borrowers seek to refinance into conventionals to eliminate or lower PMI costs, relative changes between G-fees and MIPs stand to impact the amount of FHA-to-conventional refis.
- G-fees, currently near 50bps compare to 85bps MIP for the FHA, have less room for declines given absolute levels. However, elimination or changes to LLPAs can have significant impact on specific groups of borrowers.

Chart 70: Speeds increased after the 50bps MIP cut in January 2015, especially recent 130/135 MIP borrowers



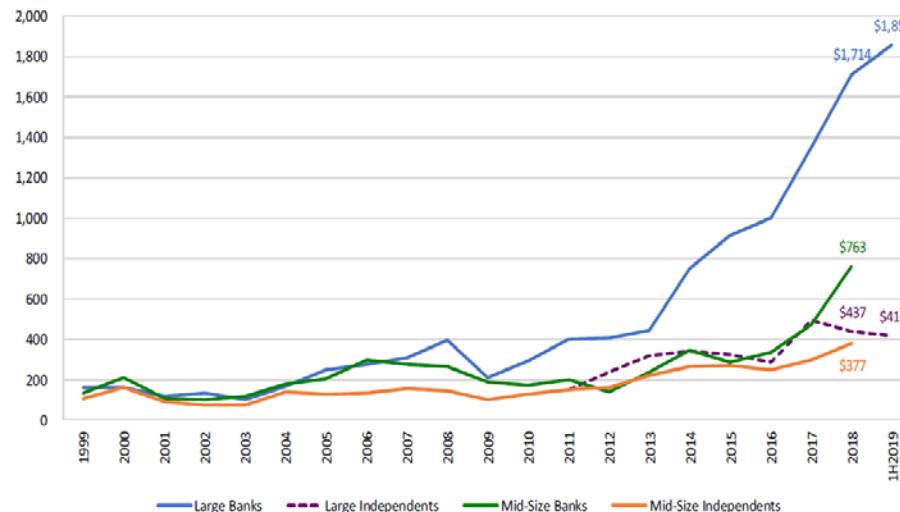
Source: BofA Global Research



Recent trends: technology-driven origination

- Mortgage origination has grown increasingly automatic and technology-driven in the past few years. Borrowers can upload their documents online, e-sign the application, and aggregate various data online.
- Shorter processing lags increase efficiency of refis.
- Better technology also improves borrower experience, boosting the borrowers' willingness to engage and follow through.
- According to data collected by the Mortgage Bankers Association (MBA), large bank technology expenses per loan have risen from a little over \$200 in 2009 to over \$1800 in the first half of 2019.

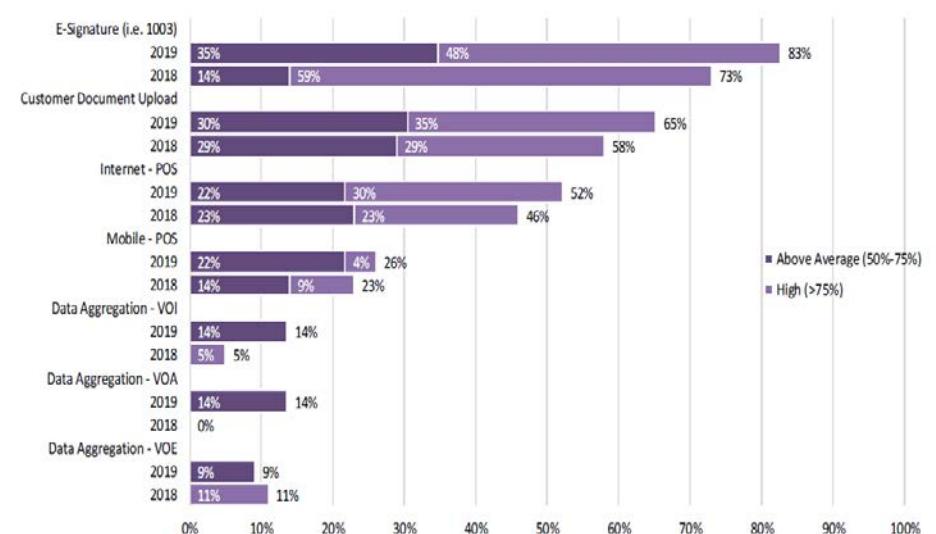
Chart 71: Technology expenses/loan have risen over the past decade per the MBA



Note: Includes all Production Technology and Corporate Technology Costs per Loan Originated during Period; Servicing Technology Costs excluded

Source: PGR: MBA and STRATMOR Peer Group Roundtables: www.mba.org/pgr

Chart 72: Mortgage applicant use more technology during application process YoY



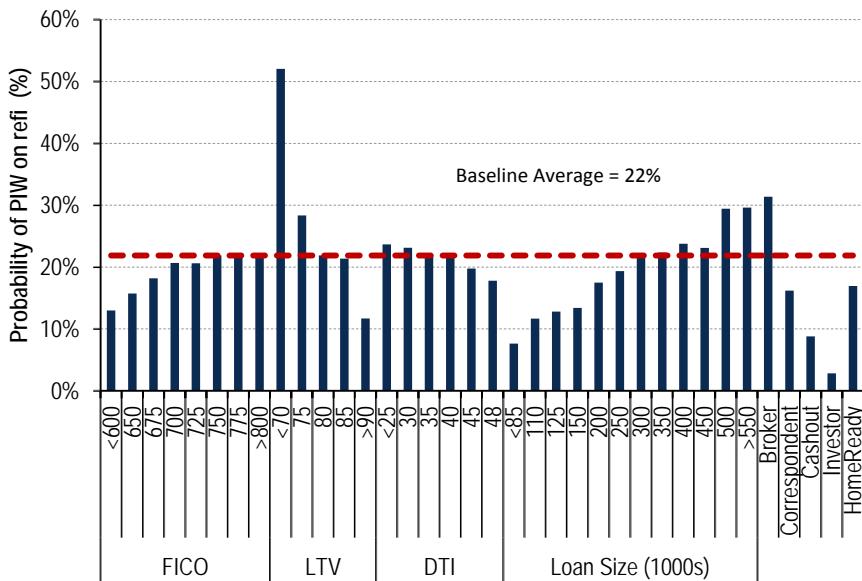
Source: MBA's 2019 Technology Profile Survey; www.mba.org/techsurveys



Recent trends: automation driving up refi efficiency

- Refi efficiency has been boosted as automation and digitization begin to disrupt the mortgage industry.
- Day 1 Certainty – a program which gained steam in late 2017, provided a suite of tools for originators, allowing for validation of the loan application upfront, automated collection of documents such as paystubs, bank and investment account statements, automated assessment of borrowers without credit scores, and the no-cost automated appraisal alternative otherwise known as Property Inspection Waivers (PIW).
- The use of these tools was highly encouraged through R&W relief for those elements of the mortgage applications that rely on it, and 67% of borrowers went through at least one element since mid-2018. Broad adoption, particularly for underwriting best credits, has resulted in speeds comparable to those on streamlined HARP loans back in 2012.
- Loans with PIWs provide a window into this. Best credits, where S-curves have steepened most in 2019, are more likely to receive a PIW. Also, loans that obtained PIWs in the past prepay faster than those who didn't, after adjusting for credit, suggesting they have an easier time refinancing again.

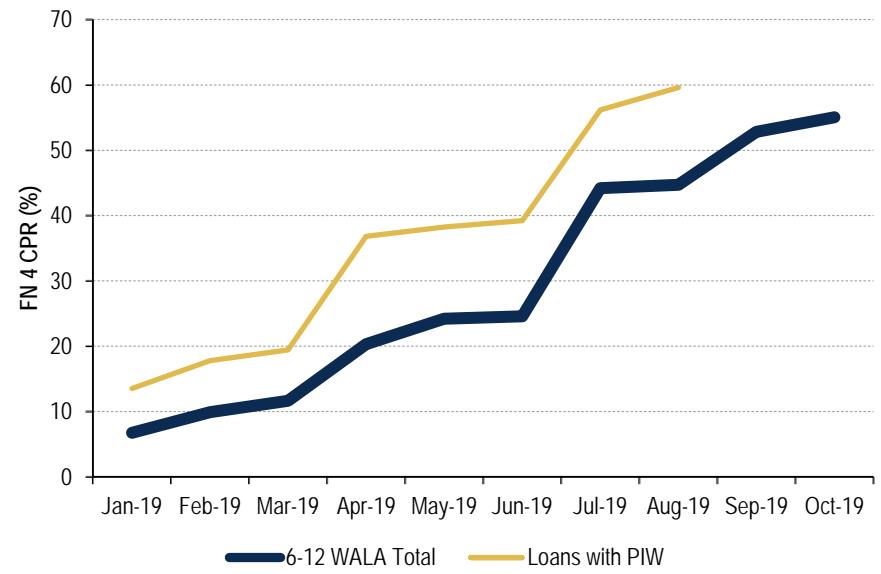
Chart 73: Probability of a PIW for a refi is higher for best credit borrowers



Source: BofA Global Research

Note: based on available CAS data from 2018 and later origination

Chart 74: Loans with past PIWs are paying 20 CPR faster in 2019



Source: BofA Global Research, FNMA



Recent trends: The certainty of Day 1 Certainty

- Originators can select specific modules of Day 1 Certainty to adopt. These range from the three specific modules:
 - The DU Validation Service launched in October 2016. The DU Validation Service (DVS) streamlines the verification of a borrower's income, employment and assets, upon the loan officer receiving the approval of the applicant. Income validation was effective October 2016, asset and employment verification took effect 10 December 2016. The complete digitization, of what were paper based workflows, is reliant on third party vendors that each of the GSEs has approved.
 - Appraisal Waivers launched in December 2016. Appraisal Waiver eligibility is reliant on a prior appraisal on the property in the GSEs Unified Appraisal Database. Property Inspection Waiver took effect on 10 December 2016, targeting refinance applications. Purchase applications became eligible for PIW as of August 2017.
 - Collateral Underwriter launched in December 2016. A risk scoring tool of lender provided appraisals. The lower the risk score, the greater then chances of receiving representation and warranty relief.
- Nonetheless, uneven adoption rates across originators hold a key to varying PIW impact by servicer.

Table 20: PIW% for FN purchase loans for top 10 originators

	FNCL Purchase	
	2018	2019
Wells Fargo	3%	3%
PennyMac	N.A.	N.A.
Quicken	7%	7%
United Shore	10%	12%
JPMorgan Chase	5%	15%
Lakeview	N.A.	N.A.
Fairway	3%	3%
U.S. Bank	1%	1%
Movement Mortgage	1%	1%
Amerihome	N.A.	N.A.

Source: BofA Global Research, Fannie Mae CAS data as of May 2019

Note: Ranked by total purchase loan issuance in 2019

Table 21: PIW% for FN refinance loans for top 10 originators

	FNCL Refi	
	2018	2019
Quicken	17%	27%
Wells Fargo	8%	14%
PennyMac	N.A.	N.A.
United Shore	19%	46%
JPMorgan Chase	10%	34%
Lakeview	N.A.	N.A.
Flagstar	12%	17%
Caliber	24%	31%
Nationstar	8%	13%
Fairway	6%	11%

Source: BofA Global Research, Fannie Mae CAS data as of May 2019

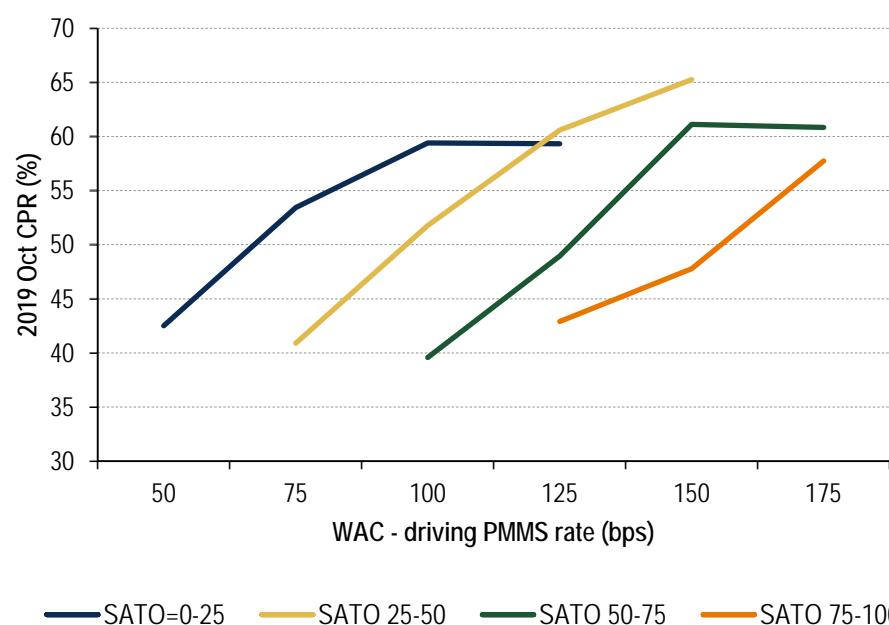
Note: Ranked by total refinance loan issuance in 2019



Recent trends: stronger SATO effect

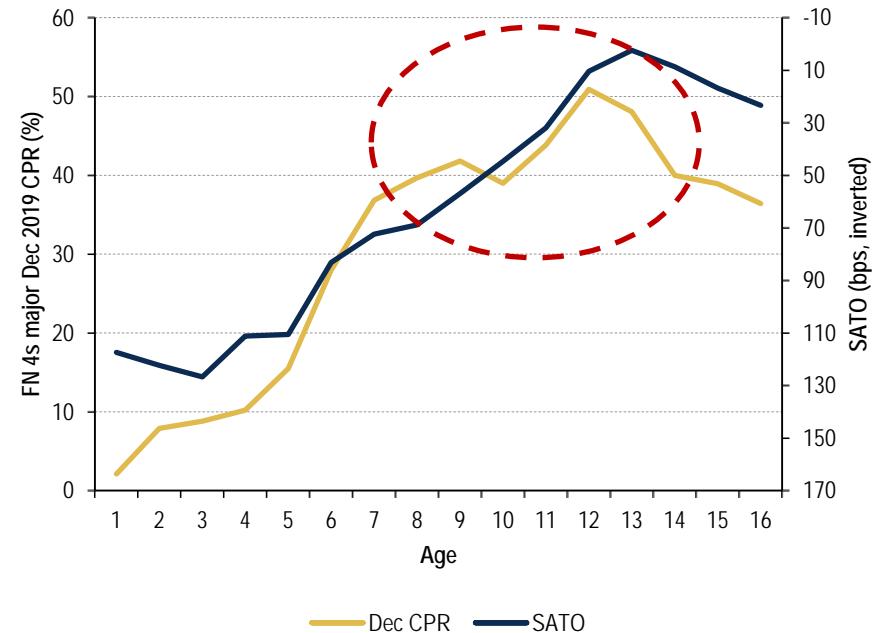
- SATO, as an indicator of the credit quality of the borrower, is found to be highly predictive of faster speeds in 2019, when controlling for incentives. This is consistent with the fact above that best credit borrowers are more likely to get PIWs.
- Furthermore, SATO is also likely to be correlated with the broader digitization and customer experience push by originators in general. These best credit borrowers who shop for lower rates are more likely to be qualified for various elements of Day 1 Certainty, in addition to PIW, and find the lender that streamlines the overall experience, resulting in a lower threshold to refinance in the first place.

Chart 3: High SATO S-curves are considerably flatter, each 25bps worth 10 CPR



Source: BofA Global Research

Chart 75: Lower SATO FN 4s prepaying faster than higher SATO post seasoning ramp



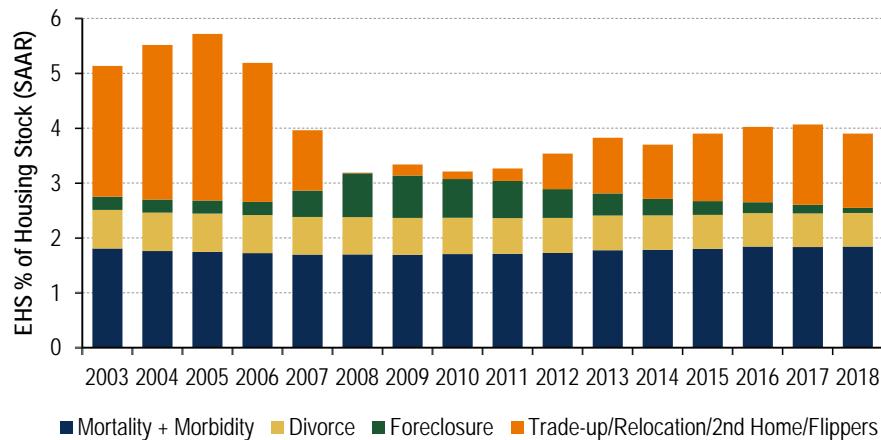
Source: BofA Global Research



Housing turnover sets a floor for prepayments

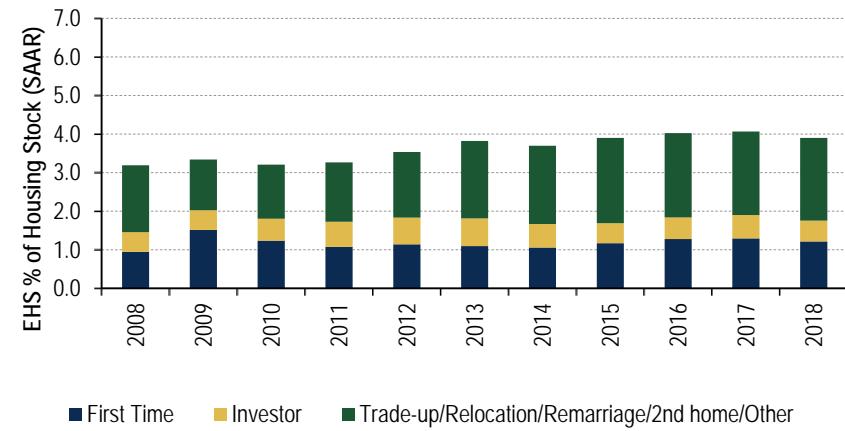
- A borrower's loan is typically paid off when the home is sold and the mortgage lien is released. Therefore, housing turnover ensures a baseline level of prepayments on MBS when the refi incentive is negative.
- One exception is FHA loans, which typically are *assumable*, so a new buyer can step into the position of the original owner. The buyer would need to qualify for the exact same loan with the same balance and the same servicer. However, amortization and HPA stands to decrease the balance of the loan relative to the sale price, leaving a buyer needing to finance the difference. This limits the impact of the feature.
- The pace of home sales is highly geared to the level of interest rates, home prices, population mobility, and shifting demographics. Housing turnover also has an involuntary component associated with foreclosure sales. Delinquent loans are typically bought out of the MBS pools by the GSEs or the servicer prior to the foreclosure, resulting in a prepayment to investors.

Chart 76: Breakdown of existing home sales by seller's motivation



Source: BofA Global Research, NAR, Census Bureau, Office of Social Security

Chart 77: Breakdown of existing home purchases



Source: NAR, BofA Global Research



Turnover components: seasoning

- Borrowers who go through the process and the expense of taking out a new loan signal their intent to remain in the home. This is true in case of purchases as well as refis as borrowers look to break even on their closing costs over time.
- This gives rise to the seasoning ramp – turnover speeds ramp up with loan age, reach a steady state after 24-30 months. The simple PSA model tries to capture this dynamic.

Chart 78: FN 4.5s were out of the money from 2004-2008 demonstrate the turnover ramp



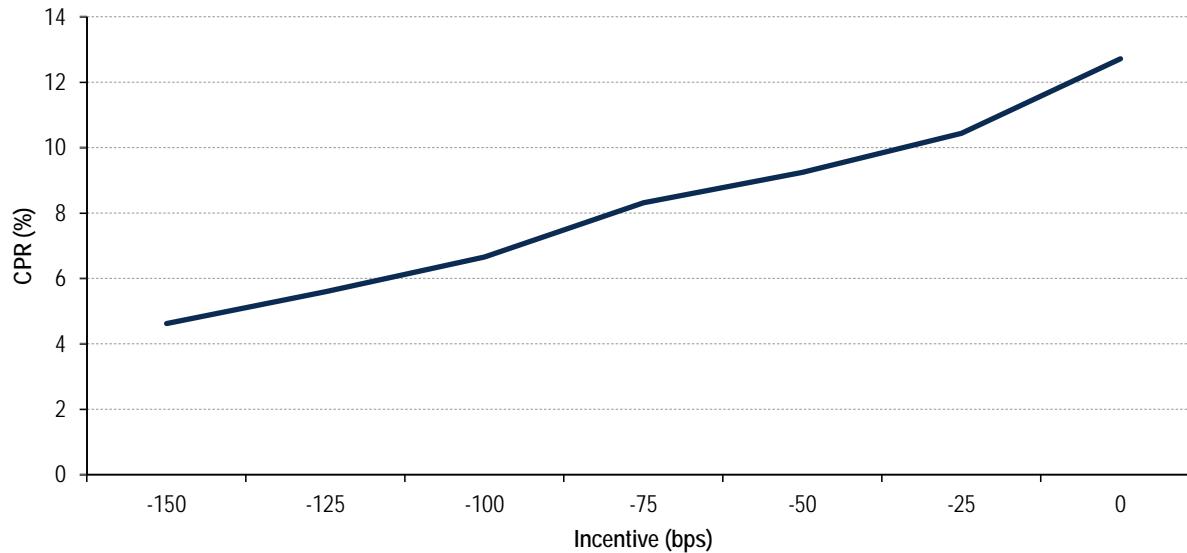
Source: BofA Global Research



Turnover components: lock-in effect

- Borrowers are said to be *locked-in* their current home when prevailing mortgage rates are higher than their existing mortgage rate. They face an economic disincentive to move, as they will need to borrow at the higher rate for the new property.
- Lock-in effect creates rate dependency on even deeply out-of-the-money loans. This gives rise to the extension risk in mortgages, as cashflows move further out when rates rise.
- Lock-in effect is ultimately tied to housing affordability, and therefore can be masked by shocks to disposable income. For example, tax cuts enacted in late 2017 increased disposable incomes of most conventional borrowers in 2018, offsetting the impact of rising rates.

Chart 79: Lock-in effect in conventionals is about 0.4 CPR for every 10bps of incentive, Oct 2018



Source: BofA Global Research

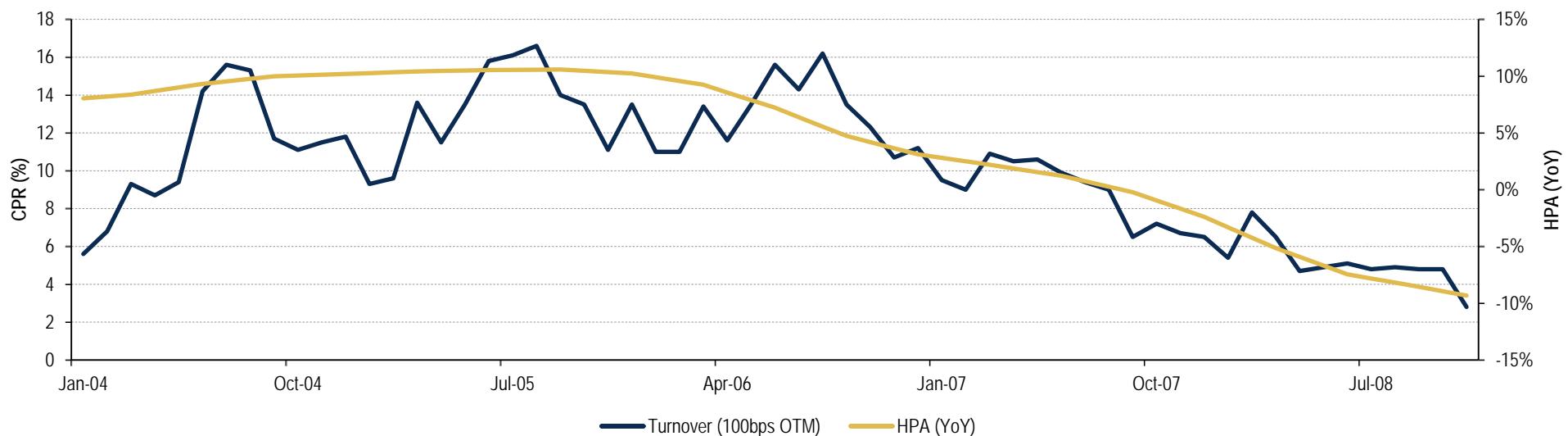
Note: FGLMC, 18-48 WALA, aggregate experience 2014-2018



Turnover components: home price appreciation

- Aggregate turnover activity tends to be driven by home price appreciation. As home prices rise, homeowners tend to buy and sell homes more quickly, driving up prepay speeds.
- Prepayments on out-of-the money mortgages also increase with HPA due to cashouts.

Chart 80: Aggregate turnover speeds follow home price appreciation over the long term

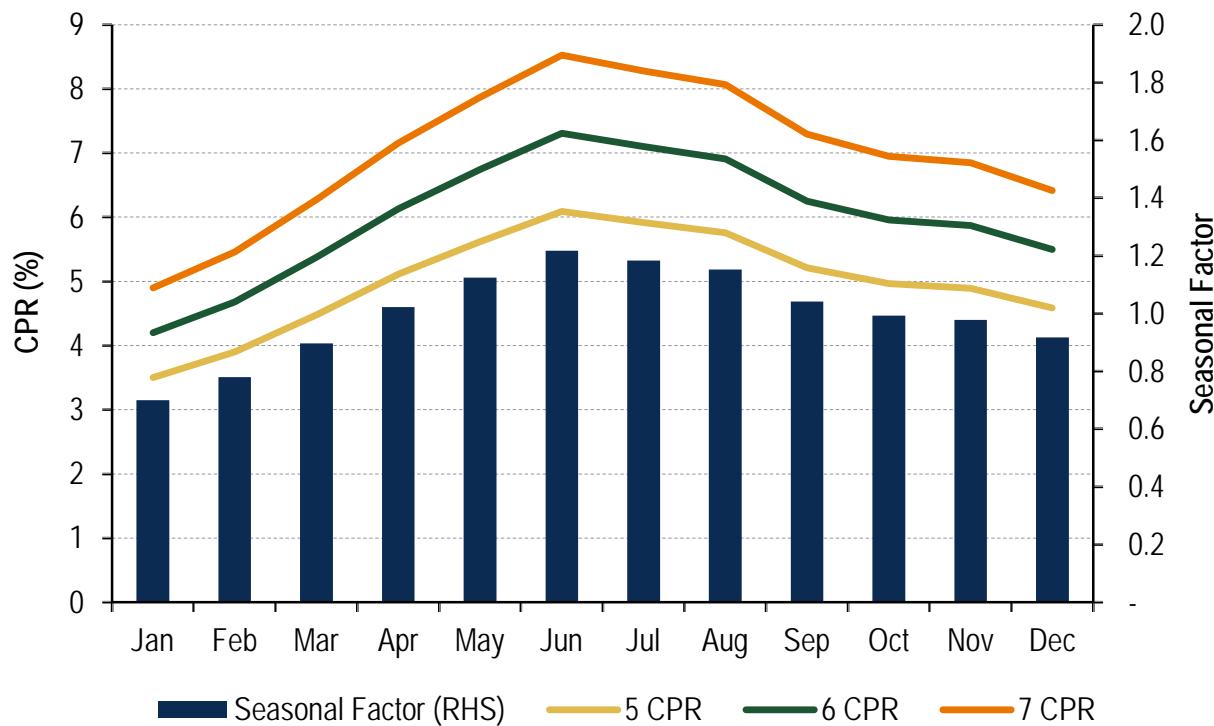


Source: BofA Global Research

Turnover components: seasonality

- Turnover is not constant throughout the year. The US home buying season begins in March and peaks in June. January is associated with the largest monthly decline. School calendar, weather, tax return season, and holiday schedule all shape the observed seasonal pattern.
- Based on the existing home sales over the last two decades, turnover at the peak of the year in June is 74% faster than at the year's lowest point in January. This results in a turnover differential of about 3 CPR throughout the year assuming a baseline pace of 5-7 CPR.

Chart 81: Seasonality variation throughout the year is about 3 CPR peak-to-trough (seasonal factors are day count adjusted)

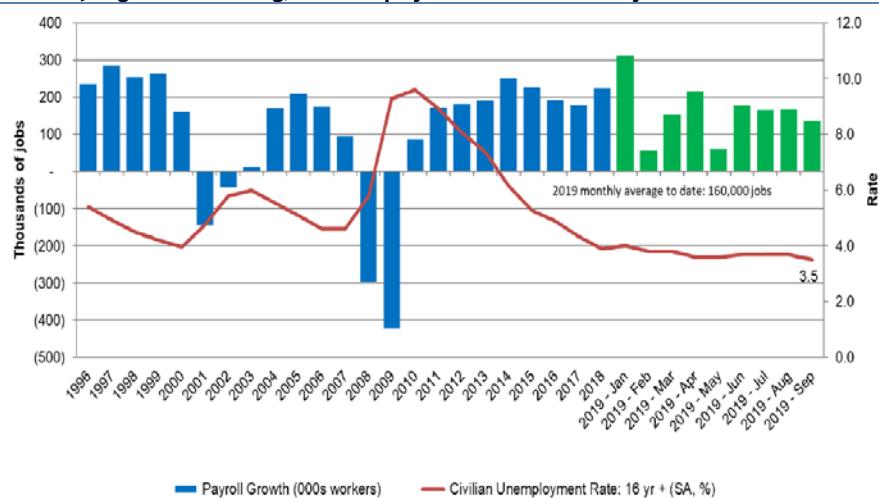


Source: BofA Global Research

Other factors affecting home sales

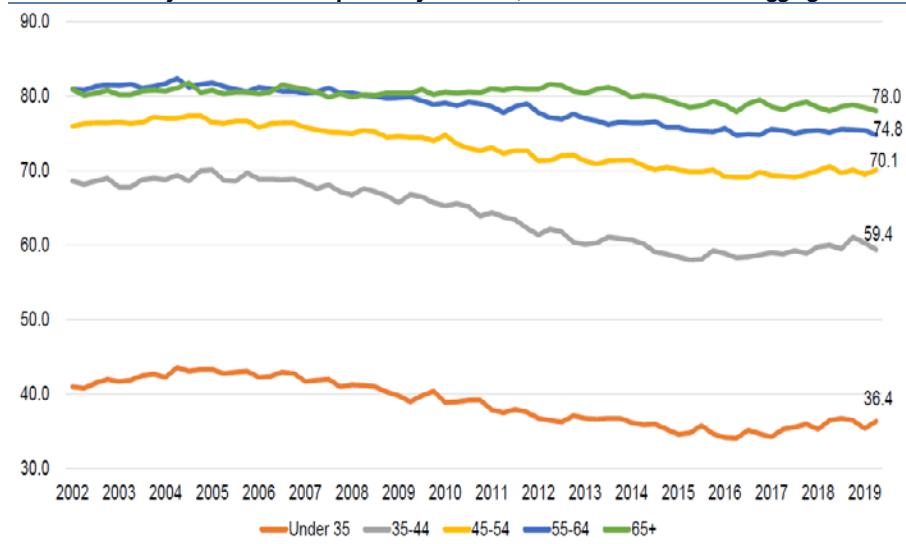
- Job market – Low unemployment rate, strong job and wage growth signal a healthy job market and lead to increased housing activity as well as rising home prices.
- Homeowner demographics – the share of younger households and income distributions of homeowners imply the type and size of homes in demand, and also the overall demand volume. GenXers born between 1974 and 1978 have been hit hardest by the financial crisis, a lasting effect. Meanwhile, homeownership among the millennials, who have not been as impacted, is nowhere near pre-crisis highs witnessed for borrowers aged 35 and younger either. These borrowers have not benefitted as much from the economic recovery and carry considerable amounts of student loan debt.
- Housing starts – new construction permits and housing starts are leading indicators of future activity.

Chart 82: Job growth is slowing, but unemployment rate close to 50-year low



Source: Bureau of Labor Statistics

Chart 83: 35-44 year-olds most impacted by the crisis, but millennials are also lagging



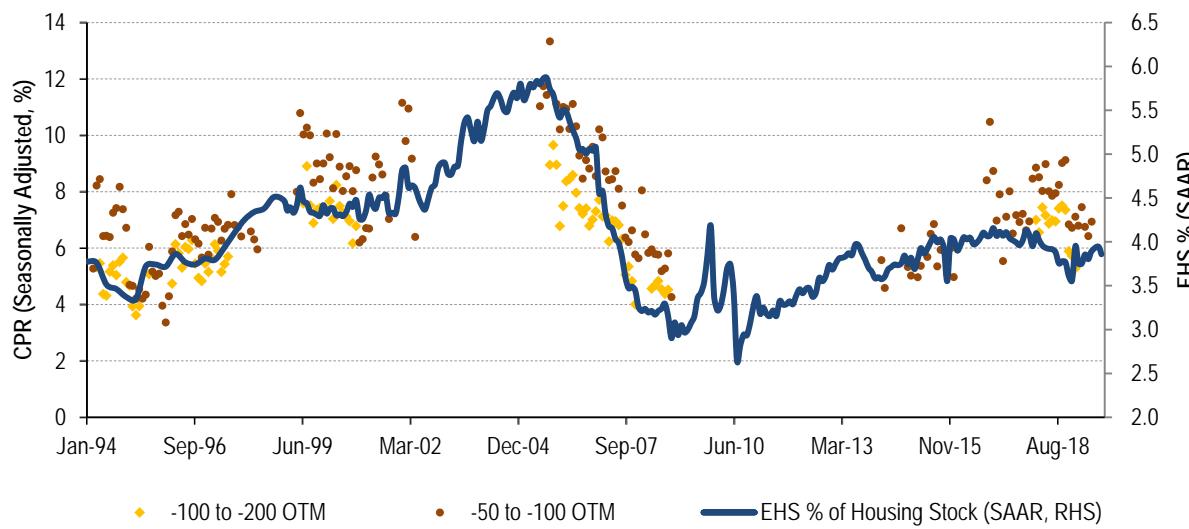
Source: Census



Establishing base-line turnover speeds

- Based on the mortgage data available today, prepayments associated with housing turnover are not measurable directly. Instead turnover is usually implied from speeds on deep out-of-the-money mortgages with highly negative refi incentives.
- Since interest rates generally declined since the 1980s, there have been few periods when deep out-of-the-money speeds are observable. Nevertheless, there is a distinct correlation of CPRs on 100-200bps and 50-100bps out-of-the-money MBS and existing home sales, normalized to housing stock.
- Pre-crisis rate of sales reached almost 6% at the peak in 2006 but is unlikely to be revisited as speculative buying receded and credit tightened. Assuming a normalized pre-crisis pace of 4.5%, baseline turnover is estimated at 6.1 CPR for 100-200 bps out-of-the-money MBS and 7.3 CPR for 50-100bps out-of-the-money mortgages.

Chart 84: Turnover primarily reflects existing home sales as percent of the US housing stock



Source: BofA Global Research

Note: FNCL >\$2bn, >24 WALA shown

Recent trends: Higher-than-expected turnover in 2018

- The most recently observed turnover in 2018 surprised to the upside. Discount speeds failed to slow as mortgage rate rose, exhibiting little to no lock-in effect. Thus, when controlling for moneyness, turnover speeds significantly overshot EHS, a typically tight relationship.
- Both transitory and lasting factors contributed to this in 2018.

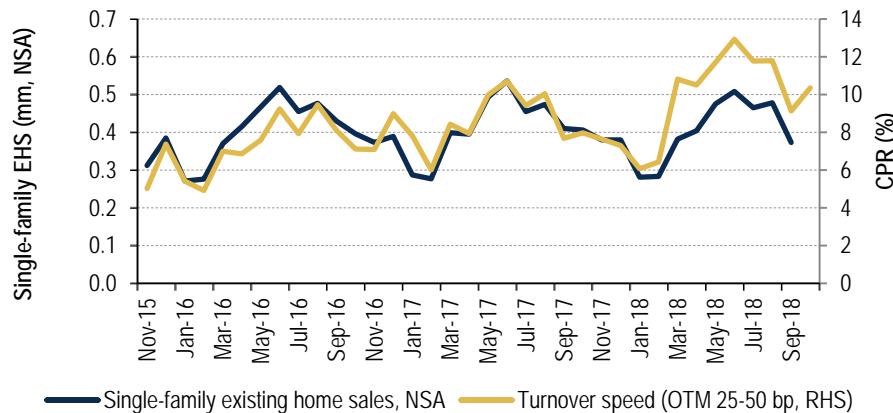
Transitory factors included:

- Rapidly rising rates – fence sitters rushing in to buy ahead of rising rates in the summer as rates were going up compared to earlier in the year.
- 2017 hurricanes – summer buyouts related to hurricanes from last year.

- Structural factors should prove more lasting:

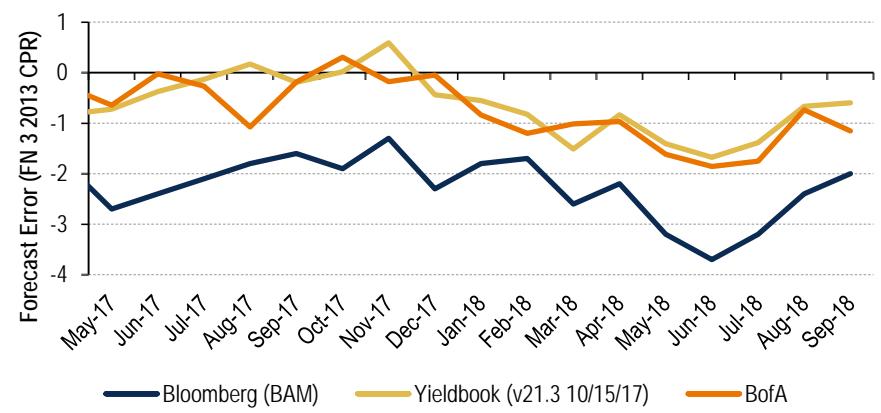
- 2018 Tax reform – for the average conventional borrower, an estimated tax savings of \$726 a year under the new tax regime, the equivalent of 36bps in rates. This tax savings boosts affordability, and thus, raises the likelihood for the marginal homeowner to trade up, increasing turnover, offsetting the lock-in effects in 2018.
- Higher DTI limit– Fannie raised DTI limits in mid-2017. Higher DTI limits freed some borrowers who were previously prevented from trading up as income growth had lagged home price appreciation since the end of 2012. This loosening of the credit box likely boosted turnover.
- Strong housing market – robust home price growth boosted turnover.

Chart 85: Turnover speeds overshot EHS when controlling for moneyness



Source: BofA Global Research, NAR

Chart 86: Prepayment models generally undershot turnover in 2018



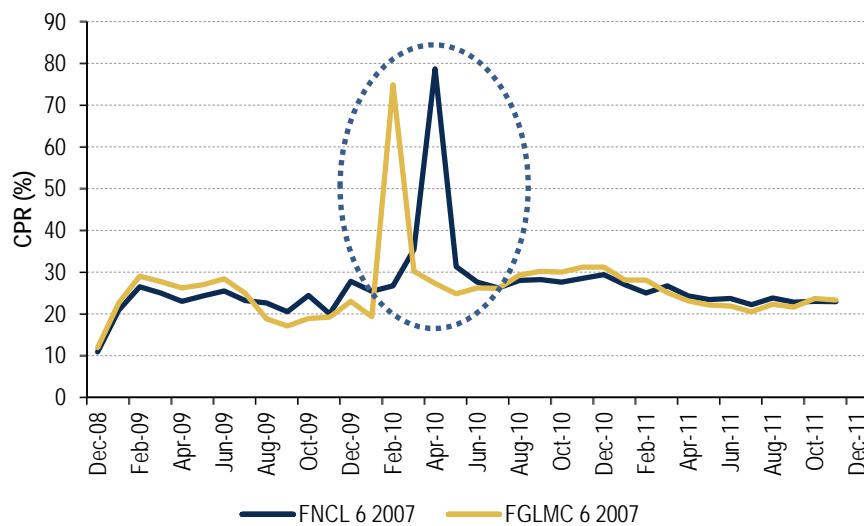
Source: BofA Global Research



Delinquent loan buyouts: conventionals

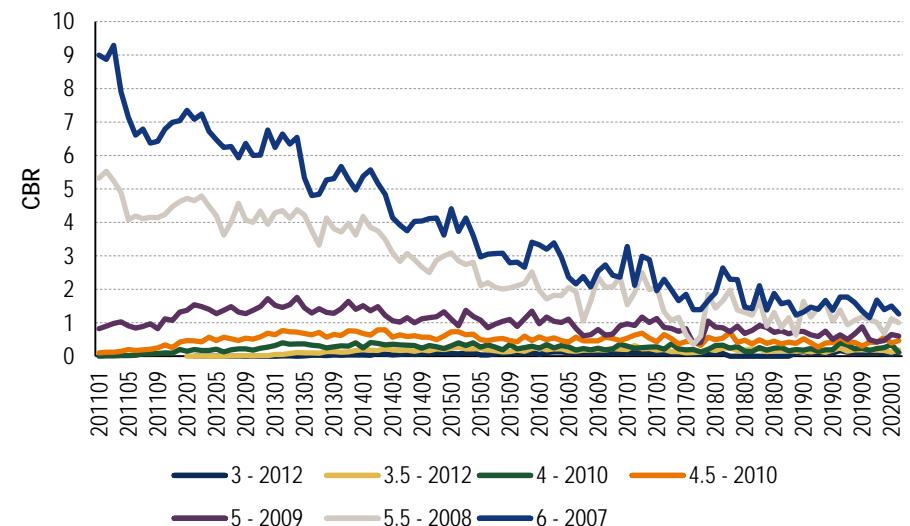
- Delinquent conventional loans are typically bought out of MBS pools by the GSEs well in advance of entering foreclosure. This results in prepayments on the MBS pool.
- After FAS 166/167 took effect in 2010, loans securitized in conventional MBS pools went on the balance sheet of the GSEs. Lacking any off-balance sheet treatment, GSEs have subsequently enacted a policy of buying out the loans after the 90-day delinquency mark, as it is cheaper to fund non-paying loans on balance sheet than by paying the coupon of the MBS pool.
- After the initial buyout spike in 2010, *constant buyout rate (CBRs)* on conventional loans now range from 2-4 CBR on seasoned 2006-2007 paper to less than 1 CBR on newer production mortgages originated in a tighter post-crisis credit environment. Aggregate CBR for 30-year conventionals is currently at 0.3.
- In addition to vintage, credit variables such as FICO, LTV, and SATO are predictive of variation in CBRs.

Chart 87: Buyouts in 2010 led to a spike in CPRs, driving net supply to -\$145bn



Source: BofA Global Research

Chart 88: CBRs declined over time as home prices rose and the economy improved



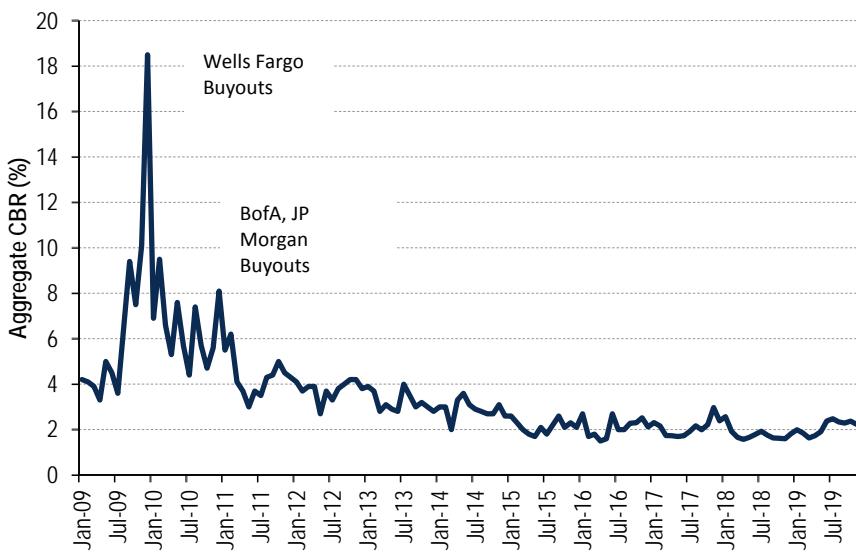
Source: BofA Global Research



Delinquent loan buyouts: GNMs

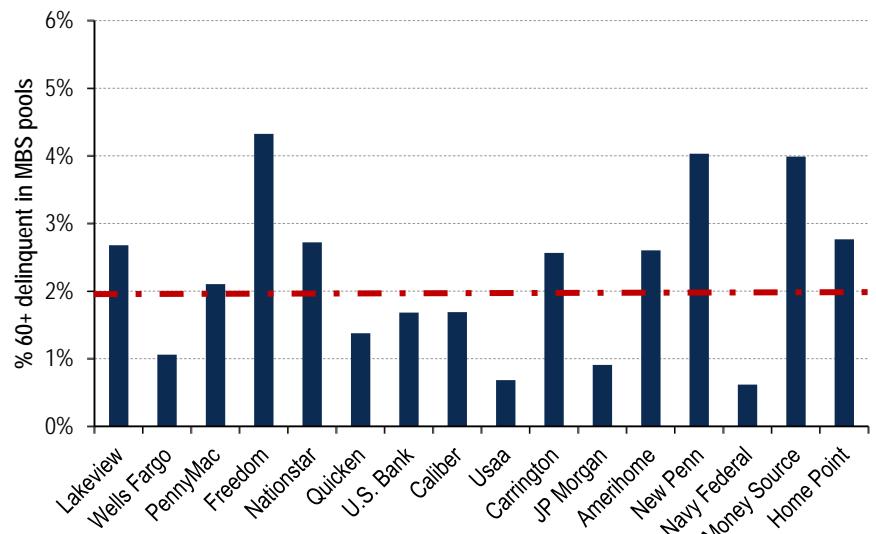
- The weaker credit profile of the FHA and RHS borrowers results in considerably higher delinquencies and buyouts in GNMs than conventionals, limiting their extension risk. Aggregate CBR is currently at 2.0.
- In contrast to the GSEs, GNMA buyouts are conducted by the individual issuers/servicers. They are not required to buy out the loans when they reach the 90-day mark. The timing is generally up to the servicer as is the decision on which loans get bought out and which pools get affected. This can create erratic prepayments on pools, particularly when larger servicers buy out delinquent loans in bulk.
- FHA reimburses the advanced MBS coupon at a fixed rate, so servicers generally have an incentive to buy out the highest interest rate loans first.
- GNMA can force buyouts, at their discretion, once the overall delinquency levels across the servicer's GNMA MSRs exceeds 5%. Today, however, most servicers are well below that threshold and delinquencies are relatively benign due to better underwriting and rising home prices.

Chart 89: GNMA buyouts can spike, driven by individual servicers



Source: GNMA

Chart 90: Top GNMA servicers have low delinquencies in their MBS pools today



Source: GNMA, as of Nov 2019



Modeling short-term prepayments

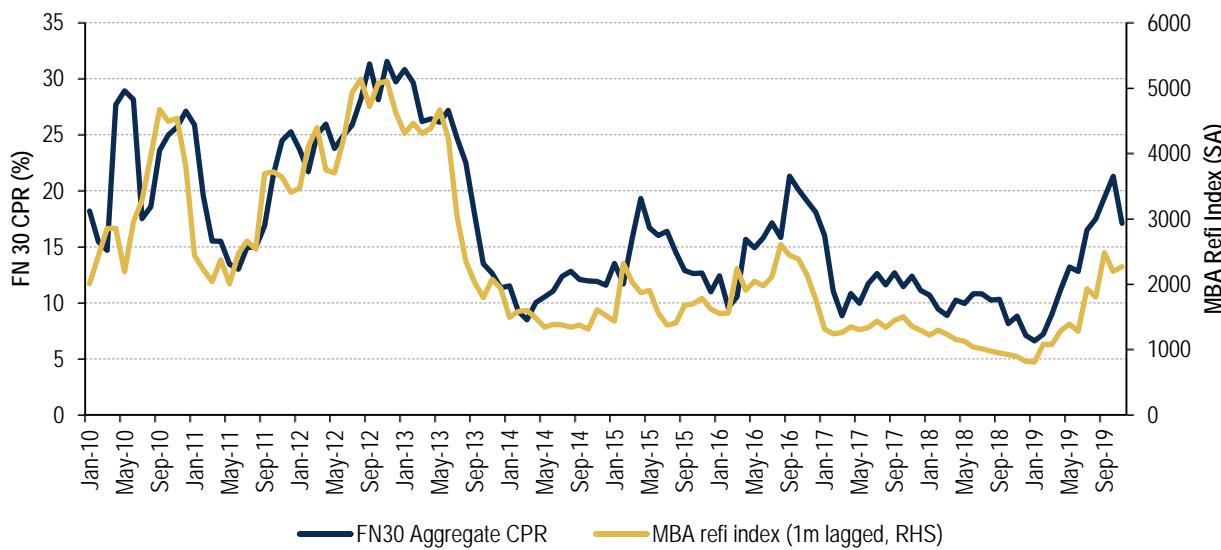
- Most prepayment models are estimated based on decades of observed prepayments, typically used to project many years of MBS cashflows.
- Long-term prepayment models can be improved upon for short-term projections, using additional data not available on a forward basis. Short term prepayments are particularly important, carrying implications for financing rates and providing early indications of structural changes in prepayment trends.
- The Mortgage Bankers Association (MBA) Weekly Applications Survey of originators provides a leading industry indicator of prepayment activity. The survey tracks mortgage application counts and average loan sizes. Indices for refinances and purchases are produced, as well as breakdowns into conventional, government, FHA, and VA.
- The survey covers the work week Monday-Friday, and is released the following Wednesday. Seasonally adjusted and unadjusted series are available on Bloomberg. Given current time-to-close around 50 days, application volume tends to appear about two months before the corresponding prepayments flow through.
- Survey participants were last updated in late 2011 – as of that point, it covered only retail and consumer direct channels, but not brokers and correspondents. Despite the dated coverage and the rise in non-banks and other alternative lending channels, the index remains a robust measure of *near-term* changes in mortgage volumes.
- Other, more granular, short-term metrics may be available from some providers, such as those based on scrubbing title search data.



Some caveats of note to the MBA refi index

- Since the survey covers applications rather than actual closings, it is exposed to fluctuations in the *pull-through* rate, the ratio of loans closed to applications. In particular, pull-through rate tends to rise when interest rates rise, as borrowers are more likely to close on an application locked at the earlier lower rate. Conversely, pull through rates tend to fall when interest rates drop due to *fallout* – borrowers will reapply at the lower rate instead of closing on earlier loan at the higher rate.
- Comparing the refi index over long time horizons is fraught with issues. For example, application counts decline over time as more and more borrowers refinance into lower coupon out-of-the-money loans. As a result, the refi index is biased lower over time, adjusting for rate. Also, the mix of originators remains in flux while the index is rebalanced infrequently. For example, lack of aggressive non-bank servicers in the index, who became prominent since 2011 when the index was last rebalanced, biases the index lower.
- Not every prepayment results in the origination of a new loan – for example, increased cash sales would drive up prepayments, while the index remains unchanged. MBA index does not capture this.

Chart 91: MBA refi index broadly tracks aggregate speeds, with some notable deviations due to varying lags and pull-through rates



Source: MBA, FNMA, BofA Global Research



Valuations, hedging and relative value



Prepayments are critical to mortgage valuation

- Prepayment rate impacts the expected return and the average life of MBS.
- Premium priced bonds typically pay a coupon above the prevailing market yield, thus early return of principal through amortization and prepayments gives rise to *premium erosion*. Early paydowns need to be reinvested at a lower market yield, creating reinvestment risk.
- Discounted bonds pay a coupon below the market yield; thus, prepayments on them are desirable as paydowns are reinvested at a higher rate.
- Par priced MBS are insensitive to prepayments, as principal can be reinvested at the same rate.
- The complexities in MBS valuation primarily arise because prepayments are not static, and are generally inversely correlated to market yields, rising and falling with bond prices.

Table 22: Premium MBS: FNCL 3.5s priced at 103-04, yield falls as speeds increase

Speed	10 CPR	15 CPR	20 CPR	25 CPR
Yield	2.97	2.80	2.62	2.42
Average Life	7.35	4.65	4.13	3.31

Source: Bloomberg

Table 23: Discount MBS: FNCL 2s priced at 99-10, yields rise with speeds

Speed	4 CPR	6 CPR	8 CPR	10 CPR
Yield	2.10	2.11	2.12	2.13
Average Life	6.5	5.93	5.42	4.97

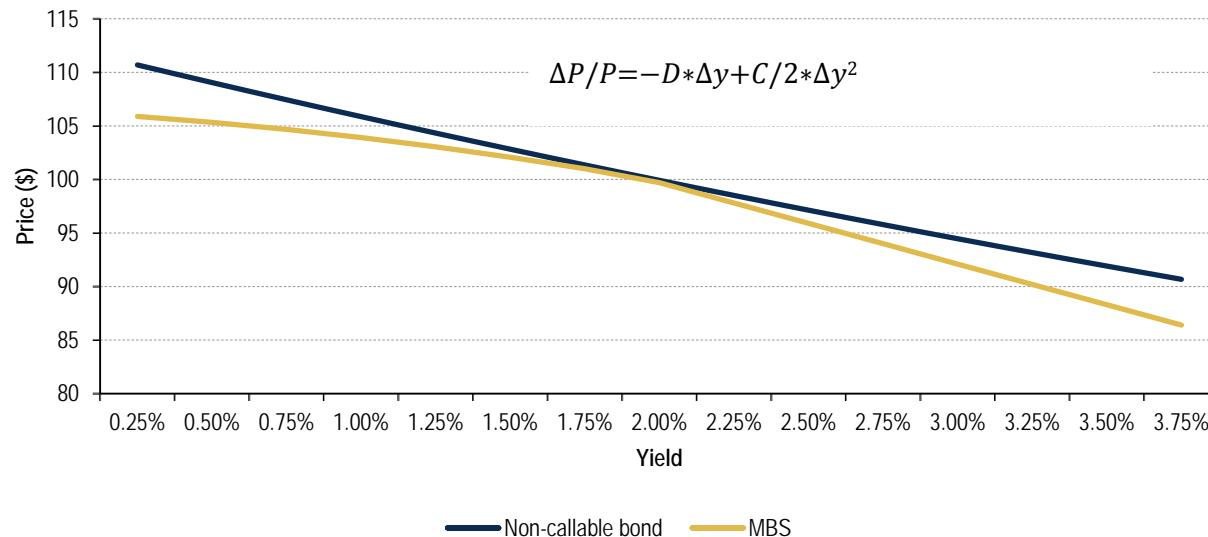
Source: Bloomberg



MBS exhibits negative convexity

- Prepayments are inversely correlated to market yields – CPRs generally rise when rates rally, and fall when rates sell off. Thus, as the premium increases, CPRs also increase – i.e., *contraction risk*. Conversely, as the bond becomes more of a discount CPRs decline – i.e., *extension risk*.
- MBS should underperform non-callable bonds, such as Treasuries, when rates move in either direction, all else being equal. This behavior gives rise to the *negative convexity* of MBS, for which investors are compensated through higher yields. Cuspy mortgages are most negatively convex.
- Due to negative convexity, the MBS price function is often approximated as a second order polynomial with respect to rates.

Chart 92: Par priced MBS profile compared to similar duration, par priced UST at 2.0% yield



Source: BofA Global Research



The embedded options in MBS

- Another way to think about negative convexity is in terms of the embedded prepayment options in MBS.
- Borrowers prepay faster when it is in their financial interest to do so. The higher the refi incentive, the more money the borrower will save by paying off the loan. Thus, the borrower owns a receiver option on mortgage rates, struck at the note rate of their existing mortgage.
- Turnover also has some dependency on rates, chiefly through lock-in effect. Borrowers slow the pace of sales when rates rise, extracting economic value of living in a home at below market rates. The borrower is also long a payer option on the mortgage rate, struck at the note rate of the existing mortgage.
- The investor who is long MBS cashflows is correspondingly short both mortgage rate options to the borrower or the option straddle. A short position in interest rate options exposes the investor to risks embedded in options: *gamma* (convexity), *vega* (implied volatility), to a lesser extent *theta* (remaining term) and any residual straddle *delta* (duration).
- Investors realize the economic cost of the short option position through negative convexity over time. Correspondingly, the investor needs to be compensated for that option cost through higher yields. As a result, MBS yields should be above those on comparable bullet bonds of similar duration and liquidity.
- Embedded options and negative convexity necessitate a separate set of interest risk metrics for MBS.



MBS price function: effective duration and convexity

- Effective Duration:** measures a bond's first order, linear sensitivity to interest rates. Duration is the slope of the price function at any given yield, usually quoted in percent.

$$\text{Duration } (D) = -\frac{\frac{1}{P} \frac{dP}{dy}}{\Delta y} \approx -\frac{P^+ - P^-}{2P\Delta y}$$

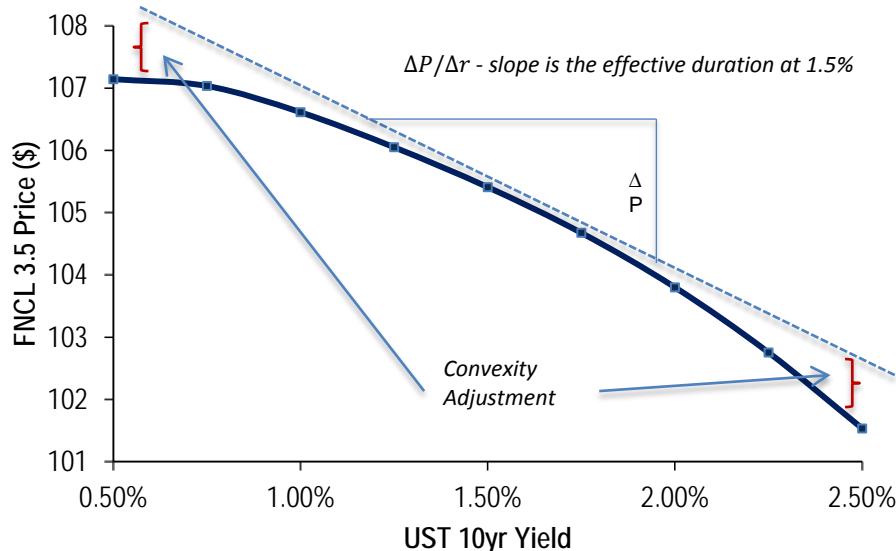
P is the full market price, $P^{+/-}$ is the full price of the security under Δy shocks to the curve.

- Effective Convexity:** measures the second order sensitivity to interest rates, or the curvature of the price function at any given yield. Convexity is usually quoted in percent.

$$\text{Convexity } (C) = \frac{\frac{1}{P} \frac{d^2P}{dy^2}}{\Delta y} \approx \frac{P^+ + P^- - 2P}{P\Delta y^2} \approx D^2 - \frac{D^+ - D^-}{2\Delta y}$$

$D^{+/-}$ are durations under Δy shocks to the curve.

Chart 93: Visual illustration of duration and convexity



Source: BofA Global Research

Chart 94: Duration, convexity, and price function: a numerical example

$$\begin{aligned} \text{Clean Price} &= 103.04 \\ \text{Accrued Interest} &= 0.04 \\ \Delta y \text{ (25bps shock)} &= 0.0025 \\ P &= 103.04 + 0.04 = 103.08 \\ P^+ &= 102.19 \\ P^- &= 103.28 \end{aligned}$$

$$D = -\frac{102.19 - 103.28}{2 \times 103.08 \times 0.0025} = 2.48$$

$$C = \frac{102.19 + 103.28 - 2 \times 103.08}{103.08 \times 0.0025^2} = -48$$

$$\frac{\Delta P}{P} = -2.48 \times \Delta y - \frac{48}{2} \times \Delta y^2$$

For reporting purposes, convexity is often divided by 100, so -0.48

Source: BofA Global Research



Negative convexity impact on duration

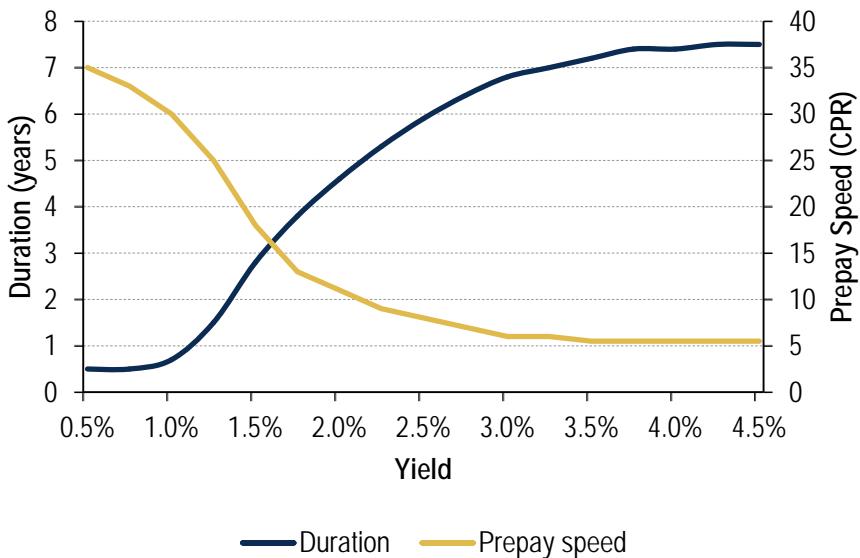
- MBS effective duration is not constant. Negative convexity of the mortgage price with respect to rates implies shortening durations in rallies and lengthening durations in selloffs.
- This ties into the intuition behind traditional bond duration measures such as *Macaulay* or *modified durations*: lower rates and higher prepay speeds imply shorter maturities.
- Convexity implies something about the change in duration. Reworking the formula above:

$$\Delta D = (D^2 - C) * \Delta y$$

For most but the longest, most out-of-the-money MBS passthroughs this approximates to:

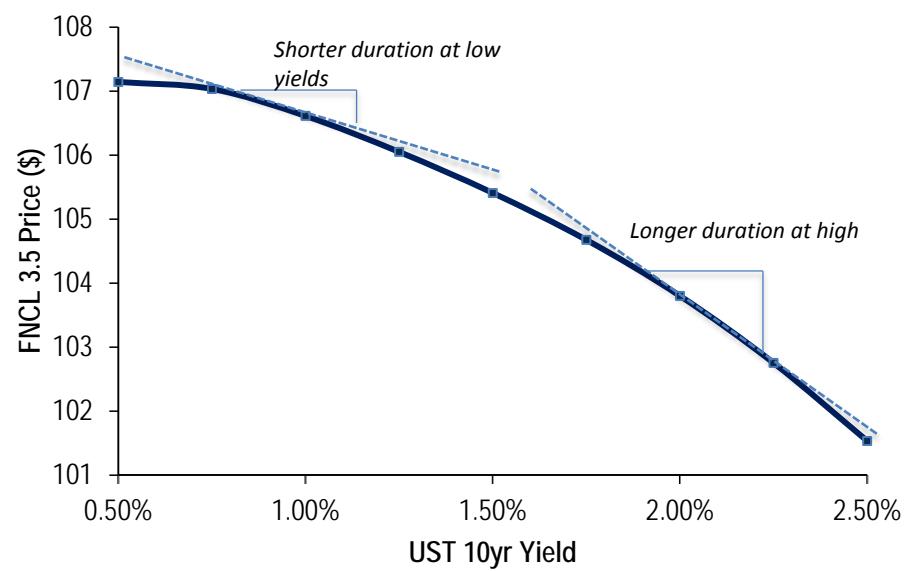
$$\Delta D \approx -C * \Delta y$$

Chart 95: MBS duration moves with rates, inversely correlated to prepayments



Source: BofA Global Research

Chart 96: Negative convexity implies shorter durations at lower rates



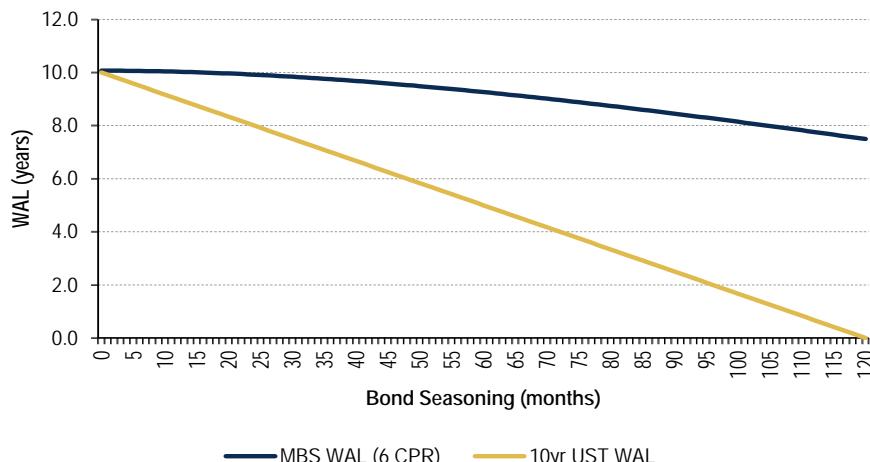
Source: BofA Global Research



Common relative value metrics for MBS – return measures

- **Yield-to-maturity** – Traditional yield measure of MBS cashflows computed with either a fixed CPR vector or a base case prepayment projection at static prevailing interest rates.
- **Forward yield** - Similar to yield-to-maturity, except that MBS cashflows, including prepayments, are projected assuming the forward curve is realized.
- **Current coupon or par coupon yield** - The coupon of a hypothetical par-priced mortgage bond, an estimate of the prevailing secondary market mortgage rate. Current coupon is used extensively for modeling mortgage rates as well as relative value purposes. The advantage of the current coupon yield is that it is easy to calculate and is the least sensitive to prepayment assumption differences.
- **Carry** – Total return on MBS, typically over a one-month horizon, assuming static interest rates and volatility. Comprised of the coupon earned net of the cost of financing and any premium erosion due to prepayments. Owing to the amortizing nature of MBS and the long terms of the underlying loans, *rolldown* contributes very little to MBS carry. This contrasts with other bonds, such as Treasuries, where rolldown contributes to returns significantly. Carry is usually quoted in ticks.
- **Hedge Adjusted Carry (HAC)** – Carry of MBS net of that forgone on any interest rate, duration and/or convexity, hedges.

Chart 97: MBS cashflows don't roll down the curve materially



Source: BofA Global Research

Table 24: Carry calculation – a numerical example

MBS Data	Hedge Data
# of days	30
Price	103-04
Coupon	3.5
MBS Repo Cost	165bps
SMM(30 CPR)	0.02928553
Monthly Amortization	0.00144
SMM + Amortization	0.03072553
Hedge Ratio to UST 10yr	0.2

MBS carry

$\text{Coupon Income} = 32 * 3.5 * 30/360 = 9.3 \text{ ticks}$
 $\text{Financing Cost} = 32 * 1.65 * 30/360 * 103-04/100 = 4.5 \text{ ticks}$
 $\text{Premium Erosion} = 32 * 3-04 * 0.03072553 = -3.07 \text{ ticks}$
 $1\text{m MBS carry} = 9.3 - 4.5 - 3.07 = 1.73 \text{ ticks}$

Hedge carry

$\text{Coupon Income} = 32 * 1.7 * 30/360 = 4.5 \text{ ticks}$
 $\text{Rollotdown} = 32 * 9 * (1.70\% - 1.68\%) = 5.8 \text{ ticks}$
 $\text{Financing Cost} = 32 * 1.50 * 30/360 = 4 \text{ ticks}$
 $1\text{m UST 10yr Carry} = 4.5 + 5.8 - 4 = 6.3 \text{ ticks}$

Hedge Adjusted Carry

$$\text{HAC} = 1.73 - 0.2 * 6.3 = 0.47 \text{ ticks}$$

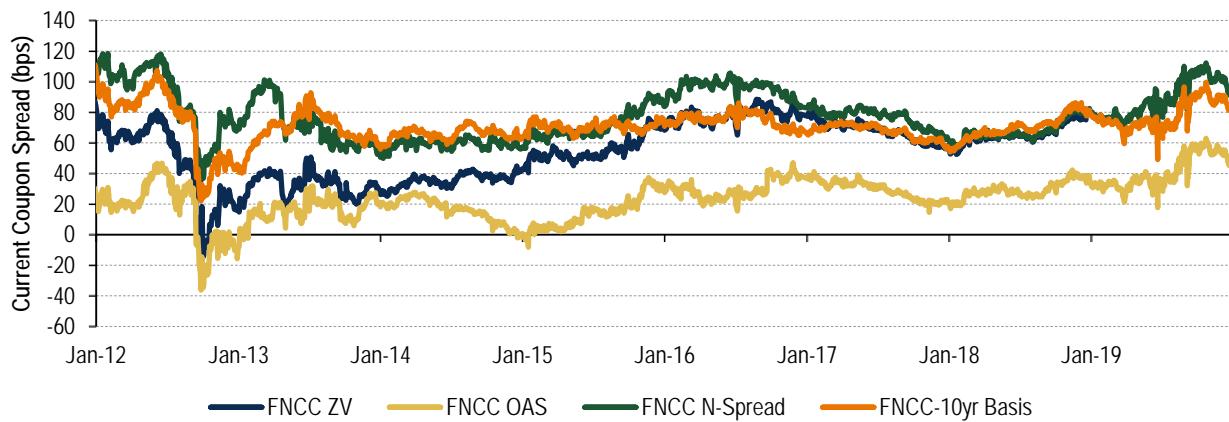
Source: BofA Global Research



Common relative value metrics for MBS – spreads

- **Nominal spread or WAL spread** - The yield differential between a mortgage security and a benchmark interest rate security with a maturity matching the weighted average life of the MBS. Commonly referred to as the I-spread to the Treasury curve or N-spread to swaps, both available on Bloomberg. Nominal spread is the projected excess return on MBS hedged 1:1 to a single point on the curve assuming static interest rates.
- **Zero Volatility Option Adjusted Spread (ZVO or ZVOAS)** - The projected excess return on MBS along the realized forward curve, hedged across the entire interest rate curve. It is calculated as the constant spread over the forward curve such that the discounted present value of cashflows generated along the forward curve equals the market price.
- **Option Adjusted Spread (OAS)** - The expected excess return on MBS hedged across the entire curve as well as hedged for the embedded interest rate options. It is calculated as the constant spread over the forward curve such that the average discounted present value of cashflows generated along simulated interest rate paths equals the market price. Interest rate paths are usually simulated using an arbitrage-free interest rate model calibrated to the forward curve and market prices of interest rate options, caps, and floors.
- **Mortgage basis** - The spread between the current coupon MBS and Treasuries or swaps. Often cited as a nominal spread to the 10yr UST or the 50/50 blend of 5yr and 10yr UST yield, however, can refer to any of the spread metrics above. Buying mortgages versus treasuries or swaps is termed as a *basis trade*.

Chart 98: What's the basis? MBS duration varies with prepay/rates so CC spread to a single point on the curve, 10yr or 5/10 blend, is flawed in the long term. ZVOAS and OAS don't suffer from this, but are more model dependent, making it difficult to replicate across investors



Source: BofA Global Research



OAS and ZVOAS – theory

OAS – Typically computed with the aid of a prepayment model and an interest rate model calibrated to value interest rate options. It is computed as:

$$\text{MBSPrice} = \frac{1}{N} \sum_{i=1}^N \sum_{t=1}^T \frac{CF(i,t)}{(1+r(i,1)+s)*(1+r(i,2)+s)*\dots*(1+r(i,t)+s)}$$

where s is the OAS, N is the total number of interest rate paths, T is the term of the MBS, $CF(i,t)$ and $r(i,t)$ are the cash-flow and short term interest rate at time t in scenario number i

Pros of OAS

- Models prepayments under many different interest rate scenarios, accounts for the distribution of prepayments in time.
- Incorporates interest curve shape, reflects realistic hedge ratios, and can incorporate correlations between yields of different maturities as well as volatilities.
- Accounts for the interest rate optionality of MBS, chiefly volatility and convexity exposures.

Cons of OAS

- Highly model dependent and can vary materially between investors – a chief drawback of OAS.
- The model is complex, computationally intensive, and can be hard to interpret.

ZVOAS – OAS computed along a single path, the forward curve. It does not account for the optionality embedded in the MBS. ZVOAS is typically larger than OAS and the difference between the two is the *option cost* embedded in the MBS.
ZVOAS is computed as:

$$\text{MBSPrice} = \sum_{t=1}^T \frac{CF(t)}{(1+r(1)+z)*(1+r(2)+z)*\dots*(1+r(t)+z)}$$

where z is the ZVOAS, $CF(t)$ and $r(t)$ are the cashflow and the short-term forward rate at time t .



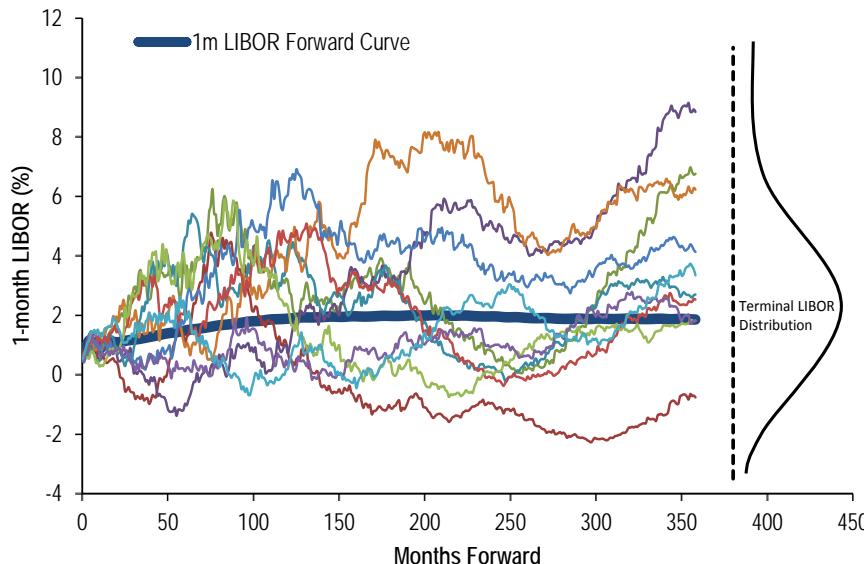
Practical steps in the OAS calculation

Practical steps to solve for OAS

An interest rate tree is constructed using a *term structure model*. Common term structure models cited in academia include Ho-Lee, Hull-White, Black-Karasinski, Black-Derman-Toy, and the LIBOR market model (BGM). Each has its pros and cons with respect to completeness and ease of implementation.

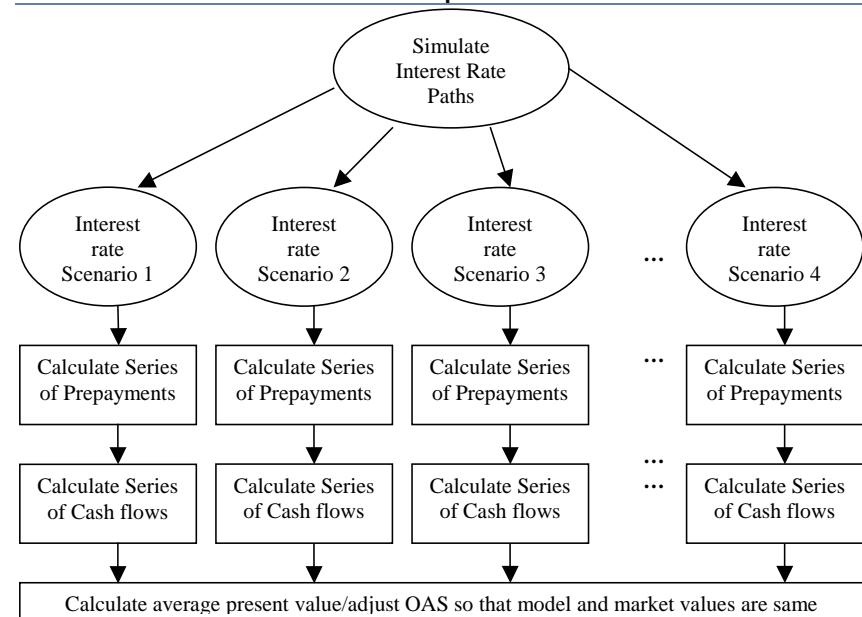
1. Path dependency of MBS necessitates Monte Carlo simulation rather than backward induction used to value plain vanilla options. Interest rate paths are sampled from the interest rate tree, and primary mortgage rates are generated along each path.
2. Refinancing incentive, prepayments, and cashflows are computed along each path.
3. Iteratively solve for OAS such that the average present value of cashflows along all paths equals the market price of the bond.

Chart 99: Hypothetical sampling of 1m LIBOR paths using a BGM simulation



Source: BofA Global Research

Chart 100: Illustration of the OAS calculation process



Source: BofA Global Research



Using the OAS model to compute durations and convexities

- OAS spread, already adjusted for rate, curve, and volatility exposures theoretically represents expected excess return offered by the MBS for risks not directly correlated to interest rates (or at least not explicitly modeled in the OAS model). Among these are liquidity premium, presence of non-economic buyers, policy risk, and model risk, etc.
- Assuming the OAS does not change as interest rates move, an OAS model can be used to calculate mortgage prices under any number of interest rate or volatility shocks, as well as the price function of MBS defined by effective duration and convexity.
- For example, $P^{+/-}$ for the effective duration and convexity calculation are computed as follows:
 1. Compute OAS using a market MBS price.
 2. Shock rates up by some amount Δy , typically 10 or 25bps, and reconstruct the interest rate tree.
 3. Sample interest rate paths from the shocked tree and re-compute MBS cashflows along each path.
 4. Compute the average present value of all paths using the OAS spread to discount from step 1.
- Effective durations and convexities computed using the OAS model in the manner above are sometimes termed *Option Adjusted Duration (OAD)* and *Option Adjusted Convexity (OAC)*.
- Other price sensitivities can be computed similarly by shocking individual model inputs and assuming constant OAS: *partials* or *key rate durations (KRDs)* to various points on the curve, volatility duration, current coupon duration (i.e., sensitivity to the mortgage rate), prepayment duration, spread or OAS duration.



Using duration to manage MBS interest rate risk

- Effective duration and convexity collectively describe the second order polynomial MBS price function with respect to interest rates. They can be used to hedge the interest rate risk associated with MBS using benchmark securities such as Treasuries or swaps.
- Dollar duration and dollar value of a basis point, or dv01, describes the amount of interest rate risk, in dollars, associated with duration to be hedged for a particular bond:*

$$\text{Dollar Duration} = \text{Face Amount} * \frac{\text{Full Price}}{100} * \frac{\text{Effective Duration}}{100} = 100 * \text{dv01}$$

- With dv01 at hand, *hedge ratios* can be computed specifying the relative face amount of the hedge needed. For example one can hedge with UST 10yr bonds as follows:

$$\text{Hedge Ratio} = \frac{\text{MBS dv01}}{\text{UST 10yr dv01}} = \frac{\text{MBS dollar duration}}{\text{UST dollar duration}}$$

- Investors rarely hedge individual bonds. Instead durations and convexities for a portfolio can be aggregated by applying market value (MV) weights, then hedged in aggregate.

$$\text{Portfolio Duration} = \frac{\sum \text{MV}_i * \text{Duration}_i}{\text{Portfolio NAV}}$$

$$\text{Portfolio Convexity} = \frac{\sum \text{MV}_i * \text{Convexity}_i}{\text{Portfolio NAV}}$$

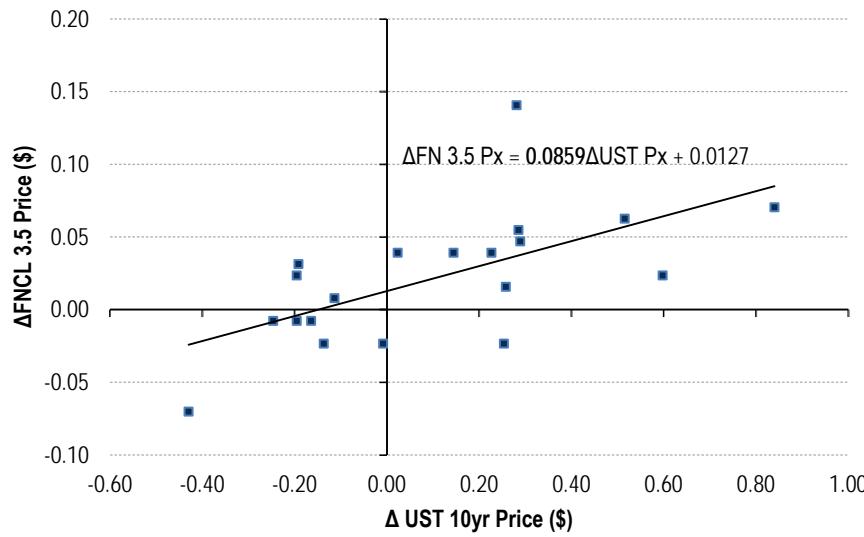
- Since duration is not constant, MBS investors need to *delta hedge* their position, i.e., adjust the hedge ratio to the new duration periodically. Negative convexity will be realized through P&L in that case as rates and prepayments move over time.



Empirical duration

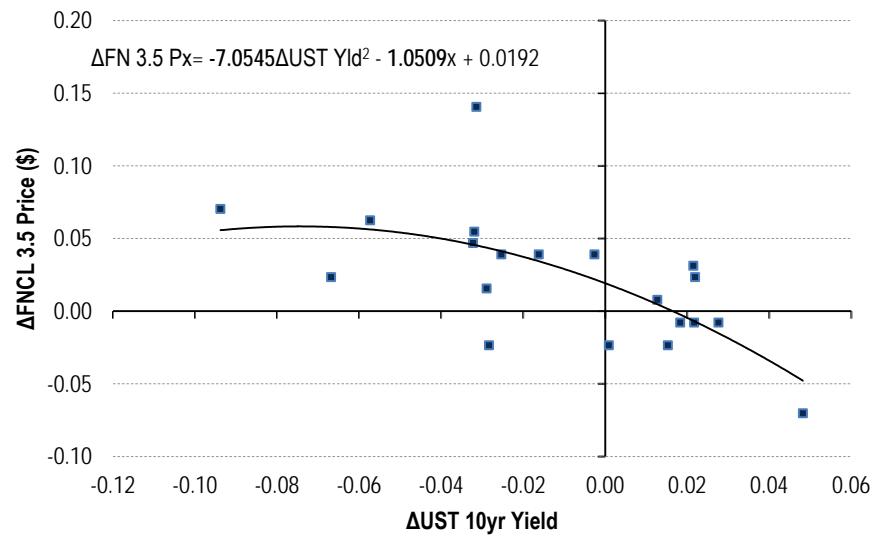
- Effective duration is usually an output of an OAS model: a first order approximation of the mortgage price to rate. However, for certain liquid MBS, durations and hedge ratios can be observed directly in the market.
- Empirical hedge ratios are calculated through linear regression of MBS price changes against the price changes of some hedging instrument, like UST10s. Similarly, empirical duration is obtained by directly regressing the MBS price change versus benchmark yield changes. The regressions are estimated over time, typically 20 days or 60 days.
- Empirical convexities may be similarly estimated as well, but being a second order term they are often unreliable, drowned out by other market dynamics.

Chart 101: 20-day empirical hedge ratio for FN 3.5s is 0.086



Source: BofA Global Research
As of January 24, 2020

Chart 102: 20-day empirical duration is 1.05, convexity of -0.14 is unreliable ($C=-7.05*2/100 = -0.14$)



Source: BofA Global Research
As of January 24, 2020



Empirical vs model durations

- There are several pros and cons to using empirical or model durations. In practice, investors rely on both to varying degrees to hedge their exposures. More weight is placed on the empiricals when markets are trading in a range and volatility is low. On the other hand, models are more reliable when significant market changes are afoot and past pricing is not reflective of the present environment.

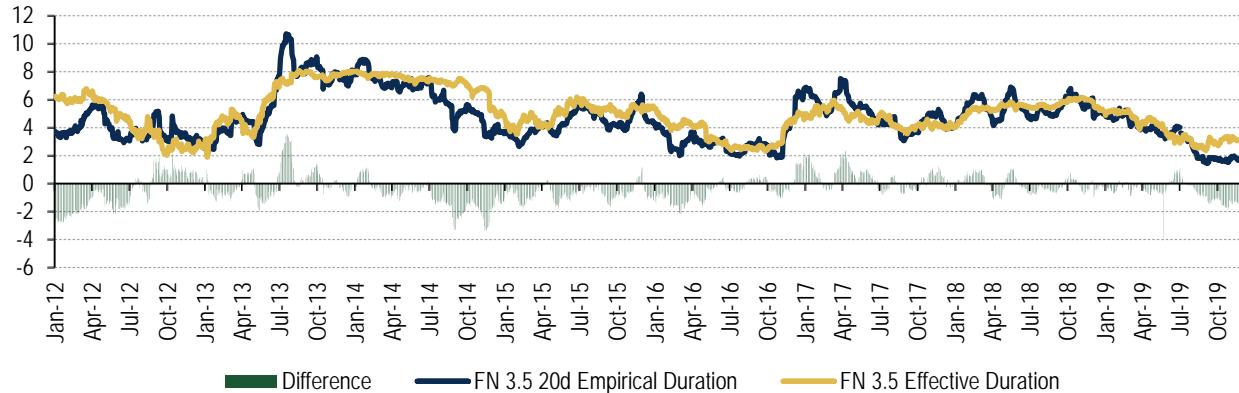
Pros of empirical durations

- No model risk – OAS models are complicated and subject to many, possibly imperfect, assumptions.
- No constant OAS assumption - can capture relevant rate-dependent market dynamics missing from models.

Cons of empirical durations

- Only applicable to very liquid MBS with observable market prices.
- Empiricals are inherently backward looking, extrapolating past experience may not be applicable.
- Only the duration measure is reliable, no ability to extract curve exposures or other sensitivities.
- Can be skewed by outliers, or specific look-back period selection.

Chart 103: Empirical durations and model durations generally track each other but substantial differences can persist



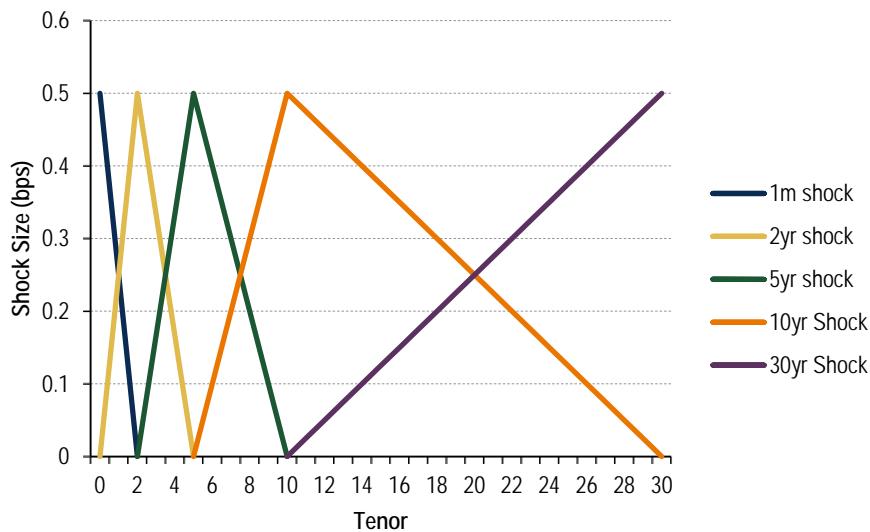
Source: BofA Global Research, FNMA



Key rate durations (KRDs) or partial durations

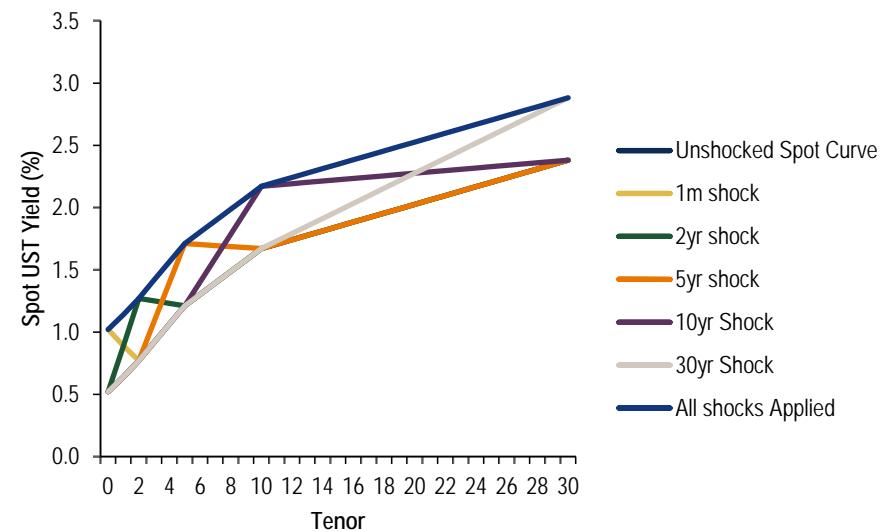
- MBS pays principal over 30 years through prepayments and amortization. MBS cashflows are exposed to many points on the curve. Therefore, interest rate risk can be further reduced by hedging several points on the curve.
- KRDs are used to measure MBS sensitivity to individual points on the spot curve. Shocks are linearly interpolated between individual shock points in such a way as to collectively add up to a parallel shock.
- Since mortgage prices are non-linear with respect to rates, KRDs may not add up to the OAD. In practice they are often normalized to the OAD or the empirical duration.
- Theoretical curve exposure doesn't always bear out in practice. Certain market dynamics can raise correlations to specific parts of the curve, like the Fed propensity for buying UST 10s and MBS at the same time, for example.

Chart 104: 50bps KRD shocks are linearly interpolated between each shock point



Source: BofA Global Research

Chart 105: Spot curves under the KRD shocks, 50bps shock shown



Source: BofA Global Research



Hedging convexity

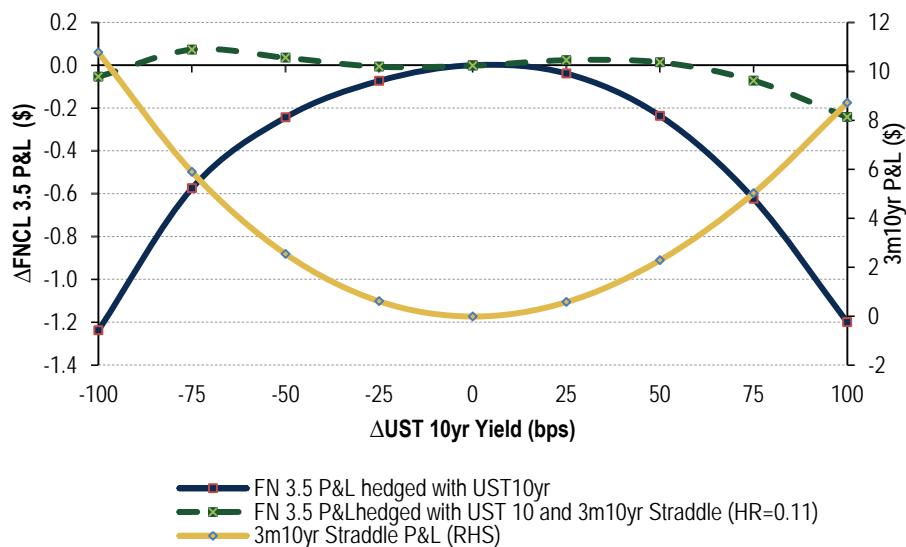
- Investors can hedge convexity by buying positively convex exposure in the market, for example, short-dated swaption straddles. Straddles are positively convex and make money when interest rates move. Similarly to the case for hedging duration, a hedge ratio needs to be computed:

$$\text{MBS convexity adjustment} = -\frac{\text{Price} * C}{2} * \Delta y^2$$

$$\text{Hedge Ratio} = \frac{\text{MBS convexity adjustment}}{\text{swaption straddle gamma for } \Delta y \text{ shock}}$$

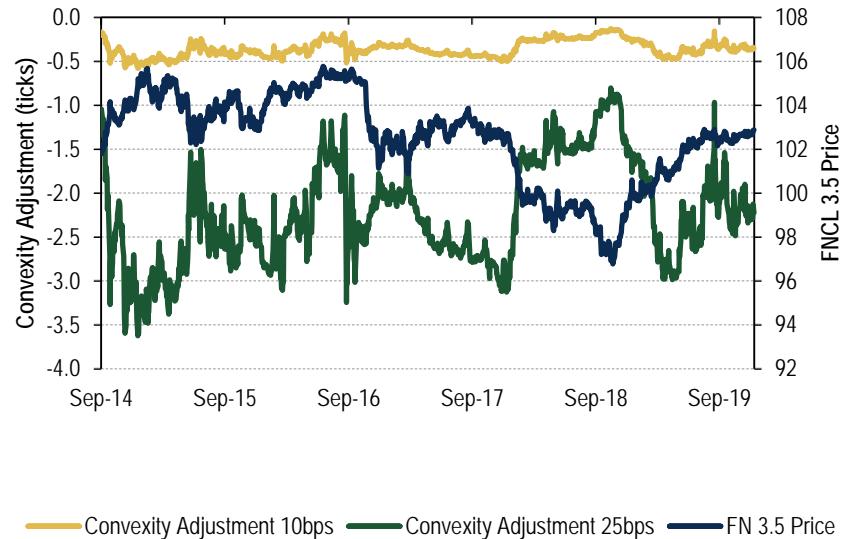
- While reducing portfolio price volatility, a long straddle position will also reduce the expected portfolio yield. Typical carry cost associated with the long gamma straddle MBS hedge ranges from 1 to 1+ per month in ticks, or 35-55bps per year. Long straddle position will also add some vega, or volatility exposure.
- Convexity hedges need adjustment over time as well as the convexity and moneyness of the underlying MBS changes.

Chart 106: FN 3.5 P&L profile vs 3m10yr straddle, hedged at 0.11 Hedge Ratio



Source: BofA Global Research

Chart 107: Convexity cost on FN 3.5s ranges from a + to 3.5 ticks for 10 and 25bp move in rates



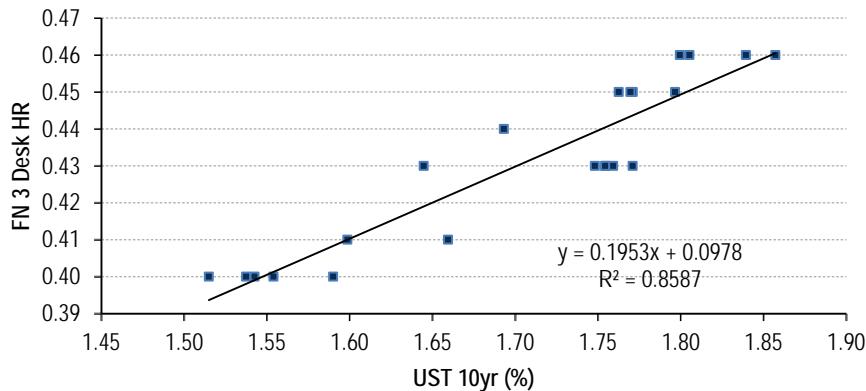
Source: BofA Global Research



Empirical option costs and convexity hedging

- In practice many MBS investors don't always hedge gamma and choose to take on the convexity risk. Instead, investors simply rebalance their duration hedges periodically as rates move, a practice known as delta hedging, again borrowing from option theory. A few hedge vol opportunistically when major event risks loom.
- Delta hedging works so long as realized rate volatility remains muted. Under that scenario, convexity related losses remain low. This is due to the quadratic nature of the convexity adjustment. Convexity loss on a single day with a 10bp realized move in rates is equivalent to 4 days of 5bp moves (up to 20bps total), or 25 days of 2 bp moves (up to 50bps total). Delta hedging breaks down when realized volatility picks up, and the investor is unable to rebalance the duration hedges quickly enough while rates move.
- The estimated cost incurred due to convexity is the option cost estimated by models, defined as the difference between ZVOAS and OAS. However, it can also be estimated from the observed moves in durations, either empirical or modeled, relying on the fact that duration scales linearly with convexity for most MBS.
- For example, suppose MBS hedge ratios move by 0.02 for every 10bps move in 10-yr yield. Such a rate move implies a convexity adjustment of 1/3 of a tick. This can be hedged with gamma straddles, incurring the carry cost associated with them, providing an estimate of option cost.
- Alternatively, suppose an investor rebalances weekly and 1y10y implied normal vol is 65bps. One can expect a 9bps rate move every week ($65\text{bp} * \sqrt{5}/\sqrt{252}$). A quick estimate of the annual option cost yields 17 ticks, or 54bps of annual underperformance ($1/3 \text{ tick} * 52 \text{ weeks} = 17 \text{ ticks}$). Assuming more frequent rebalancing, recognizing that some weeks will prove more volatile than others can further refine this, but these effects are opposite, and tend to offset each other.

Chart 108: FN 3 hedge ratio moves by 0.02 for every 10bps move in 10s in Oct 2019



Source: BofA Global Research

Table 25: Convexity cost non-linear for FN 3s assuming 0.02 move in HR/10bps move in 10yr

Scenario	10yr	Est. HR	Desk HR(P&L in ticks)			
			UST 10yr	P&L	FN 3	Total
-20	1.49	0.40	-25.0	23.8	-1.1	-1.1
-10	1.59	0.42	-12.5	12.2	-0.3	-0.3
-5	1.64	0.43	-6.2	6.2	-0.1	-0.1
0	1.69	0.44	0.0	0.0	0.0	0.0
+5	1.74	0.45	6.2	-6.3	-0.1	-0.1
+10	1.79	0.46	12.5	-12.8	-0.3	-0.3
+20	1.89	0.48	25.0	-26.1	-1.1	-1.1

Source: BofA Global Research



Volatility duration

- The short option position embedded in the MBS gives rise to volatility exposure. As *implied volatility* rises, these options increase in value causing MBS to underperform. If *realized volatility* increases, MBS lose money versus benchmark hedges through negative convexity.
- Volatility duration measures the price sensitivity of MBS to the shocks in implied volatility levels.

$$\text{Volatility } dv01 = -\frac{dP}{dv} \approx -\frac{P^+ - P^-}{2\Delta v}$$

$$\text{Hedge Ratio} = \frac{\text{MBS volatility } dv01}{\text{swaption straddle vega for } \Delta v \text{ shock}}$$

- Entire volatility surface ends up shocked since vols are correlated. SABR (Stochastic Alpha Beta Rho) model is widely used in the industry to model volatility.
- The borrower holds the option for the life of the loan, with a WAL of 3- to 6-years, so long-term vol straddles are usually used for hedging. For example 3y10y, 5y5y, or 3y7y can all be used.
- Long-term option straddles contribute some amount of gamma as well as vega. In practice, a combination of long-term straddles and short-term straddles is used to hedge both the gamma and the vega exposures simultaneously with the hedge ratios solved for in a linear system equations. Below is an example with 3m10yr and 3y10y swaption straddles:

$$\begin{cases} HR_{3m10y} * vega_{3m10y} + HR_{3y10y} * vega_{3y10y} = \text{MBS volatility } dv01 \\ HR_{3m10y} * gamma_{3m10y} + HR_{3y10y} * gamma_{3y10y} = \text{MBS convexity adjustment} \end{cases}$$



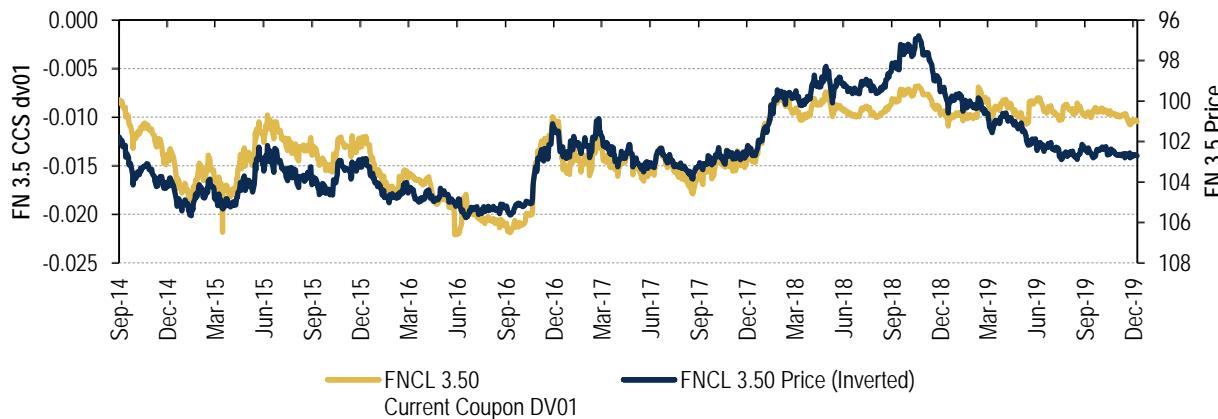
Current coupon spread duration

- Mortgage prepayments and the refi incentive are ultimately driven by the primary mortgage rate, not the benchmark Treasury or swap yields. Mortgage originators sell new mortgages through MBS; therefore, mortgage rates are most highly correlated to the current coupon yield. MBS investors hedging their securities with Treasuries and swaps are exposed to the mortgage basis.
- Most OAS models generate mortgage rates along each interest rate path using the projected current coupon yield and some model for primary/secondary spreads. Therefore, sensitivity to the current coupon yield, or the current coupon spread to the treasury or swap curve, can be computed.

$$CCS \text{ Duration} = -\frac{1}{P} \frac{dP}{dy} \approx -\frac{P^+ - P^-}{2P \Delta CC \text{ spread}}$$

- CC spread duration** is difficult to observe and hedge in passthroughs, as CC spread is correlated to the OAS. Nevertheless, certain highly prepayment sensitive MBS can be hedged with liquid passthroughs in such a way as to offset the CC spread exposure.

Chart 109: Current coupon sensitivity increases with MBS premiums



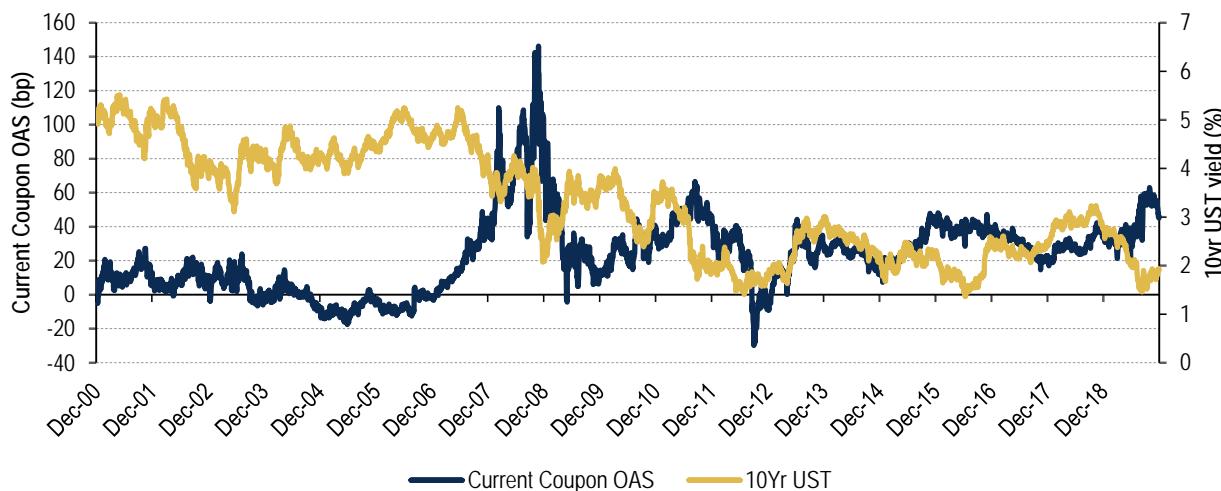
Source: BofA Global Research



Spread duration

- MBS valuation is inherently exposed to changes in the OAS. The OAS duration is computed by measuring the price sensitivity of the MBS to OAS. Since interest rates and cashflows are unaltered when the OAS shock is applied, only the discounting changes. Therefore, OAS is closely related to the timing of cashflows, or probabilistic WAL of the MBS pool.
- OAS is inherently difficult to hedge – compensating investors for factors not tied to interest rates such as model risk, liquidity risk, policy risk, etc. OAS does exhibit some macro correlation to broad market spreads that can be hedged, i.e., credit, but includes mortgage specific attributes as well. Spread duration is used extensively in risk management, including VaR models.
- OAS volatility has picked up post crisis, with the GSEs absent; they helped maintain an OAS pricing regime as agency debt issued helped manage duration and convexity exposures.

Chart 110: OAS has become notably more volatile following the crisis, with no major investor enforcing relative value based on OAS



Source: BofA Global Research



Performance attribution

With all the risk sensitivities in hand, MBS market price changes can be attributed to yields, volatilities, CC spread and OAS as follows:

Chart 111: Performance attribution Example of realized performance attribution

With all the risk sensitivities in hand, MBS market price changes can be attributed to yields, volatilities, CC spread and OAS as follows:

- Changes in Treasury and swap curves

$$\text{Curve Return} = - \sum KRD_i * \Delta y_i$$

- Convexity losses

$$\text{Convexity Return} = -\frac{c}{2} * \Delta y^2$$

- Changes in Implied volatility

$$\text{Volatility Return} = -\text{Vol Duration} * \Delta v$$

- Changes in Current Coupon Spread

$$\text{CCS Return} = -\text{CCS Duration} * \Delta CCS$$

- OAS Changes

$$\text{OAS Return} = -\text{Spread Duration} * \Delta OAS$$

- Any residual return is usually attributed to excess carry on the MBS, ie, realized interest income net of funding as well as any rolldown.

Source: BofA Global Research

Chart 112: Example of realized performance attribution

	FNCL							
	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00
Price	100-026	101-312	103-032	104-10+	105-25	107-01	107-24	108-28
Daily Change	6.0	2.8	2.0	1.5	1.3	0.0	0.0	0.0
1-day Performance vs. Treasury and Swap Hedges								
Vs. Treasury Curve	-2.7	-3.7	-2.3	-1.9	-3.3	-4.0	-6.6	-6.4
Swap Spread	0.9	0.4	0.2	0.1	0.4	0.4	0.7	0.7
Volatility	-1.2	-1.2	-0.8	-0.5	-0.4	-0.4	-0.2	-0.1
Convexity	-0.1	-0.1	-0.1	0.0	0.0	-0.1	0.0	0.0
CC Spread	0.3	0.5	0.6	0.7	0.4	0.5	0.3	0.2
OAS	-3.1	-3.7	-2.5	-2.3	-3.7	-4.5	-7.4	-7.3
Excess Carry	0.6	0.5	0.3	0.1	0.0	0.0	0.0	-0.1
1-week Performance vs. Treasury and Swap Hedges								
Vs. Treasury Curve	-0.3	-7.4	-8.1	-6.4	-8.9	-8.6	-17.3	-16.8
Swap Spread	1.2	0.4	0.2	0.2	0.8	0.7	1.4	1.4
Volatility	-4.0	-3.9	-2.7	-1.8	-1.3	-1.2	-0.6	-0.3
Convexity	-0.2	-0.3	-0.2	-0.1	0.0	-0.1	0.0	0.0
CC Spread	0.1	0.0	0.1	0.1	0.0	0.1	0.0	0.0
OAS	0.5	-5.7	-6.8	-5.5	-8.9	-8.5	-18.4	-18.1
Excess Carry	2.1	2.1	1.4	0.8	0.5	0.4	0.4	0.2
1-month Performance vs. Treasury and Swap Hedges								
Vs. Treasury Curve	10.3	-1.1	-5.5	-1.5	-2.1	-14.6	-30.4	-26.7
Swap Spread	1.5	0.2	-0.1	-0.2	0.2	0.0	0.9	1.0
Volatility	-3.7	-3.6	-2.5	-1.7	-1.2	-1.1	-0.6	-0.3
Convexity	-0.7	-0.8	-0.6	-0.5	0.0	-0.3	-0.1	0.0
CC Spread	-1.0	-1.5	-1.9	-2.4	-1.8	-1.7	-1.0	-1.0
OAS	4.9	-1.7	-3.9	0.8	-7.4	-25.6	-50.4	-49.8
Excess Carry	9.3	6.3	3.5	2.4	8.2	14.1	20.7	23.4

Source: BofA Global Research



OAS: caveat emptor

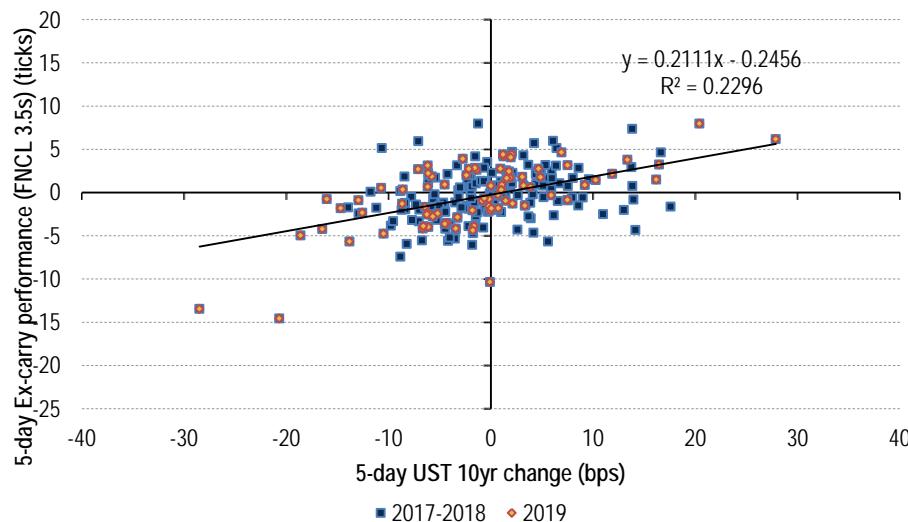
- Investors hedging interest rate and volatility across the curve, using KRDs and other sensitivities, should theoretically expect to earn OAS over the life of the MBS, assuming interest rate and prepayment models are correct.
- Most investors do not have such long-term investment horizons, however. Since the onset of the financial crisis and the deleveraging of the GSEs, the non-relative value oriented, non-hedging players such as the Fed, the banks and overseas investors have come to dominate the market. Absent a large OAS buyer like the GSEs, OAS can widen or tighten significantly and for extended periods of time, affecting mark-to-market returns.
- Furthermore, an unprecedented degree of post-crisis government intervention in terms of QE purchases, bank regulation, as well as the impact of new rules on origination and S-curves also affects OAS. To the extent that markets are increasingly trading to these factors, OAS loses relevance as a relative value metric.
- From a technical perspective, OAS is susceptible to outliers, as valuations across interest paths are asymmetric. This skew follows from prepayments and negative convexity – MBS prepay as rates rally limiting price upside. Most models are calibrated to near-the-money options as liquidity in the longer-term options that are more than 100bps out-of-the-money is lacking. As a result, in the simulation less than half of the paths are anchored to liquid market pricing, with the rest inferred based on the normality of rates assumption, which may not be correct at the tails. Prepayment assumptions may also be questionable under tail scenarios.
- Finally models aren't always right. The model portfolio of rate and vol hedges is sometimes referred to as a *replicating portfolio*. Historically, replicating portfolios can explain about 92% of MBS price changes.
- To the extent the OAS changes are correlated to macro factors tied to interest rates, constant-OAS based risk measures such as OAD or OAC could end up overstating or understating MBS exposure. When OAS tends to move with interest rates MBS are said to trade *rate directional* or *spread directional*.



OAS spread directionality

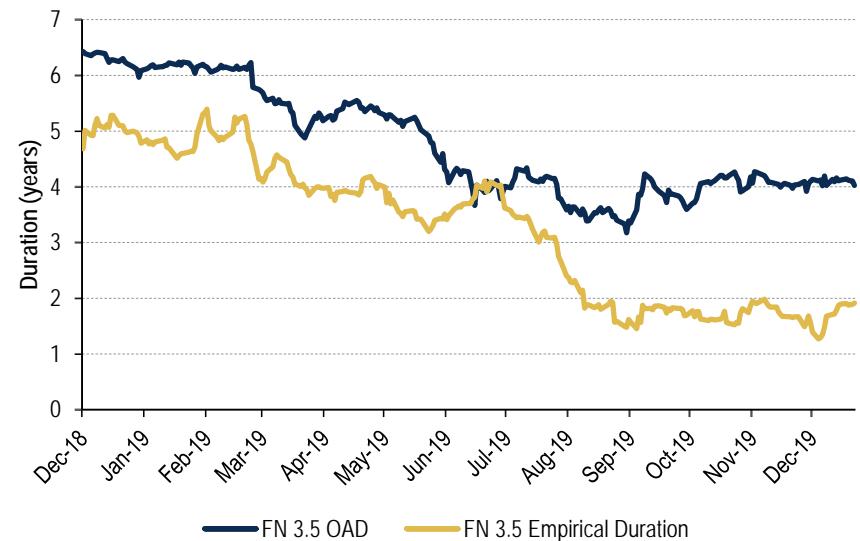
- Spread directionality affects realized durations. If OAS tends to widen when rates rise then mortgages trade *longer* than model durations and underperform model hedges in selloffs and outperform in rallies. Conversely, if OAS tends to tighten when rates rise then mortgages trade *shorter* than model durations, outperforming in selloffs and underperforming in rallies.
- Empirical durations are fit based on observed data and thus, incorporate any embedded rate directionality. If OAS widens when rates rise, empirical hedge ratios will be longer than model. Conversely, empirical hedge ratios will be shorter than model when OAS widens in rallies. To the extent the drivers of the directionality are understood and expected to persist, empirical durations provide a better measure of actual interest rate risk.
- Shorter empirical hedge ratios can enhance the carry proposition of agency MBS.

Chart 113: Example of directional mortgage performance



Source: BofA Global Research

Chart 114: Empirical hedge ratio is shorter than OAD in 2019, implying rate directionality



Source: BofA Global Research



Notable post-crisis examples of rate directionality

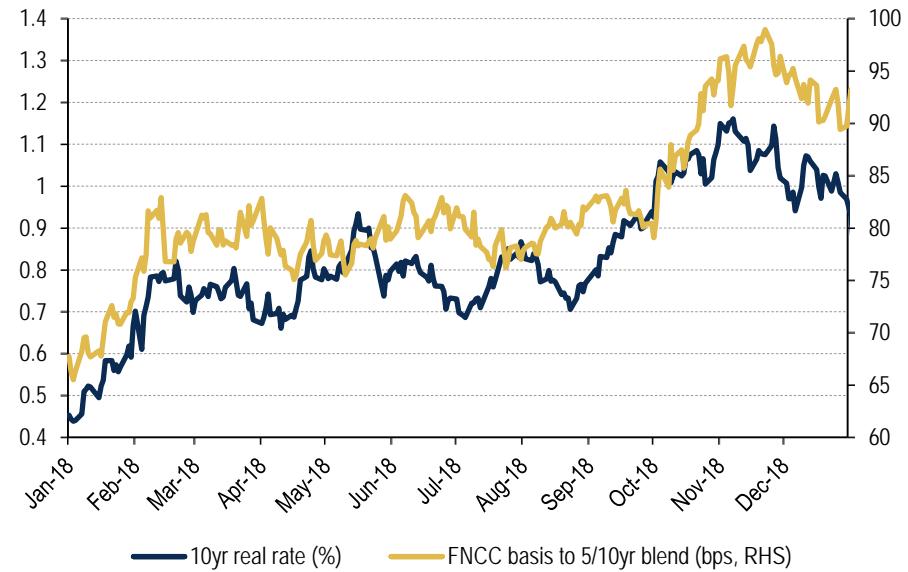
- MBS directionality is not constant, and changes direction depending on the prevailing interest rate regime.
- In 2012, with the onset of QE3, the Fed was expected to purchase MBS and Treasuries. As a result, rates rallied and spreads tightened in anticipation. The opposite happened during the taper tantrums in 2013, when the market expectations for balance sheet unwind were closely tied to rates, causing underperformance into higher rates.
- In 2015 and early 2016, the global economy stagnated and rates rallied. Balance sheet worries took a back-seat, and mortgages began underperforming in rallies as concerns over prepayments and supply intensified.
- In 2018, rates sold off on the back of the newly implemented tax reform. Real rates shot up on hawkish Fed expectations, causing MBS to underperform into selloffs, and outperform into rallies.
- In 2019, as rates rallied and the Fed relented, prepayment and supply concerns caused MBS to underperform into rallies.

Chart 115: Typical rate directionality patterns observed historically



Source: BofA Global Research

Chart 116: Basis widened as real rates rose and Fed was hawkish in 2018



Source: Bloomberg, Fed



Tail wags the dog: MBS hedging needs and the rates markets

- The size of the MBS market is large enough that hedging activities of mortgage investors can have a significant effect on the rate and volatility markets. This was particularly true pre-crisis, when more MBS exposure was hedged, notably by the GSEs.
- Negative convexity can drive rapid positive feedback behavior in rate markets. As rates rally, mortgage assets become shorter in duration and investors are forced to buy back rate hedges, generating additional demand for rates. Originators are also forced to buy back duration as fallout increases in rallies. Servicer MSRs exhibit negative convexity, resulting in incremental duration demand from banks that need to hedge them to protect from reporting losses.
- Negative convexity generated a significant feedback loop in 2003, when most borrowers went in-the-money at the same time.
- MBS hedging can have a significant impact on vol markets as well. For example, to the extent fewer investors are engaged in OAS extraction, sans the GSEs, implied vol may not be able to recover to pre-crisis levels.

Chart 4: MBS hedging flows contributed heavily to the 90bps rally followed by the 130bps selloff in 2003



Source: BofA Global Research



Negative convexity of the MBS universe

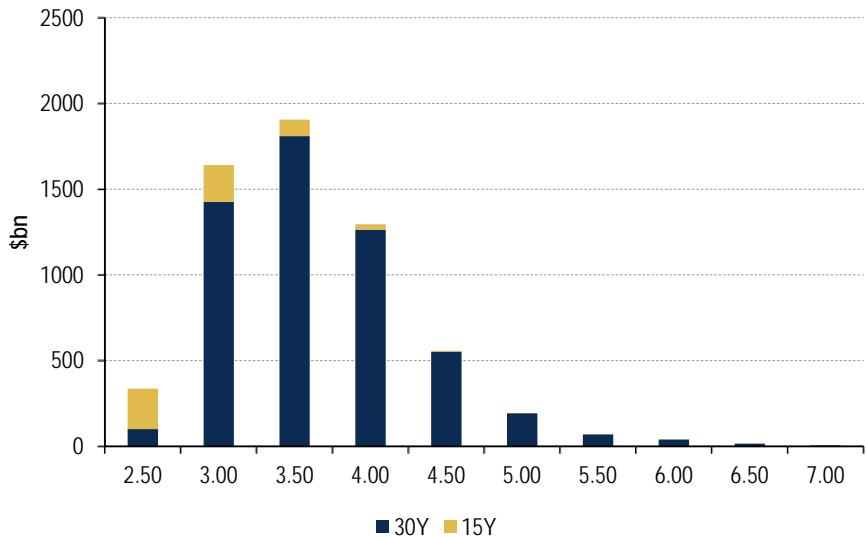
- The 2003 experience was so eventful that investors still look at the negative convexity of the mortgage universe, typically in 10-year equivalents. Post-crisis, this risk is mitigated, as borrower note rates are more staggered, fewer investors hedge MBS, and the Treasury market dramatically increased in size relative to the MBS market.

Table 26: Convexity hedging needs for a 25bps move in rates, 10-year equivalents

Hedge needs (\$bns)	Pipeline	MSRs	REITs	GSEs/MMs	Total	UST Market	Share of UST Market
2020	41	1	12	19	73	7300	1.00%
2003	53	28	1	87	169	1669	10.10%

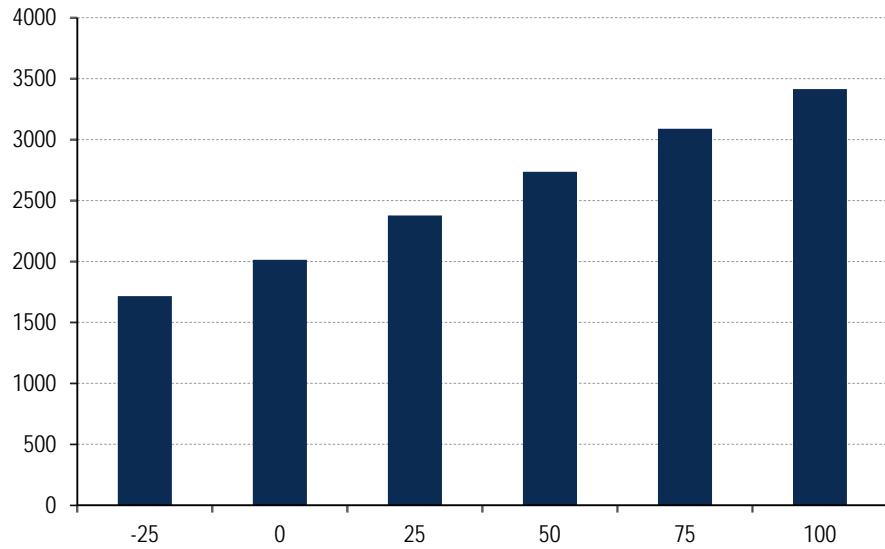
Source: FNMA, BofA Global Research

Chart 117: MBS universe coupon distribution



Source: BofA Global Research, FNMA, FHLMC, GNMA
As of Nov 2019

Chart 118: MBS universe duration in 10-year equivalents



Source: BofA Global Research
As of Dec 2019



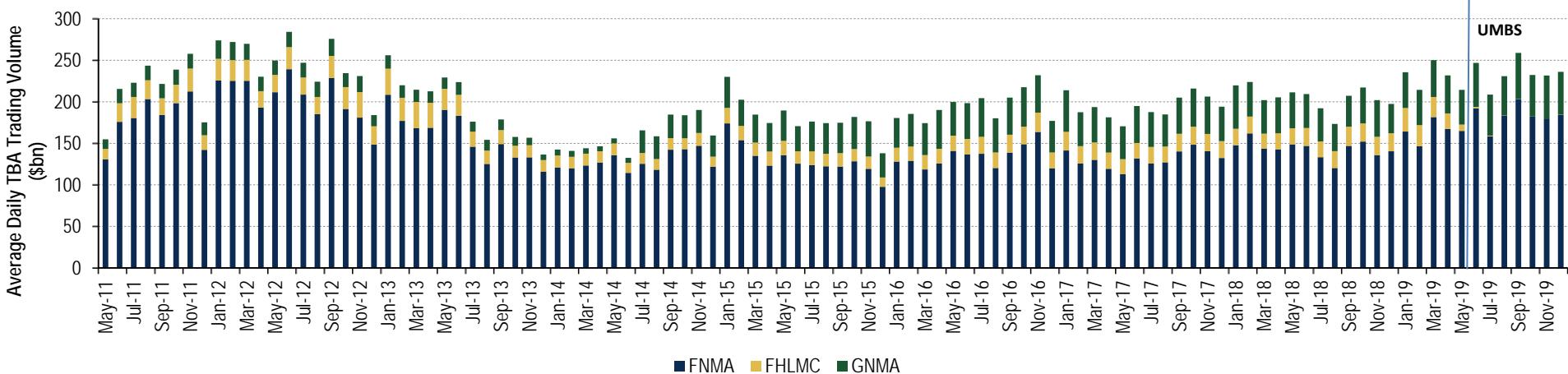
The TBA market and dollar rolls



Over-the-counter TBA market

- The to be announced or TBA segment of MBS is an over the counter (OTC) futures contract used as a financing and delivery mechanism of MBS pass-through pools.
- Specific contract details are set including the product type, coupon rate, and settlement date. For example, FNCL 4 12/19 is UMBS 30-year term, 4 coupon for December 2019 delivery. Typically, a large number of pools over a certain minimum size are eligible to be delivered into a particular contract.
- TBA trading rules are set by SIFMA – dictating settlement dates, setting good delivery guidelines, establishing procedures and charges for failed delivery, margining requirements.
- Counterparties notify each other of the exact mortgage pool CUSIPs to be delivered two business days before the settlement date (48-hour day). Pools are then delivered on the settlement date. Fail charges apply if timely delivery is not made.
- TBA trading accounts for over 90% of all MBS trading activity. Contracts have short terms, greatly diminishing counterparty risks. TBAs are usually traded up to three months out (front month, back month, and back-back month). Most on-the-run contracts offer reliable liquidity with a narrow bid-ask, 0.5-1 ticks.
- TBA makes MBS fungible which greatly enhances liquidity and reduces idiosyncratic pricing risk. High volumes result in a high degree of pricing transparency, including intra-day pricing.

Chart 119: Daily TBA trading volume is generally between \$200-300b, FHLMC trading almost disappear after UMBS came into effect



Source: TRACE



Bloomberg: BBTM screen, live 30yr TBA contracts

Chart 120: Bloomberg: BBTM screen displays live TBA pricing

TBA		Actions	Settings	Fixed Income Trading		
13:41		4) TBA30	5) TBA15	6) MBS	7) Swaps	8) Butterflies
		3.0	3.5	4.0	4.5	
UMBS	Jan	101-08 / 09	102-22+ / 23+	103-28 / 29	105-05 / 06	
	Feb	101-06 / 07	102-22 / 23	103-29 / 30	105-06+ / 07+	
	Mar	101-03+ / 04+	102-20 / 21	103-29 / 30	105-07 / 08	
	Jan/Feb	/	00 ⁵ ₈ / 00 ³ ₄	/	- 02 ¹ ₄ / - 02 ¹ ₈	
	Feb/Mar	02 ⁵ ₈ / 02 ³ ₄	01 ⁷ ₈ / 02	00 ³ ₈ / 00+	/	
FGLMC	Jan	101-10 / 11	102-25 / 26	103-30 / 31	105-07 / 08	
	Feb	101-08+ / 09+	102-24+ / 25+	103-31 / 00	105-09 / 10	
	Mar	101-05+ / 06+	102-22+ / 23+	103-30+ / 31+	105-09 / 10	
	Jan/Feb	/	/	/	/	
	Feb/Mar	/	/	/	/	
G2SF	Jan	102-16 / 17	102-28+ / 29+	103-13 / 14	104-13+ / 14+	
	Feb	102-13 / 14	102-29+ / 30+	103-16 / 17	104-19+ / 20+	
	Mar	102-09+ / 10+	102-30 / 31	103-16 / 17	104-21 / 22	
	Jan/Feb	03 ¹ ₈ / 03 ¹ ₄	- 01 ³ ₈ / - 01 ¹ ₄	- 03 / - 02 ⁷ ₈	- 06 ¹ ₈ / - 06	
	Feb/Mar	/	- 00 ³ ₈ / - 00 ¹ ₄	- 01 ³ ₄ / - 01 ⁵ ₈	/	
Benchmarks						
Treas 2Y	99-31 ³ ₄ / 00	1.629 / 625	- 00 ¹ ₄	Treas 7Y	98-22+ / 23	1.825 / 823 + 01
Treas 3Y	99-30+ / 30 ³ ₄	1.641 / 638	--	Treas 10Y	98-22 / 22+	1.896 / 894 + 01+
Treas 5Y	100-04 ³ ₄ / 05	1.719 / 717	- 00 ¹ ₄	Treas 30Y	101-00 / 01	2.328 / 327 + 01+

Source: Bloomberg



Bloomberg: BBTM screen, screen with live G2 contracts

Chart 121: Bloomberg: BBTM screen with live G2 pricing

TBA		Actions		Settings		Fixed Income Trading	
13:43							
		④ TBA30	⑤ TBA15	⑥ MBS	⑦ Swaps	⑧ Butterflies	⑨ GNII
21) UM30	22) UM15	23) GD30	24) GD15	25) GN30	26) GN15	27) GNII	
		3.0		3.5		4.0	
Jan	102-16 / 17	2 - 2 --		102-28+ / 29+	1 - 2 + 01	103-13 / 14	2 - 2 + 01
Feb	102-13 / 14	2 - 2 + 01		102-29+ / 30+	1 - 1 + 00+	103-16 / 17	2 - 2 + 01
Mar	102-09+ / 10+	2 - 2 + 01		102-30 / 31	1 - 1 + 00+	103-16 / 17	3 - 2 - 01
Jan/Feb	03 ¹ ₈ / 03 ¹ ₄	1 - 1 + 00 ¹ ₈		- 01 ³ ₈ / - 01 ¹ ₄	1 - 1 --	- 03 / - 02 ⁷ ₈	1 - 1 --
Feb/Mar	/	-		- 00 ³ ₈ / - 00 ¹ ₄	1 - 1 + 00 ¹ ₈	- 01 ³ ₄ / - 01 ⁵ ₈	1 - 1 + 00 ¹ ₄
	4.5			5.0		5.5	
Jan	104-13+ / 14+	1 - 2 - 00+		105-09+ / 10+	1 - 1 + 00+	105-12+ / 13+	1 - 1 --
Feb	104-19+ / 20+	1 - 2 - 00+		105-17+ / 18+	1 - 1 + 00+	105-12+ / 13+	1 - 1 --
Mar	104-21 / 22	1 - 1 - 03		105-22+ / 23+	1 - 1 + 00+	105-12+ / 13+	1 - 1 --
Jan/Feb	- 06 ¹ ₈ / - 06	1 - 1 - 00 ¹ ₈		- 06 ⁷ ₈ / - 06 ³ ₄	1 - 1 + 00 ³ ₄	/	-
Feb/Mar	/	-		/	-	/	-
Benchmarks		Roll Analysis-		Jan/Feb	Rte	0	
Treas 2Y	99-31 ³ ₄ / 00	1.629 / 625	- 00 ¹ ₄	Cpn	CPR	Drd	
Treas 3Y	99-30+ / 30 ³ ₄	1.641 / 638	--	3.00	12.64	3.125	6.731
Treas 5Y	100-04 ³ ₄ / 05	1.719 / 717	- 00 ¹ ₄	3.50	19.48	-1.375	7.253
Treas 7Y	98-22+ / 23	1.825 / 823	+ 01	4.00	29.56	-3.000	7.033
Treas 10Y	98-22 / 22+	1.896 / 894	+ 01+	4.50	35.83	-6.125	6.231
Treas 30Y	101-00 / 01	2.328 / 327	+ 01+	5.00	23.70	-6.875	6.012
							4.726
							73.884

Source: Bloomberg



Yield table analysis: YT

Chart 122: Bloomberg YT screen offers yield table and scenario analysis

G2SF 3.5 ALL Mtge				Actions		Settings		Yield Table												
US GENERIC				3.907(316)39 CUSIP None		As of 12/2019														
12/2019	401P	19.5C	2.0B			Coupon	3.50%													
3Mo	410	20.0	2.2	Orig Amt	1.2MMMM	LTV/HLTV	95/82	Accrual	1/1-1/31	Age	39	3Yr	3Mo							
6Mo	382	18.9	2.4	Curr Amt	622.4MMM	MAXLS	2,354,465	Next Pay	2/20/20	WAM	316	26Yr	4Mo							
12Mo	302	15.1	2.0	Factor	0.52736278	WAOLS	254,079			WAC	3.907									
Life	183	7.0	--	# Pools	13,629															
↓ Price-to-Yield																				
Settle	01/21/20	0 MED	+300 MED	+200 MED	+100 MED	-100 MED	-200 MED	-300 MED												
Vary	0	319 PSA	112 PSA	114 PSA	169 PSA	769 PSA	887 PSA	909 PSA												
Price	102-30	2.6842	3.0831	3.0798	2.9832	1.4998	1.0953	1.0137												
Avg Life		4.16	8.74	8.66	6.89	1.59	1.32	1.27												
Mod Duration		3.71	7.03	6.98	5.74	1.55	1.29	1.25												
Prin Win Date	2/20-4/46	2/20-4/46	2/20-4/46	2/20-4/46	2/20-4/46	2/20-4/46	2/20-4/46	2/20-4/46												
I Spread	100	122	122	116	-8	-46	-46	-54												
Dec19	Nov	Oct	Sep	Aug	Jul	Jun	May	Apr	Mar	Feb	Jan	GOVT(I)	6M	1Y	2Y	3Y	5Y	7Y	10Y	30Y
401P	434	393	389	363	309	300	263	221	186	172	197	13:46	1.60	1.52	1.63	1.64	1.72	1.82	1.89	2.33
19.5C	21.2	19.3	19.3	18.2	15.7	15.3	13.2	11.0	9.2	8.3	9.4	Disc 30/360	3Y	99-30 ^{3/4}	5Y	100-05				

Source: Bloomberg



TBA – what's deliverable?

- Common tradable TBA contracts include UMBS 30yr, UMBS 15yr, Ginnie II 30yr.
- Deliverable pools are often assigned the same ticker. The most common TBAs and tickers are as follows:
 - FNCL = 30-year UMBS
 - G2SF = 30-year Ginnie IIs
 - FNCI = 15-year UMBS
- Either Fannie or Freddie MBS is deliverable into UMBS TBA.
- Not all outstanding MBS are available for delivery. Good delivery guidelines set by SIFMA restrict minimum pool size, term, and other parameters.

Table 27: A subset of Good Delivery Guidelines, per SIFMA

Restriction	Current Requirement
Minimum deliverable (<8% coupon)	At least \$25k minimum Only 1 pool if delivering less than \$500k At most 2 pools if delivering less than \$1mm At most 3 pools if delivering \$1mm Larger deliveries are broken down into 1mm lots, each one to satisfy conditions above
Final maturity and term	Legal final >15yrs 1m and <30yrs 1m for 30yr conventionals; loan term between 15 and 30 years Legal final <15yrs 1m for 15yr conventionals; loan term less than or equal to 15yrs Legal final >28yrs for 30yr Ginnies, except for Platinums
Ginnie II Majors	Only Ginnie II multi-lender pools, also called <i>majors</i> are deliverable. Pool numbers start with MA. Ginnie II single-issuer pools, or <i>customs</i> , are not deliverable
Jumbos	Cannot exceed 10% of the pool. 100% jumbo pools such as FNCK, FGT6, or G2JM are not deliverable.
Non-standard loans	Non-standard loans such as coop loans, relocation loans, or buydown loans can't exceed 10% of the pool

Source: SIFMA



TBA settlement and fail charges

- TBAs settle once a month on Class A settle date for 30-year UMBS, Class B for 15-year UMBS, and Class C for GNMA. SIFMA maintains the settlement date schedule.
- Failure to deliver on time results in daily TMPG fail charges which accrue daily. The rate is set at the greater of 2% - Fed Funds and 1%.
- If the pools are allocated after the factors are released on the fourth business day of the next month, the buyer may be entitled to CPR claims to prevent adverse selection. If a fail persists over multiple months CPR claims are cumulative.
- CPR claims protect buyers of premium TBAs from adverse selection and receipt of particularly fast bonds once the factors are known, rebating any premium erosion beyond that implied by an average CPR for a particular coupon, known as the *fail speed*.
- When failing over multiple months the TBA seller also needs to make all the missed principal and interest cashflows on the pools delivered during failure, effectively providing free funding for the buyer.

Table 28: TBA delivery: fail charges

Fail charge	Calculation
TMPG	Daily charge of 2% per annum – Fed Funds (lower bound), and a floor of 1% per annum
CPR claims	Excess principal erosion compared to the aggregate coupon cohort if delivered CPRs are higher, i.e.: $(TBA\ price\ at\ allocation - 100) * (Paydown\ on\ the\ delivered\ pools - Generic\ cohort\ paydown) / 100$ Generic cohort encompasses all the pools in the coupon, its 1m CPR is known as the <i>fail speed</i> .
Principal and Interest payment	Principal paydowns and interest payments on the pool during the failure period

Source: BofA Global Research

Table 29: Example: TBA fail charges

Coupon = 4	
Face \$100mm	
Full price, with accrued = \$105.04 at allocation	
Delivered 40 days after settlement date, which is after next month's factor date	
On the next factor date, paydown on the delivered pools is \$4mm at 35 CPR, 3.52562% SMM	
Generic FN 4 CPR: 20 CPR, 1.8423% SMM	
TMPG	$(40 / 360) * \max(2\%, 1.5\%, 1\%) * 105.125 = 0.12$
CPR claims	$(105.125 - 100) * (3.52562\% - 1.8423\%) = 0.086$
P & I	$4 + 3.5\% * 100 * 30 / 360 = 4.29$
Total	4.50

Source: BofA Global Research



Cheapest to deliver

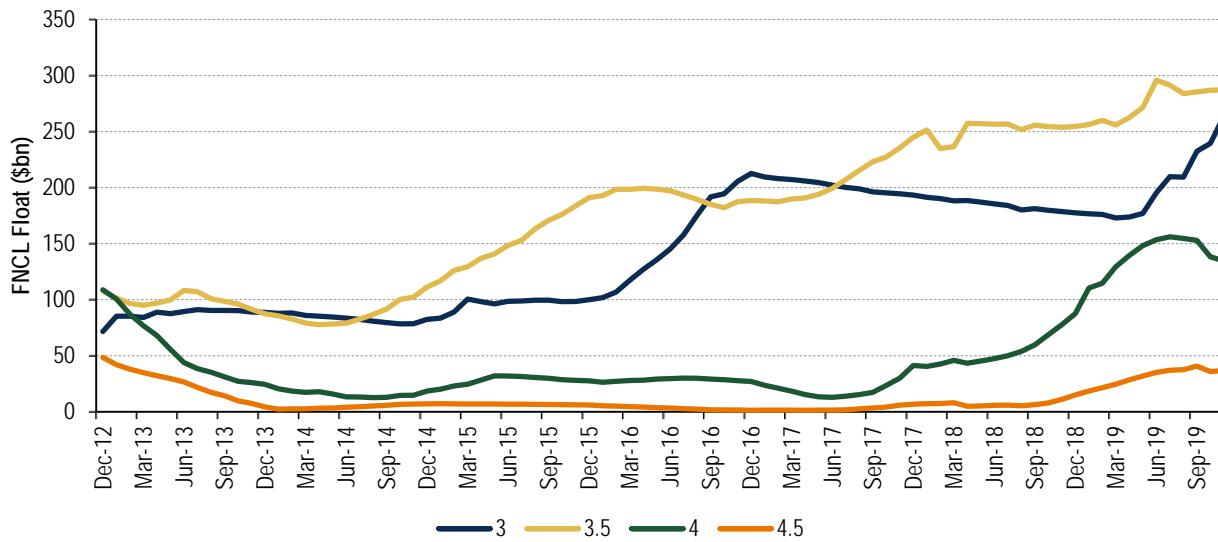
- The TBA seller can deliver from a wide selection of eligible agency pools; the TBA buyer takes on the delivery risk over which pools will be delivered, in addition to the usual duration and prepayment risk associated with a long MBS position.
- A seller is incentivized to deliver the cheapest collateral. As a result, pools delivered *through-the-box* (TTB), will typically have some of the worst convexity and carry characteristics. For premium TBAs, TTB bonds are likely to have the shortest average lives or the highest option costs. For discounts, the longest bonds with the most extension risk are most likely to be delivered.
- TBA pricing reflects this cheapest-to-deliver (CTD) option and OAS model inputs require the specific characteristics of the expected TTB bonds to correctly value TBAs. TTB is observable monthly; however, can change if rates, composition of pools available for delivery, or the S-curves shift materially.



The free float

- The range of cheapest-to-deliver bonds is bounded by the availability of pools in the *free float*.
- Only those pools that are TBA eligible and not locked up in permanent holdings (Fed, CMOs, HTM books) can be delivered. The latter can create considerable uncertainty as to what the cheapest-to-deliver characteristics are.
- Pools with desirable collateral features will trade at a payup to the TBA and are not likely to be delivered, particularly if the payup exceeds the delivery fail charge. They are often excluded from the free float calculation.
- Since the Fed is mandated to keep all the pools it is delivered and is not selling their pools, their gross buying improves the quality of the free float over time.
- Analysis of the composition of the free float is key to anticipating cheapest-to-deliver changes.

Chart 123: FNCL free float of 3s through 4.5s over time. Free float increases in production coupons and decreases in those out of production.



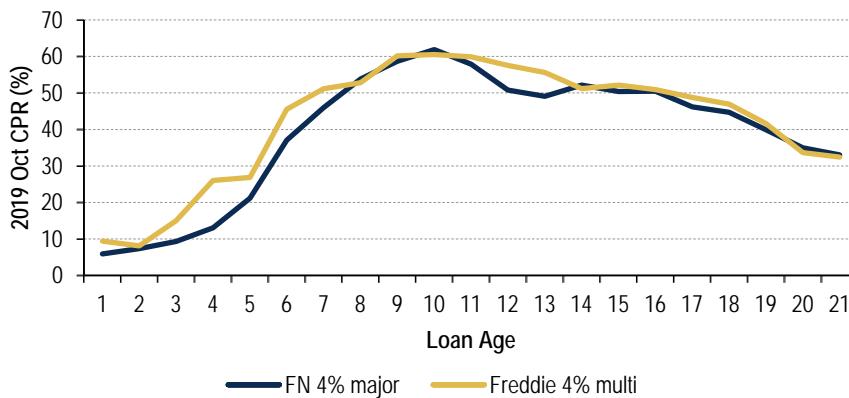
Source: BofA Global Research



Recent trends: multi-lender pools, GSE pooling alignment

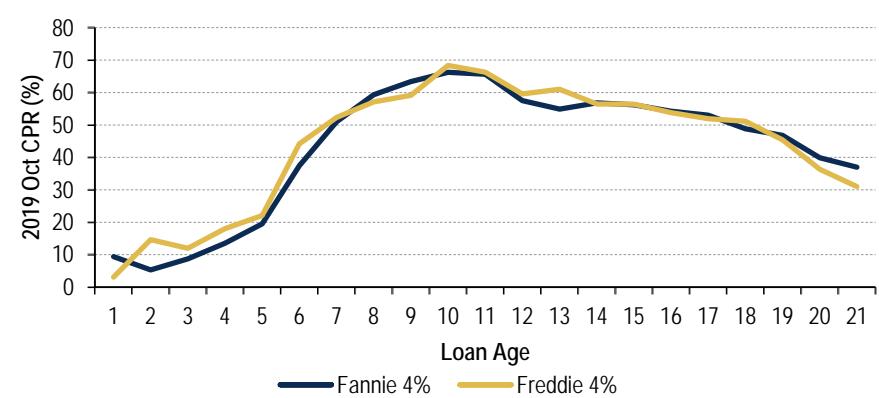
- Though the two GSEs are forced to have consistent underwriting criteria as well as align along securities features by the FHFA, differing pooling methodologies by the GSEs can create prepayment profile, and thus, price differences.
- In recent years the free float has come to be dominated by the large multi-lender pools at both GSEs, issued monthly in each coupon. Fannie Mae pools are dubbed *majors*, similar to Ginnie Mae, and pool numbers start with MA. Freddie Mac combines their monthly multi-lender and cash window production pools into a single super, pool number prefixed with SD8 for 30-year mortgages.
- With the bulk of collateral tied in these multi-lender pools, adverse selection risk to the TBA buyer is minimized. However, some collateral ends up being carved out of the majors. The quantity and prepayment profile of these carve-outs can alter the profile and pricing of the major for a given month.
- Of primary concern to the market is the potential for competition based on pooling, which involves increasing carve-outs of weaker, cheaper collateral, so that the GSEs can offer better pricing to most originators participating in their major, increasing their market share. If enough collateral ends up carved out, there is a risk that the TBA deliverable shifts away from the major pools.
- Of concern to the FHFA is the potential for one GSE to end up with persistently better TBA deliverable, particularly if the weaker carve-outs end up being locked up outside the free float. This would undo the original impetus for UMBS. To ensure UMBS TBA remains fungible and neither GSE enjoys a lasting advantage with respect to pricing, FHFA has expressed interest in aligning pooling practices in late 2019.

Chart 124: Freddie multis ramp faster than Fannie majors in October 2019



Source: BofA Global Research

Chart 125: Controlling for pooling characteristics, GSEs are comparable



Source: BofA Global Research

Note: >225K, ex-NY, >700 FICO, <90 LTV



Calculating current coupon off the TBA stack pricing

- TBA price transparency allows for the easy determination of the *current coupon* or CC MBS yield.
- Interpolate between front and back month to 30-day forward prices for the entire TBA stack.

Table 30: Example calculation of current coupon off TBA stack

Snapshot as of 11/1/2019	Delivery	FNCL 2.5	FNCL 3	FNCL 3.5	FNCL 4	FNCL 4.5
Front Month	11/13/2019	99-11	101-18	102-21	103-24	105-05
Back Month	12/12/2019	99-09	101-15+	102-21+	103-26+	105-08+
30d Forward	12/1/2019	99-096	101-16+	102-212	103-25+	105-071

Source: BofA Global Research

- Interpolate two coupons closest to \$100 to obtain coupon of a par-priced bond: 2.66%. Bloomberg reports this after converting to semi-annual compounding.
- Recently the entire stack has traded above par due to low rates and wide spreads – to address this, some have switched to par-\$102 for this computation, often referred to as CMM-102.
- CMM-102 calculation gives 3.21%.
- The primary advantage of CC over CMM-102 lies in the calculation of spreads. Spreads to Treasuries or swaps on par-priced current coupon MBS will be largely insensitive to prepayments. In contrast, the spread on a \$102 priced MBS is highly sensitive to prepayment assumptions, limiting its usefulness as an objective relative value metric. CC spreads are also typically used to estimate mortgage rates in OAS models.
- When all traded TBA prices are premiums or discounts, the above calculation is impossible. For instance, rate rallies in September 2012, June 2019, and March 2020 resulted in this.
- Several frameworks exist in estimating a current coupon under such scenarios, relying on assumed prices for the missing TBAs. All have limitations, creating high subjectivity in model based risk and valuation metrics. When lacking TBAs to interpolate, Bloomberg will report the yield on closest to par TBA, calculated using the median prepayment estimate available on VALL.



TBA tick performance

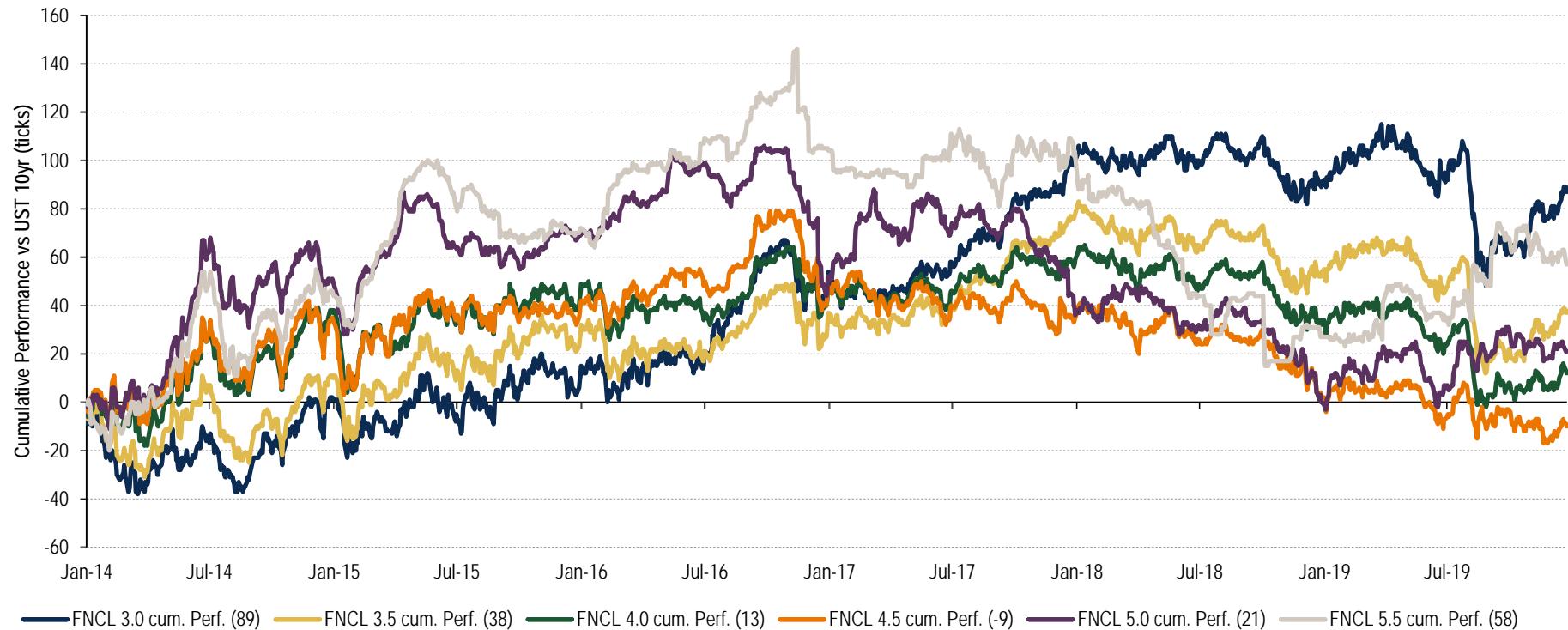
- MBS daily performance is often quoted on a hedged basis, in **ticks** (1/32nds).
- Hedges are usually Treasuries or swaps. 10-year is often used or the entire curve hedge using KRDs

$$\text{Tick Performance} = 32 * (\Delta \text{TBA Price}_t - \sum HR_i * \Delta \text{Hedge Price}_i)$$

Hedge price change includes any changes in the accrued and rolldown. Hedge ratio from a previous day is typically used for this calculation in order to properly recognize the convexity costs associated with holding MBS.

- Cumulative performance is often presented over longer stretches of time

Chart 126: FNCL cumulative performance versus 10-year Treasury bond (ticks)



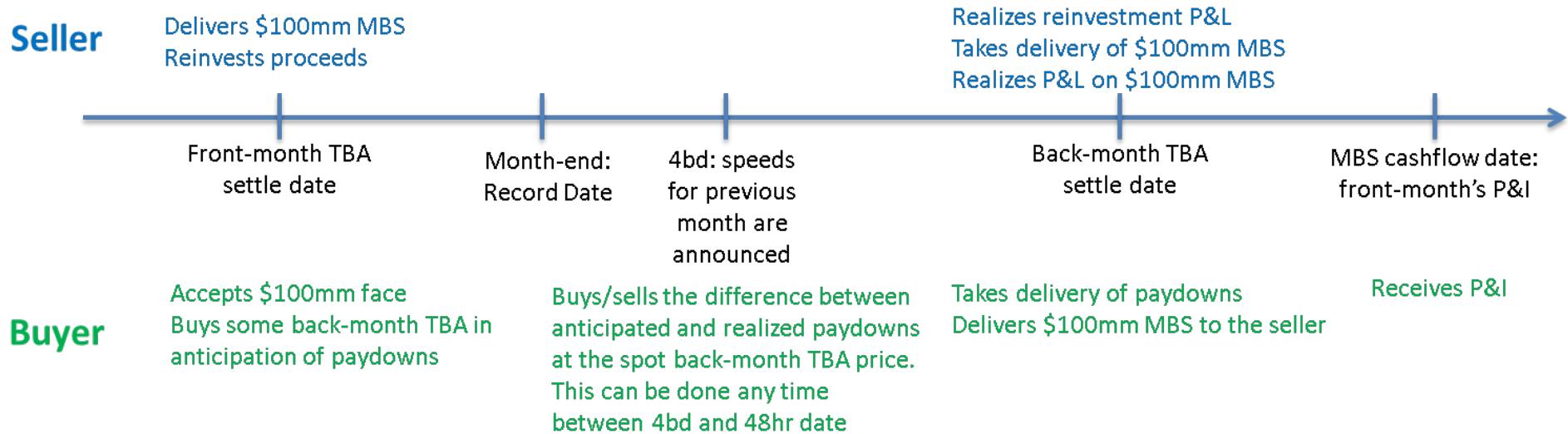
Source: BofA Global Research



Dollar roll transaction

- A *dollar roll* transaction is a 1-month funding method for MBS, similar to a repo agreement. An investor sells *the roll* by selling front-month TBA and covering the short with the back-month contract. Conversely, an investor can *buy the roll* by doing the reverse. Dollar rolls comprise the majority of daily TBA trading volumes.
- If the position is not closed, the buyer of the roll will take delivery of the MBS pools, hold them for a month, and deliver the same par amount of MBS back to the seller next month. Being TBA trades, the pools delivered in the two months don't necessarily have to be the same pools.
- The seller of the roll will receive cash in the front month equal to the price plus accrued interest, free to invest for one month before repurchasing MBS in the back-month. The buyer of the roll is entitled to the P&L on the delivered MBS for the front month.
- The difference between the front-month price and the back-month price is called the *drop*, sometimes simply referred to as the roll or the dollar roll.

Chart 127: Mechanics of a dollar roll transaction



Source: BofA Global Research



Properties of the dollar roll

- The roll is priced such that the MBS investor is indifferent between rolling, or holding, TTB MBS.
- The key determining variables are the value of the foregone interest cashflow the roller of MBS foregoes, financing cost, and any anticipated premium erosion due to the principal paydown for the month. Ignoring present value, the roll is determined by the equation:

$$\text{Dollar roll} = \text{coupon} + (\text{amortization} + \text{prepays}) * (100 - \text{TBA price}) - \text{financing cost}$$

Note this equation is identical to the carry calculation for MBS.

- With the TBA coupon and amortization fixed, the dollar roll price, CPR and the financing cost become interdependent: any combination of two implies a third. Rising financing costs generally imply a decrease in the drop. For premium TBA, faster prepayments decrease the roll, with the effect reversed for discounts.
- On the front-month settle, the roll seller delivers MBS and remains long the back-month contract. The roll seller retains the MBS price risk during the month. The roll seller retains the bulk of the risk of the MBS, so retains the economic returns as well.
- The roll buyer takes delivery of the MBS but retains a short TBA position, which eliminates price risk. The roll buyer has to repurchase MBS to replace principal paydowns, so bears the risk associated with the current month's prepayments. This is typically small, and lacking market risk exposure, roll buyers generally earn just enough to break even on their financing costs.
- The roll buyer finances the MBS for the roll seller. Investors with lower financing costs should hold MBS, or buy the roll, while those with higher financing costs should sell the roll.



Dollar roll example: the carry trade

- If rates and volatility are unchanged, then back-month TBA price should converge to the front-month price over the course of the roll cycle, i.e. it will increase by the amount of the drop.
- In that scenario roll seller's P&L will equal the dollar roll. Thus, the roll is the equivalent to the monthly carry on TTB MBS. This makes rolls a key determinant of MBS relative value.
- Under the same scenario the roll buyer will earn just enough to break even.

Table 31: The carry trade: MBS investor earns the roll of 6+ net of financing costs while roll buyer earns nothing

Coupon = 3.5

Face = \$100mm, Paydown = \$1mm

Financing rate = Reinvestment rate = 170bps

Front-month full price, with accrued = \$103

Back-month full price, with accrued = \$102.25+, Drop = 6+

Spot TBA price as of back-settle = \$103

	Roll MBS		Hold MBS		Roll Buyer	
Cashflows, as of front-settle	Roll proceeds	103.00			Cash delivered	-103.00
	MBS delivered	-103.00			MBS accepted	103.00
Balance sheet, as of front-settle	Cash	103.00	MBS	103.00	MBS	103.00
Cashflows as of back-settle	Financing cost (170bps)	-0.15	Financing cost (170bps)	-0.15	Financing cost(170bps)	-0.15
	Interest earned (170bps)	0.15			Purchase 1mm Paydowns	-1.03
Balance sheet, as of back-settle	Cash delivered	-102.80			Cash for MBS delivered	102.80
	PV of MBS received	103.00				
P&L	MBS	103.00	PV of MBS, 0.99 face	102.03	PV of principal cashflow	1.03
	Cash	0.20	PV of principal cashflow	1.03	PV of interest cashflow	0.29
		0.20		0.20		0

Source: BofA Global Research



Breakeven financing, CPR, and roll specialness

- The dollar roll, prepayment rate, and financing rate are interlinked - fixing any two, we can solve for the third. CPR is a fundamental variable while financing rate and rolls are market prices.
- **Roll specialness** – difference between market observed roll price and a theoretical price at an assumed prepay rate and financing rate. When positive, investors are incentivized to roll MBS and the roll is *trading special* to given assumptions. Rolls can trade special for a number of reasons:
 - **Outsize demand for cash MBS** in the front-month, bids up the front-month TBA price. This can come from CMO desks needing collateral for new deals, or demand from a large balance sheet buyer, such as the Fed or a money manager.
 - **Collateral scarcity** in a front-month contract – when there are not enough bonds available to satisfy front-month delivery obligations the roll is bid up as the TBA shorts seek to avoid fail charges. Thus, contracts where the free float is thin tend to trade special. Collateral scarcity can also arise when a large investor is unwilling to roll bonds, for example due to replacement concerns or accounting considerations.
 - **Outsized selling** in the back-month – originators sell the back-month TBA reflecting supply.
 - **Ongoing TBA shorts (or MBS hedgers)** can drive up the roll as investors are forced to buy the roll every month. For example, holders of individual MBS CUSIPs or CMOs hedging with TBA unwind their front-month short and sell next month's TBA before each monthly settle.
- There is a limit to how special rolls can get. Recall that the failing party is effectively financing the bond and is on the hook for any CPR higher than the fail speed. Thus, if TMPG fail charge is 1%, the roll for a premium TBA shouldn't trade above the drop computed using -1% financing rate and the fail speed. Once the roll reaches that level the TBA short will choose to fail on delivery and pay the corresponding fail charges and penalties. In such cases roll is said to be *trading through fail*.
- **Breakeven (implied) financing rate** – This is the interest rate at which the investor is indifferent between rolling and taking delivery at a given CPR and market observed roll price. This is the effective financing rate for the TBA position which can be compared with repo cost for cash bonds. By bidding up the drop, roll buyers are effectively willing to finance the MBS cheaper. When trading special, breakeven financing rate is below market rate or even negative.
- **Breakeven CPR** – Market-implied prepayment speed for TTB pools from the observed roll and financing cost. Specialness biases breakeven CPR lower for premiums and higher for discounts.



Dollar Roll Analysis on Bloomberg: RA

Chart 128: Bloomberg RA screen calculates the implied drop, financing rate, or prepayment speed with two out of three inputs

FNCL 3.5 3/20 103-12 - 01 / Prev 103-13 TRAC												
At 26 Feb Op 103-12 Hi 103-15 Lo 103-10+ Yield 1.899/1.899 BAM LOAS 51.3												
FNCL 3.5 3/20 Settings					Roll Analysis							
US TBA 4.559(342)14 CUSIP 01F032633												
Std. Settlements 3/12/20 4/15/20 5/13/20 6/11/20					Factor Date 2/2020							
Roll Analysis		Cashflows										
Mortgage Data Net 3.5 Gross 4.559 Original Term 30y 0m Remaining Term 342 28y 6m Balance 1,000,000.00 Stated Delay 54					Default Pricing Imm. Price 103-12 Forw Drop - 0 $\frac{1}{2}$ 1/32s Forw Price 103-11 $\frac{1}{2}$ Reinv Rate 1.581 Prepayment 39.21 CPR		Settlement Dates 03/12/20 04/15/20		Evaluation of Arbitrage B/E Fin Rate 1.600 Solve For Prepayment Speed ARB \$/MM -18.57 32nds -0.06 BP -2			
Mortgage Roll Cost At 103-12 1,033,750.00 Accrued 11 Days 1,069.44 Amount Invested 1,034,819.44 34 Days Interest 1,545.16					Continued Holding Future Value of Payments 44,911.80 Remaining Principal: 957,985.14 at 103-11 $\frac{1}{2}$ 990,167.45 Accrued 14 Days 1,303.92							
Total Future Value 1,036,364.60					Total Future Value 1,036,383.17 Dollar Advantage 18.57							
Prepay History	Feb20	Jan	Dec	Nov	Oct	Sep	Aug	Jul	Jun	May	Apr	Mar19
1M CPR	37.2	37.8	39.8	52.0	51.6	42.3	11.2	12.5	12.6	11.0	6.7	4.7
3M CPR	38.3	43.6	48.0	49.3	47.0	35.9	8.0	12.3	10.4	7.5	5.0	3.9
6M CPR	44.1	45.3	43.1	40.0	33.4	24.6	5.4	8.7	7.2	5.5	4.3	3.8

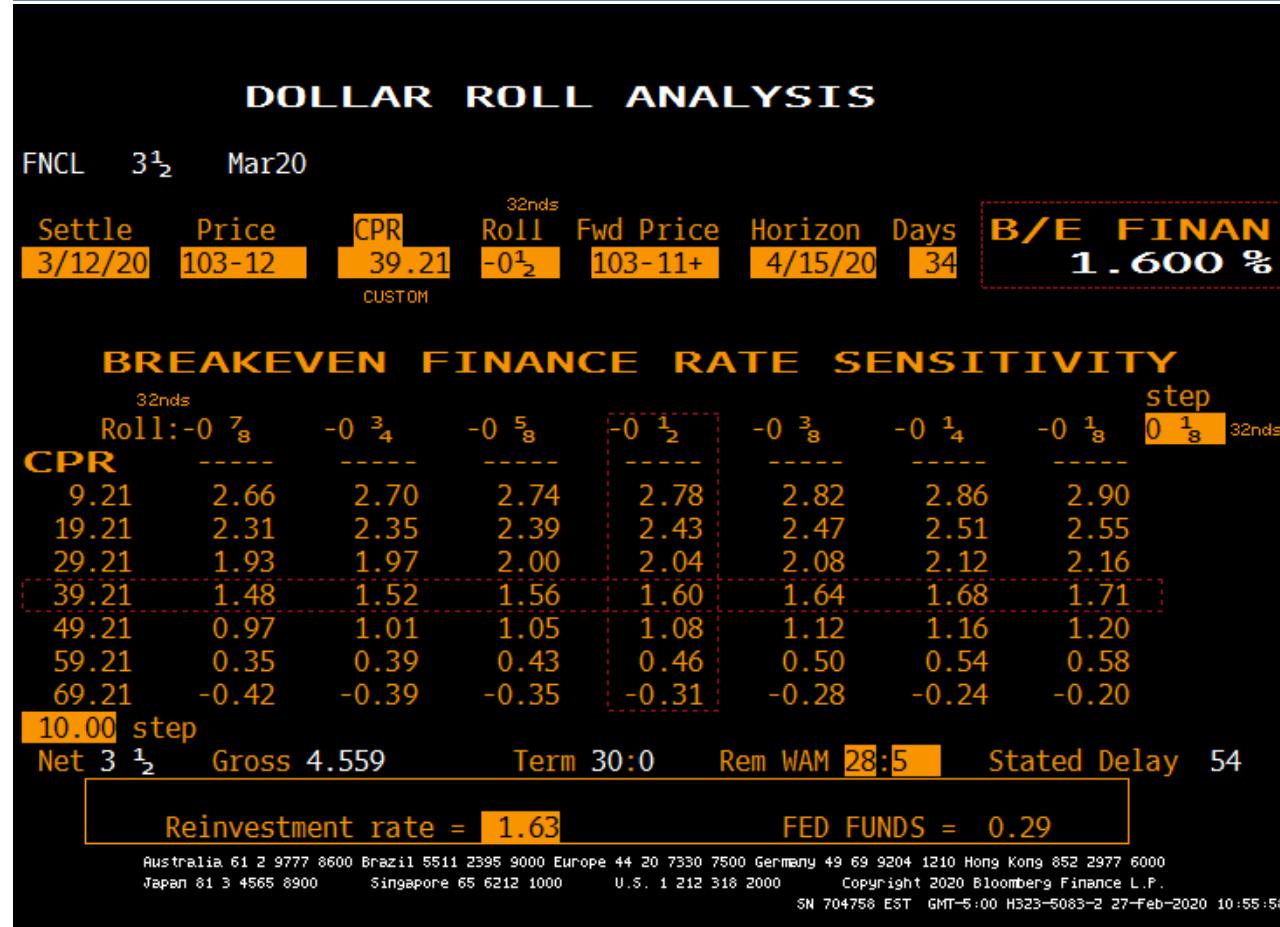
Australia 61 2 9777 8600 Brazil 5511 2395 9000 Europe 44 20 7330 7500 Germany 49 69 9204 1210 Hong Kong 852 2977 6000
 Japan 81 3 4565 8900 Singapore 65 6212 1000 U.S. 1 212 318 2000 Copyright 2020 Bloomberg Finance L.P.
 SN 704758 EST GMT-5:00 H323-5083-2 27-Feb-2020 10:53:39

Source: Bloomberg



Breakeven Finance Scenarios: RAM

Chart 129: Bloomberg RAM screen offers scenario analysis for dollar rolls



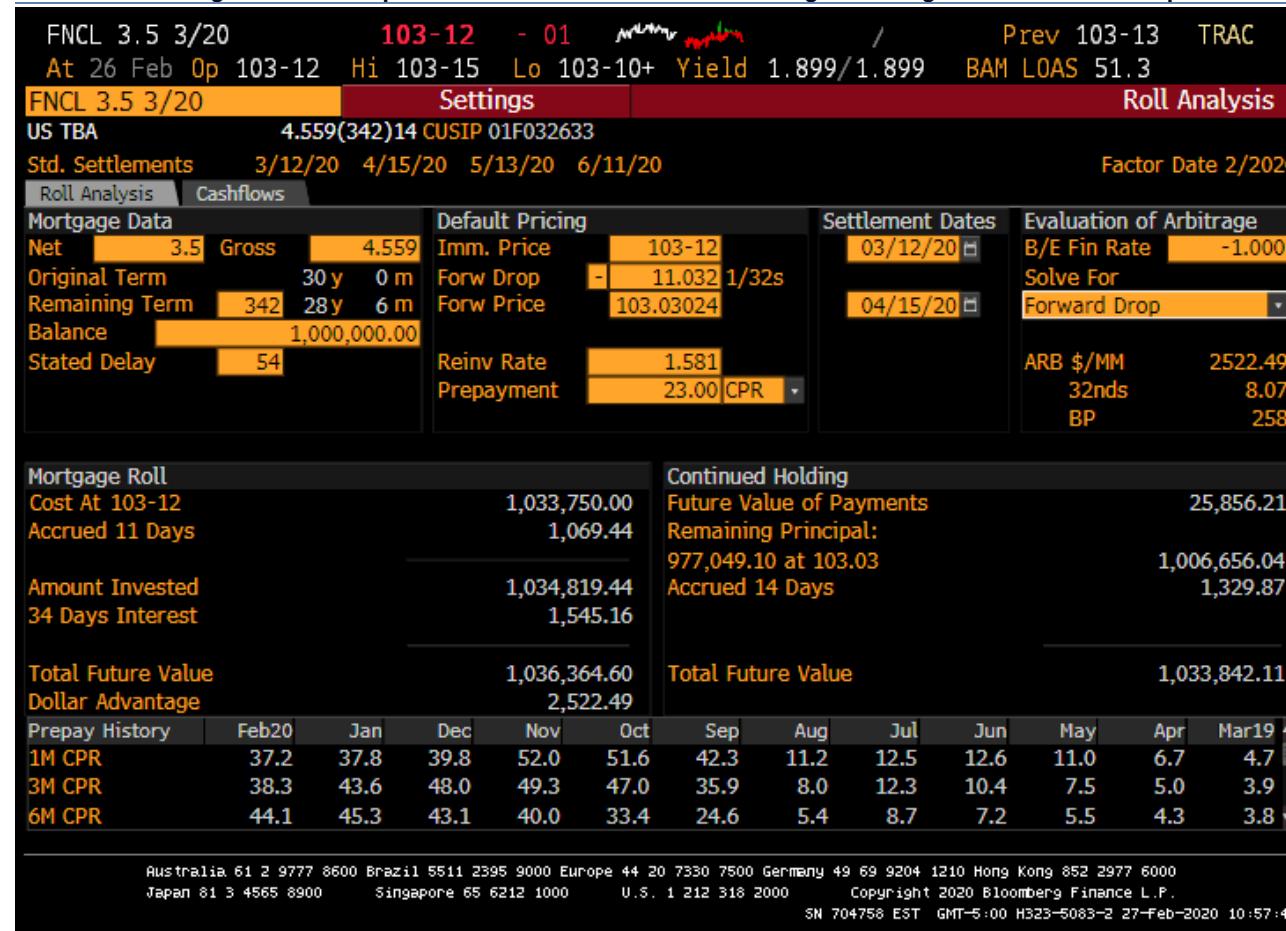
Source: Bloomberg



Finding a ceiling for the dollar roll

- Recall that the failing party effectively funds the security since it is liable for all principle and interest payments. It is also liable for CPR claims if the delivered premium bonds prepay faster than the generic coupon cohort. Finally, it will pay the TMPG charge.
- Thus, rolls won't trade above the implied drop computed using the fail speed, and funding equal to -TMPG charge. The Bloomberg RA screen can be used to compute this value.

Chart 130: Bloomberg RA solves the implied fail level of 11 ticks for the roll assuming TMPG charge of 1% and 23 CPR fail speed



Source: Bloomberg



Dollar rolls: theory versus practice

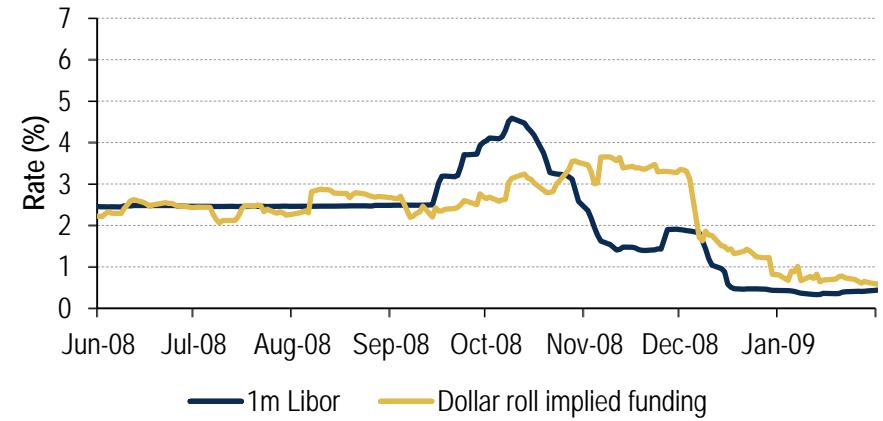
- Dollar roll specialness is one potential way to beat the aggregate MBS index. Indices assume the MBS is held by the investor, tracking actual cashflows for returns. When rolls trade special, TBA investors earn higher returns than cash bonds: 1 tick of specialness over the course of the year adds approximately 38bps to returns. Roll specialness, while technical in nature, is missed in OAS models, biasing OAS to underestimate realizable returns. Cash bonds do not realize these gains; they are only accessible by trading in the TBA market.
- Deliverable risk, uncertain funding costs, near-term prepayment risk can all distort efficient roll pricing.
- MBS funding costs implied by the dollar roll generally follow other short-term rates, such as 1m LIBOR. However, distortions can occur. For example, after Lehman Brothers went bankrupt in September 2008, LIBOR spiked as credit risk got priced in amid bank counterparty fears. As LIBOR normalized in the wake of TARP, ongoing deleveraging in the banking system raised funding costs for every capital intensive asset, including MBS. Dollar rolls remained depressed, implying elevated funding rates into 2009.
- Another notable distortion happened in the late Summer of 2018. As the Fed stepped up the pace of balance sheet unwind, MBS investors, and in particular money managers, had to absorb and fund a record number of bonds, putting pressure on dollar rolls. Unlike repo, money market funds are typically unable to lend in the dollar roll market given the forward nature of the transaction, and could not provide relief.

Chart 131: MBS rolls traded special during much of QE3, boosting actual returns



Source: BofA Global Research

Chart 5: MBS funding decoupled from LIBOR during the financial crisis



Source: BofA Global Research



Normalizing dollar roll pricing

- Rolls are often used as a proxy for TBA carry, and as a relative value metric. While implied CPRs and financing rates can be compared directly, care needs to be taken when comparing rolls of different roll cycles, Fannies with Ginnies, or when comparing to carry of other assets, such as rate hedges.
- Roll periods differ in the number of days, and therefore incorporate different financing costs when funding cost is above zero. All else equal, financing cost is a function of the number of days in the roll cycle:

$$\text{Financing cost} = \text{financing rate} * \text{full price} * \# \text{ of days in the cycle}/360$$

where the rate is calculated using the Actual/360 convention, such as LIBOR. To normalize this funding cost to 30 days the following adjustment needs to be added to the roll:

$$30\text{-day financing adjustment} = \text{financing rate} * \text{full price} * (\#\text{of days in the cycle}-30)/360$$

- Rolls also incorporate the difference in accrued interest, contingent on the exact settle dates in the dollar roll, which are subject to weekends and holidays. Since MBS accrues interest from the first of the month the contribution of this to the roll is :

$$\text{Accrued roll impact} = 100 * \text{coupon} * (\text{Back-settle day of month} - \text{Front-settle day of month})/360$$

- To make rolls comparable, we can assume that the settle dates are always on the same day of the month, effectively backing out the accrued roll impact above, and adding the financing adjustment.
- When comparing the carry on MBS to other assets, such as USTs, it's important to adjust for the implied path of forward rates. The reason for this is that carry typically reported for USTs and swaps is computed at spot funding levels, while dollar rolls imply funding from front- to back-month TBA settle. For example a 25bps Fed hike on TBA settle date 15s days out would drive the roll lower by $25\text{bps} * \#\text{days} / 360$. Meanwhile 30-day UST carry only reflects funding that is 12.5bps higher. One can either adjust the financing cost for the roll by 12.5bps or the USTs to make the numbers comparable.

Table 32: Hypothetical examples of \$105 priced FN 4 roll – adjusted 30-day roll is the same despite significantly differing observed levels

Front-month settle date	Back-month settle date	# days	Forward 1mL	Observed Roll (ticks)	Financing Cost Adjustment (ticks)	Accrued roll impact (ticks)	Adjusted 30-day Roll (ticks)
13-Aug	13-Sep	31	1.75%	2.000	$0.16 = 32 * 1.75\% * \$105 * (31-30)/360$	$0 = 32 * 4 * (13-13) / 360$	$2.16 = 2 + 0.16 - 0$
13-Aug	11-Sep	29	1.75%	1.625	$-0.16 = 32 * 1.75\% * \$105 * (29-30)/360$	$-0.71 = 32 * 4 * (11-13) / 360$	$2.17 = 1.625 - 0.16 + 0.71$
13-Aug	15-Sep	33	0.00%	2.875	$0 = 32 * 0\% * \$105 * (33-30)/360$	$0.71 = 32 * 4 * (15-13) / 360$	$2.16 = 2.875 + 0 - 0.71$

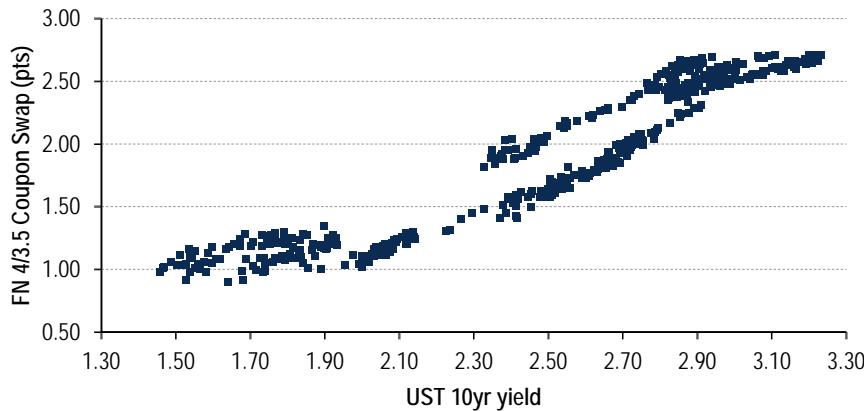
Source: BofA Global Research



Common TBA trade constructs: coupon swaps

- A coupon swap is a long TBA position hedged with another TBA of the same issuer, maturity, and settle date but lower coupon, used to express an up- or down-in-coupon view.
 - FNCL 4/3.5 swap: long \$100mm FNCL 4s, short \$100mm FNCL 3.5s
 - G2SF 4/3 swap: long \$100mm G2SF 4s, short \$100mm G2SF 3s
- The swap level is quoted as the difference between the two coupon prices. Higher coupons generally have faster prepayments and shorter durations. As a result, coupon swaps trade with negative duration – i.e., prices rise with rates. Curve steepness is also a driver of value – coupon swap has a built-in curve steepener since the higher coupon is exposed to the shorter end of the curve.
- Investors typically take a larger position in the higher coupon to construct a duration-neutral trade. Coupon swap performance is usually quoted on a duration-neutral basis.
- Relative carry directly factors into coupon swap pricing. Depending on speeds and rolls, coupon swaps may be positive or negative carry.

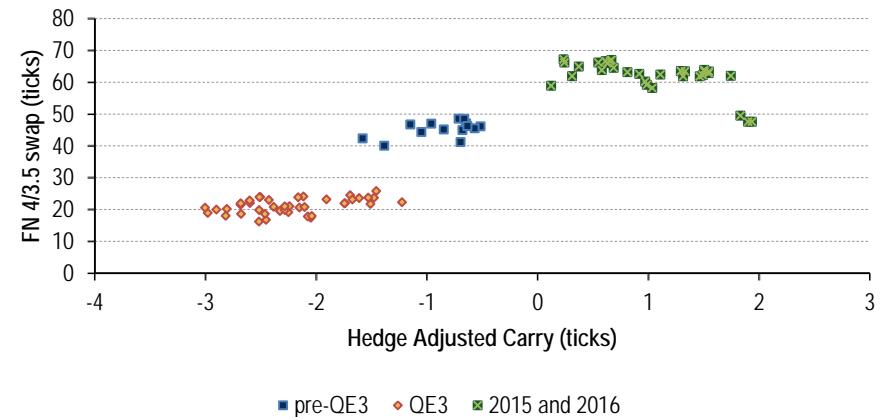
Chart 132: Coupon swaps are short duration due to the mismatch of durations of the two coupons



Source: BofA Global Research

Note: Data from 2017-2019

Chart 133: Each tick of carry worth 10 ticks in the coupon swap (1.63% - 1.73% 10yr UST range)



Source: BofA Global Research

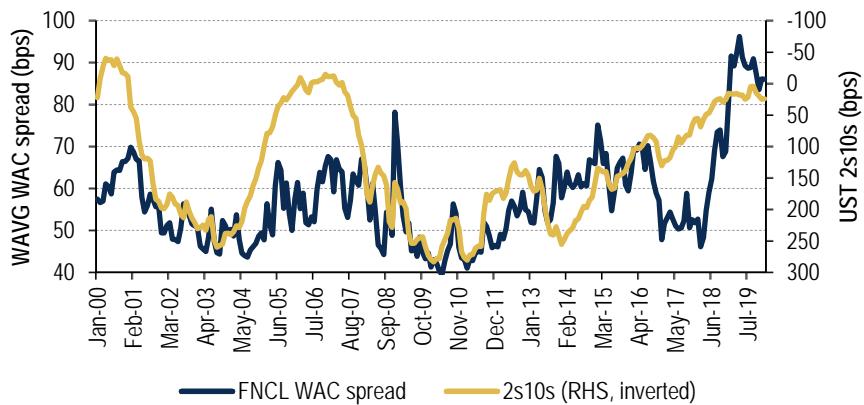
Note: Data from August 2012



Coupon swaps and WAC spreads

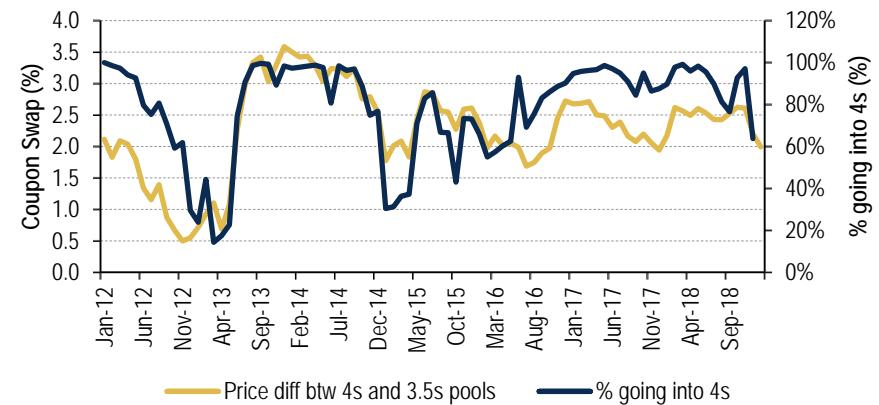
- Coupon swaps affect best execution, with narrower swaps favoring production of lower coupons, all else equal. Conversely, higher prices of the coupon swap, favors selling the loan into higher coupon pool.
- As a result, coupon swaps tend to inversely correlate with WAC spreads. By the same logic, the built-in curve steepener in the coupon swap implies that WAC spreads tend to rise when the curve is flat and the coupon swaps are narrow, and tighten when the curve steepens.
- Higher WAC spreads, in turn, increase prepayments all else equal, and thus, stand to lower the value of the coupon swap when the higher coupon is a premium.
- One example of this was in early 2019, as the GSEs increased buy-up/buy-down multiples, raising WAC spreads, which ultimately contributed to further collapse in the coupon swaps. Rising mortgage rates at the time also contributed to this, causing WAC spreads to hit peaks in early 2019. WAC spreads began to stabilize only after rates rallied, and prompted the introduction of the 112.5 WAC spread cap by the FHFA in June of 2019.

Chart 134: WAC spreads tend to be highest when the yield curve is flat



Source: BofA Global Research

Chart 135: % of 4.5% loans pooling into 4s vs. 3.5s is tied to the price diff between 3.5s and 4s



Source: BofA Global Research



Common TBA trade constructs: butterflies

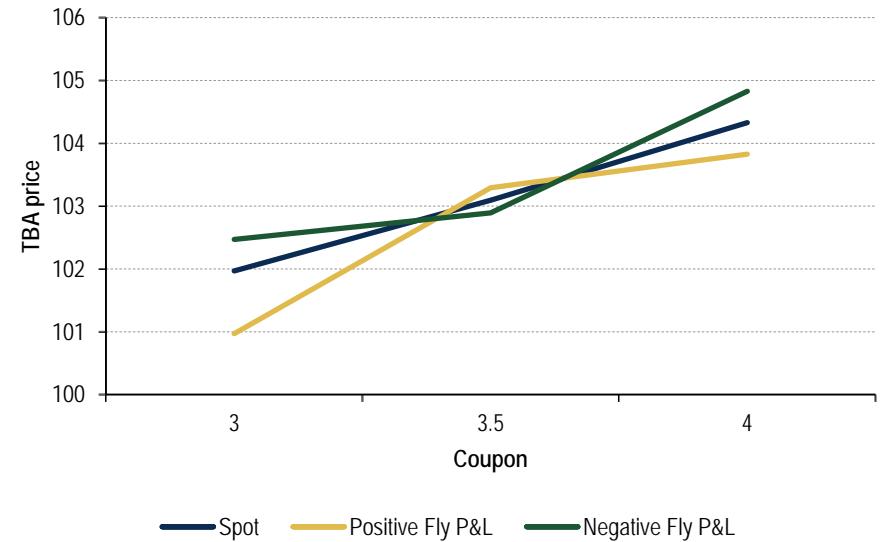
- Butterfly - a long and a short position in the two adjacent swaps around a given coupon.
 - FNCL 3.5s butterfly: long \$100mm 3.5/3 swap, short \$100mm 3.5/4 swap
 - FNCL 3.5s butterfly: long 200mm FNCL 3.5s, short 100mm FNCL 3s, short 100mm FNCL 4s
- 1:2:1 trade is approximately duration neutral, but may have some residual duration depending on the hedge ratios.
- Butterfly level is quoted as the cost of entering the 1:2:1 trade:
 - FN 3 at 101-31, FN 3.5 at 103-03, FN 4 at 104-10+ → 3.5 fly Price = $2 * 103-03 - 101-31 - 104-10+ = -0.03+$
- Butterfly is a way to bet on the relative performance of the fly coupon. Fly carry is a significant value driver, computed using the dollar rolls for the three TBAs.
- Alternatively, a fly is a view on the relative convexity of the coupon stack around the central coupon. The fly appreciates as the coupon stack grows more negatively convex. This is not necessarily the same as a bet on the negative prepayment convexity.

Chart 136: FN 3.5 fly trades with the observed carry; worth about 5-10 ticks per each tick of carry



Source: BofA Global Research

Chart 137: Fly is a bet on the convexity of the coupon stack prices



Source: BofA Global Research



Intermediates and 15s30s swaps

- Intermediate duration MBS are shorter-term fixed mortgages – 10yr, 15yr, 20yr, and 25yr

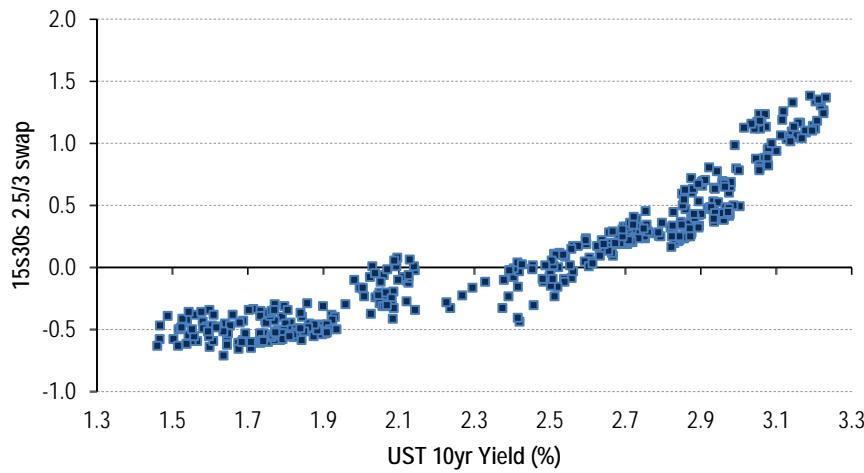
Table 33: Intermediates and 15s30s swaps

	UMBS			Golds		Ginnie
Agency	15YR	20YR	10YR	15YR	20YR	15YR
Ticker	FNCI	FNCT	FNCN	FGCI	FGTW	G2JO/GNJO
Outstanding (\$bn)	204	87	17	234	76	33/5

Source: BofA Global Research, as of Nov 2019

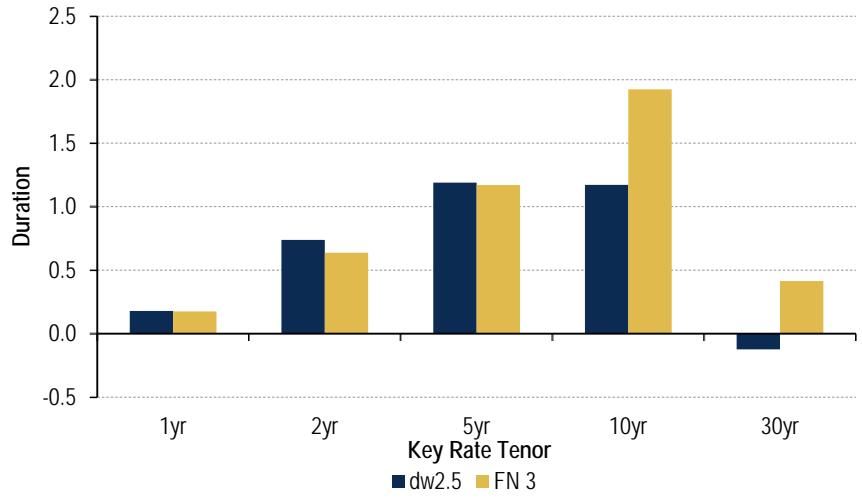
- 15s are the largest, most liquid and trade to their own TBA contract. 10-year pools are deliverable into 15-year TBA and 20-year pools are deliverable into the 30-year TBA contract, enhancing liquidity. 15yr Fannies, Golds, and Ginnies are referred to as *Dwarfs*, *Nuggets*, and *Midgets*, respectively.
- 15s trade on swap to 30s with prices quoted on a 1:1 basis. Typically, the 15yr coupon in the swap is 50bps or 100bps lower than the 30-year coupon to match up moneyness when the yield curve is upward sloping, i.e., dw2.5/3 or dw2.5/3.5 swaps are quoted.
- Due to differing amortization schedules, 15s30s swaps are short duration, short spread duration, and have a built-in curve steepener. Performance is quoted on a hedged basis.

Chart 138: 15s30s swaps are short duration (mid-2018 - 2019)



Source: BofA Global Research

Chart 139: KRDs of 15-year MBS are less exposed to the 10yr and 30yr



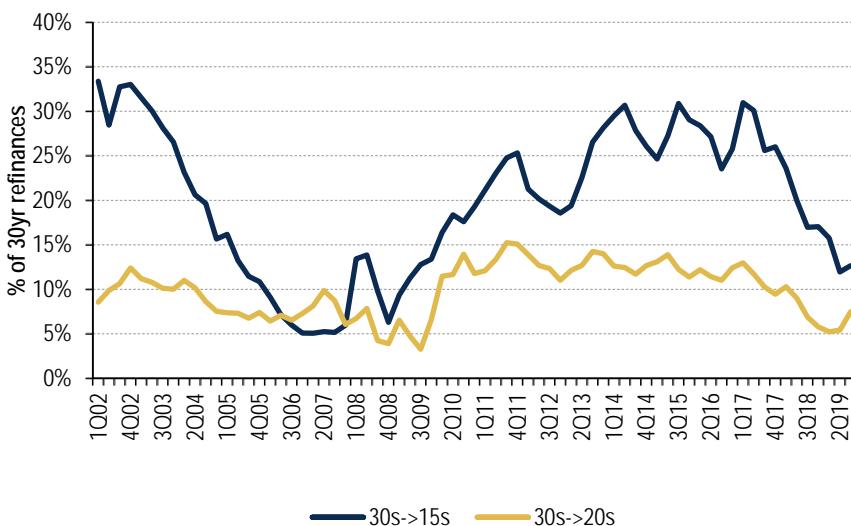
Source: BofA Global Research



Intermediates: supply, demand, and prepayment dynamics

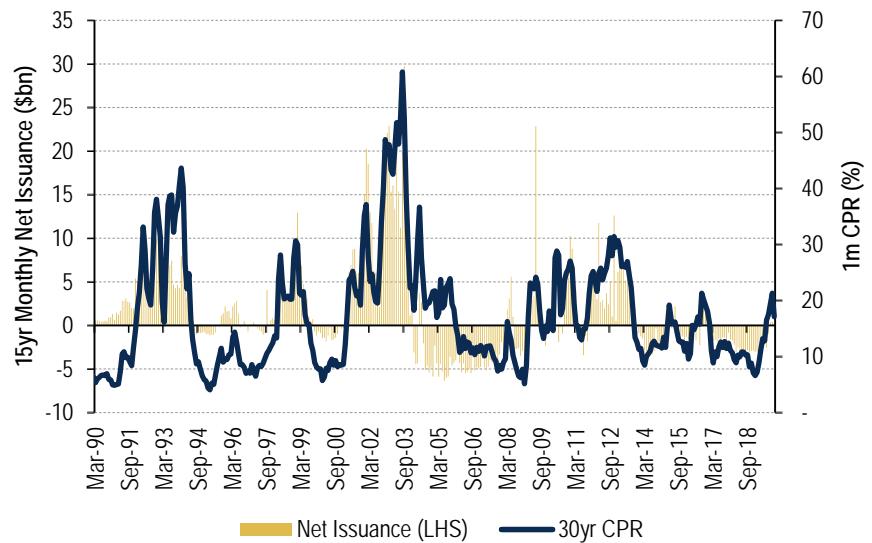
- Most intermediates are originated through refinancing. Purchase borrowers generally favor the longest 30yr terms to reduce monthly payments; seasoned borrowers often move to shorter terms when refinancing to avoid extending their mortgage obligation.
- These seasoned borrowers usually have better FICOs, lower LTVs, and lower loan balances.
- Issuance is also driven by curve steepness; when the curve is steep, there is more rate incentive to move into a shorter mortgage.
- As the remaining term shortens, speeds are driven by turnover and curtailments rather than refinancings as the bulk of the monthly mortgage payment becomes principal.
- With turnover playing a larger role and smaller loans, S-curves are generally flatter on 15s
- REITS, banks, money managers seeking shorter duration form the investor base for 15s and 20s

Chart 140: % of refinances into 15s increased post-crisis as borrowers deleverage, and has recently decreased back to 2005 level



Source: BofA Global Research, FNMA

Chart 141: 15yr net issuance closely tracks 30yr CPR



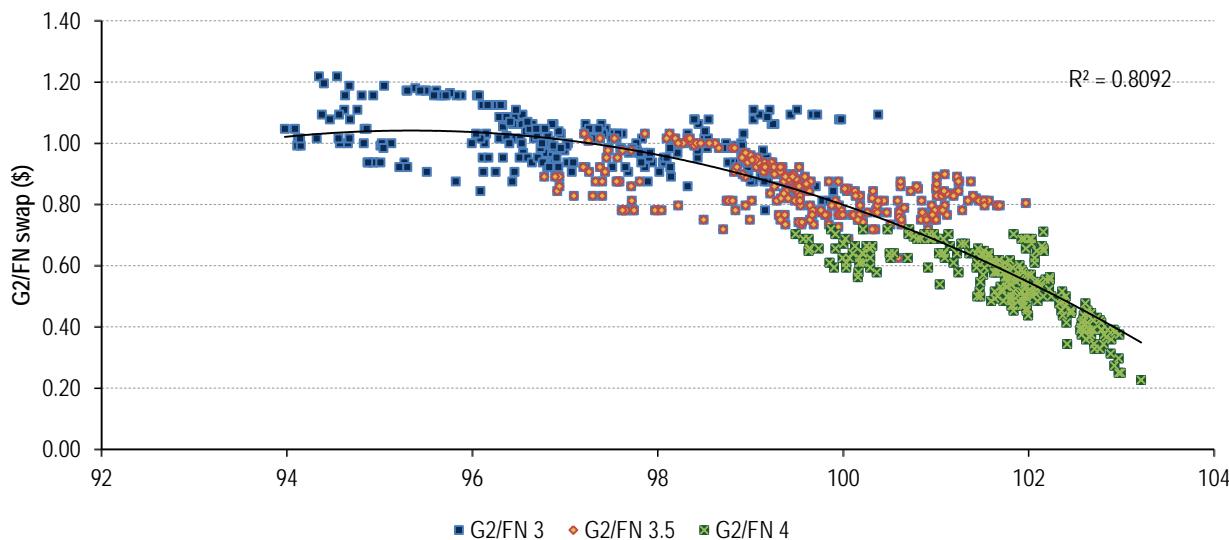
Source: BofA Global Research, FNMA



Common TBA trade constructs: G2/FN swaps

- GNMAs are often traded and quoted on swap to the more liquid Fannies. The G2 program is the dominant pooling choice today evidenced by issuance volumes. G2/FN swaps are quoted on a 1:1 basis, as a price difference between G2 TBA and FNMA TBA for a given coupon.
- GNMAs are the direct obligation of the US Government, therefore enjoy the sovereign guarantee, 0% risk weight, and liquidity treatment comparable to Treasuries. Because of this, swaps usually trade positive. However, swaps have inverted at times in the past, mostly due to prepayment differentials.
- Relative rise of non-bank issuers in GNMAs, higher buyouts due to the inferior credit profile and presence of modified loans, increasing VA shares, and 2015 MIP cut all bias GNMA speeds faster. As a result, G2s have shorter durations and G2/FN swaps trade with negative durations. Faster speeds also erode carry for the premiums.

Chart 142: G2/FN swaps exhibit negative duration in 2018-2019 since Ginnies had higher baseline speeds



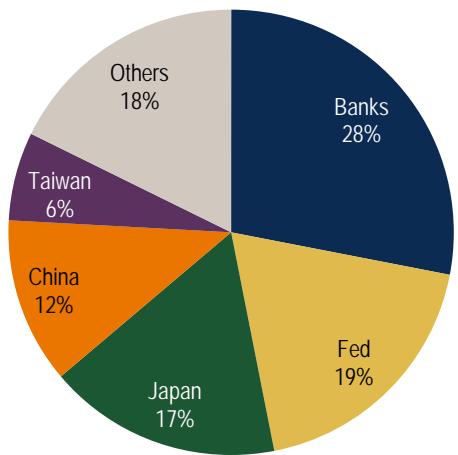
Source: BofA Global Research
Data covers mid-2018 to mid-2019



Other factors driving G2/FN swaps

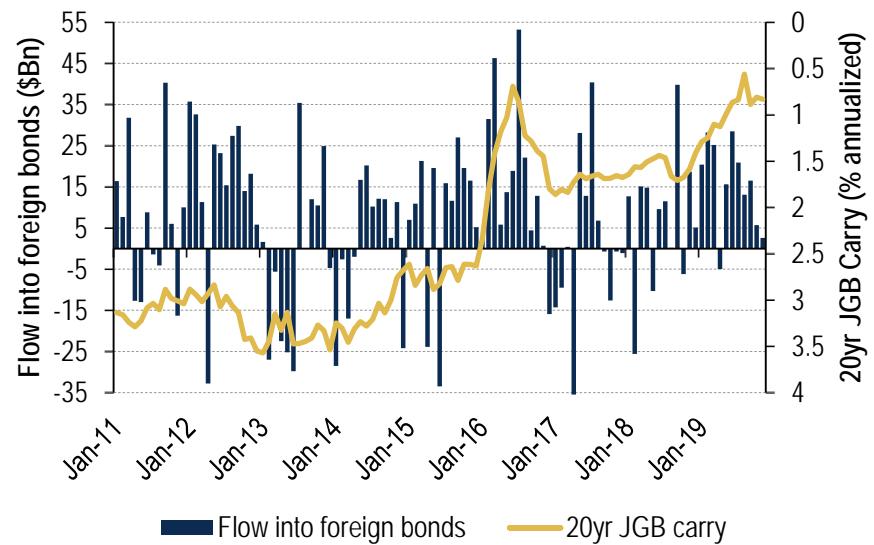
- Full faith and credit guarantee makes GNMA's attractive to foreign investors and central banks. Japan, China, and Taiwan all have substantial Ginnie Mae holdings and comprise a meaningful portion of flows.
- This exposes G2/FN swaps to unique risks associated with these borrowers, for example, currency hedging costs and global opportunity costs. For instance, Japanese life insurance companies prefer to hedge the forex currency when the Yen is weak, given lower buying power, and vice versa.
- GNMA is also preferred by banks, due to better capital and liquidity treatment. Thus, the swaps are driven by the dynamics of bank demand and LCR needs.
- Both sets of these investors tend to slow the pace of GNMA purchases when market volatility spikes, pushing the swaps lower. On the other hand when present in the market these buyers can dominate flows, pushing swaps beyond levels pointed to by relative value metrics.

Chart 143: GNMA holding structure heavily skewed towards overseas and banks



Source: Fed Z1, TIC, BofA Global Research, as of 3Q19

Chart 144: Japanese purchases of foreign bonds increase as JGB carry declines

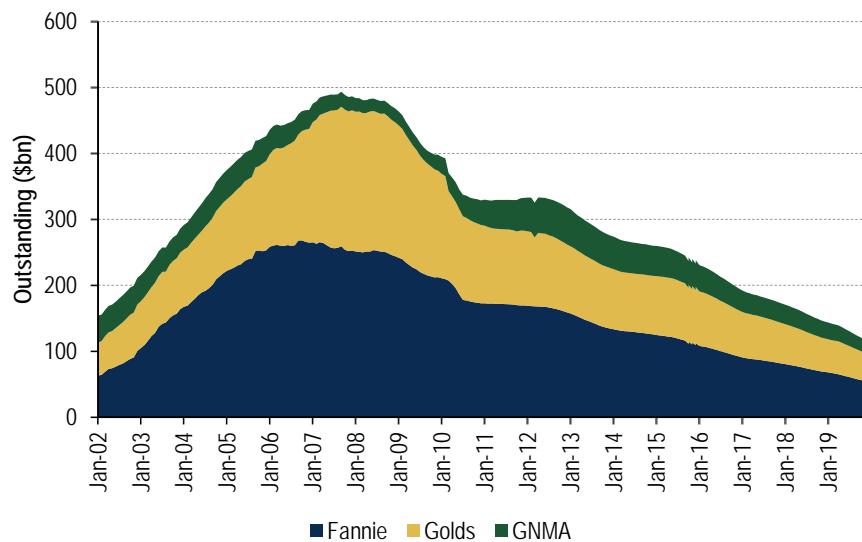


Source: BofA Global Research, Bloomberg

ARMs

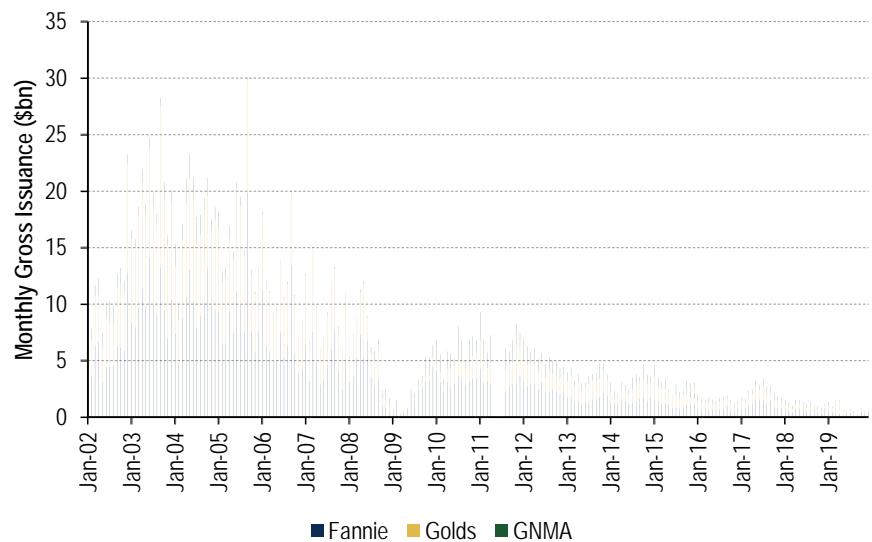
- Adjustable Rate Mortgages (ARMs) – borrower payment fluctuates with a floating rate index rather than fixed for the entire term. Typical products are *hybrids*, on which the rate and payment is fixed for a defined term, then begins to float, resetting indexed to a benchmark short-term rate subsequently.
- ARM borrowers face interest rate risk in exchange for a lower rate in an upward sloping yield curve environment. Like intermediates, these products offer a larger advantage in a steep curve environment. Unlike the intermediates though, amortization schedule remains at 30-years resulting in a lower monthly payment, increasing affordability.
- ARMs do not strictly trade through TBA contracts and dollar rolls do not apply. However, new issue production is sold on a forward basis by the large originators, before the pools are created similar to TBA.
- The Agency ARM sector is \$110bn in size and has been declining steadily post-crisis. Tighter underwriting standards are partially to blame, as are the borrower risk preferences.

Chart 145: GSE ARM balances have been on a steady decline post-crisis



Source: BofA Global Research, FNMA, FHLMC, GNMA

Chart 146: ARM gross issuance has declined post-crisis to under \$1bn per month



Source: BofA Global Research, FNMA, FHLMC, GNMA



Features of ARMs

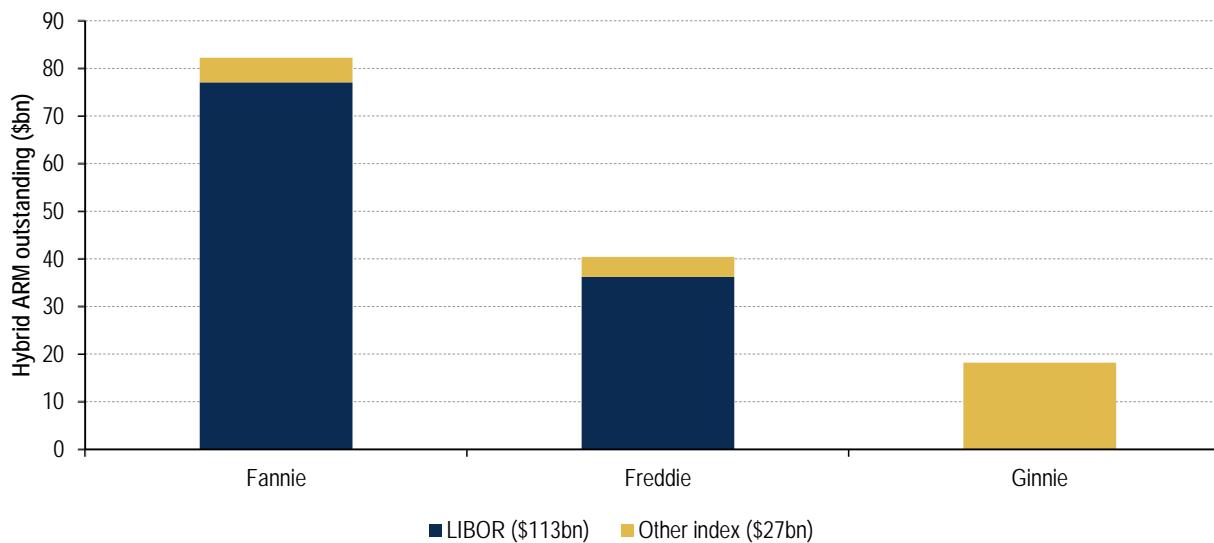
- Most common agency ARMs are 30-year 3/1, 5/1, 7/1, and 10/1 ARMS that are fixed for 3-, 5-, 7-, and 10- years respectively before beginning to reset annually. For example FN 2.25 5/1 LIBOR ARM with a *net margin* of 1.6% is fixed at 2.25% for 5 years, then pays 1mL + 1.6%. A borrower in that pool pays 2.90% for five years and resets to 1mL + the *gross margin* of 2.25%.
- A lookback period, typically 45 days, is used to determine the value of the index at reset. 1yr LIBOR is most common for GSE issues, while 12m CMT is popular for GNMA issues.
- Since the duration of a post-reset ARM floater portion is short, total durations are much shorter than 30yr MBS. Durations are largely driven by the length of the introductory fixed period. 30-year amortization schedule results in comparable spread durations to the 30yr fixed MBS.
- ARMs include three embedded caps on rate resets – *first reset cap*, *periodic cap*, and *lifetime cap*. For example, 2/2/5 cap limits rate increases to 2% on first reset, 2% at each periodic reset, and by up to 5% total over the lifetime of the loan. For example, rate for a borrower with a 2/2/5 structure and 2.90% fixed rate go up to 4.90% on first reset, at most 2% per reset subsequently but never higher than 7.90%.
- Due to the embedded cap structure, an investor is short a series of interest rate caps to the borrower, adding some net positive duration and reducing the post-reset value of the bond. The floater investor benefits from a floor, typically set at the net margin of the pool.



ARMs and LIBOR transition

- Given the potential elimination of LIBOR in 2021 FHFA has instructed the GSEs to stop guaranteeing LIBOR ARMs by the end of 2020, with the application date cutoff of September 30 2020. SOFR is expected to be the index on ARMs to be introduced in 2H20. GSEs will also stop guaranteeing CMT ARMs sometime in 2021.
- For existing LIBOR ARMs, Agencies generally have the leeway to replace LIBOR, if it is eliminated. We expect the GSEs to follow the lead from the Chicago Mercantile Exchange (CME) on this, through which most interest rate swaps and Eurodollar futures are cleared, in order to ensure that MBS cashflows tied to LIBOR remain hedgeable.
- The original documents for the underlying hybrid ARM loans, also typically define what happens in the event that LIBOR is deemed unavailable. Most loan documents allow the holder of the loan to determine a comparable replacement index, generally the specific guaranteeing entity in the case of Agency MBS.

Chart 147: LIBOR indexed ARMs outstanding by Agency



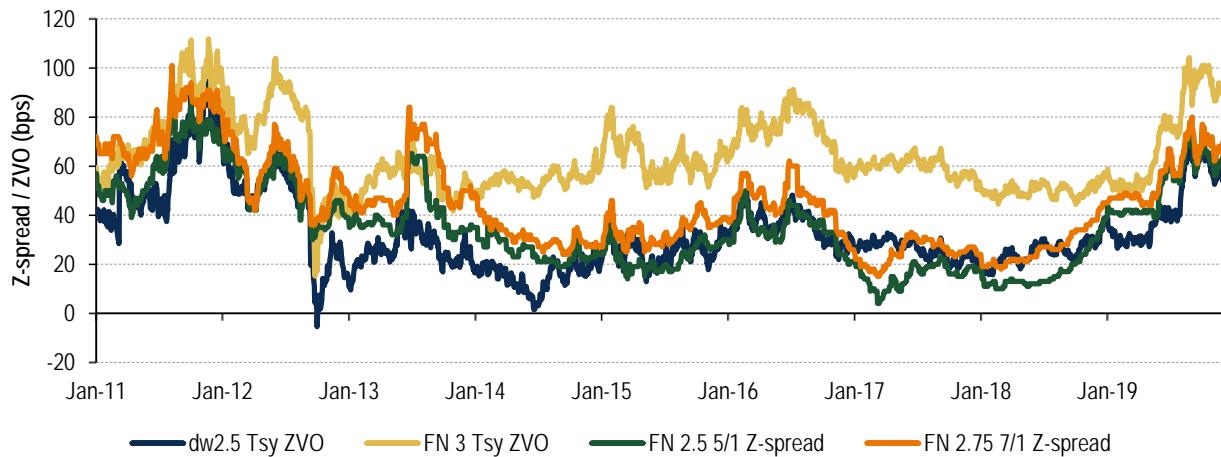
Source: BofA Global Research



ARM valuations

- The pricing convention for an ARM is a nominal Z-spread at 15 CPB to the Treasury curve. It assumes *constant prepayment balloon model (CPB)* - prepays at 15 CPR during the fixed rate period and a *balloon payment* of the entire remaining balance upon reset to the floating rate.
- Investors also rely on *bond equivalent effective margin (BEEM)* and the *discount margin (DM)* to value ARMs. Both measures are nominal spread to the ARM index, i.e., 1yr LIBOR. The difference is that BEEM is a semi-annual yield while the discount margin is pegged to the index. Unlike the Z-spread, there is no balloon prepayment assumed on reset.
- The floating portion of an ARM has considerable value since the net margin on the pool typically exceeds the discount margin for MBS floaters in the market. This price premium creates prepayment risk on the floater.
- ARMs are less liquid than 15-year or 30-year TBAs. Z-spreads generally move closely with the fixed rate TBA ZVOs of comparable moneyness but a spread between the two can persist at times due to technicals.

Chart 148: ARM Z-spreads over time, compared to fixed dwarf and Fannie spreads



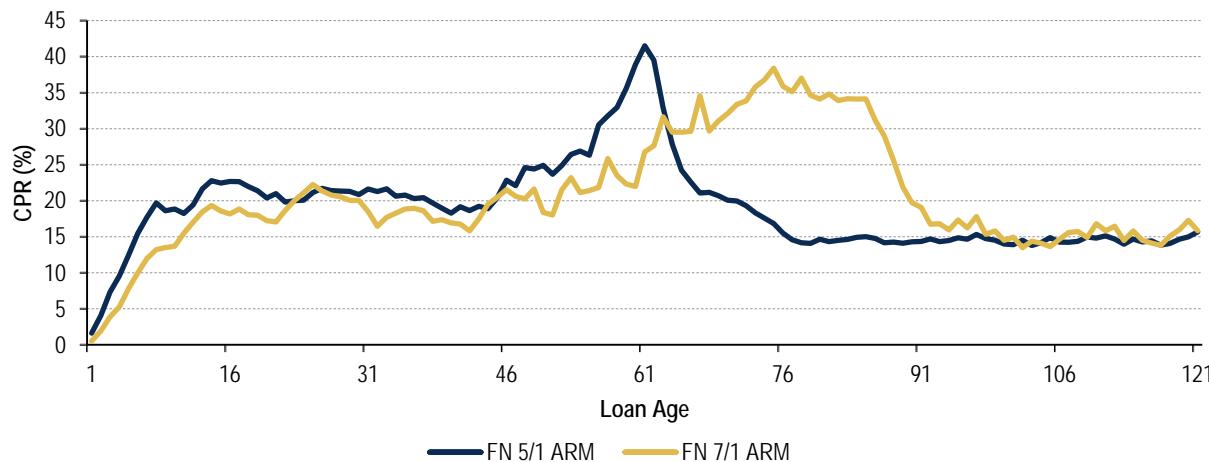
Source: BofA Global Research



ARM prepayments

- ARMs have a short six-month seasoning ramp, after which they tend to prepay at a relatively constant CPR.
- As the borrowers approach the first reset, prepayments tend to rise sharply. Borrowers prefer payment stability and refinance in anticipation of the reset to lock into another ARM or fixed rate mortgage. The amplitude of this spike is critical to the valuation of the tail, which usually trades at a premium.
- After the initial reset, speeds are driven primarily by turnover and term refis into 15s or 20s.
- Turnover in ARMs is elevated. Borrowers who don't intend to stay in the home indefinitely are incentivized to take out ARMs. They can usually obtain lower ARM payments without bearing the eventual reset risk since they don't plan to be around when that happens. Thus, taking out an ARM signals something about the eventual intention to move.

Chart 149: FN 5/1 at-the-money seasoning ramp (+/- 25bps of rate incentive, experience covering 2006-2016)



Source: BofA Global Research



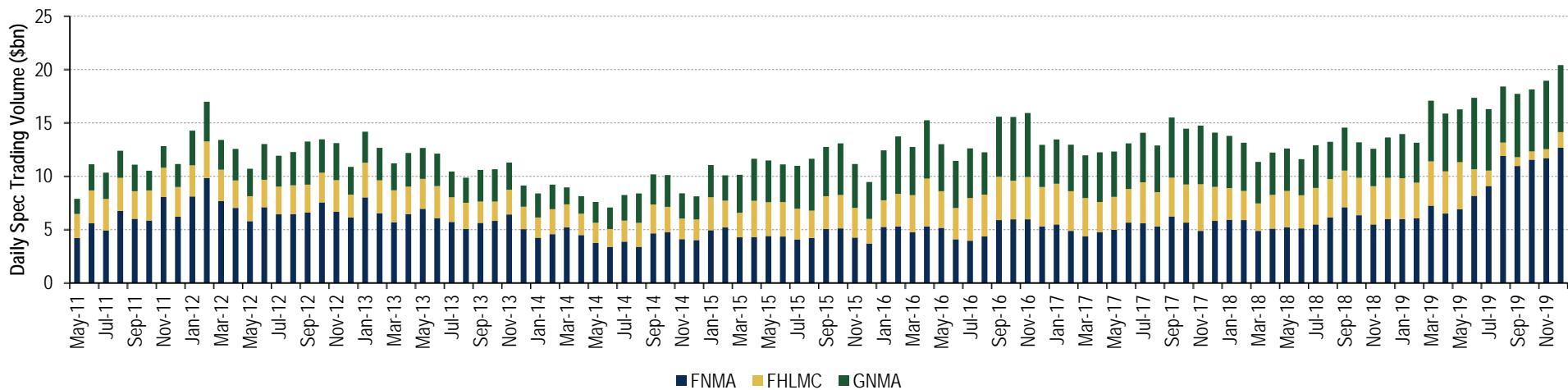
Specified pools



Specified pools

- Trading in individual MBS pools, each carrying a fixed pool number and a CUSIP, is dubbed *specified pool*, or *spec* trading. Pools commonly trade for TBA settle but can trade t+3.
- Pools that constitute the cheapest-to-deliver will be delivered into TBA and will rarely trade on a specified basis. Consequently, deliverable specified pools trade at a payup to the TBA. The option to deliver ensures a liquidity back-stop for them.
- Non-deliverable pools can trade back of the TBA reflecting undesirable prepayment characteristics or the lack of TBA deliverability which decreases liquidity.
- Since specified pools are not usually delivered into TBA, rolls are not available for financing. Therefore, specs are more directly exposed to availability of repo.
- The primary determinants of cheapest-to-deliver are the weighted average life, prepayments, and convexity of MBS, dictated by the underlying mortgage characteristics. Therefore, specified pools pricing and risk is usually defined by some mortgage feature, or prepayment story, that is key to valuation. For example, WALA > 36 months or maximum loan balance of \$85k.
- Specifieds trading at a payup typically offer better convexity profile: extension protection, prepay protection or both. Originators will pool the loans with desirable features separately by story in order to monetize the payup.

Chart 150: Specified pools have daily trading volumes around \$12bn, rising recently as TBA profile worsened



Source: TRACE



Specified collateral stories, a summary

Table 34: Specified collateral stories, a summary

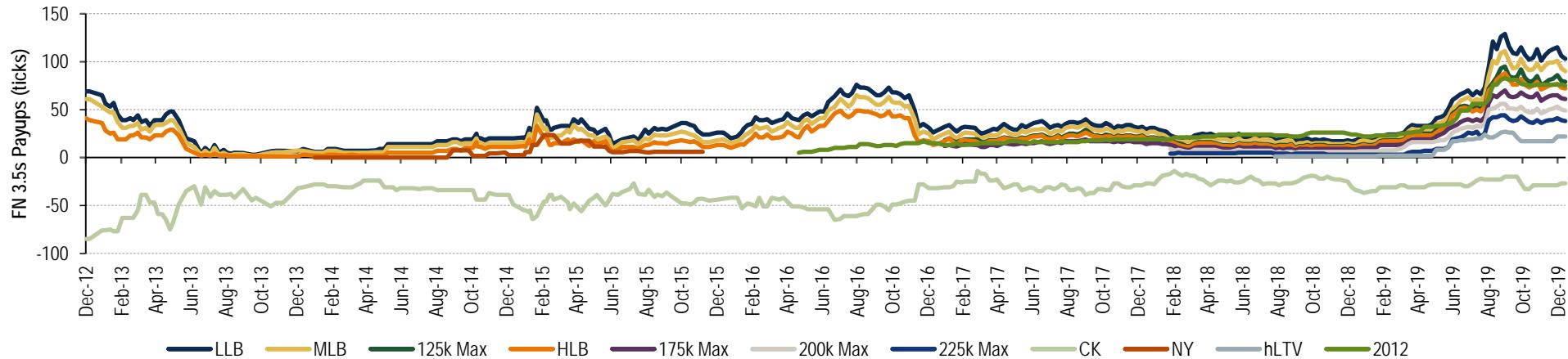
Collateral Story	TBA Deliverable*	Call Protection	Extension Protection	Story
Low loan Balance	✓	✓	✓	Smaller dollar savings, fixed refinance costs disincentivize prepayments on smaller loans. Smaller loans are also less profitable to originate, and the process is less streamlined. Lower priced homes experience higher turnover as borrowers trade up, creating extension protection.
New Production	✓	✓	✗	Turnover and refi seasoning ramps result in slower speeds for the first few months of the loan, boosting carry on premium coupons.
Seasoned (25+ WALA)	✓	✓	✓	Seasoned pools are burned out, reducing convexity. If sufficiently seasoned, they also have shorter amortization schedules protecting from extension. Pre-October 2017 loans are ineligible for HLRO refi.
Post-peak	✓	✓	✗	Solicitation and pooling restrictions can distort the seasoning ramp, resulting in a handful of pools comprising the TBA deliverable, with most others trading at a payoff. Particularly relevant in G2s.
Geography	✓	✓	✗	Better convexity profiles due to certain state-level taxes and policies.
Investor	✓	✓	✗	Investor loans face additional LLPAs and underwriting hurdles.
Low FICO	✓	✓	✗	Weak credit limits the borrowers' ability to secure a mortgage, results in higher LLPAs. Credit generally cures over time.
High-SATO	✓	✓	✗	Re-emerging story. These borrowers either do not shop for rates, or fail to qualify for automated underwriting.
High LTV	✓	✓	✗	High LTV borrowers face higher LLPAs. LTVs can cure over time due to rising home prices or loan amortization.
Housing Finance Authority (HFA)	✓	✓	✗	A subset of high LTV story. State HFAs provide credit to first-time, low-income borrowers, often via down payment assistance, tax credits, and reduced fee and MI requirements. Such borrowers typically face higher refinance frictions.
Jumbo	✗	✗	✗	Jumbos are the antithesis of the loan balance story. Dollar refi incentives are larger, i.e., faster refis or higher lock-in when out-of-the-money. They are not TBA deliverable and trade back of TBA.
Modified/ Reperformers	✗	✓	✗	Modified loans with extended terms lower payments, decreasing dollar refi incentive. Step-up mods have very low coupons for 5 years.
Low-WAC	✓	✓	✗	Pools with WACs below those of the TBA face lower refi incentives. Tend to trade when WAC spreads expand.
No-PIW pools	✓	✓	✗	Emerging story. Borrowers who received PIWs tend to prepay faster, imparting a payoff to non-PIW collateral.
10s / 20s	✓	✗	✓	These shorter term mortgages offer extension protection due to shorter amortization schedule. Payup depends on the curve steepness.
FHA	✗	✓	✗	FHA prepay are slower than VA in GNMA, commanding a payoff
Rural Housing	✗	✓	✗	RHS loans are ineligible for a conventional refi, and face few solicitations
RELOs	✗	✗	✓	Relocation loans are targeted towards employees who are transferred at their employer's request. They tend to exhibit higher turnover.
MHA/HARP an HLRO	Mixed	✓	✓	Not currently issued. Borrowers, who went through HARP, are ineligible for HLRO refi. HLRO borrowers can't take another advantage for 15 months.

Source: BofA Global Research



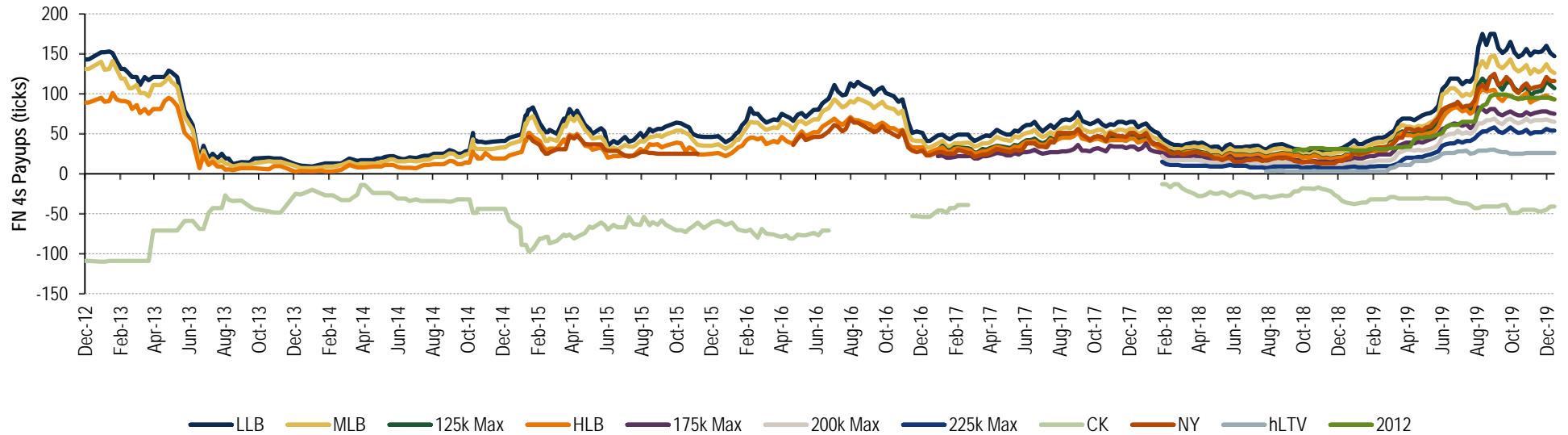
Historical payups by story

Chart 151: Historical FN 3.5s payups, by story



Source: BofA Global Research

Chart 152: Historical FN 4s payups, by story



Source: BofA Global Research



Specified pools versus TBA

- Trading TBA vs specs is akin to trading treasury futures vs. cash bonds. With TBA/futures, investors earn the roll along the way instead of collecting monthly cashflows.
- Specified pool portfolios can be used to craft custom carry and convexity characteristics for a portfolio, for example to better track the index or to increase carry versus TBA.
- Dollar roll financing, often cheaper than repo, is only available to TBAs, however.
- Since the TBA tends to be more liquid, specs are typically marked and traded based on a payup to the TBA bearing the same coupon. Specified pools have inherent *payup risk*, due to factors affecting the demand for the sector, or a particular story.
- TBA is often used as a hedge for specified pool portfolios to eliminate duration and basis risks. Alternatively, some investors treat TBA and specs as substitutes in the portfolio. Such investors are particularly exposed to the payup risk.
- Some MBS investors cannot, or choose not to trade TBA, and are thus fully invested into specs. They tend to look at the sector as basis.

Table 35: Advantages and disadvantages of specified pools versus TBA

Advantages of TBA	Advantages of specified pools
No payup risk	Ability to craft the desired risk and carry profile through specific stories
Better Liquidity	No deliverable risk due to specified CUSIPs
Price transparency, easier to hedge	Usually better convexity and carry versus cheapest-to-deliver bond
Dollar roll financing – no need for repo	Ability to trade payup stories with better convexity or carry profile
Ability to earn roll specialness	Margining agreement not required for corporate settle (T+3)
Ability to trade RV strategies - short positions, swaps, butterflies etc.	Usage decreases tracking error vs. the benchmark index, which has considerable exposure to seasoned MBS
Simplified line item management	
No idiosyncratic pool risk	

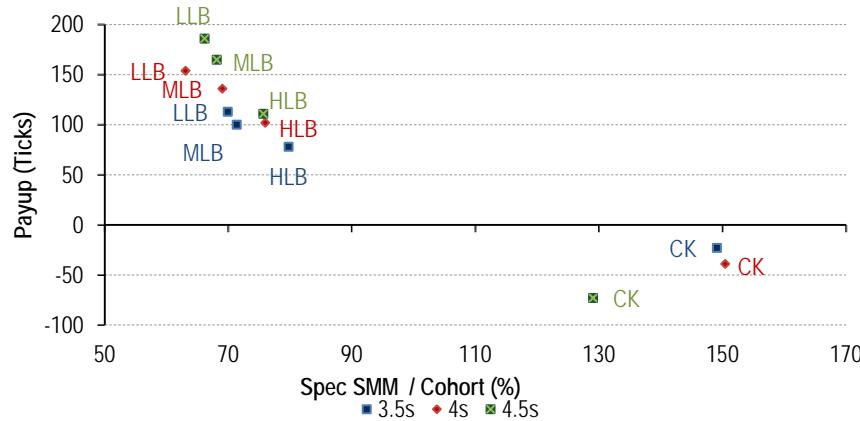
Source: BofA Global Research



Payup drivers and payup risk

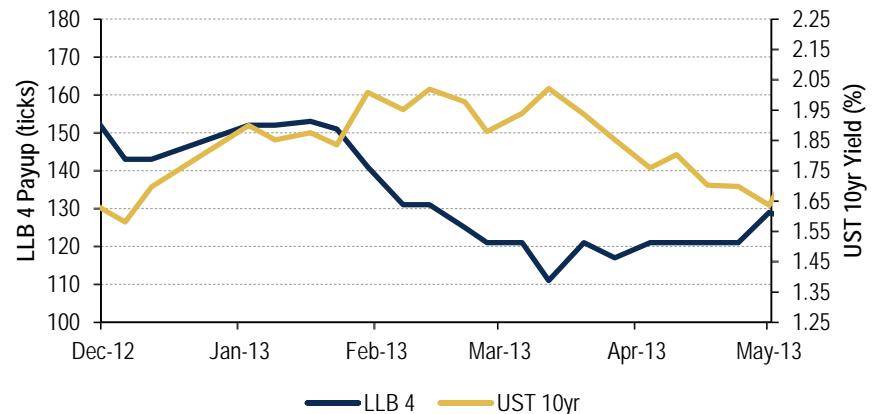
- Prepayments are key drivers of MBS carry and yield. For premium pools, longer average lives than the TTB TBA are generally valuable, while shorter bonds are desirable for discounts. Therefore, premiums with low prepayments generally trade at a payup as do discounts with high turnover. Relative prepayment speeds versus the TBA correlate to payups.
- Slower prepayments tend to increase duration. The duration mismatch between the TBA and the specified pools causes nominal payups to fluctuate with interest rates. Thus, payups have inherent durations. Typically, *payup risk* is defined as the residual risk to the nominal payup after this duration has been hedged. One of the most notable examples of payup risk was observed in early 2013, when payups collapsed even when rates remained little changed.
- Other than the spot prepayment differential, payups are affected by the relative shape of the S-curve versus TBA. Flatter S-curves imply better convexity, resulting in higher payups, and impart optionality to the payups. Thus, a pool that prepays similarly to the TBA can still command a substantial payup if it prepays slower into a rate rally, or has a limited extension risk profile.
- Deliverability is another payup determinant – the option to deliver into TBA is valuable, particularly in times of weak liquidity or when payups are low. Non-deliverable pools will trade back of deliverable ones, all else equal.

Chart 153: Payups are highly correlated to relative prepayment speeds



Source: BofA Global Research

Chart 6: Payup risk on display in early 2013 - payups drop 30 ticks, UST unchanged



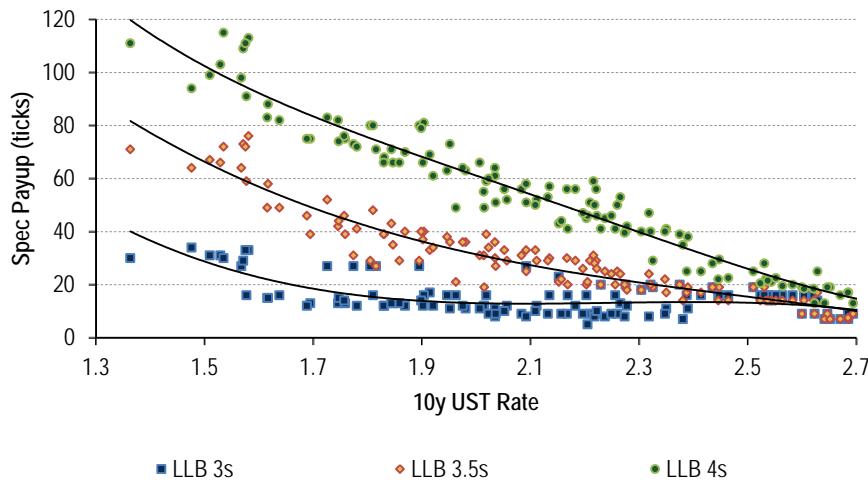
Source: BofA Global Research



Payout risk drivers

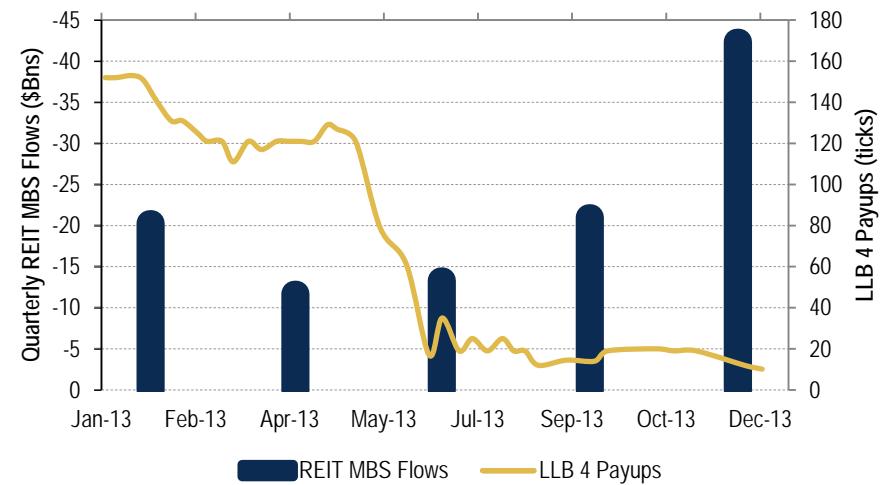
- **Fundamental changes** – when prepayment behavior changes for specs or TBA, so do payups. 2019 was notable for this, as TBA S-curves steepened relative to most specified stories, driving payups higher.
- **Realized convexity** – Specified pools often exhibit better convexity than the TBA. Thus, the payout, or the specified pool hedged with TBA, tends to have positive convexity. Deliverability option also adds positive convexity as payups on TBA deliverable pools can't go negative.
- **Relative funding costs** – TBA funding is implied by the dollar roll while specified pools are funded on repo. When specialness rises and the front-month contract is bid up, the carry on TBA rises relative to cash bonds. The higher carry on TBAs decreases the appeal of the specified pool, lowering the payout.
- **Deliverable risk** – TBA deliverable change can alter the relative carry profile of a specified pool.
- **Technical drivers** – Specified pools are less liquid than the TBA, with supply and demand shocks having the potential to affect payups.
- **Mismatched volatility exposure** – Flatter S-curves on most call protected stories imply lower volatility exposure. Thus, rising volatility tends to increase the payout.

Chart 154: Payouts are long convexity and vol – non-linear to rates



Source: BofA Global Research

Chart 155: REIT unwinds in 2013 contributed to the payout collapse



Source: BofA Global Research



Specified pools are exposed to their investor base

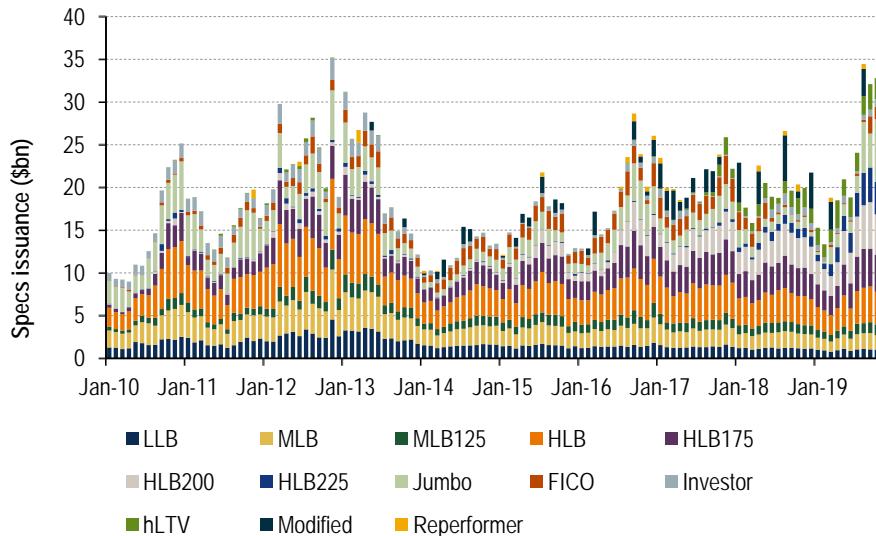
- **Index money managers** – TBAs reflect performance of the cheapest-to-deliver bonds, with roll specialness often a significant contributor to performance. On the other hand, US mortgage indices typically track the broad performance of all cash bonds. Thus, passive index money managers can make their portfolios more representative of the index by purchasing specified pools. Using specified pools also decreases the reliance on the roll and roll specialness for returns, further reducing tracking error.
- **Mortgage REITs** – These leveraged entities invest specifically in mortgages assets. TBAs, considered derivative instruments, can only comprise a limited portion of the portfolio income in order to qualify for tax-free REIT status. Moreover, REIT portfolios are required to hold a certain minimum amount of *whole pools*, i.e. a REIT has to own the entire MBS pool. Both of these restrictions result in specified pool demand. Inherent leverage combined with the desire to reduce earnings volatility further pull REITs towards stories where cashflows are more predictable and convexity reduced.
- **Active money managers and hedge funds** – Opportunistically express views on rates and speeds using specified pools. Leveraged players also gain exposure to the mortgage market with some protection from MBS convexity.
- **Dealer CMO desks – Collateralized Mortgage Obligations (CMOs)** are structured cashflows backed by mortgages. CMO desks are active in specified pool sectors, as they seek specific prepayment profiles to construct tranches with bespoke characteristics desired by CMO investors.



Specified pools, supply and origination

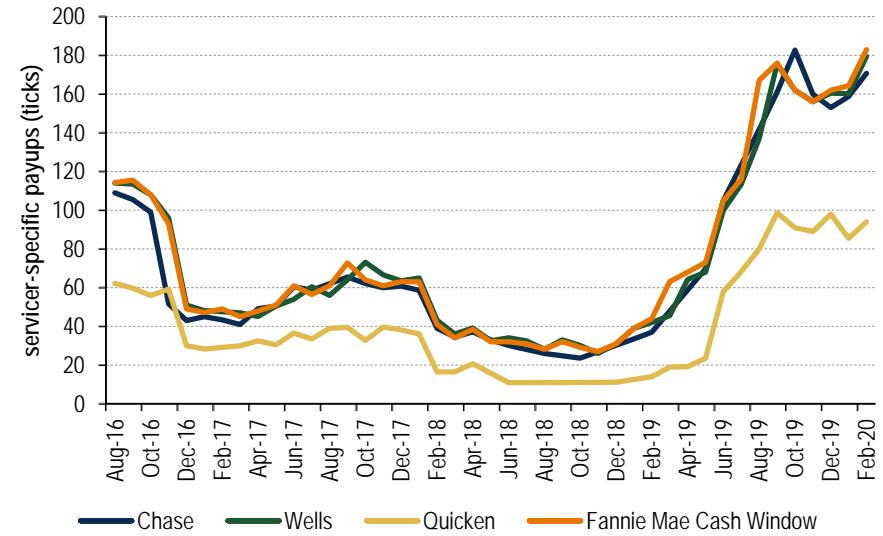
- New issue specified pools are sold by originators on a monthly origination cycle for TBA settle. This flow comprises a significant portion of trading volumes and drives benchmark pricing.
- Originators and the GSE cash windows strategically pool the month's production of mortgages to maximize their profits. Widely traded specified stories traded at a payup (loan balance, hLTV, geography) end up pooled separately to lock in a payup above the TBA. The remainder, if any, is pooled into generic bonds for delivery into TBA. Generic new production tends to be commingled in a multi-lender major.
- Pooling into a separate GNMA II pool creates non-deliverable customs. Production coupons, not in the money, typically bear limited payups, and the loss of TBA deliverability disincentivizes the creation of G2 specs for all but the highest payup stories. Spec trading is thus, dominated by conventionals.
- Servicers don't all get the same execution due to perceived differences in liquidity and prepayments. For example, non-bank servicers are more efficient at targeting and closing refis than their bank counterparts. Thus, their pools will sell at lower payups.
- Liquidity also drives payups. Larger issuers and pools tend to trade tighter.

Chart 156: New issue volume by story (30yr conventionals, excluding the generic new production)



Source: BofA Global Research

Chart 157: Servicer payups can exhibit considerable tiering, FN LLB 4s



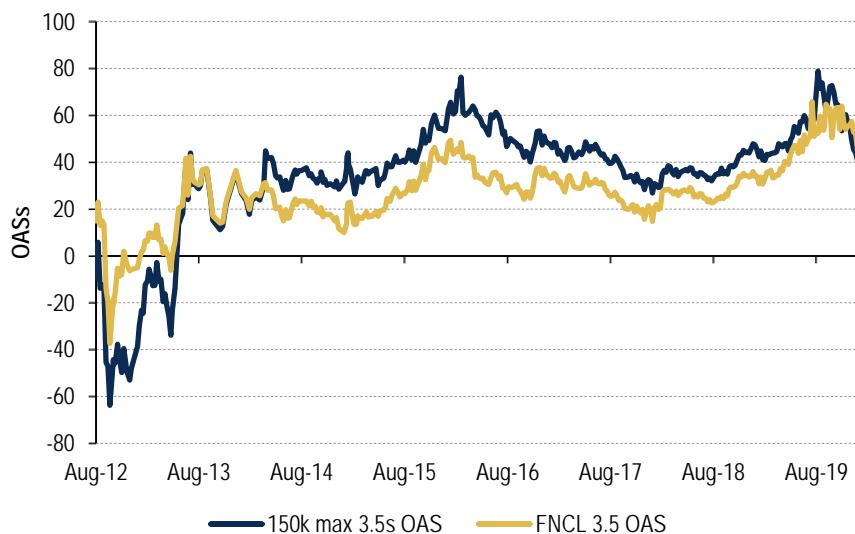
Source: BofA Global Research, desk inquiry



Valuation: yield and spread analysis

- Premium specified pools typically have longer average lives and durations compared to TBA, since speeds are slower.
- Yields tend to be higher, particularly when premiums and payups are high. They are also biased higher when the yield curve is steeper, owing to longer cash flows.
- ZVOAS tends to be wider than TBA, reflecting higher base-case carry. Despite higher yields and ZVOAS, nominal spreads can sometimes be tighter, particularly when the yield curve is steep, as they are measured to a single WAL point on the curve.
- OAS on call protected pools is usually wider than TBA. Underlying reasons for this include a combination of worse liquidity and payup risk. The latter gets magnified with nominal payup itself, as does the concession.
- Specified pool investors hope to monetize this spread concession to generate superior returns versus TBA.

Chart 158: TBA OASs are typically lower than those of specified pools



Source: BofA Global Research

Table 36: A snapshot of price, yield, and spread metrics for HLB 3.5 and TBA

	FN 3.5 TBA	FN 3.5 HLB
Price	103-15+	107-06+ (TBA+119)
Yield	1.73	2.03
Spread to Treasuries (I-spread)	63	89
Spread to Swaps (N-spread)	60	89
ZVOAS	58	82
OAS	46	62
WAL	2.2	5.6
Model Effective Duration	1.3	3.8

Source: BofA Global Research, as of 2/27/2020



Specified pool valuations: OAS model payups

- Model payup is determined by pricing the specified pool cashflows using the OAS of the TBA. Since it relies on the OAS, this methodology focuses on the longer term value of the bond from convexity.
- A common relative value metric is %OAS, defined as:

$$\%OAS = \frac{\text{Actual Payup}}{\text{Model Payup}}$$

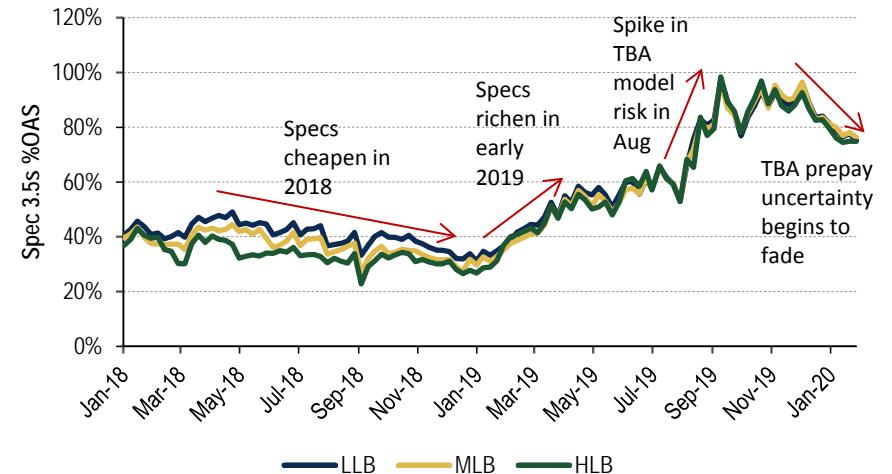
- The OAS spread concession on specified pools implies that market payups rarely approach the model payup so this ratio is generally below 1.0.
- Time series of model payups versus actuals can be used for rich/cheap analysis.
- One caveat is that %OAS metric is inherently subject to model risk, particularly with respect to the TBA. In times of considerable prepayment uncertainty, TBA is usually more exposed to this risk than call protected pools. In such an environment, %OAS will rise as TBA OASs widen versus specs, and loses relevance as a rich/cheap metric. Mid-2019 was an example of this.

Table 37: Example: computing the model payup and %OAS

FNCL 3.5 Pool	Price	OAS	Equal OAS Price	Model Payup (ticks)	Market Payup (ticks)	% OAS
TBA	103-05	38		0		100%
HLB	106-01	38	106-29	120	90	75%
2012	105-23	38	106-24	115	82	71%

Source: BofA Global Research

Chart 159: Time series of %OAS in 2018 and 2019 shows rich/cheap, spike in model risk



Source: BofA Global Research



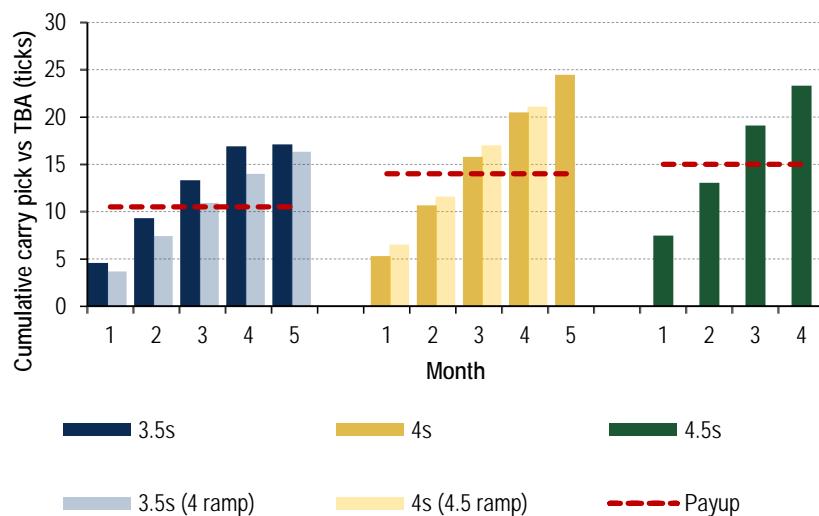
Specified pool valuations: months to break-even

- Desirable specified pool prepayment characteristics result in excess carry versus TBA. This is particularly true during refi waves, when TBA prepayments spike.
- Investors can earn this excess carry, if prepayments bear out and rolls don't change. Ignoring optionality, payup can be thought of as the present value of this excess carry, or yield.
- A simple relative metric is therefore:

$$\text{Months to break-even} = \frac{\text{Payup}}{\text{Hedge Adjusted Carry}}$$

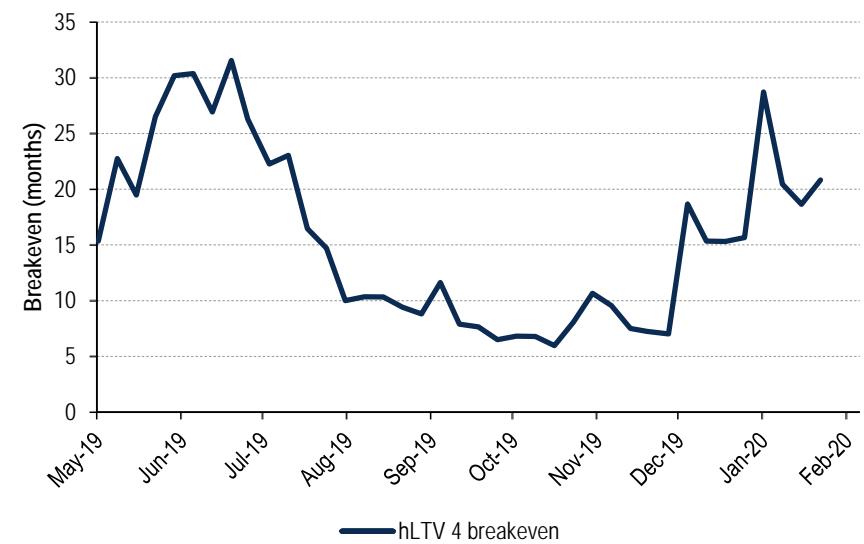
- Lower break-even periods signify relative cheapness of the pool.
- One common improvement to this metric is to use projected carry on pool and TBA, rather than spot.
- This approach focuses on short term value and carry profile of specified pool stories and ignores any option value embedded in the payup. Correspondingly, it is best used for pools where call protection is not lasting, i.e. new production, hLTV and durations are close to that of the TBA.

Chart 160: Accumulated carry exceeds the new prod payup at the 3 or 4 month breakeven point



Source: BofA Global Research

Chart 161: Breakeven time series for hLTV 4s



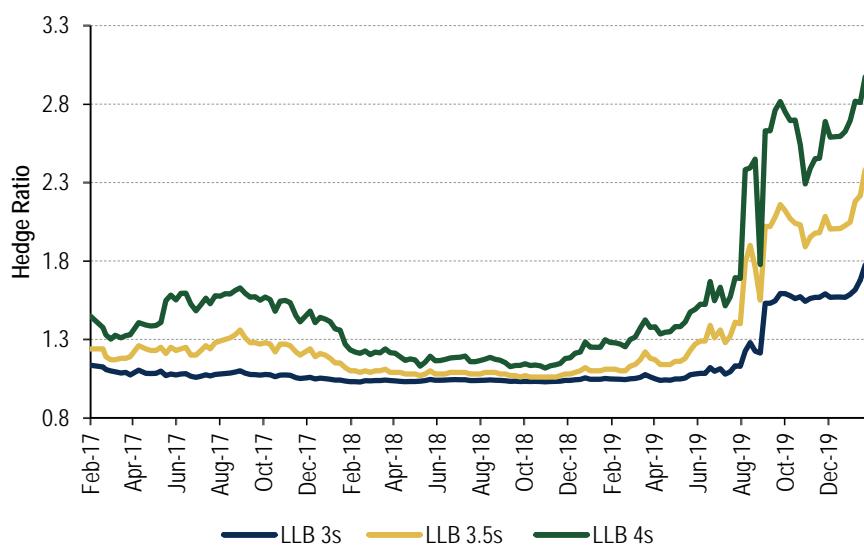
Source: BofA Global Research



Hedging specified pools

- Specified pools can be hedged with rates like all MBS, but are commonly hedged with the TBA bearing the same coupon. This hedges the interest rate and the mortgage basis risk of MBS. TBA hedges are also appealing with respect to certain accounting considerations. The fact that pools are deliverable into TBA results in the offsetting of exposures. TBA short requires the specified investor to buy the roll every month.
- Most call-protected pools have longer durations than TBA. This results in hedge ratios to the TBA that are greater than 1. Either the entire duration risk exposure is hedged with the TBA, or only the nominal par amount. In the latter case, the remaining duration of the payup may be hedged with rates. This improves carry, particularly when rolls are trading special, but implicitly leaves some basis exposure unhedged.
- As payups approach zero, the hedge ratio approaches 1.0. At this point, *payups begin to behave as options since they can't go negative*. If the option is deep enough out-of-the money and the hedged carry is negative, the pool can become cheapest to deliver.

Chart 162: Specified hedge ratios vs TBA over time



Source: BofA Global Research

Table 38: Hedging example and impact on hedge adjusted carry

	Price	Duration	dv01	Carry (ticks)
LLB 3.5	106-25 (+119 to TBA)	5.5	0.0588	0.67
FN 3.5 TBA	103-01	2.5	0.0258	0.34
UST10yr		9.08	0.091	1
Hedged with TBA only:				
$TBA\ HR = 0.0588 / 0.0258 = 2.28$				
$HAC = 0.67 - 2.28 * 0.34 = -0.11\ ticks$				
Hedge payup separately with UST 10s:				
$TBA\ HR = 1$				
$UST\ 10yr\ HR = (0.0588 - 0.0258) / 0.091 = 0.3613$				
$HAC = 0.67 - 1.0 * 0.34 - 0.3613 * 1 = -0.03\ ticks$				

Source: BofA Global Research



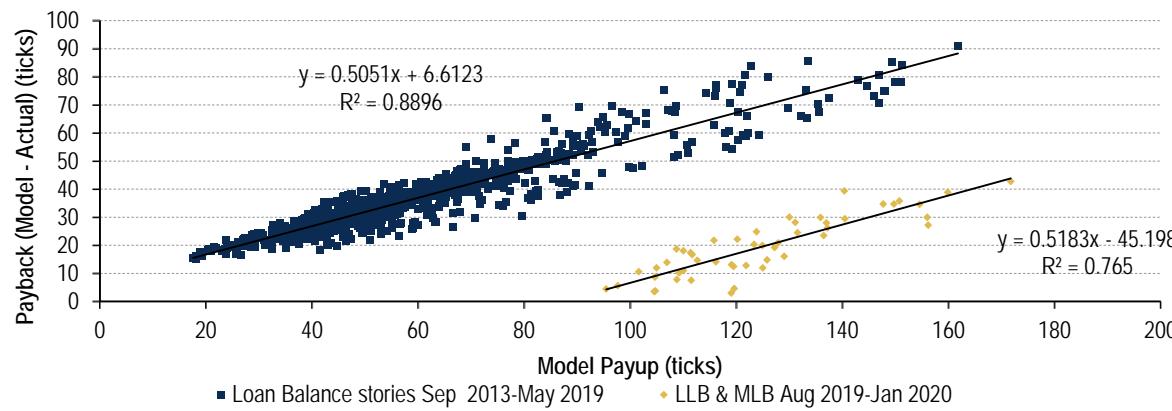
Establishing hedge ratios

- OAS concession on specified pools tends to scale with the nominal payup, as payup risk grows. Thus, payups don't increase as much as the model anticipates in a rally, and don't decrease as quickly in a selloff – in other words, realized durations are shorter than those implied by any OAS model even when model prepayments are correct.
- The concession to the model payup tends to scale linearly with the payup, implying that %OAS remains roughly constant. This allows for an easy transformation between model and market hedge ratios.
- Where S is the empirically observed slope between the payup concession, or payback, and model payup a very close approximation for the adjusted duration D^* is:

$$D^* = D_{spec} - \frac{S(D_{spec}P_{spec} - D_{TBA}P_{TBA})}{P_{spec}}$$

- There are a handful of caveats to the above approach. First, model payups depend on one's OAS model, which can differ substantially. Second, as %OAS increases in times of prepayment uncertainty paybacks decline, so estimating S properly may require adjustments for such regime shifts, for example since mid-2019.
- An alternate method arriving at specified hedge ratios is to compute them empirically. This suffers from similar drawbacks as doing it for TBAs: they are backward looking, and highly dependent on the sample period.

Chart 163: OAS concession on 3.5s scales linearly with the model payup; $S=0.5$, but fitting requires adjustments for different regimes



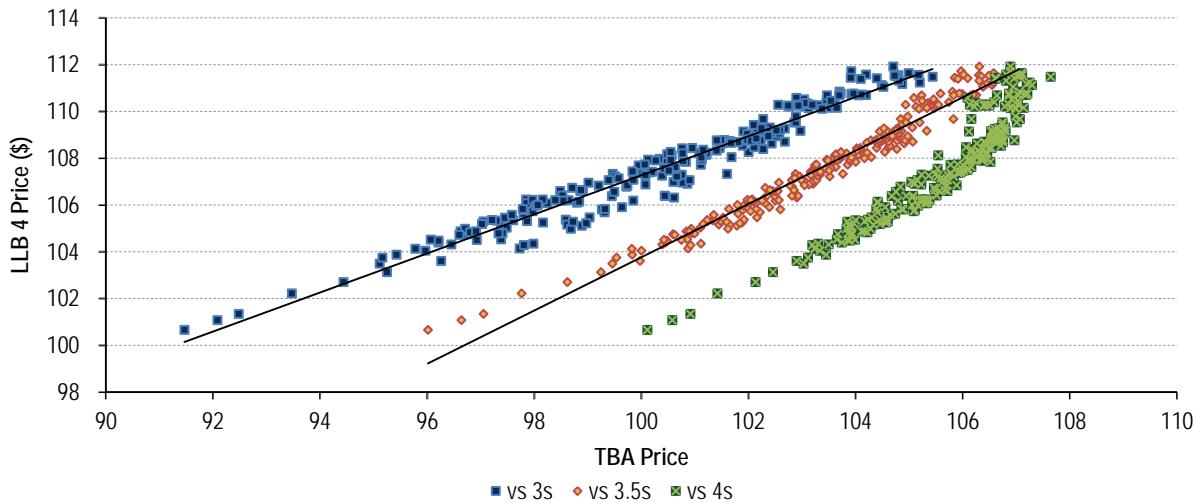
Source: BofA Global Research



Alternative hedges – lower coupon TBA

- One alternate way to hedge spec pools is with lower coupon TBA: ie, LLB 4s with TBA 3s. Conceptually, the two are both ways to shield a portfolio from prepay exposure
- Lower coupon TBA will have longer durations and lower convexity, more closely resembling those of the call protected specified pool. Thus, it is a better hedge over a larger range of rates.

Chart 164: Lower coupon FN 3s TBAs offer an effective hedge to LLB 4s



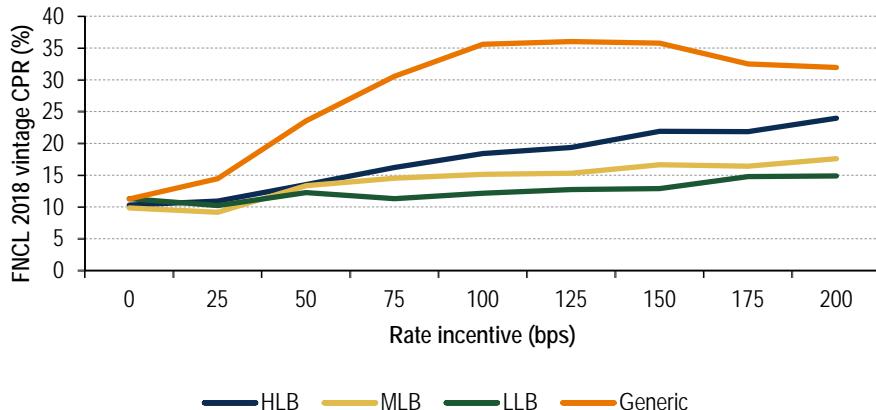
Source: BofA Global Research

- Besides being a better hedge, this type of hedging can result in an additional carry pick. Hedging with a lower coupon TBA can avoid a short position in an out-of-production coupon where dollar rolls trade special due to distorted technicals.
- The downside of this approach is the inherent coupon swap exposure. For example, if the 4/3 swap underperforms, and LLB 4s trade in-line with the 4% TBA, then the position hedged with 3% TBA will also underperform.

Loan balance pools

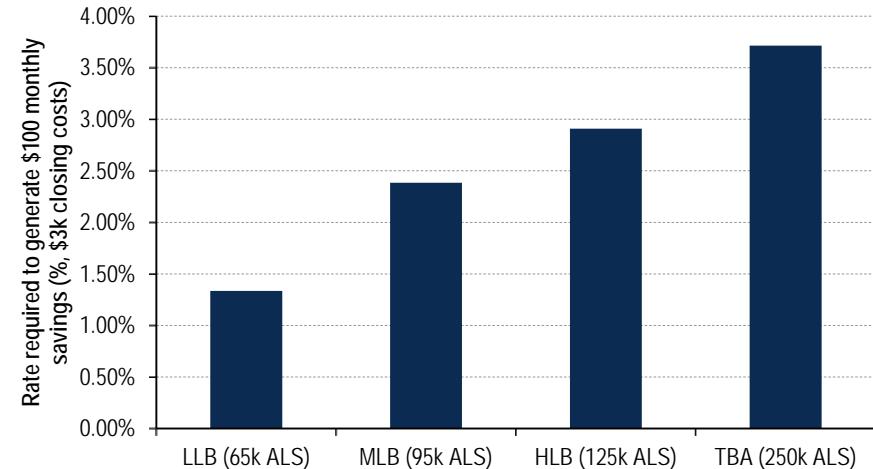
- Low loan balance borrowers experience a proportionally lower dollar refi incentive for the same difference in rate, particularly when factoring in fixed costs. Also, lenders are less incentivized to solicit and process these borrowers since origination profits scale with loan balance. Finally, smaller loans have high loss severities and are less likely to obtain an appraisal waiver from the GSEs.
- Pooling conventions exist to enhance liquidity:
 - Low loan balance (LLB)** pools have max loan size of \$85k.
 - Medium loan balance (MLB)** pools have max loan size of \$110k.
 - High loan balance (HLB)** pools have max loan size of \$150k.
 - MLB 125k** are also traded as are **200k max** and **225k max**.
- Increases in conforming loan limits lead to higher TBA loan sizes, creating new loan balance stories over time.
- When discounts, turnover is faster on loan balance pools since these borrowers trade up into larger homes more often, facing relatively small dollar amount of lock-in.
- Driven by borrower economics, it is the most robust prepayment protection story. The protection only increases over time as loan balances amortize down.

Chart 165: Loan balance pools S-curves offer prepayment protection vs the cohort



Source: BofA Global Research, based on Oct-Dec 2019 speeds

Chart 166: Loan balance pools require lower rates to generate comparable savings, 4.5% WAC



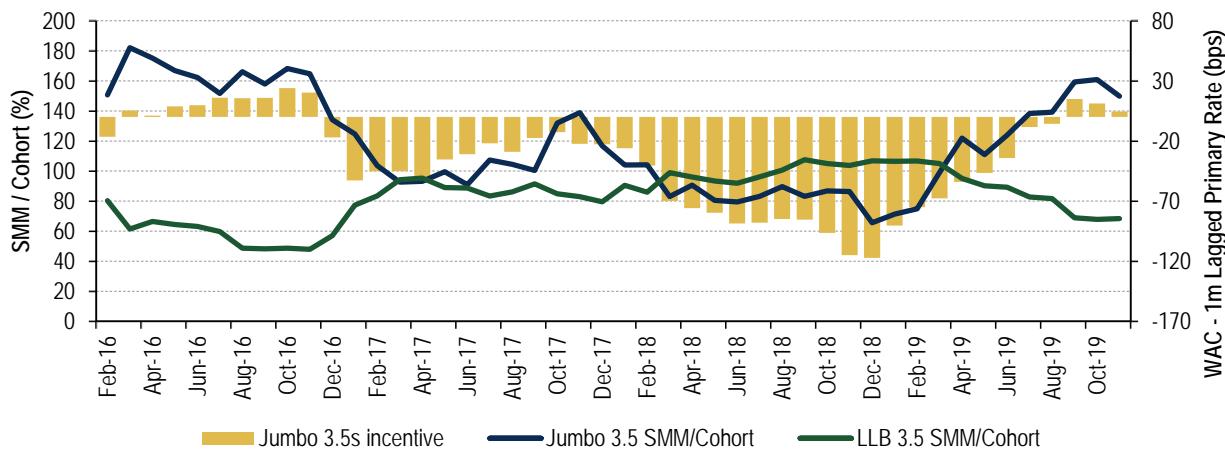
Source: BofA Global Research



Jumbos – loan balance pools in reverse

- Jumbo prepayment profile is the opposite of the loan balance story – bigger loan size and fixed costs decrease the refi elbow, steepening the S-curve. Overall credit profile is better and origination costs are relatively lower, making jumbo borrowers prime refi solicitation targets. Greater call risk is matched by greater extension risk as well, as the dollar amount of lock-in increases.

Chart 167: Jumbos trade inverse to loan balance payups



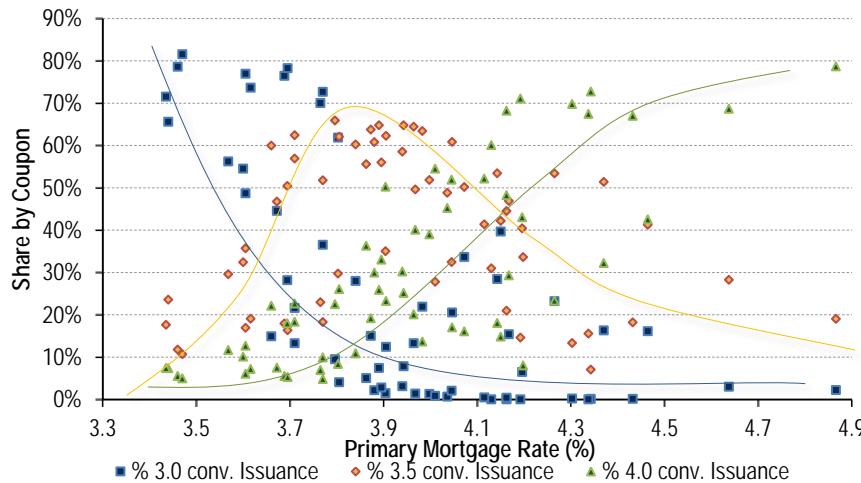
Source: BofA Global Research

- This inferior convexity makes jumbos cheapest to deliver. To avoid repricing the entire TBA market to this, jumbos are restricted to 10% of the TBA deliverable pools – an option that jumbo originators are likely to exercise to the fullest. The remainder of jumbo production is either retained or gets pools under separate non-deliverable prefixes, primarily CK for 30yr Fannies, 3P for 30yr Freddies, and JM for 30yr Ginnie IIs.
- These non-deliverable jumbo pools trade back of the TBA due to worse convexity as well as liquidity. Jumbos can be barbelled with loan balance paper in the portfolio to produce TBA-like prepayment profile.
- Given the typically high credit profile of the jumbo borrowers, banks often retain these loans rather than securitize, opting to save the 50bps G-fee and take on the credit risk.

New production

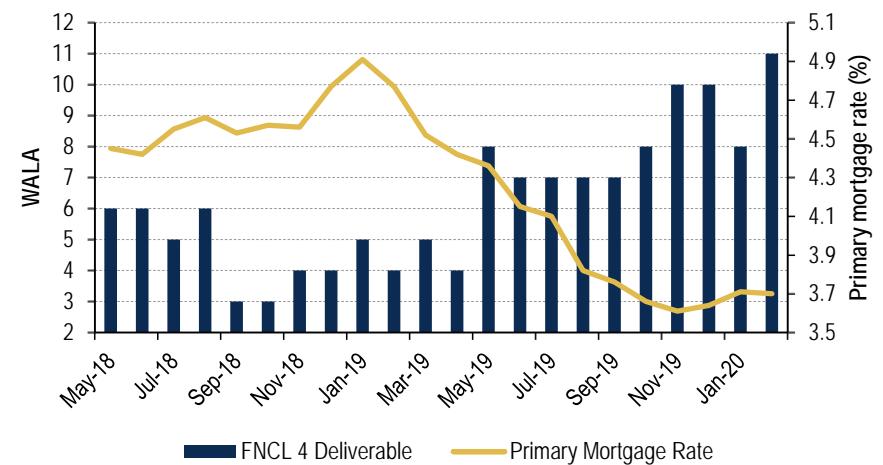
- As mortgage rates rally, best execution and mortgage production shifts down-in-coupon. Once a new coupon begins to trade, generic new production, non-story, pools become TBA by definition.
- Meanwhile, the production shift is rarely discrete – issuance likely continues in the previous production coupon. As higher coupons come in-the-money, to the extent there is sufficient free float available, TBA deliverable may shift to more seasoned collateral which prepays faster. In this case, generic new production will trade at a payup to the TBA.
- The value of the new production payup is driven by the steepness of the refi and turnover seasoning ramps, during which investor earns incremental carry over TBA, typically six months. The bond will subsequently become cheapest-to-deliver.
- The payup is mostly exposed to rates going higher in the interim, idiosyncratic prepay risk, funding shocks and rolls. There is considerable tiering by servicer.
- Generic, non-story collateral destined to become TBA, typically comprises 60-70% of issuance, and has a typical payup breakeven of 3-4 months. This sets the floor for story bond payups in each coupon, which also have an embedded ramp in addition to desirable convexity characteristics.

Chart 168: Production shares shift with rates, but not in a discrete fashion



Source: BofA Global Research

Chart 169: Deliverable shift in 4s in mid-2018 to Feb 2020



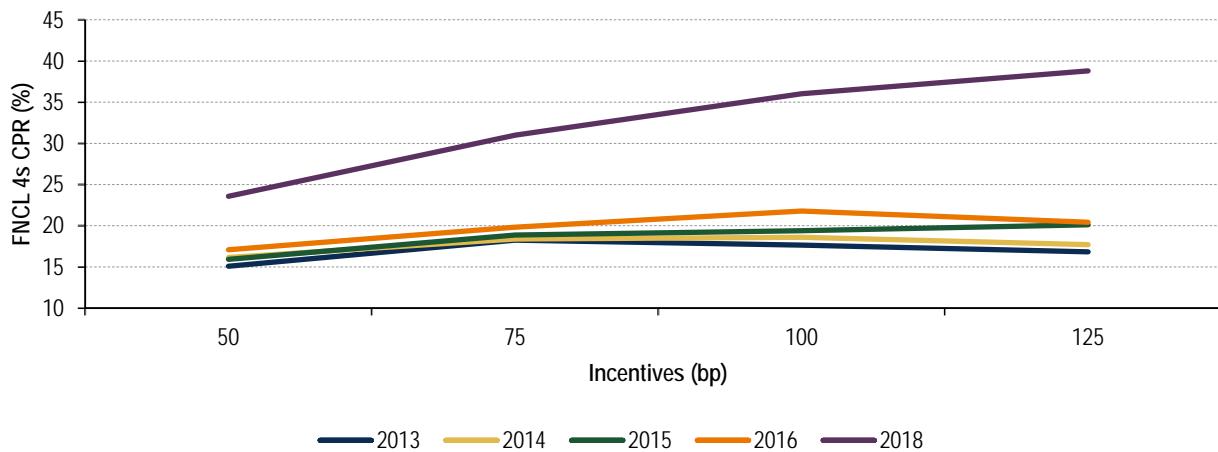
Source: BofA Global Research



Seasoned pools

- Premium seasoned pools (2+ years seasoning) are typically past the peak TBA speed observed between 6 and 12 WALA, have accumulated considerable burnout, and borrower documentation is dated, making them less likely to be solicited.
- Higher coupons have experienced more burnout, all else equal. Thus, the prepayment profile of seasoned paper is especially attractive for the deep in-the-money pools.
- When discounts, borrowers well up the turnover ramp elevate speeds, boosting carry. Shorter remaining amortization schedule further limits extension.
- Thus, seasoned pools are one of the few stories commanding a significant payup when in- and out-of-the-money.
- Pools comprised of pre-May 2009 borrowers are known as *pre-HARP*. These borrowers were eligible for HARP from 2009 to 2018 and are thus, particularly burned out.
- Pre-2017 borrowers did not go through Day 1 Certainty underwriting, and have exhibited markedly slower speeds than those originated after 2017 during the 2019 refi wave.

Chart 170: Seasoned pools exhibit flatter S-curves



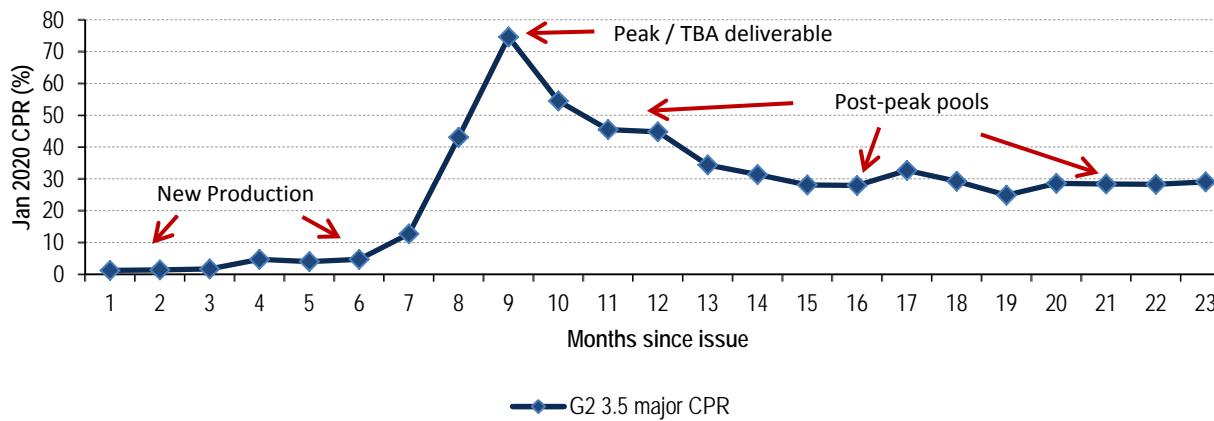
Source: BofA Global Research, FNMA, 2019 Nov CPR



Post-peak pools

- When seasoning ramps exhibit a peak speed that is significantly above the bulk of the float, and assuming there are sufficient bonds available to deliver at that WALA, all bonds immediately pre- and post-peak will offer a carry pick to the TBA and trade at a payup.
- Such steep WALA ramps typically arise when borrowers are prevented from refinancing, typically during the first 6-8 months of the loan as part of non-solicitation policies aimed at curbing churning. For example, GNMA can't guarantee loans that are less than 210 days seasoned since the passage of the 2018 Economic Growth, Regulatory Relief, and Consumer Protection Act. Once these borrowers become eligible, this pent up demand gets flushed within a space of a month or two, resulting in abnormally high CPRs.
- Payups primarily reflect the favorable carry differential versus TBA. Unlike seasoned pools, post-peak pools have little burnout and don't offer extension protection, resulting in similar convexities to the TBA.
- When post-peak pools trade at meaningful payups, TBA rolls tend to trade special as considerable portions of the float hedged with the TBA result in monthly roll buying.

Chart 171: Ginnies exhibit steep refinancing peaks at 9 WALA, causing post-peak pools to trade at a payup



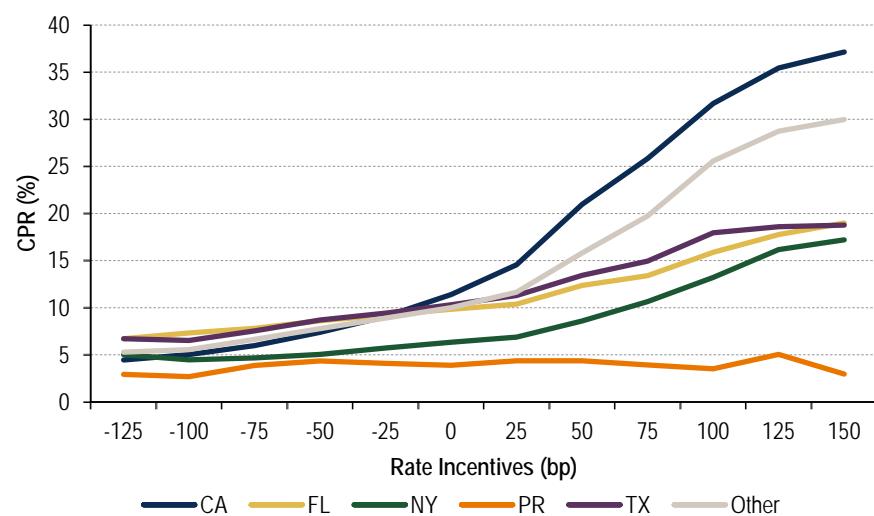
Source: BofA Global Research



Geo pools

- Geo pools refer to pools backed by loans from a specific geographic area. Different states maintain distinct mortgage/real estate taxes.
- Borrowers are subjected to different incentives when moving or refinancing.
 - California has the lowest taxes/fees, making those pools faster.
 - NY is the steepest, making them slower at mild incentives.
 - Puerto Rico pools have very low voluntary speeds at all incentives.
- Differences are modeled with an elbow shift and/or adjusted s-curve steepness – e.g., for NY we use 25bp shift and 73% steepness.

Chart 172: S-curve comparisons of geo pools



Source: BofA Global Research, based on 2019 observed speeds

Chart 173: Refinancing costs for \$270k, <60 LTV, and prime credit

	FL	CA	TX	NY
Title Insurance	834	659	1488	994
Courier/Messenger Fees	35	35	35	35
Application Fees	395	395	395	395
Recording Fees	159	62	42	200
Processing/Underwriting Fee	595	595	595	595
Tax Service Fee	84	84	84	84
Settlement/Closing Fee	388	388	388	0
Abstract Title Search	180	180		
Title Policy Endorse	100		25	
Intangible Tax	540			
City/County Tax/Stamps	945			
Title Examine Fee	125			
Attorney Doc Review			150	
Title Attendance Fee				175
Attorney Fees			600	
NY Mortgage Tax				5535
Municipal Lien Search			400	
Total	4379	2397	3201	9013
CEMA Loan				3478

Source: Chase Bank Website

*In New York, borrowers can avoid mortgage tax with a CEMA loan, which typically locks borrowers with their current lenders and may incur additional administrative fees.



Investor pools

- Investor borrowers face an additional LLPA of 2.125% - 4.125% based on the LTV of the borrower, and this drives speeds slower.
- Investor loans take longer to close, so speeds don't spike up as fast as the TBA. Investors are also significantly less likely to obtain a property inspection waiver from the GSEs.
- Call protection offered by this story has not been constant. Investor speeds converged to owner-occupied after QE3 with payups approaching generic new production. 2019 refi wave has shown investor loans prepaying slower once more, as these borrowers failed to benefit from increased automation and digitization.
- Credit performance of investor pools is similar to those of generic agency collateral. As a result, high LLPAs above, combined with tight credit spreads in the non-agency RMBS market, have shifted a material portion of investor production out of Agency MBS and into PLS.

Chart 174: Investor loans offered call protection in 2012

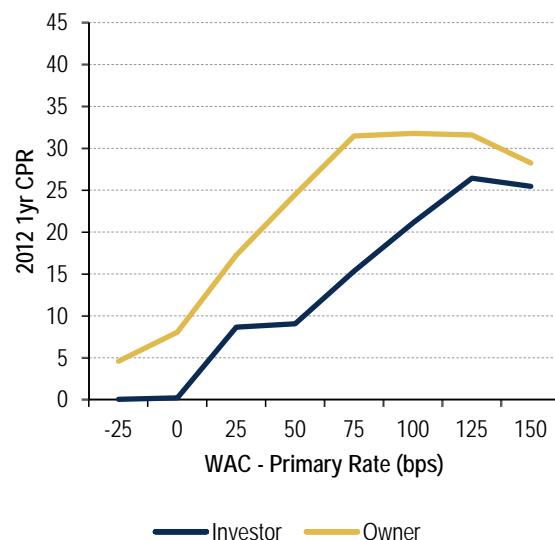


Chart 175: ... marginal in 2016 as S-curves converged...

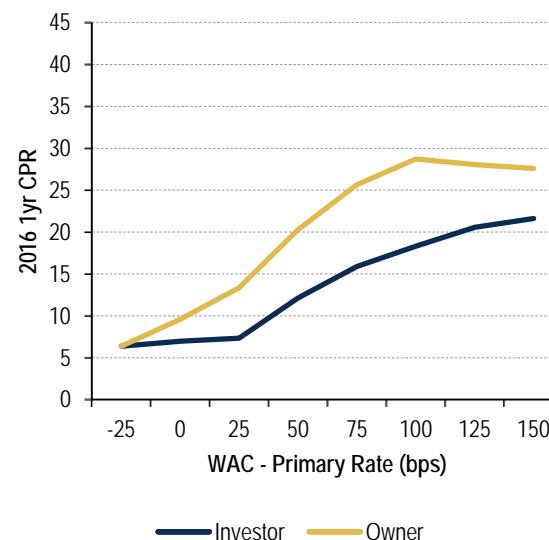
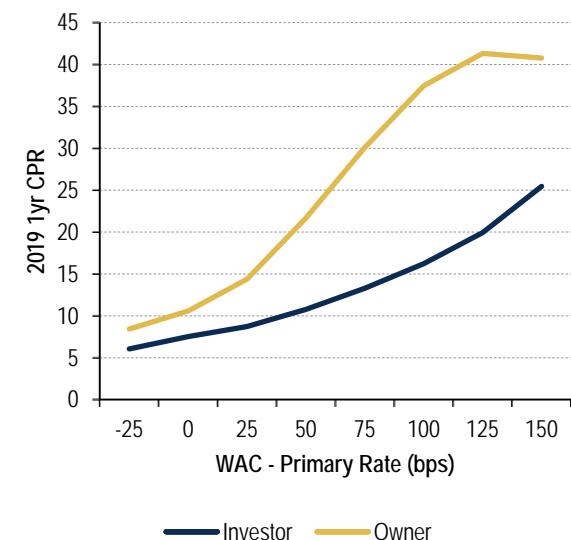


Chart 176: ...re-emerging again in 2019



Source: BofA Global Research

Note: 12-36 WALA, >175k

Source: BofA Global Research

Note: 12-36 WALA, >175k

Source: BofA Global Research

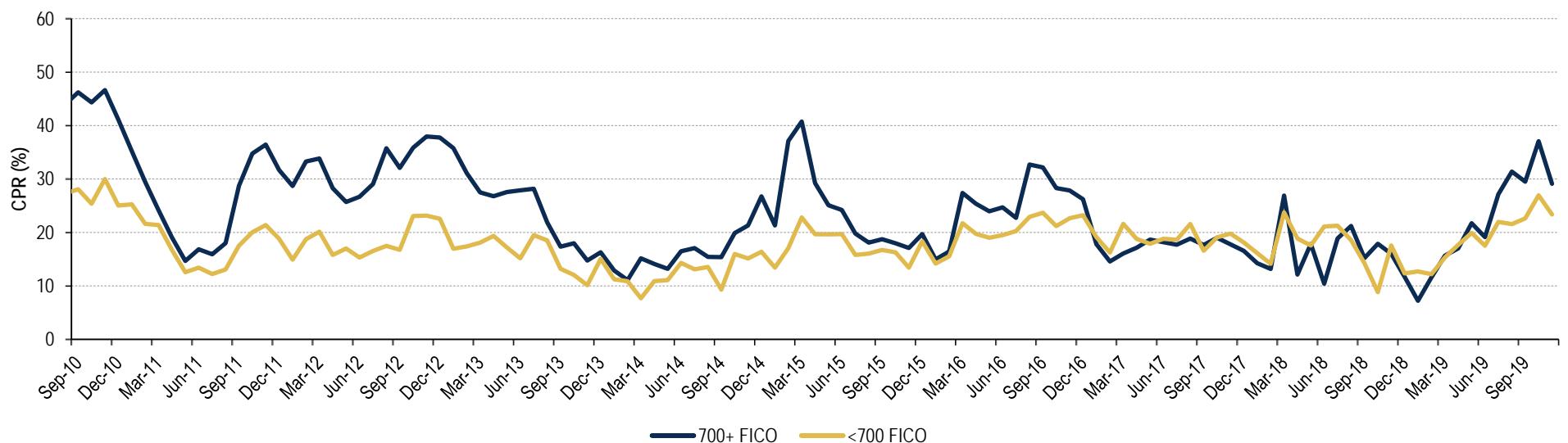
Note: 12-36 WALA, >175k



Low FICO pools

- Current borrowers with <700 FICO face additional LLPA fees, between 0.5% and 3.75% upfront.
- Typical conventions for pools are maximum 680 FICO, 700 FICO, and 720 FICO.
- Call protection has eroded over time with FICO pools paying close to the 700+ borrowers. Nevertheless, low FICOs do exhibit longer lags and don't spike up as much as the TBA.
- Lower FICOs are not as likely to qualify for an appraisal waiver, imparting value to the story recently.

Chart 177: Conventional 30yr CPRs, fixed 75bps in-the-money, >150k ALS, 12-36 WALA



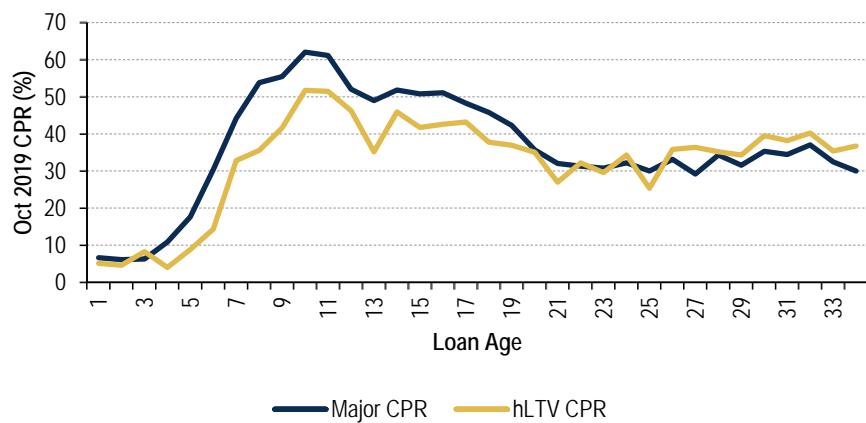
Source: BofA Global Research, FHLMC



High LTV pools

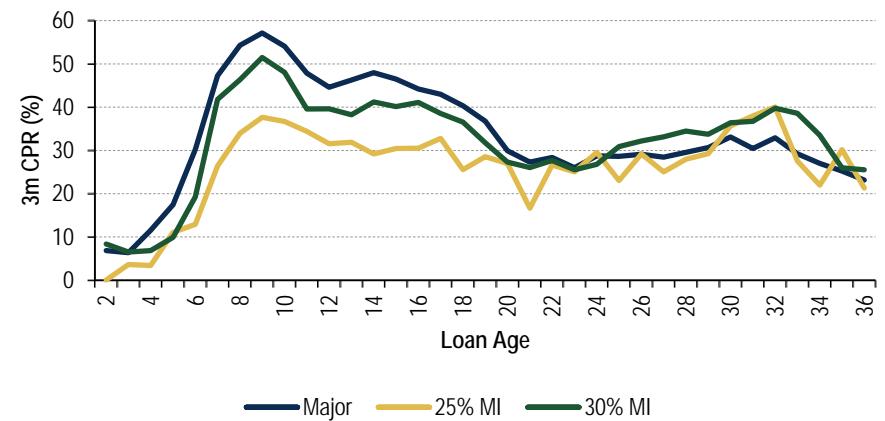
- Typically defined as 100% purchase, with LTVs at or above 95. Usually dubbed as hLTV.
- These borrowers face higher LLPAs on refi, resulting in a slower prepayment ramp compared to generic new production pools. Refi high LTV borrowers have demonstrated their ability to refi, and are less likely to command a payup.
- Some portion of hLTV purchase borrowers are part of the Fannie Mae HomeReady™ and Home Possible® 97 LTV programs aimed at low to moderate income borrowers. This characteristic is desirable since such borrowers face additional refi frictions. No disclosure currently identifies these loans, but the required PMI coverage is 25% rather than 30% for these programs, aimed to lower the cost of PMI.
- Prepayment behavior is closely tied to the outlook on home prices, with protection eroding once LTVs approach 80. At that point, these less burned out borrowers, also incented by the possibility of dropping PMI early, can prepay faster than generic collateral.

Chart 178: hLTV borrowers ramp slower than FN 4 major pools, but catch up eventually



Source: BofA Global Research

Chart 179: 25% MI is preferable, with HomeReady borrowers offering protection, FN 4 shown



Source: BofA Global Research



Housing Finance Authority (HFA) pools

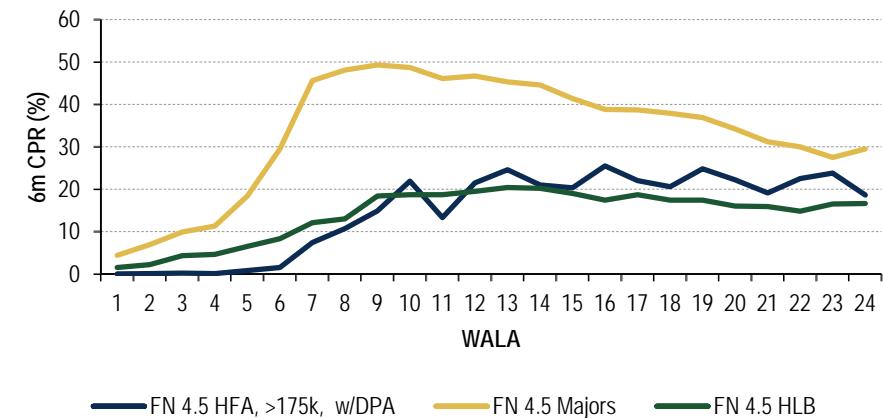
- Local state Housing Finance Authorities (HFAs) aim to provide affordable housing to eligible individuals and families. They do this by extending a mix of grants, down payment assistance (DPA) and tax credits.
- Conventional MBS are issued as extensions of the HomeReady™ and Home Possible® 97 LTV programs, titled HFA Preferred™ (FNMA), and the HFA Advantage ® (Freddie Mac). Thus, the loans have to satisfy similar criteria. Those guaranteed by FHA and VA are issued as GNMA. Freddie has been less active.
- A subset of hLTV, HFA borrowers face material refi frictions. In many cases, DPA is repayable if the loan is refinanced before a certain time, effectively adding a second lien. Combined LTV exceeding the LTV on a pool is a signal of this. Tax credits too, allowing the borrower to offset a portion of mortgage interest directly against federal tax liabilities, would be lost. Finally, if the new loan is not part of the HomeReady™ and Home Possible® programs, then MI requirements could increase, and the loan could be subject to higher LLPAs.
- Identifying HFA pools, unless serviced directly by one of the housing authorities, can be challenging. A handful of master servicers dominate the business, each working with their respective HFAs. Typically, pools are comprised of loans from a single state, with a known HFA master servicer for that state.
- HFA programs differ across states, sometimes within the state itself, and can change over time. Fragmented nature of this market, limited disclosure, and relatively small size limit the liquidity of HFA pools. See [A guide to Agency HFA specified MBS](#) for a more extensive 2017 primer on the sector.

Table 39: Common HFA master servicers by state – 100% state + servicer point to HFA collateral

Servicer	State
Alabama HFA	AL, MO, NC, WA
Colorado HFA	CO
Idaho HFA	CT, IA, ID, NM, SD, TX
Kentucky HFA	KY
Lakeview	CA, DE, TX, WA
Massachusetts HFA	MA
New Hampshire HFA	NH
New Mexico HFA	NM
Pennsylvania HFA	PA
Rhode Island HFA	RI
Standard Mortgage Corp	LA
US Bank	AK, AR, AZ, CA, CO, DE, DC, FL, GA, IN, IL, KS, KY, LA, MD, MI, MN, MT, NE, NV, OH, OK, SC, TX, VT, WY
Utah HFA	UT
Virginia HFA	VA
Wisconsin HFA	WI

Source: BofA Global Research

Chart 180: HFA w/DPA is comparable to HLB, but like all LTV stories this will wane over time

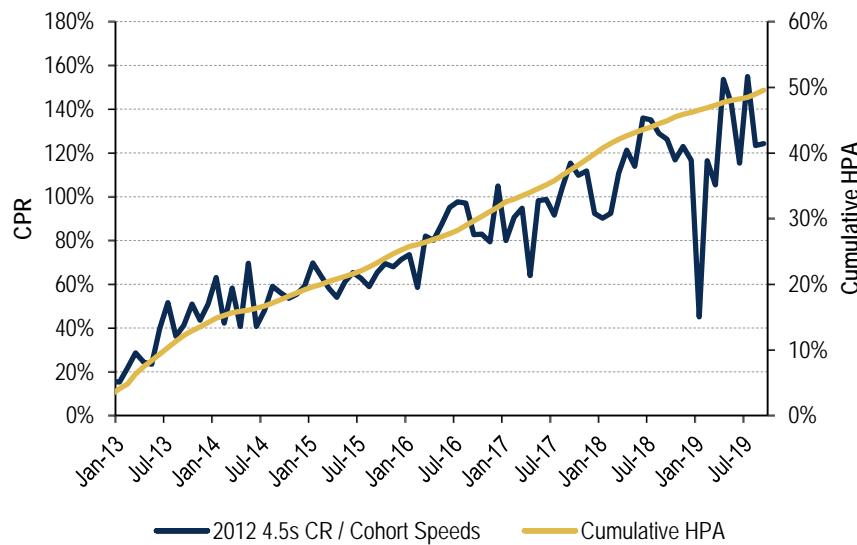


Source: BofA Global Research

HARP/MHA and HLRO pools

- Borrowers who underwent HARP could only take advantage of the program once. This created a degree of prepayment protection as borrowers needed to qualify for a full underwriting and potentially obtain PMI in order to refinance. Many MHA borrowers were thus essentially locked out of refinancing until LTVs declined below the GSE maximum of 97, with buyouts and turnover dominating performance until then.
- HARP ended in December 2018 and the new HLRO program meant to replace it has not seen much use, as home price growth has been positive since then. Unlike HARP, the new program is multi-use, but can only be used once every 15 months. Thus, premium HLRO pools would trade at a payup to the TBA.
- HLRO requires LTVs above 97. Loans with LTVs above 105 are ineligible for TBA delivery and would be pooled separately, referred to as CQ/CR – FNMA's 30yr pool prefix for 105-125 LTV and 125+ LTV respectively. Corresponding prefixes for Freddie Mac are 3S and 3V (legacy U6/U9).
- Just like high LTV, HARP and HLRO borrowers eventually cure. Premium HLRO in particular, would see a spike in prepayments in month 15 once they are eligible to re-use the program, possibly becoming cheapest to deliver.

Chart 181: HARP/MHA speeds cure with HPA, eventually exceeding cohort



Source: BofA Global Research

Table 40: Non-deliverable HARP/MHA and HLRO pool prefixes

LTV	FNMA	FHLMC
105-125	CQ	3S, (U6 - HARP)
125+	CR	3V, (U9 - HARP)

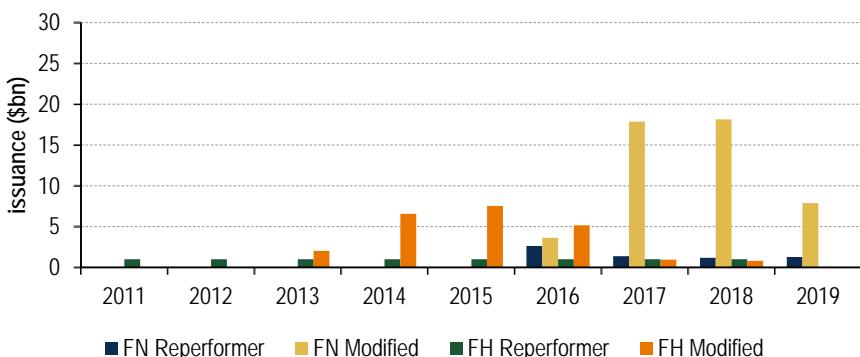
Source: BofA Global Research



Modified and reperformer pools (RPLs)

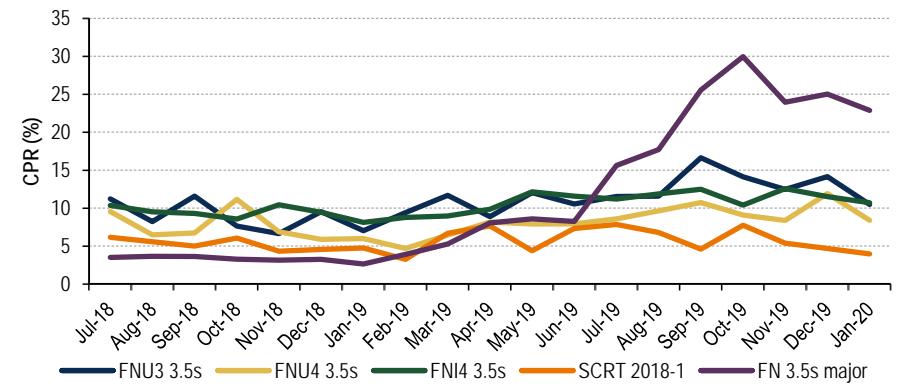
- GSEs resecuritize some of their previously delinquent loans as Agency MBS pools. Unlike in GNMA, GSEs pool these separately into non-deliverable pools. Loans are required to be current for at least six months before pooling.
- Supply is constrained given the strong credit performance in recent years. Fannie has been the more prolific issuer in this space.
- Common types of reperformers are:
 - **Reperformers** – non-modified loans where borrower resolved their own situational impairments. Prepayments are comparable to generic cohort over time. R3 is FNMA's prefix.
 - **Modified fixed rate** – rate and term modification. Term is often modified to 30 or 40-years, lowering payment and reducing the dollar refi incentive. I4 and I3 are the prefixes for 40- and 30-yr year Fannies respectively.
 - **Modified step-up** – rate and term modification, with step-up provisions where rate increases over time. Most were done under HAMP. Rates are extremely low for the first 5 years providing prepay protection. U3 and U4 are the 30 and 40-year pool prefixes for Fannies respectively.
 - **Forbearance** – borrowers are 12+ months current at securitization, but need to pay off forbearance amount on refi, slowing speeds. Not issued as pools, but as part of Freddie Mac's SCRT program, where bonds are guaranteed.
- Lower voluntary speeds are somewhat offset by elevated defaults and buyouts of 2-5 CBR.

Chart 182: Modified and reperformers issuance



Source: BofA Global Research, Fannie Mae, Freddie Mac

Chart 183: Modified speeds in teens or lower, not very responsive to rates

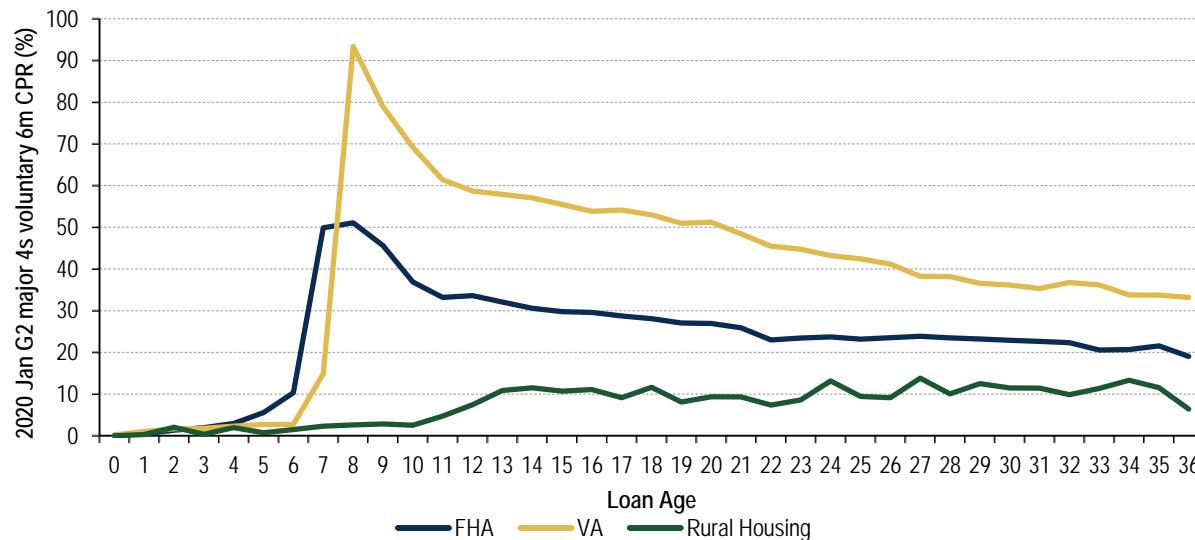


Source: BofA Global Research, Fannie Mae, Freddie Mac

FHA and Rural Housing

- Within GNMA, FHA prepays slower than VA due to worse credit quality, more complicated refi process, and higher funding fees. 100% FHA pools can thus trade at a payup because of this call protection.
- Rural housing collateral provides even more call protection. Relatively low competition for these borrowers, lower loan balances, and a stringent set of requirements to qualify for the program, for borrowers that are otherwise ineligible for a conventional refi, all serve to slow down speeds.
- Like all G2 specified pools, the loss of TBA deliverability into G2 disincentivizes creation, and many such pools end up being re-securitized into CMOs.

Chart 184: Rural housing aging ramp is much flatter compared to VA and FHA



Source: BofA Global Research



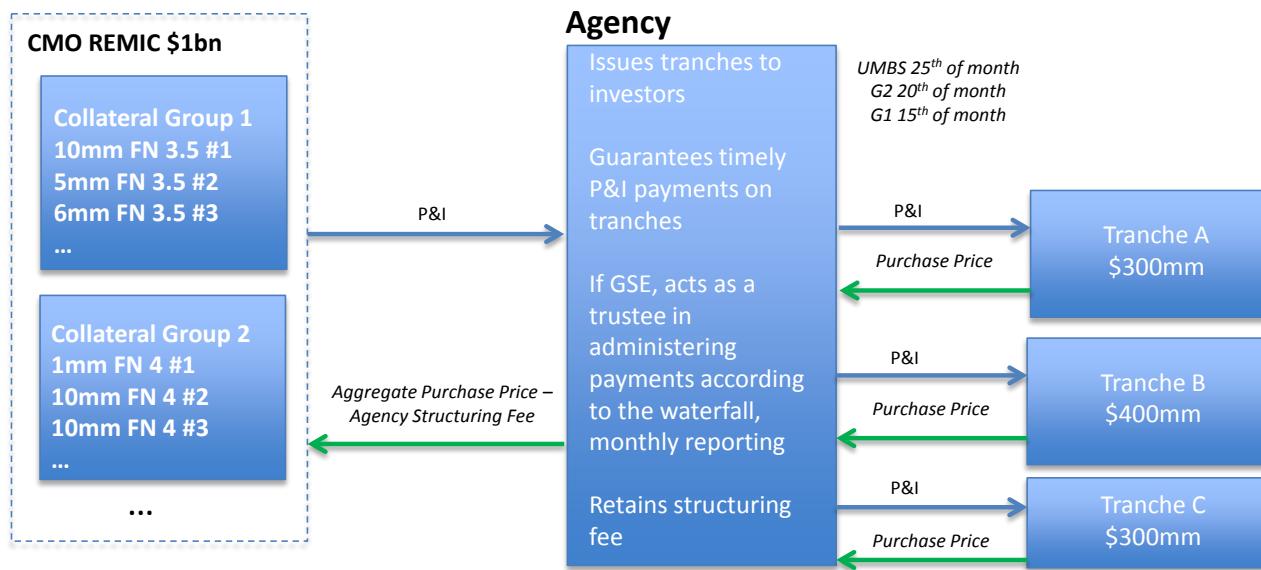
Collateralized mortgage obligations



Introduction to CMOs

- Agency collateralized mortgage obligations (CMOs) are REMIC (Real estate Mortgage Investment Conduit) trusts whose assets consist solely of agency MBS pools. GSEs and GNMA, the issuing entities and guarantors. GSEs serve as trustees and administrators for their deals.
- Each CMO is backed by a defined pool of MBS pools. Typically, these underlying pools are sorted into *collateral groups*. These assets are funded by issuing bonds, called *tranches*. The CMO market consists of primary issue and secondary trading of these securities. Each CMO tranche has an individual CUSIP. GNMA tranches are typically callable by the external trustee once the underlying assets factor down to 1%. Non-economic residual tranche is also created at the price of \$0 for REMIC tax accounting reasons.
- Deliverable Fannie and Freddie UMBS can go into any GSE deal, while non-deliverables have to match their respective issuer. Only GNMA MBS can comprise a GNMA CMO.
- Agencies redistribute all the underlying monthly pool P&I generated across outstanding tranches. This is done in accordance with predetermined rules spelled out in each CMO's prospectus. These rules are referred to as the *principal and interest waterfall*.

Chart 185: Agency CMO cashflow example



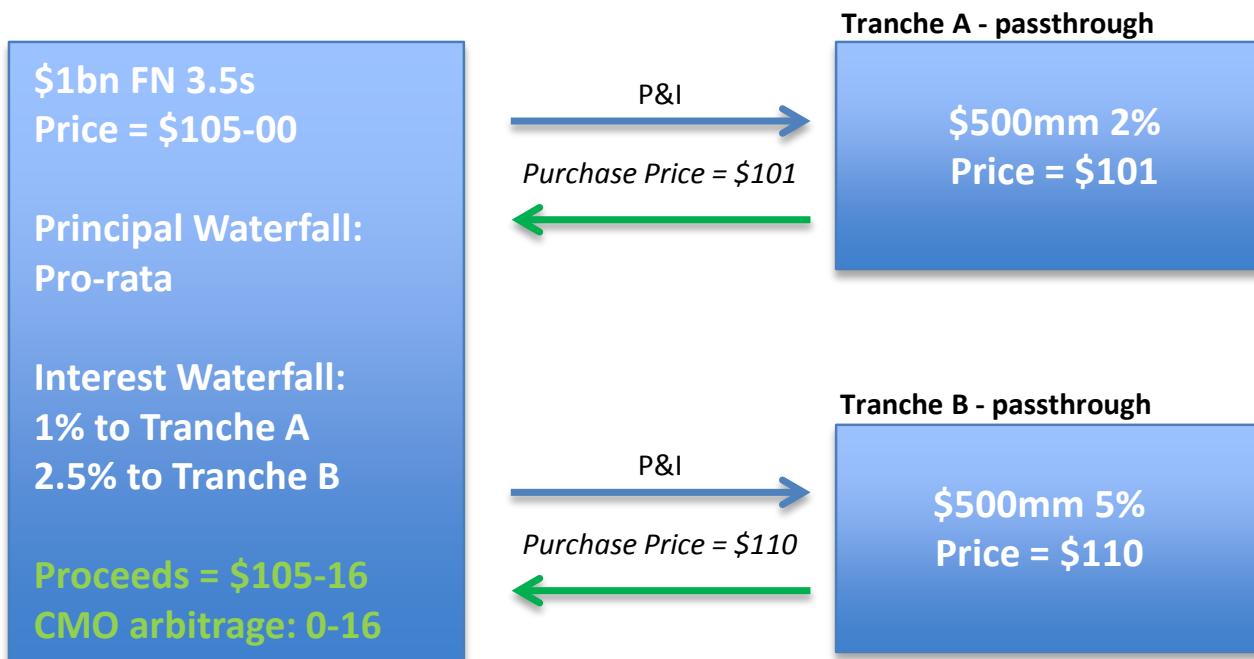
Source: BofA Global Research



CMO structuring and arbitrage

- CMOs and the corresponding waterfalls are typically structured by dealers. However, investors or even the GSEs themselves can contribute assets and structure a transaction.
- Agencies will create the actual REMIC and issue the tranches according to the prospectus prepared by the dealer. In return, the agency will charge a nominal structuring fee.
- When not structuring on behalf of a client, dealers create CMOs to try to earn a *CMO arbitrage*. CMO arbitrage is the difference between the value of the underlying pools and the aggregate price of CMO tranches, net of the agency structuring fee.
- CMO arbitrage exists because investors have different tolerance for risk and are willing to pay up for customized cashflows on at least one of the tranches. Tranche cashflows can be tailored to produce many desired combinations of pricing, duration, and convexity not readily available in the passthrough market.

Chart 186: Example of CMO arbitrage



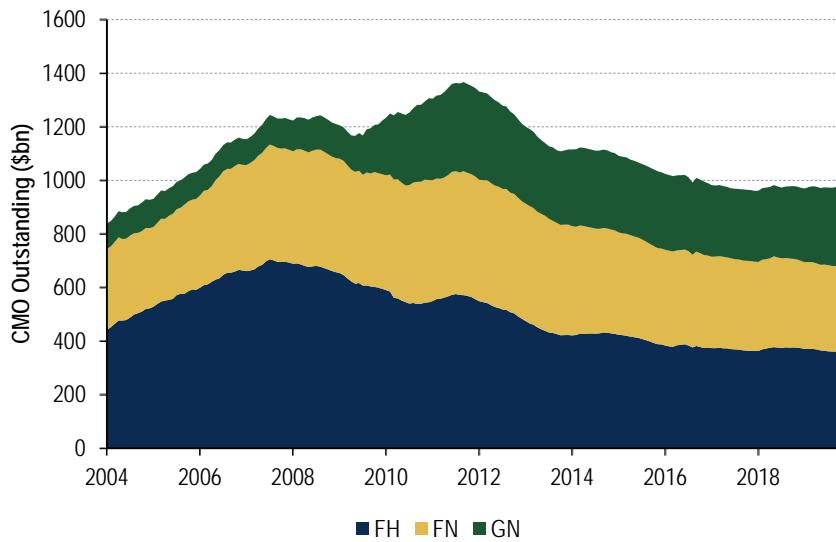
Source: BofA Global Research



The agency CMO market

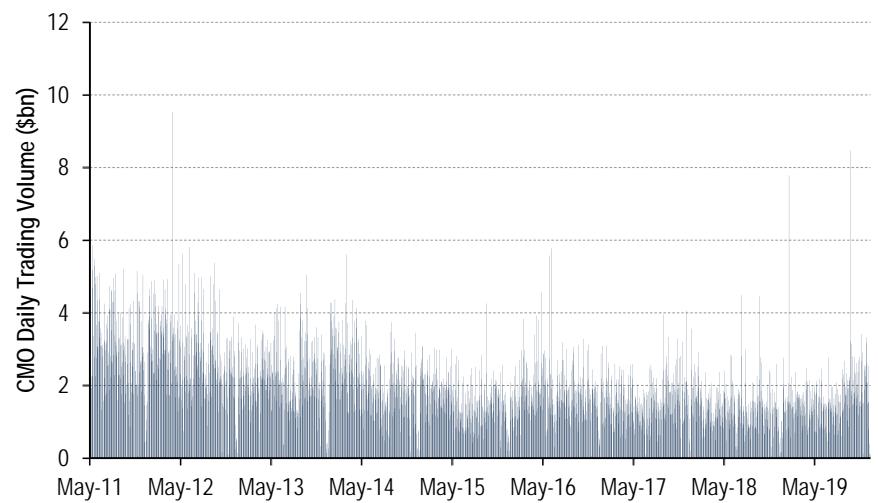
- There are over \$1tr dollars of agency CMOs outstanding today and over \$1bn trades daily.
- Banks, insurance clients, money managers, and hedge funds comprise the investor base.
- CMO tranches are not pools and hence not TBA deliverable. Since they are obligations of the agencies, CMOs enjoy the same capital treatment as the underlying passthroughs.
- Since the cashflows are customized, specific to each deal, agency CMOs are generally less liquid than passthroughs, at least in the on-the-run production coupons.
- Liquidity treatment may vary, but agency CMOs are generally considered liquid instruments based on empirical research by the Federal Reserve.

Chart 187: The Agency CMO market is close to \$1tr outstanding



Source: BofA Global Research

Chart 188: CMO daily trading volume is around \$2bn



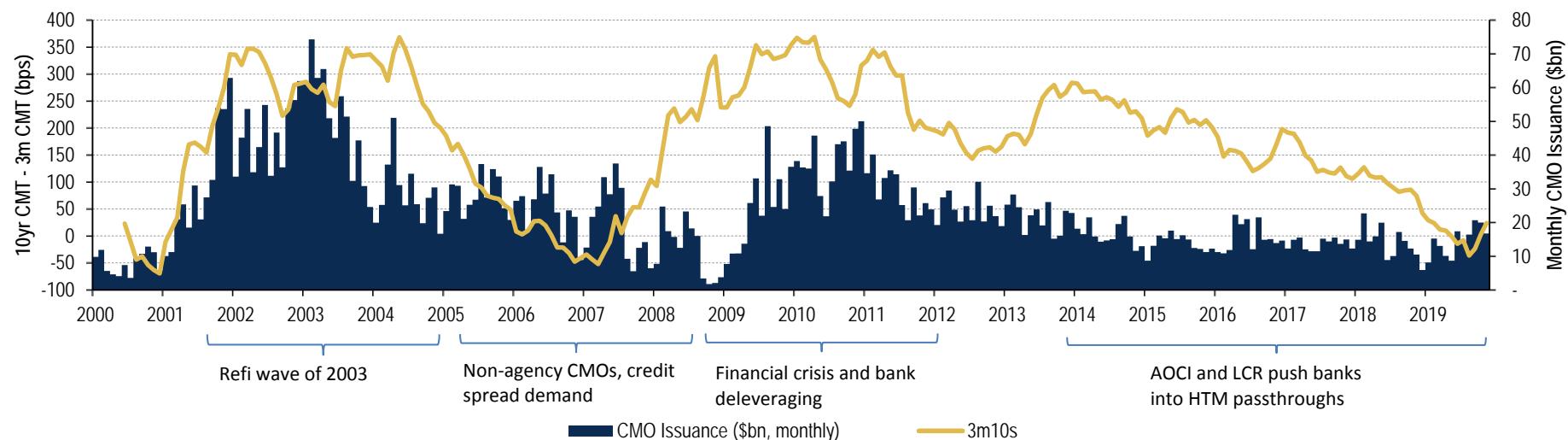
Source: TRACE



Agency CMO issuance, trends and drivers

- Agency CMO issuance can vary substantially, having reached a high of \$73bn/month in 2003 and now averaging closer to \$15bn/month.
- The shape of the yield curve, prepayments, regulations and MBS prices are all factors driving issuance.
- Steeper yield curves generally increase CMO arbitrage and issuance. Underlying MBS spreads have also tended to tighten in flatter environments, squeezing the economics of issuance.
- High prepayments tend to increase CMO issuance as investors are more willing to pay up for prepayment protection.
- Flatter yield curves, flatter S-curves, and regulations all have biased CMO issuance lower post-crisis.
- For deliverable UMBS, the choice of agency is mostly arbitrary with comparable structuring fees and timelines, and is often client driven. Demand for GNMA securitizations tends to be regulatory-driven.

Chart 189: Historical trends and drivers of agency CMO issuance



Source: BofA Global Research



Common CMO structuring techniques

Table 41: Common CMO structuring techniques

Cashflow structuring method	Examples	Characteristics
Direct transfer of cashflows	Passthrough strips	Principal is passed directly through to the tranche. Weighted average life is unchanged. Reallocation of interest creates bonds with a wide range of dollar prices.
Sequential allocation of principal	Sequentials	Principal is paid down sequentially. Creates bonds with a wide range of weighted average lives.
Dynamic allocation of principal based on prepayment speeds	PAC, TAC, support	Redistributes prepayment risk between tranches with some having less negative convexity at the expense of others.
Allocation of interest to pay principal	VADM, sequential Z-bond	Creates very stable cashflows on the VADM by diverting interest from the Z-bond to pay principal. Z-bond interest is accrued to principal over time.
Separation of principal and interest	IO, PO	Creates bonds that are highly sensitive to prepayments. Otherwise termed MBS derivatives.
Indexing of coupon payments	Floater and inverse floaters	Creates par floaters relatively insensitive to prepayments at the expense of the inverse floater.
Secondary tranching of cashflows	Inverse IOs, PAC sequentials, support Zs, sequential IOs, re-REMICs, etc	Secondary separation of cashflows.

Source: BofA Global Research



CMO structures: passthrough strips

- Passthrough strips are some of the simplest CMO structures. All principal from the underlying CMO collateral is paid directly to the CMO tranche. Correspondingly, weighted average life of the CMO passthrough matches the underlying assets.
- Interest can be set on a passthrough to target a specific dollar price. This is often targeted at banks, who prefer bonds priced closer to par due to accounting considerations associated with premiums and discounts.
- Creating a par strip from a premium MBS creates a second passthrough of even greater premium. Similarly, an even bigger discount is created from discount MBS.

Chart 190: Making a par strip out of premium MBS, no-arbitrage example



Chart 191: Making a par strip out of discount MBS, no-arbitrage example



Source: BofA Global Research

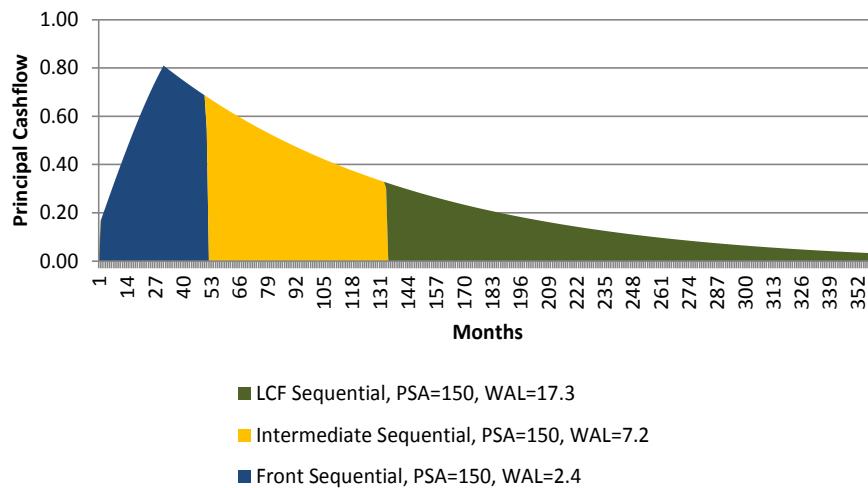
Source: BofA Global Research



CMO structures: sequentials

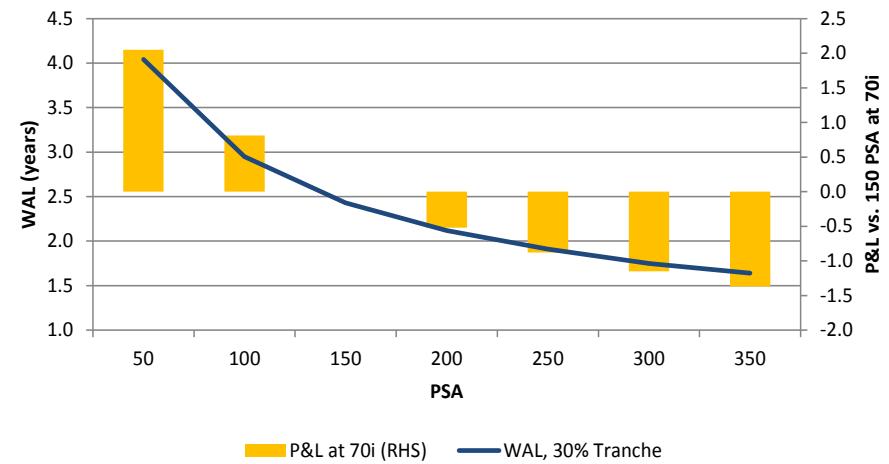
- Principal is paid out to tranches in specified order. Bonds that are paid first, or *front sequentials*, will have shorter durations and WALs than the underlying collateral. Those paid last, known as *last cashflow* or *LCF*, will have longer weighted average lives and duration than the underlying MBS.
- Usually no principal is allocated to a sequential bond until the bond in front of it is paid off. This period is called the *lockout period*. The period during which the bond is receiving principal is called the *principal window*. Both periods depend on the rate of prepayments.
- Sequentials in their principal window receive all the paydowns on collateral. This creates inherent *leverage* to the near-term prepayment speeds which scales with the ratio of collateral to the bond balance. Thus, 33% front pay sequential will experience CPRs approximately 3x that of the underlying collateral. LCF excepted, this leverage increases over time as the bond pays down.
- Premiums or discounts on sequentials have a risk exposure to the mortgage rate, i.e., the long end of the curve, despite potentially very short bond cashflows.

Chart 192: Sequential tranching example of cashflows at 150 PSA, 8.8 WAL



Source: BofA Global Research

Chart 193: Sample WAL and P&L profile of a 30% front-sequential, \$104px, 2.43 WAL @150 PSA



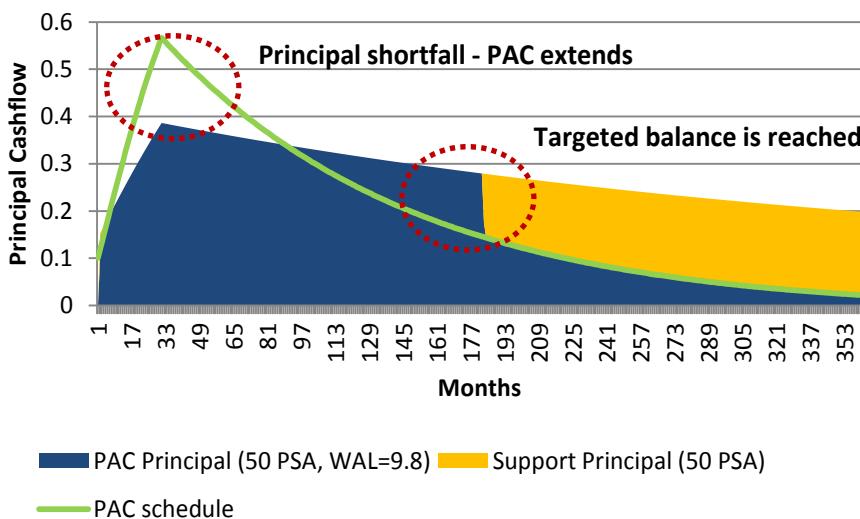
Source: BofA Global Research



CMO structures: PACs and supports

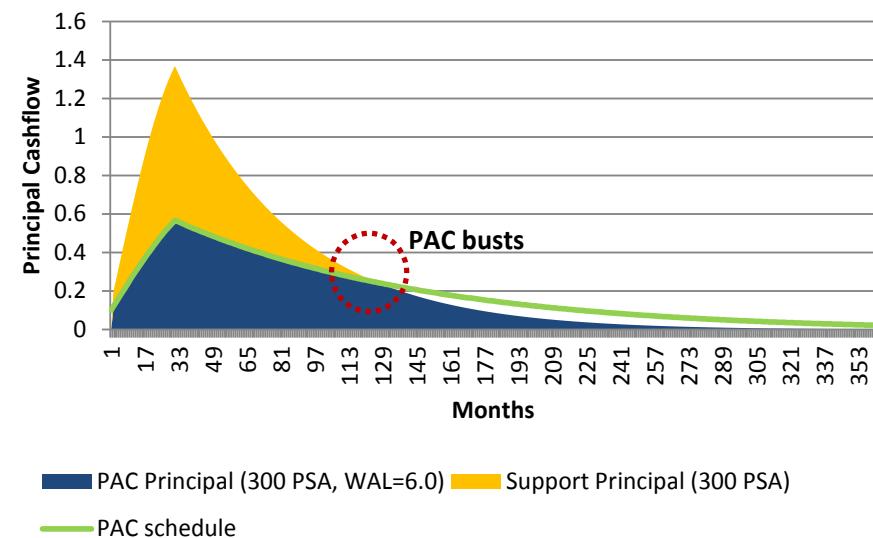
- Planned Amortization Class (PACs)** are designed to protect against extension and call risk by creating a companion or support bond which absorbs excess prepayment variability. The larger the companion bond, the more stable the PAC profile is. PACs trade tighter than the underlying bond.
- Target balance schedule is defined in the CMO prospectus for each PAC in the deal. Principal is then allocated sequentially on each distribution date: first to the PAC until the target balance is reached, and then the companion. If the principal proceeds are insufficient to bring the PAC down to its target balance for the month, then all available proceeds go to the PAC and the support gets nothing. If any principal proceeds remain after the PAC reaches targeted balance, then the support bond gets paid down.
- If the companion bond is paid off prior to the PAC maturity, the PAC becomes busted. A busted PAC is simply a passthrough. One way to bust a PAC is by exposing it to a rate whipsaw, a rally in rates that pays down the support before a back up that extends the PAC. This is called *whipsaw risk*.

Chart 194: Support bond is locked out for 15 years at 50 PSA



Source: BofA Global Research

Chart 195: PAC remains on schedule for 10 years, then busts at 300 PSA

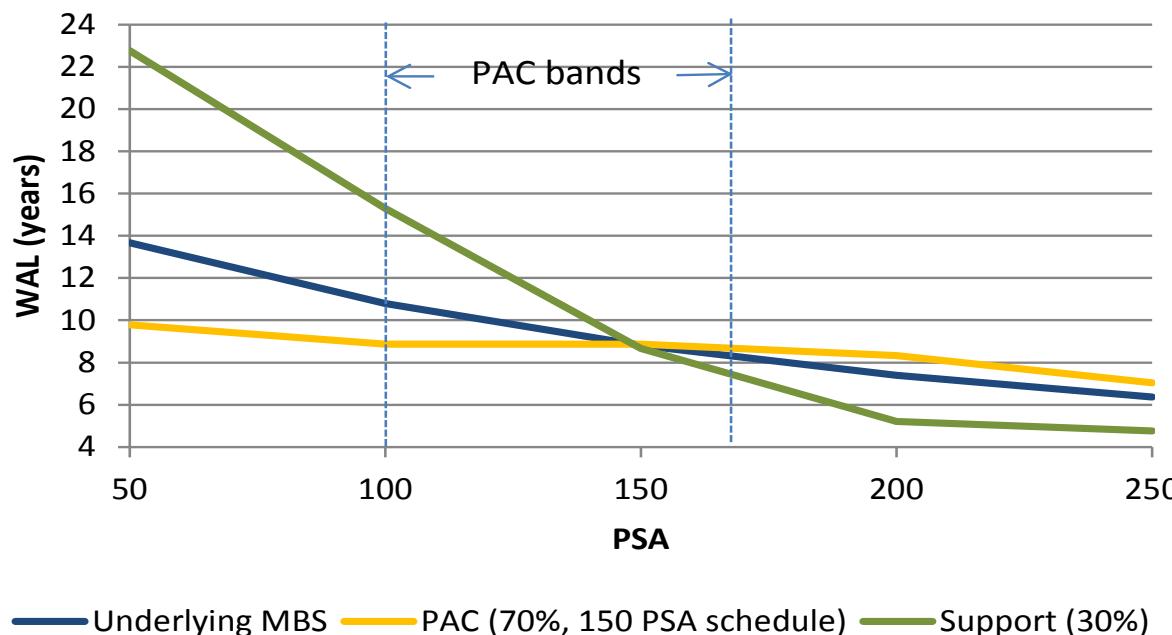


Source: BofA Global Research

PAC bands

- The PAC cashflow stability is defined by a *PAC band*, or *PAC collar*, an upper and lower bound of PSA speeds at which the PAC realizes the planned amortization schedule. If realized lifetime speeds exceed the upper band over the life of the PAC, then the PAC will bust. Realized speeds below the lower band will see the PAC extend.
- The size of the support determines the stability of the PAC cashflow. The thicker the support in relation to the PAC, the wider the PAC bands.
- As the PAC and support bonds pay down, the bands will change over the life of the PAC. Slower speeds generally widen the PAC bands, while faster speeds tighten it. If the speeds remain within the PAC bands, the PAC stays on schedule but both bands will drift upwards:
 - At PSAs below the upper band, more support is accumulating relative to the PAC over time increasing the upper band.
 - At PSA above the lower band, the support is paying down, decreasing future support cashflow to absorb any extension.

Chart 196: WAL is stable on the PAC if speeds remain between the PAC bands



Source: BofA Global Research

Sequential tranching of PACs, and TACs

- PAC classes themselves are often tranches up sequentially into Type I, Type, and Type III PACs etc. Type I PACs have the highest priority with the widest PAC bands with the lowest priority PACs acting as supports if the support bond is paid off. PAC bands get tighter as the priority decreases, and those bonds will correspondingly trade at a discount to the Type I PAC.
- **Targeted Amortization Class (TACs)** are similar to a PAC but does not provide extension protection. TAC support bond is never locked out of principal cashflows but receives principal faster when prepayments increase to keep the TAC on schedule. TAC schedule is usually set to the *pricing speed*, a PSA at which all WALs for the deal are reported. TAC and the support tranche both extend at lower speeds.
- TACs are attractive in low rate environments when investors' primary concern is call risk. Lacking extension protection, TACs will usually trade at a discount to a comparable PAC.



CMO Structures: VADMs and Zs

- Very Accurately Determined Maturity (VADMs)** bonds are similar to PACs in that they pay on a predetermined schedule. The companion bond to a VADM is called a Z-bond. Unlike a PAC where principal is either diverted from, or directed to the support bond, VADM principal is paid out of interest proceeds due on the Z.
- Z-bond**, usually a locked out sequential, PAC, or a support bond, pays no cashflow to the investor during the *accrual phase*. Instead interest is capitalized into the outstanding balance every month. VADM is paid down during this accrual phase.
- VADMs don't extend. Maturity of the VADM is set by the expected cashflows at 0 PSA. Unable to extend, VADM's don't have whipsaw risk. Other bonds in the structure share the extension risk of the underlying MBS.
- VADMs do have some call risk, particularly those backed by support Zs. Lockout period risk on the Z translates into call risk on the VADM. Once the lockout expires, Z-bond and the VADM pay down.

Chart 197: 70/27/3, 3.5 coupon, and 36-month accrual phase. VADM WAL is 1.6

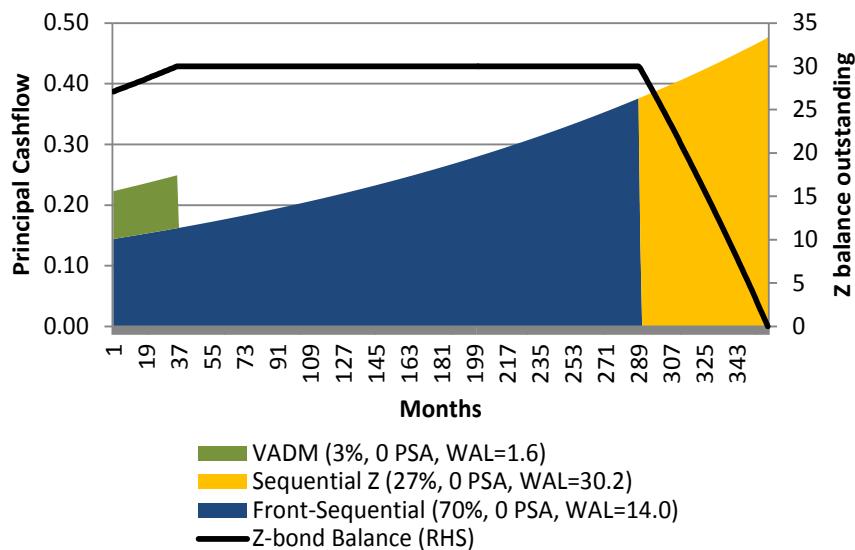
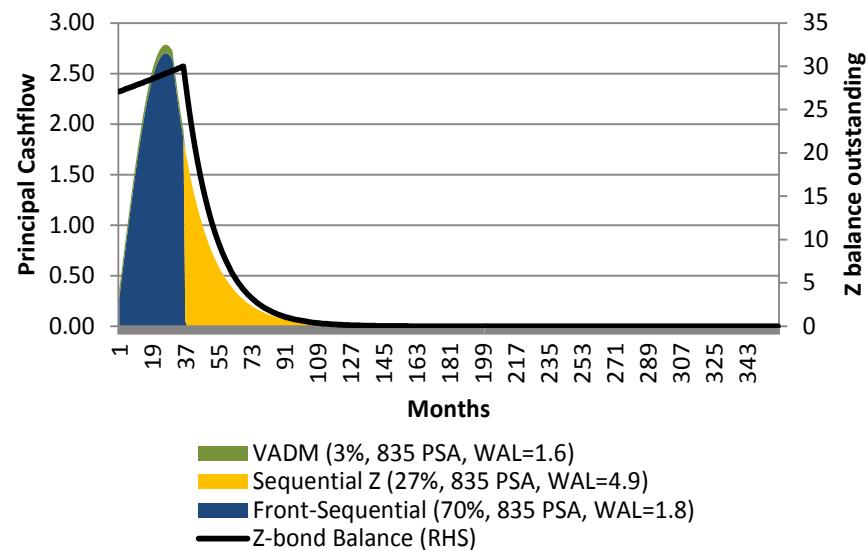


Chart 198: Anything faster than 850 PSA will shorten the VADM to lockout period



Source: BofA Global Research

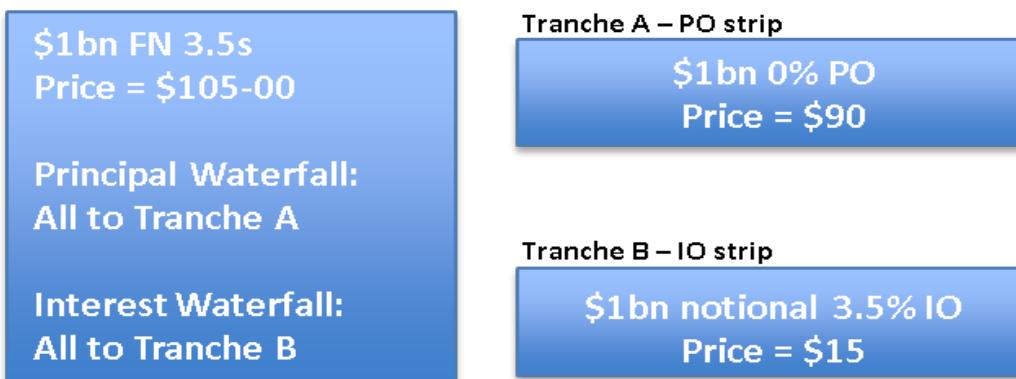
Source: BofA Global Research



CMO structures: IOs and POs

- Tranches can be structured so they are backed solely by the underlying principal or interest:
 - A passthrough strip with a coupon of 0% is called a *Principal Only strip (PO)*
 - A bond only entitled to receive interest, but not principal is called an *Interest Only strip (IO)*
- IO receives cashflows as long the underlying bond is paying interest. Thus, value is tied directly to the WAL of the underlying bond. Unlike a VADM which gets paid off once the Z is out of lockout if still outstanding, there is no ultimate principal payment backing the tranche. Thus, the IO price falls as the WAL shortens. The balance of the underlying bond on which the IO interest is paid is termed the *notional balance*.
- POs, lacking interest payments, trade at discount to par and are highly sensitive to the time value of money as well as the WAL of the underlying bond. PO price increases as the WAL decreases.
- IOs and POs can be stripped off of other CMO tranches, i.e., sequentials, PACs, etc.
- Due to the high sensitivity to the prepayment speed and WAL, IOs and POs are collectively dubbed *MBS derivatives*. Their characteristics are covered separately in this primer.

Chart 199: IO and PO structures, no arbitrage example



$$\begin{aligned} \$1bn * 0\% + \$1bn * 3.5\% &= \$1bn * 3.5\% \\ \$1bn * \$90 + \$1bn * \$15 &= \$1bn * \$105 \end{aligned}$$

CMO structures: floaters and inverse floaters

- Capped floaters can be created out of fixed rate bonds by creating a corresponding inverse floater. Inverse floater is leveraged to the index at the ratio of Floater Balance / Inverse Floater Balance. i.e., an 80/20 split makes the coupon to the inverse floater indexed to 4x index.
- Floaters can also be created by stripping out an *Inverse IO* (IIO), which bears no principal.
- The closer the index is to the strike rate, i.e., a rate that puts the floater coupon at the cap, the more the floater becomes like a fixed rate bond. Thus, a floater is usually close to zero duration and priced close to par only so long as the cap is out-of-the-money. In that case the floater has limited extension or call risk and very little negative convexity. Thus, floaters generally trade tighter than an inverse floater or the passthrough itself.
- As long as the floater cap is out-of-the money, the bulk of the duration, prepayment risk and convexity reside in the inverse floater. They will thus, trade wider than the underlying bond. Inverse floater can be thought of as a long position in the MBS, funded with a floater.

Chart 200: Making a LIBOR floater and an inverse floater, 1:1 no-arbitrage example



$$\begin{aligned} \$500mm * (L+30) + \$500mm * (6.7-L) &= \$1bn * 3.5\% \\ \$500mm * \$100 + \$500mm * \$110 &= \$1bn * \$105 \end{aligned}$$

Tranche A - floater
\$500mm LIBOR+30
Price = \$100 Cap = 7%

Tranche B – inverse floater
\$500mm 6.7% - LIBOR
Price = \$110 Floor = 0%

Chart 201: Strip, LIBOR floater, IIO combination, no arbitrage example



$$\begin{aligned} \$333mm * (L+30) + \$333mm * (6.2-L) + \$667mm * 2\% &= \$1bn * 3.5\% \\ \$667mm * \$100 + \$333mm * \$100 + \$333mm * \$15 &= \$1bn * \$105 \end{aligned}$$

Source: BofA Global Research

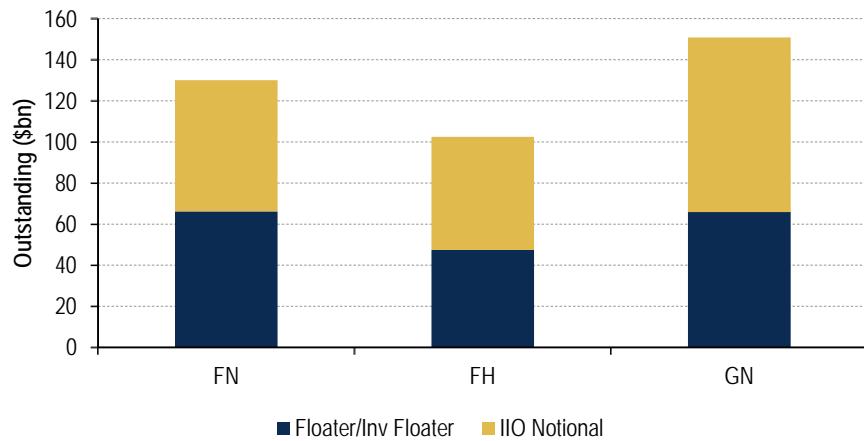
Source: BofA Global Research



REMICs and LIBOR transition

- LIBOR has been the dominant index used to create CMO floaters, inverse floaters, and inverse IOs. The potential elimination of LIBOR beyond 2021 is slated to change this, likely pushing the CMO market towards SOFR. However, a developed, credible, and liquid SOFR swap market is a prerequisite for this in order for these cashflows to be hedgeable.
- For recent vintage LIBOR CMOs, the Agencies can change the index if LIBOR is no longer available, per the fallback language in the prospectus. However, this has not always been the case. Freddie has always had the fallback language, but Fannie added it in June 2014, and Ginnie only in December 2017. As a result, Fannie floaters issued prior to 2014 can't be re-REMICed since November 2019.
- Should a new index, such as SOFR, or SOFR + historical spread, be adopted the yield on existing floaters is not guaranteed to be maintained. Whatever replaces the index is likely to match up with the practices in the swaps market, so the hedged cashflows remain hedged.
- FHFA has instructed Federal Home Loan Banks to stop purchasing investments in assets tied to LIBOR with a contractual maturity beyond December 31, 2021, as of December 31, 2019. Fannie and Freddie language to replace LIBOR, to be updated with the ARRC recommended language in 1Q20.

Chart 202: Outstanding \$180bn of LIBOR floaters and inverse floaters, \$203bn IIO notional



Source: BofA Global Research

Table 42: GSE language on recent REMICs allows them to change the index if LIBOR is gone

Sector	Language
Fannie REMIC	If we determine that the methods described above for establishing LIBOR are no longer viable, we may in our discretion designate an alternative method or, if appropriate, an alternative index for the determination of monthly interest rates on the floating rate and inverse floating rate classes. We will designate any alternative method or index taking into account general comparability and other factors; however, in that case, we can provide no assurance that the alternative will yield the same or similar economic results over the lives of the related classes.
Freddie REMIC	If LIBOR determined under the ICE Method does not appear on the Designated Page as of 11:00 a.m. (London time) on an Adjustment Date, or if the Designated Page is not then available, LIBOR for that date will be the most recently published LIBOR determined under the ICE Method. In the event that any other entity assumes the administration of LIBOR from ICE, LIBOR shall be determined, in our sole discretion, either (i) on the basis of the succeeding administrator's LIBOR determination method, or (ii) by our designation of an alternative determination method or index that has performed, or that we expect to perform, in a manner substantially similar to the ICE Method. We will select an alternative index only if tax counsel advises us that the alternative index will not cause any affected REMIC Pools to lose their classification as REMICs. We can provide no assurance that any alternative LIBOR determination method or index will yield the same or similar economic results over the lives of the affected Classes.

Source: BofA Global Research



CMO investor base

- CMO tranches create a diverse set of risk characteristics, each appealing to a separate group of investors willing to pay up for those characteristics. Thus, various portfolio fits drive execution.
- Portfolio manager mandates can vary - from floating-rate, indexed monies, stable value funds, asset-liability mandates dominant at banks and insurance companies. All of these are ripe for CMOs offering a fit, evaluated against underlying MBS or other investment grade alternatives.

Table 43: CMO investor base

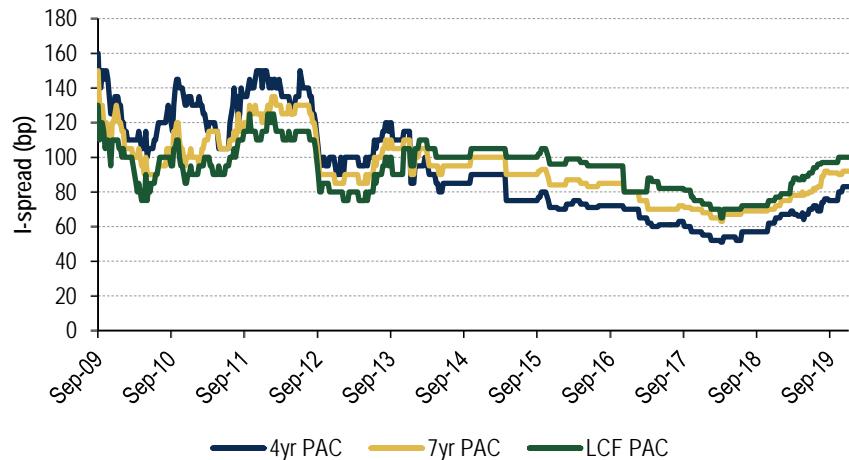
Structure	Rationale	Buyer base
Passthrough	Accounting advantage of a par strip. Minimizes spot prepayment and carry risk for par strip. Ability to target prices / coupons.	Banks, money managers.
Sequentials	Target customized duration. Shorter principal window than MBS. Create locked-out, long duration cashflows.	Banks buy to match funding. Money managers as an alternative to matched duration MBS.
PACs, VADMs	Decrease cashflow variability at the expense of spread. Target customized duration, convexity. Fixed cashflows roll-down the curve. Shorter cashflows vs MBS are an implicit steepener.	Money managers as an alternative to corporates and CMBS. Banks to match funding. Insurance to match liabilities.
Supports	Pick-up substantial spread to collateral. Increase cashflow variability and convexity.	Money managers, insurance companies, and hedge funds to express a view on prepayments, earn higher spread.
Z-bonds	Increase yield and spread. Increase duration as Zs are generally very long. Cashflows are back-ended, Zs are a flattener. Limits reinvestment risk during the accrual phase.	Money managers and hedge funds for total return, convexity Insurance companies to match very long liabilities.
Floater	Reduces interest rate risk and prepayment risk as long as the cap is deep out-of-the-money.	Banks and short-duration funds.
Inverse Floater	Increases exposure to collateral, duration, prepayment risk as long as the floor is deep out-of-the-money.	Money managers and hedge funds for total return, convexity.
MBS Derivatives	High yields and leveraged exposure to prepayments.	Money managers and hedge funds for total return, convexity.

Source: BofA Global Research



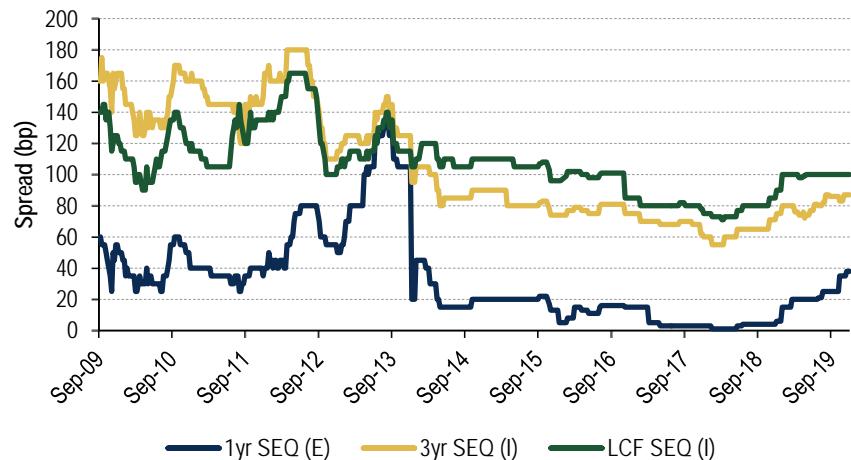
Historical CMO spread snapshot

Chart 203: Historical PAC I-spreads



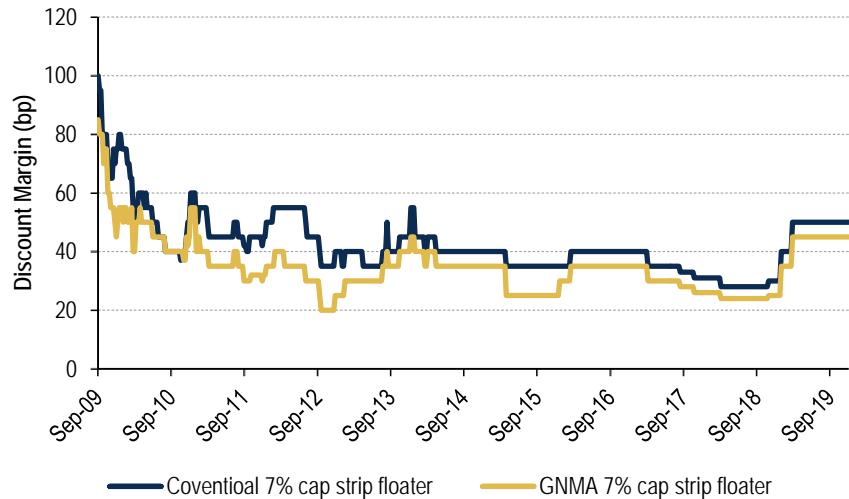
Source: BofA Global Research

Chart 204: Historical sequential spreads



*Note: E-spread for 1yr SEQ is to Eurodollar curve
Source: BofA Global Research

Chart 205: Historical floater discount margin



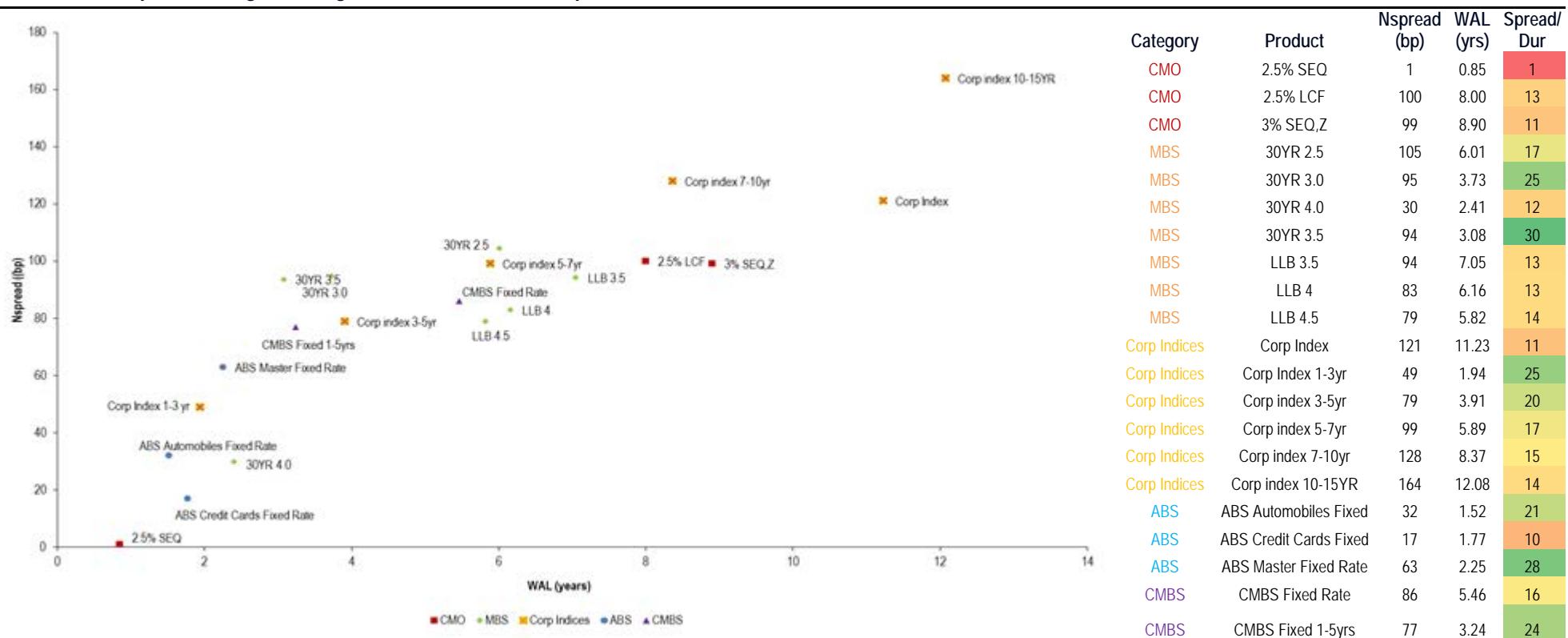
Source: BofA Global Research



CMO relative value – carry per unit of risk

- Agency CMOs span the maturity spectrum, from short to long weighted average lives. This lends to a comparison to other investment grade assets across the maturity spectrum, from asset backed, to commercial mortgage backed and high grade corporates.
- A ratio of the nominal spread to the duration of a specific bond can be a starting point used for relative value comparisons, effectively capturing relative excess carry and interest rate risk.
- One potential refinement of this is to use ZVOAS or hedge adjusted carry instead of the nominal spread, and effective duration instead of WAL, to more closely capture the characteristics of MBS cashflows and interest rate risk.
- Nominal spreads and ZVOAS do not adjust for the embedded MBS option cost, so more negatively convex bonds will tend to look wider. Similarly, non-MBS assets with highest credit risk will be the widest, so only single-A or better credits make good comparables.

Table 44: Nominal spreads vs. weighted average life for MBS, CMO and credit products



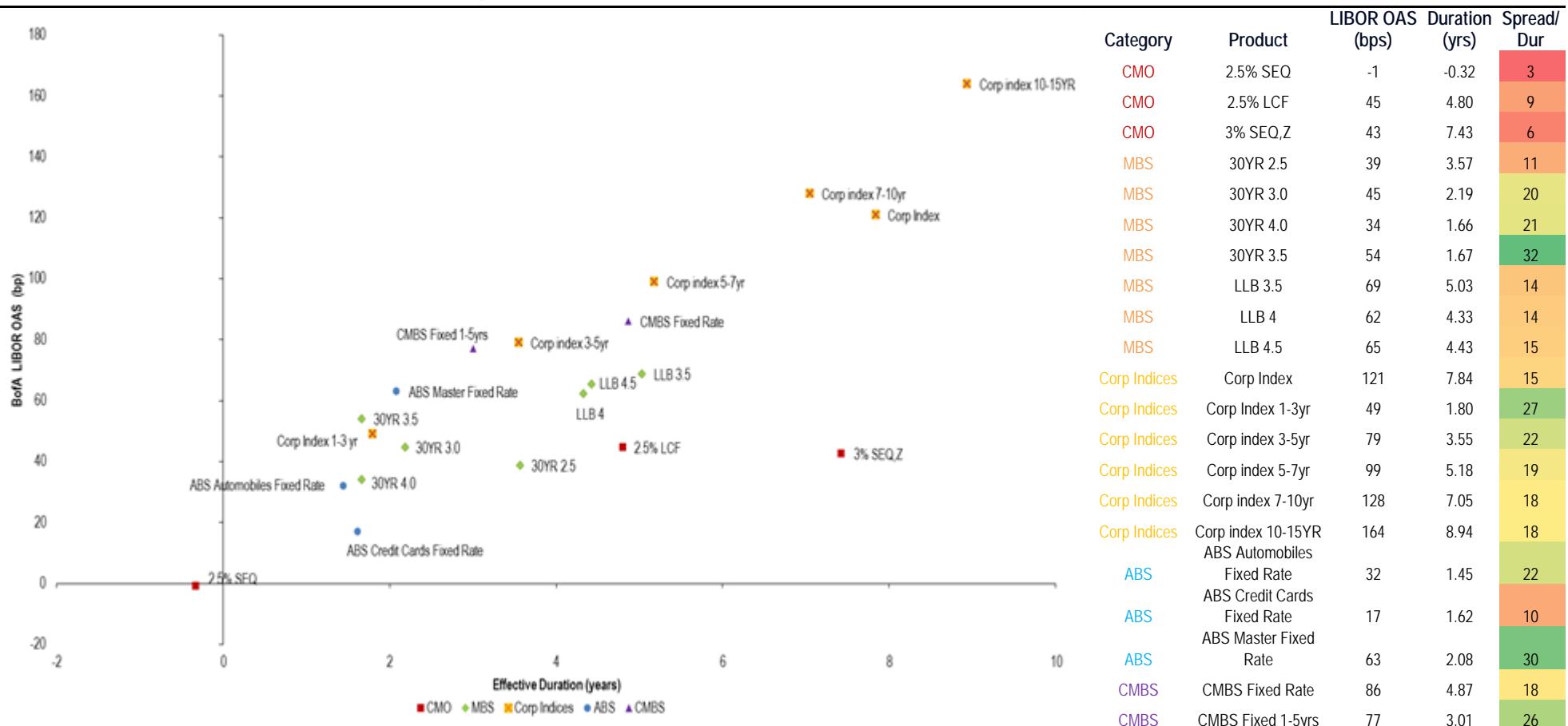
Source: BofA Global Research, as of Feb 24, 2020



CMO relative value – incorporating MBS optionality

- Because of the underlying optionality, using option-adjusted spreads may be better suited for long-term investors. Collateral choice is key; relative value is aided in comparing the OAS of a given CMO to that of the underlying collateral. This helps in understanding the inherent value of a given structure.

Table 45: BofA LIBOR OAS vs. duration for MBS, CMO, and credit products



Source: BofA Global Research, as of Feb 24, 2020



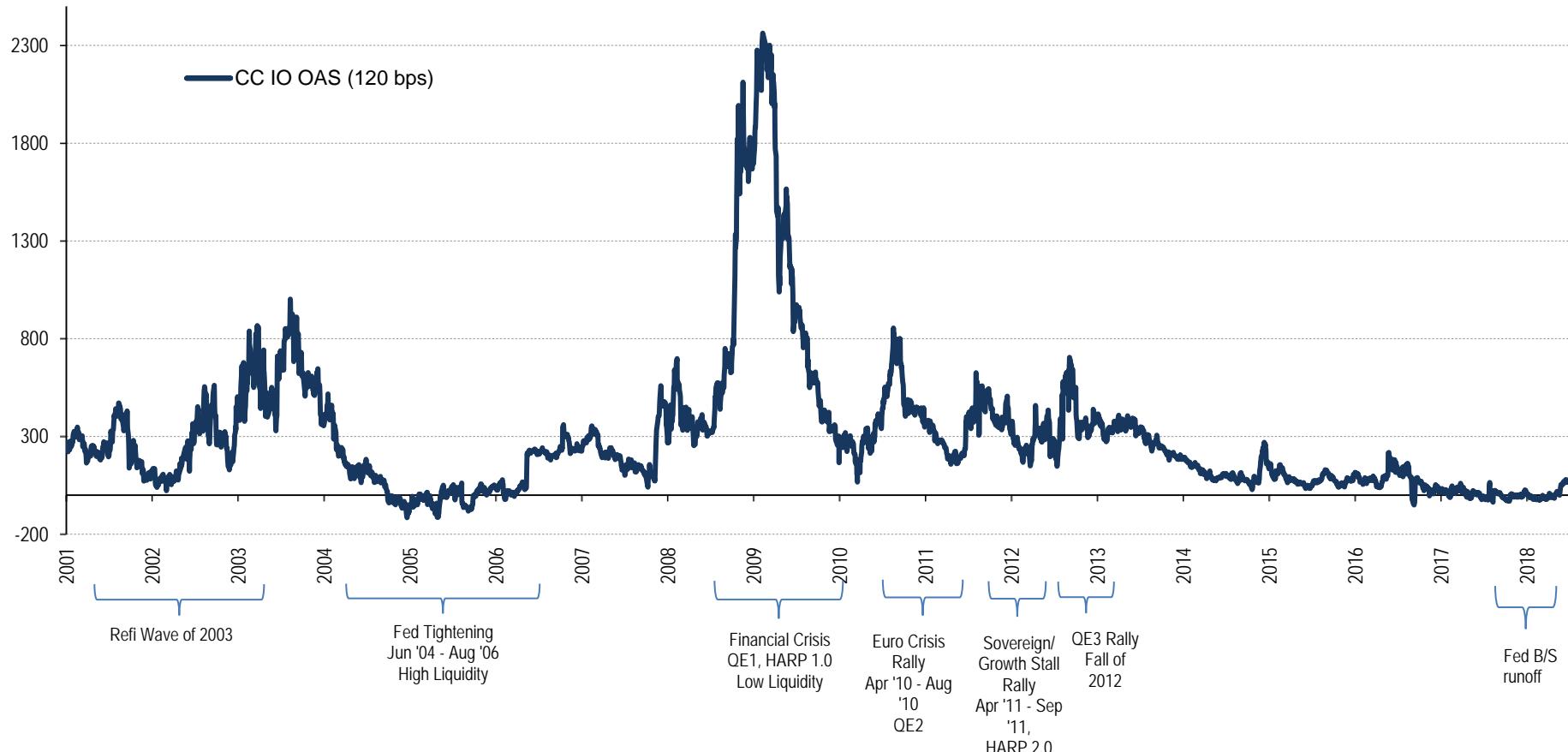
MBS derivatives



What are Agency MBS derivatives?

- Agency MBS derivatives are CMO tranches typically created by separating the interest or principal components of the underlying MBS cashflows.
- These securities exhibit high degree of leverage to the underlying MBS prepayment speeds as well as any policy changes that affects them.
- Other than prepayments, liquidity and spread risks of MBS derivatives can be significant.

Chart 206: Historical OAS on IOs backed by current coupon MBS points to significant spread risk during periods of market stress and refi waves



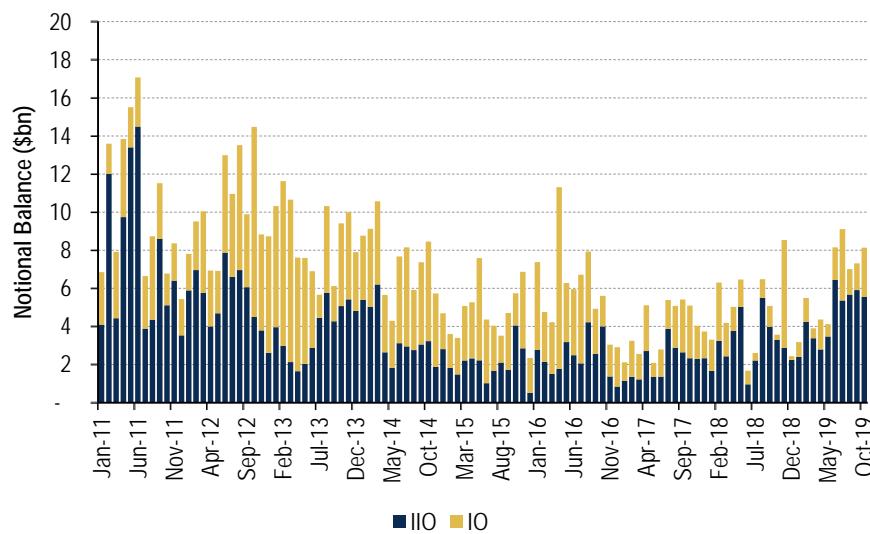
Source: BofA Global Research



Market size and issuance

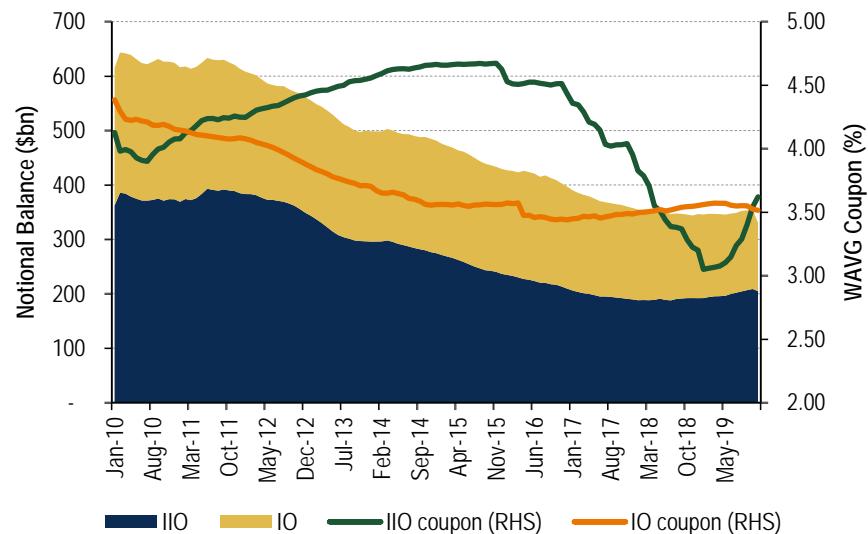
- IOs strip excess interest of the MBS, correspondingly premium MBS typically favors IO creation.
- POs drain excess principal of the MBS, increasing the coupon on what's left. Thus, POs tend to get created from discount MBS.
- IO and IIO comprise the majority of derivative issuance in recent years. Specified pools comprise the bulk of IO collateral, making prepayment characteristics more stable and IO easier to sell.
- IO cashflows can be stripped off of passthroughs or other CMO tranches such as sequentials, PACs, TACs, etc. Agency WAC IOs are unique in that they securitize excess servicing cashflows tied to agency loans but not directly tied to MBS pools.
- IO valuations will reflect both the prepayment profile of the underlying MBS collateral as well as the structure of the underlying bond.

Chart 207: IO issuance runs between \$5 and \$10bn per month, notional



Source: BofA Global Research

Chart 208: IO outstanding notional is declining as CMO issuance is subdued



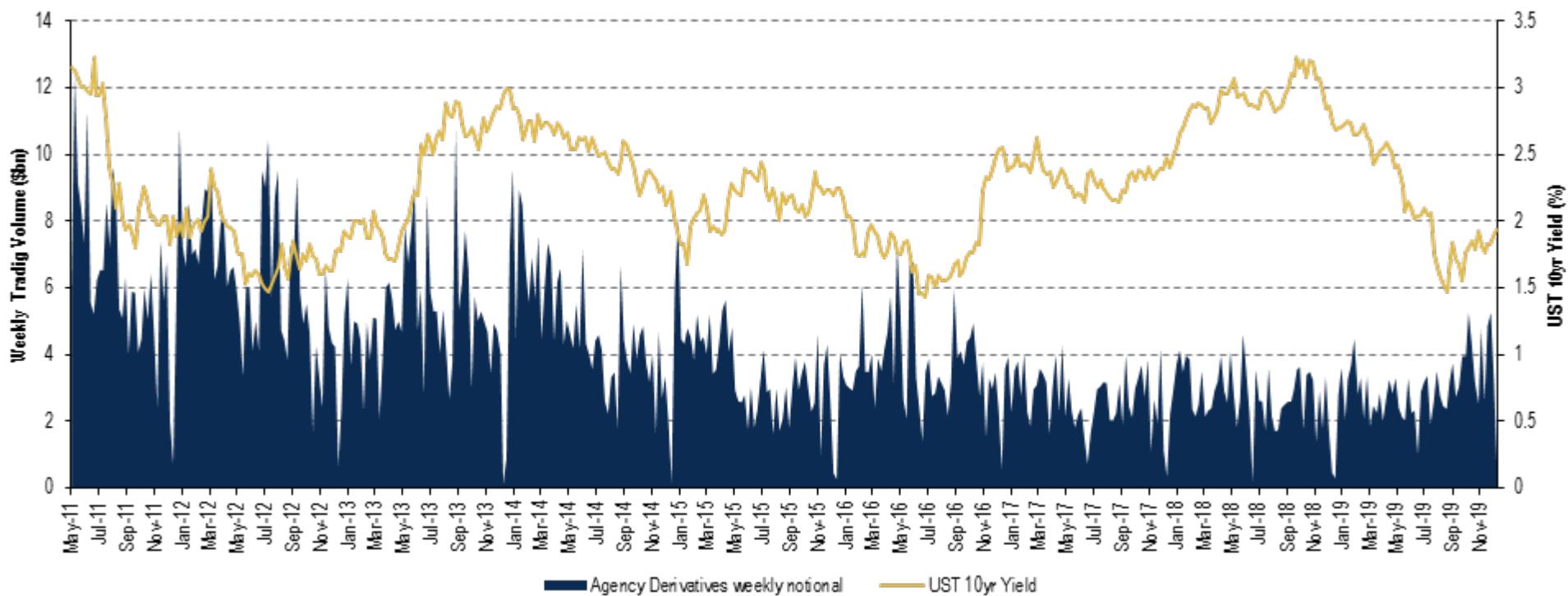
Source: BofA Global Research



Derivative trading volumes are \$2-4bn per week

- Agency derivatives typically trade over the counter for T+3 settle.
- Liquidity varies depending on prevailing rate volatility, with slower trading into sharp rallies.
- Seasonal factors also contribute, with liquidity drying up into the year-end.
- Derivatives have benefitted from the flattening of the S-curves post-crisis, increasing the number of counterparties, mortgage and macro funds involved in the sector.

Chart 209: Typically \$4bn notional balance trades per week



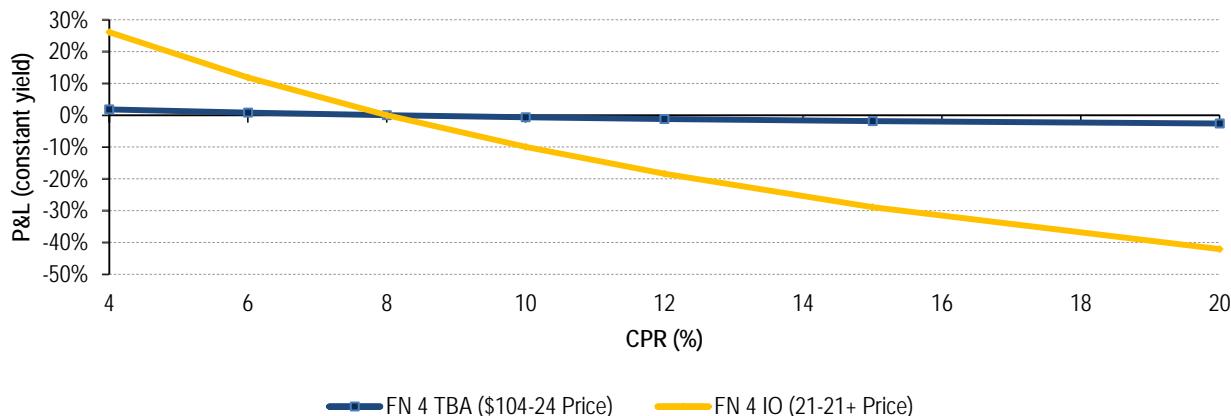
Source: TRACE, Bloomberg



Characteristics of fixed rate IOs

- Since there are no principal cashflows, entire value is dependent on the magnitude and the length of the interest cash flow stream. Prepayments reduce the notional balance and the length of the IO cashflow, therefore rising prepayments decrease the value of the IO.
- Since 1 CPR represents 1% reduction in notional principal, increasing lifetime CPR by 1 decreases annual returns, measured in yield or OAS, by approximately 100bps.
- Prepayments are inversely correlated with mortgage rates; therefore, IOs typically have a significant negative duration – i.e., value drops as rates fall, and rise as rates rise. Thus, IOs actually reduce the interest rate risk of a portfolio. With negative durations, IOs can trade at negative yields.
- Given the sensitivity to prepayments, and the relationship between primary mortgage rates and secondary CC MBS yield, IOs are inherently short MBS basis, as expressed by negative current coupon spread duration. This exposure is typically hedged by buying production coupon TBA.
- TBA basis hedges add carry and hedge some of the negative dv01, but also add negative convexity. Furthermore, basis directionality could require adjustments to the modeled dv01 needs.
- IOs can also have significant convexity and volatility exposures. The nature of the exposure depends on where on the S-curve the borrower is. Cusp borrowers at the top of the S-curve cause the IO to exhibit positive convexity, as the price rises disproportionately more when rates rise. Similarly, IOs not quite in-the-money will be highly negatively convex.

Chart 210: IO exposure is highly leveraged to prepayments compared to the underlying collateral



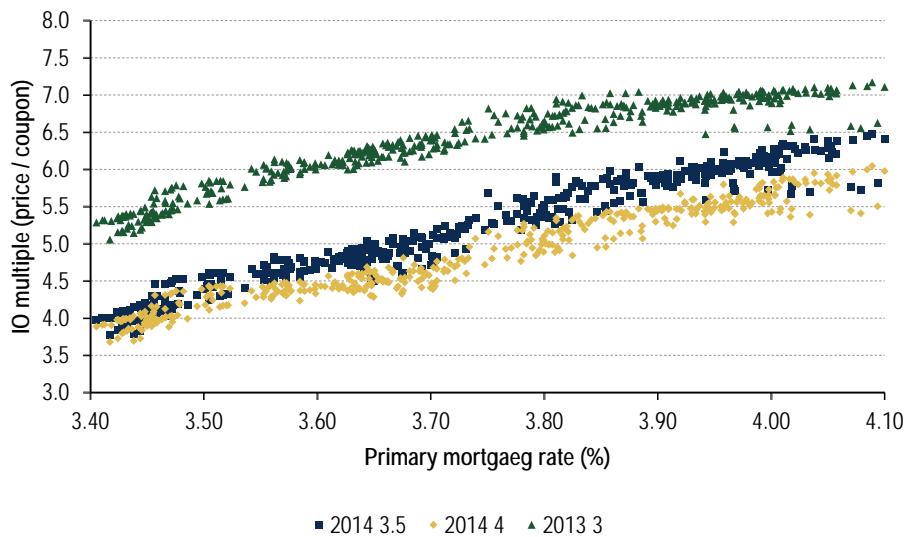
Source: BofA Global Research



IO multiples, mortgage rates, and coupon swaps

- IO prices are sometimes quoted as price multiples of the coupon. This makes it easier to compare pricing and establish relative value. $\text{Price} = \text{Multiple} * \text{Coupon}$.
- They are also useful for pricing bonds where IO coupon does not equal the coupon of the underlying MBS, such as the excess WAC IOs sold by servicers. For example, 10bps excess IO backed FN 3s prices to 0-18 assuming a 5.6x multiple.
- Multiples can be thought of as a cashflow duration measure, approximating the years of coupon received.
- IO multiples are closely related to TBA coupon swaps, particularly when prepayment profile of both legs of the swap is similar. In that case, the coupon swap behaves like a 50bps IO, and can be priced as such after adjusting for carry. The price of a 50bps IO is equal to the multiple divided by 2.

Chart 211: IO prices are commonly quoted in multiples (Mar 2015 – Dec 2017 IOS shown)



Source: BofA Global Research

Chart 212: TBA coupon swap price versus a price on a 50bps IO, priced at a multiple



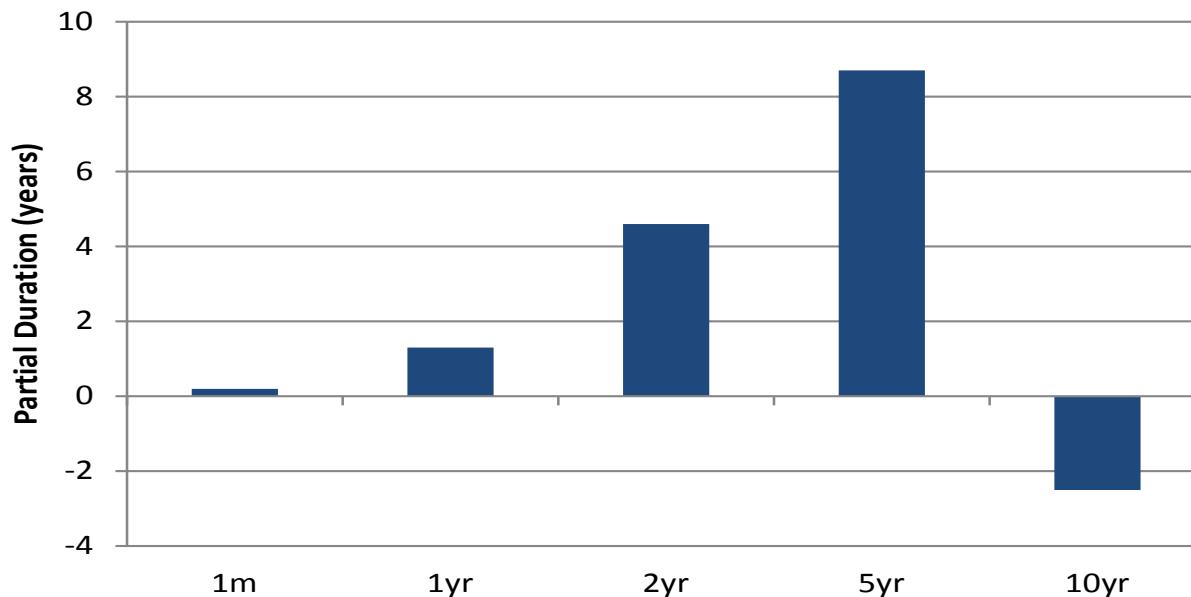
Source: BofA Global Research



Characteristics of inverse IOs

- Similar to the IO strip, Inverse IO has no principal cashflows, and therefore has a similar prepayment risk characteristics as an IO strip.
- Coupon dependence on the short-term rates means that cashflows of the IIO bond decline as LIBOR increases. Mortgage rates, however, are typically correlated with the level of the long-term rate. Thus, IIO value increases as short rates drop and increases as long rates increase. Therefore, IIOs are an implicit steepener trade. Prices can rise or fall given a parallel shift in rates.
- IIO structures are sometimes leveraged to LIBOR, further exaggerating the embedded curve bet. For example, IIO paying 8% cap – 2 x LIBOR has more short-rate exposure to LIBOR than IIO paying 5.5% cap - LIBOR.
- Yield-to-forward* is often quoted for IIOs as a relative value metric. This is the yield on the bond assuming the forward curve is realized.

Chart 213: KRD profile of a typical IIO implies long a steepener position



Source: BofA Global Research



OAS extraction and hedging

- Many IO investors engage in OAS extraction, i.e., hedging most other exposures in the bond, such as duration across the curve, convexity, volatility, current coupon basis. Complex exposures to rates, high sensitivity to prepayments, and lack of transparent pricing forces hedgers to rely heavily on OAS models.
- Given that many derivative investors hedge convexity and volatility exposures, OAS remains the most relevant relative value metric.
- Fixed rate IOs can be hedged with rates for duration and swaptions for convexity and volatility exposures. Alternatively, duration is often hedged by buying current coupon TBA with the idea that MBS prices are more closely related to the mortgage rate than treasuries or swaps.
- Hedging IIOs usually involves buying long swaps or treasuries to hedge the prepayment risk and selling shorter duration bonds or Eurodollar futures to hedge LIBOR risk. Hedge ratios are usually derived from the OAS model as it is difficult to decompose duration components empirically.

Table 46: Example of hedging IIO basis and curve exposure using FN 2.5 TBA and swaps

IIO Face	50,000,000
IIO Full Price	16-15+
FN 2.5 TBA Full Price	101-11+

Hedging out MBS basis using FN 2.5s:

A from model	B = A * IIO Mkt Value / 10000	C from model	D = C * FN 2.5 Price * 50mm / 1000000	E = B / D	F = -E * C	FN 2.5	Combined Position
IIO			FN 2.5 TBA (\$50mm face)			TBA	Market value
CC spread	CC spread	Spread	Spread	FN 2.5		TBA	IIO
Duration	dv01	Duration	dv01	TBA HR			FN 2.5 TBA
-25.7	-21,211	4.41	22,350	vs IIO			
				-0.95	47,453,052	8,242,188	48,098,117

Hedging out curve exposure:

	A from model	B = A * IIO Mkt Value / 10000	C from model	D = C * FN 2.5 Mkt Value / 10000	E = B + D	F	G = E/F	H = G * IIO Face
	IIO (\$8mm position)	dv01	FN 2.5 TBA (\$48mm position)	dv01	Combined dv01	\$50mm Swap DV01	Swap HR vs IIO	Swap Face
Aggregate	KRD	dv01	KRD	dv01				
	-1.8	-2,026	3.4	16,613	14,587			
2y	6.8	5,636	1.0	4,723	10,359	10,000	1.036	51,796,214
5y	-0.4	-297	0.7	3,511	3,214	24,000	0.134	6,696,758
10y	-6.3	-5,214	1.4	6,825	1,611	47,000	0.034	1,713,952
30y	-2.6	-2,151	0.3	1,554	-598	122,000	-0.005	-244,935

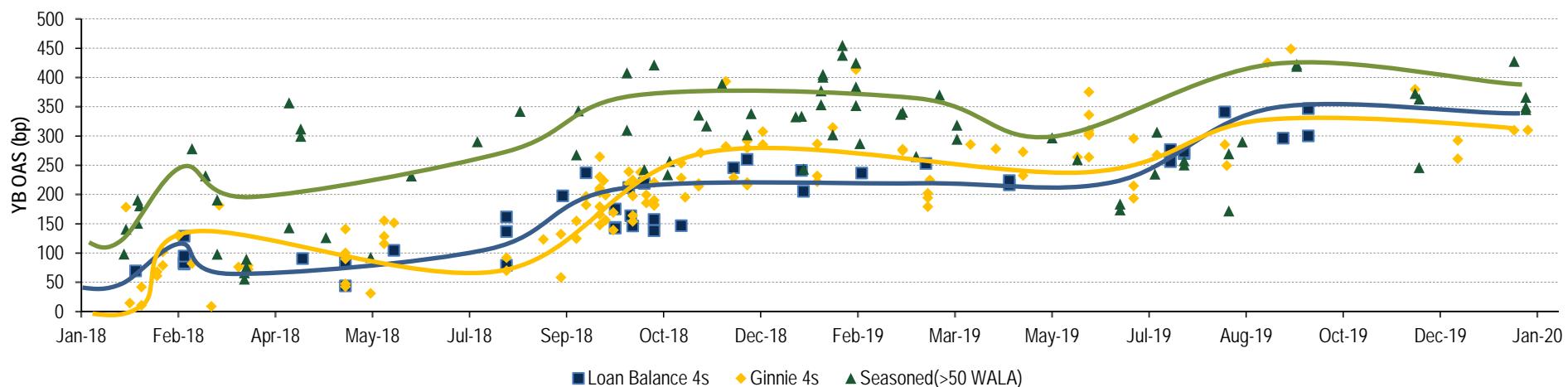
Source: BofA Global Research



Collateral stories drive deals, IO valuations

- Within Agency CMOs, IOs are most sensitive to prepayment risks. For example, in the typical par strip and IO, or par strip, floater, and IIO execution the derivative investor bears the brunt of the prepayment risk, while valuations on the strip and the floater are relatively insensitive to speeds. Therefore, the choice of collateral is most important to the IO investor in the deal.
- IO investors will buy known prepayment stories at a tighter spread compared to generic TBA collateral, where risks are magnified, boosting CMO arbitrage.
- Therefore, IO investors steer deals toward specified collateral. As a result, most deals in recent years have been backed by some sort of specified story.
- This imparts some stability to IO valuations when prepayment shocks are contained to the TBA, a phenomenon witnessed in 2019.

Chart 214: IIO spreads by collateral story over time

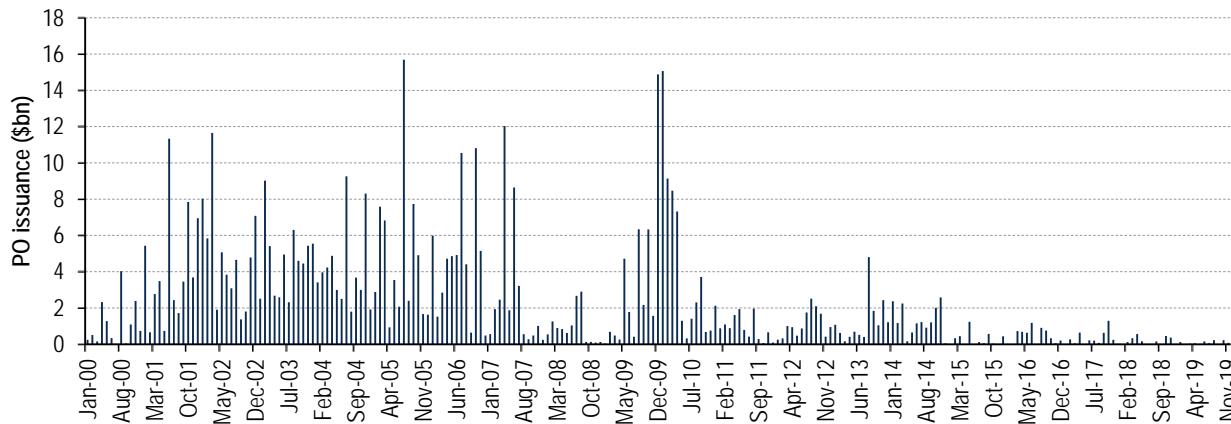


Source: BofA Global Research

A word on POs

- Principal Only (PO) tranches are the stripped principal component of the MBS cashflow. They can be made as a companion tranche to the IO when all the interest is stripped. POs are also created as a byproduct of a synthetic premium creation. For example, investor needing a 6% MBS (or a 6% cap floater/IIO combination) but only 3% MBS are available. Then \$100 of 3% MBS can be used to create \$50 of 6% MBS and a \$50 PO.
- There are no interest cashflows and the magnitude of the cashflows is known, while timing is prepayment dependent. Since faster prepayments benefit POs, they generally exhibit a large positive duration. PO prices never surpass par.
- Just like IOs, PO convexity profile depends on where on the S-curve the borrower is. Cusp borrowers at the top of the S-curve cause the PO to become negatively convex, as the price drops disproportionately when rates rise. Similarly, POs not quite in-the-money will be highly positively convex.
- Absent arbitrage, a combination of the PO and the IO will match the price, OAS, duration, and convexity of underlying passthrough.
- POs are not as common today as they once were. Servicers can buy POs to hedge servicing rights (MSRs) that have IO-like characteristics and selling TBAs. In practice, servicers often just buy TBA to hedge their IO cashflow, or in the case of many non-banks don't hedge them all, compensating losses with rising refi fees into rallies.

Chart 215: PO issuance has been negligible post-crisis as the trust IO/PO market withered



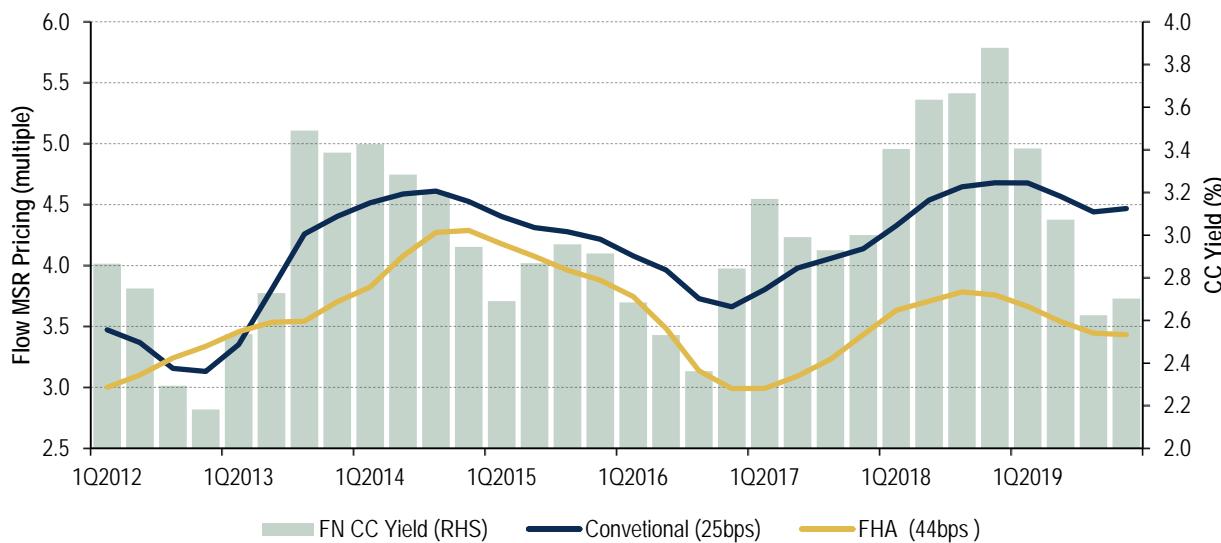
Source: BofA Global Research



MSR, another kind of IO

- Mortgage servicing rights (MSRs) are a special kind of IO retained by the servicer. MSRs represent the servicing fee that a servicer retains at origination, expressed as a percentage of outstanding balance. Minimum retained conventional MSR is 25bps and 19bps for Ginnie Mae IIs. In practice, excess IO is also retained. MSRs can only be sold to another servicer and are not easily traded, so should trade with a *liquidity discount*.
- MSR holder is entitled to the IO stream from the loan, but unlike a normal IO the servicer also takes on certain obligations and costs with respect to servicing the loan. For example, operational costs of getting in touch with and modifying delinquent borrowers, legal liability, systems, etc.
- Thus, *servicing costs* affect MSR valuations on top of the usual determinants of IO prices. Delinquent loans are more expensive to service. Hence, MSRs on weaker credit FHA loans trade at lower multiples compared to conventional.
- Recapture rates* can also affect MSR valuation for a particular servicer. To the extent the servicer refinances their own loan, they retain the new MSR and avoid a loss. Thus, the higher the expected recapture rate, the more the MSR is worth to a servicer.

Chart 216: Historical MSR pricing multiples



Source: Phoenix Capital, BofA Global Research



MBS supply and demand technicals



Defining the gross and net supply of MBS

- MBS supply is visible to the market through the daily issuance of pools. This issuance constitutes *gross supply*, or *gross issuance*. Net supply is defined as:

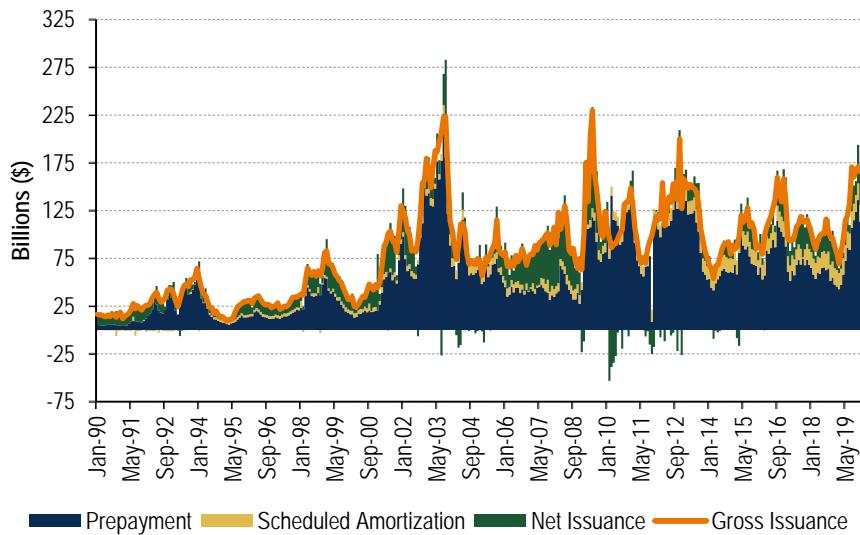
$$\text{Net Supply} = \text{Gross Issuance} - \text{Paydowns}$$

where paydowns include monthly amortization and prepayments. Since prepayments are reported monthly, net MBS supply can only be observed on that basis. The identity above works in reverse also:

$$\text{Gross Issuance} = \text{Net Supply} + \text{Paydowns}$$

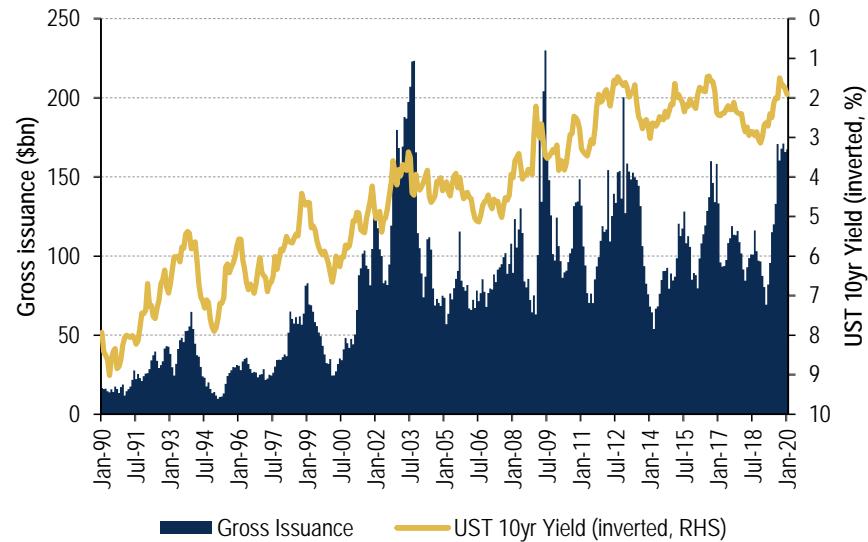
- Paydowns are the primary determinant of gross supply, which is usually much larger than net. The intuition for this stems from the fact that most mortgages are produced either as a result of purchases or refinances. Both typically result in a loan prepayment, either that of the property seller, or the old loan that is being refinanced.
- The dollar volume of paydowns is a function of MBS outstanding and prepayments. Since prepayments vary inversely with interest rates, so does the gross supply. Thus, level of interest rates is the primary determinant of gross issuance in the short- and medium-term, when MBS market size changes little.

Chart 217: Gross issuance = net supply + paydowns



Source: BofA Global Research

Chart 218: Interest rates drive gross issuance locally, and market size over the long-term



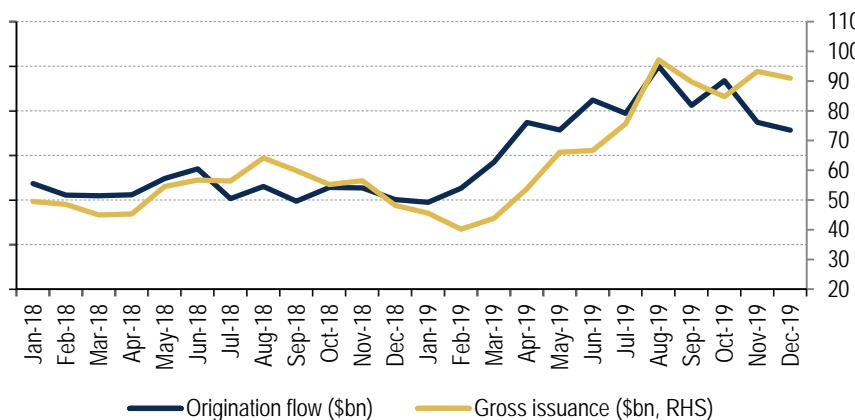
Source: BofA Global Research



Origination flows as harbingers of supply

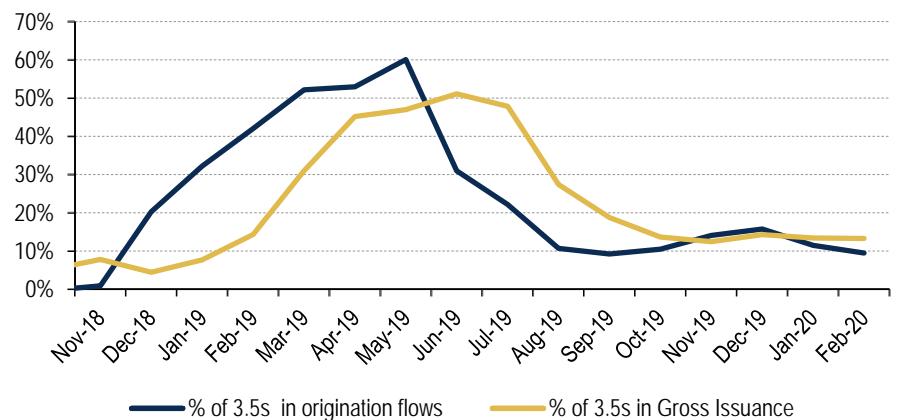
- Mortgage originators hedge rate locks by selling TBA. The loan is subsequently closed and securitized, typically about 2 months later. When the new production pool is sold, TBA hedge is purchased back.
- Many dealers aggregate and report daily TBA sales they see from originators, ignoring any hedge repurchases. These origination estimates provide a lead estimate of gross issuance.
- As a result of this dynamic, supply impacts the TBA market well ahead of the realized gross issuance. MBS funding needs will materialize only when the pool is issued, as the loan is warehouse funded prior to securitization,
- In addition to trends in volume, origination sales also provide a preview of the product and coupon mix.
- Different dealers will spot different origination levels, subject to their market share. Furthermore, market shares can fluctuate month to month.
 - Originator TBA sales may not be solely to hedge rate locks. For example, convexity hedging needs for MSRs could drive originator TBA volumes. Originations of specified stories too, hedged to longer durations than TBA, have the potential to skew origination numbers.

Chart 219: Gross issuance lags origination flows, usually by about 2 months



Source: BofA Global Research, Desk inquiry

Chart 220: Origination flows are predictive of product and coupon mix



Source: BofA Global Research, Desk inquiry



Net supply = net demand, dictates market size

- Paydowns that comprise gross supply create monthly reinvestment needs for the sector as a whole. Thus, net supply represents the net inflows required into the sector to fully fund monthly MBS gross issuance:

$$\text{Net supply} = \text{Net demand} = \text{Gross issuance} - \text{Paydowns}$$

- Since investors reinvest principal proceeds to keep existing allocations relatively unchanged on aggregate, net supply is typically of more import to MBS valuations than gross volumes.
- Because reported MBS balances include issuance for the month, but not paydowns, net supply is observed a month after gross issuance. The relationship between the reported balance and net supply between any two points in time is as follows:

$$\text{Net supply} = \Delta\text{Balance} - \Delta\text{Monthly Paydowns}$$

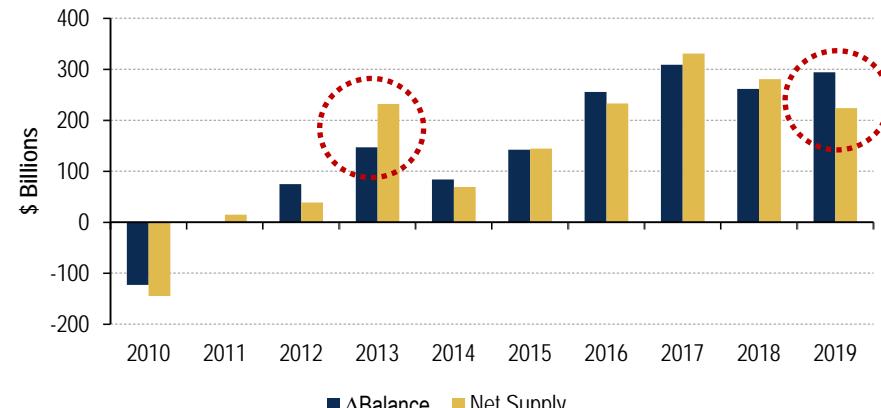
- Per the equation above, net supply drives MBS balance growth, dictating market size in the long-term.
- In the short-term, the change in outstanding balance may not be a good approximation of net supply if monthly paydowns undergo a significant change. When paydowns increase, net supply will be smaller than the change in balance, and vice versa. This, in turn, is highly correlated to rate changes.
- Net supply can be negative, when paydowns exceed gross issuance. Net supply can never be more negative than aggregate paydowns, since gross issuance can't be negative.

Table 47: Relationship between net supply, gross issuance, paydowns, and balances

ΔYoY	Balance		Monthly Paydown		Net = ΔBalance - ΔPaydown
	294	6,822	71	133	
Dec-19	6,822		133		
Dec-18	6,528		63		
Date	Balance	Gross Issuance	Paydowns	Net Issuance	
Total		1,530	1,307	224	
Dec-19	6,822	166	133	32	
Nov-19	6,787	171	131	40	
Oct-19	6,770	168	153	14	
Sep-19	6,743	160	141	19	
Aug-19	6,715	171	132	39	
Jul-19	6,669	133	124	9	
Jun-19	6,637	120	101	19	
May-19	6,619	115	103	12	
Apr-19	6,594	96	89	6	
Mar-19	6,573	82	75	7	
Feb-19	6,555	69	64	5	
Jan-19	6,546	80	60	20	

Source: BofA Global Research

Chart 221: Balance changes deviate from net supply in years where rates and paydowns change



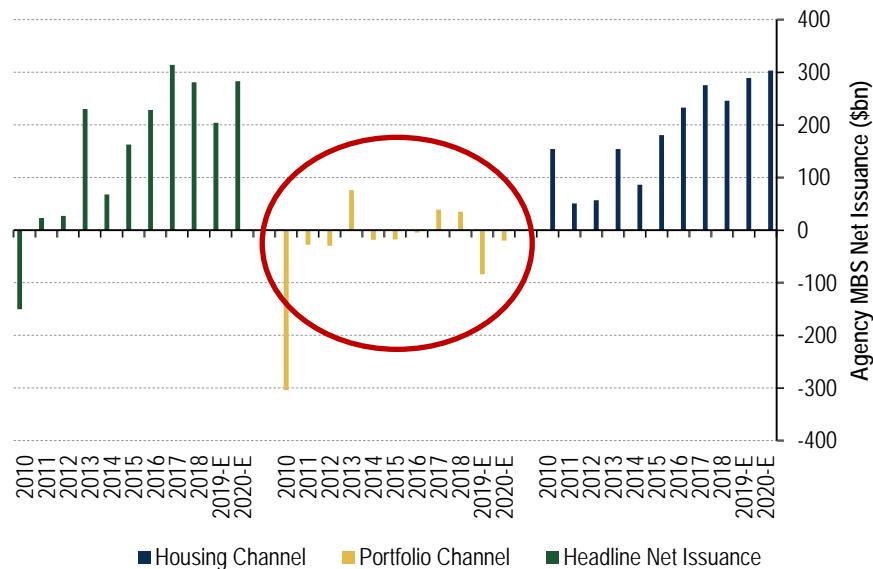
Source: BofA Global Research



Housing and portfolio channels drive net supply

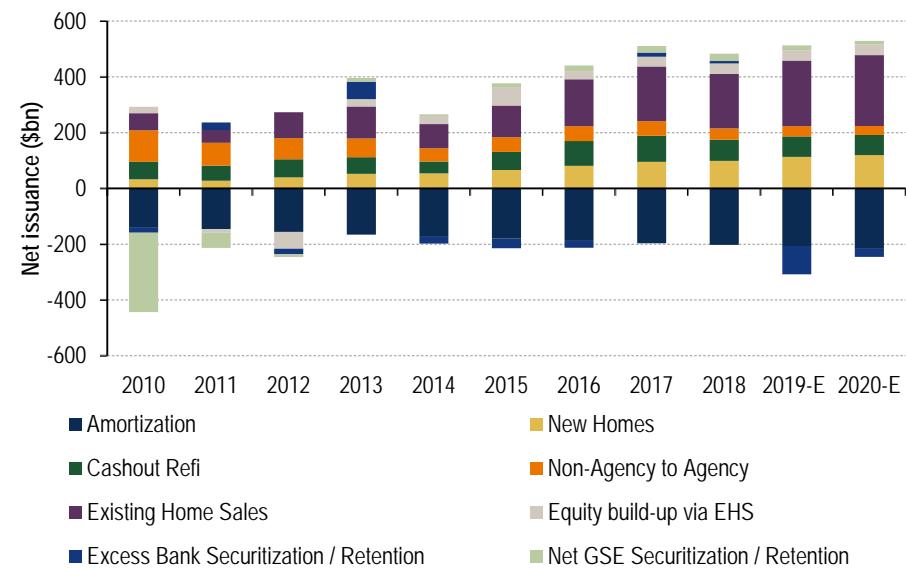
- Unlike gross supply, where variability is primarily driven by rates and prepayments, net supply is a function of housing and portfolio related factors.
- Housing channels – these factors are exogenous to the MBS market, arising from ongoing macroeconomic activities. These include loan amortization, new home sales, cashout refis, runoff from non-agency RMBS, and mortgage debt creation from sales of mortgage-free homes or those with substantial equity.
- Portfolio channels – these come from the banks and the GSEs varying the amount of loans held on balance sheet as opposed to being sold into MBS, i.e. their net securitization or retention.

Chart 222: Portfolio retention can change rapidly from year to year



Source: BofA Global Research

Chart 223: Net issuance broken out by key drivers

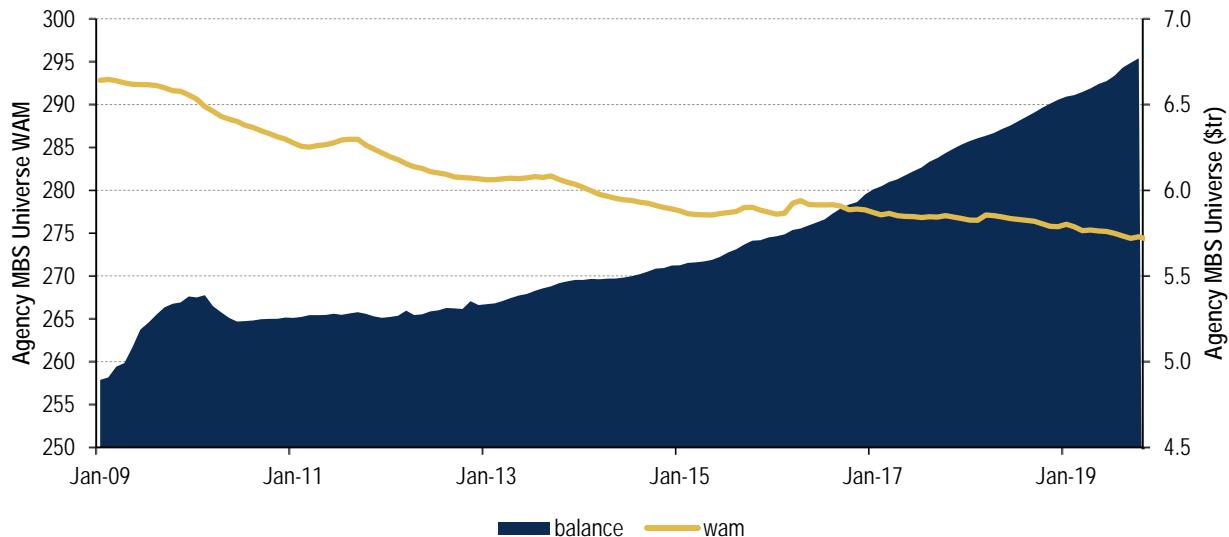


Source: BofA Global Research

Net supply driver: amortization

- Amortization measures scheduled paydowns of mortgages, amounting to over \$200bn per year, dragging down supply.
- The amortization rate has increased due to the growth of the agency MBS sector even as the average borrower deleverages, shortening maturity.

Chart 224: The drag from amortization is growing steadily as the Agency MBS universe grows and the remaining maturity on outstanding mortgages shortens



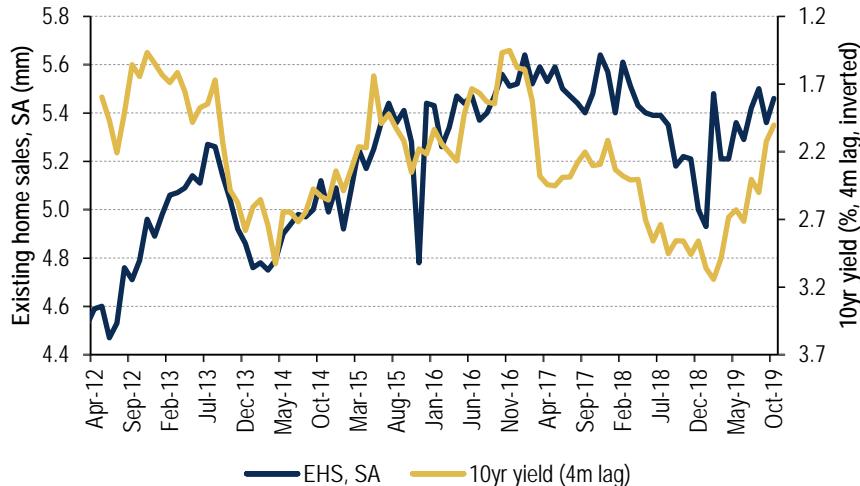
Source: BofA Global Research, FNMA, FHLMC, GNMA



Net supply driver: new and existing home sales

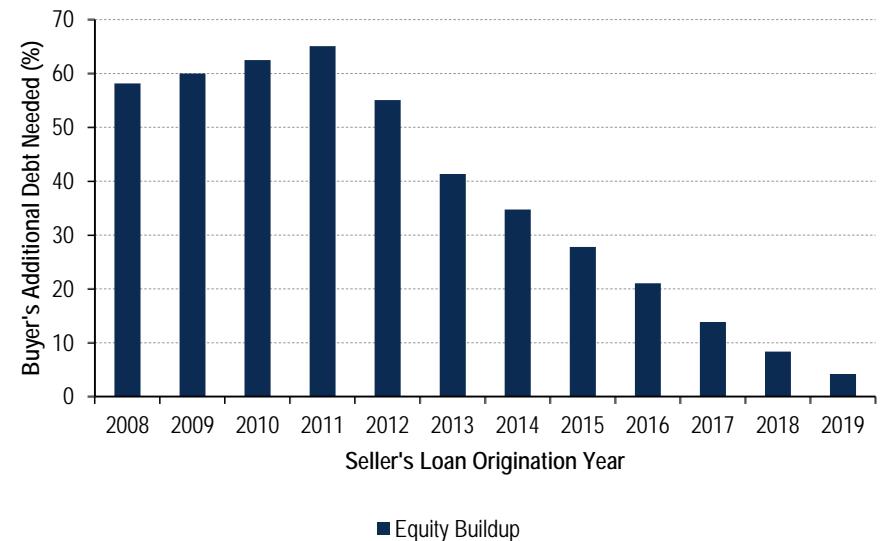
- New Home Sales (NHS) – new home sales create funding needs as only 20-30% of purchases are all-cash sales. A high share of these loans is ultimately funded via Agency MBS.
- Existing Home Sales (EHS) – existing home sales is the larger contributor, adding to net supply in two ways. First, is through home ownership transitions. This encompasses the property transitions between existing agency borrowers, borrowers whose loans are housed within bank portfolios, and mortgage debt growth by the conversion of unmortgaged properties to those bearing a mortgage.
- When the share of all-cash sales is below that of unmortgaged homes, there is a net increase in mortgages. Similar logic applies to loans held in bank portfolios. When banks retain fewer purchase loans than their overall share of mortgage holdings, MBS net supply will rise.
 - The second mechanism EHS contributes to net supply is through equity build-up. The loan balance of a prospective home buyer often exceeds that of the seller's due to scheduled amortization and HPA. When financed through Agency MBS, such sales generate net supply.

Chart 225: Lower rates stimulate home sales, taking 4-8 months to propagate into purchases



Source: Bloomberg

Chart 226: Additional debt creation on a 2020 purchase for \$100 non-distressed, 80 LTV loan



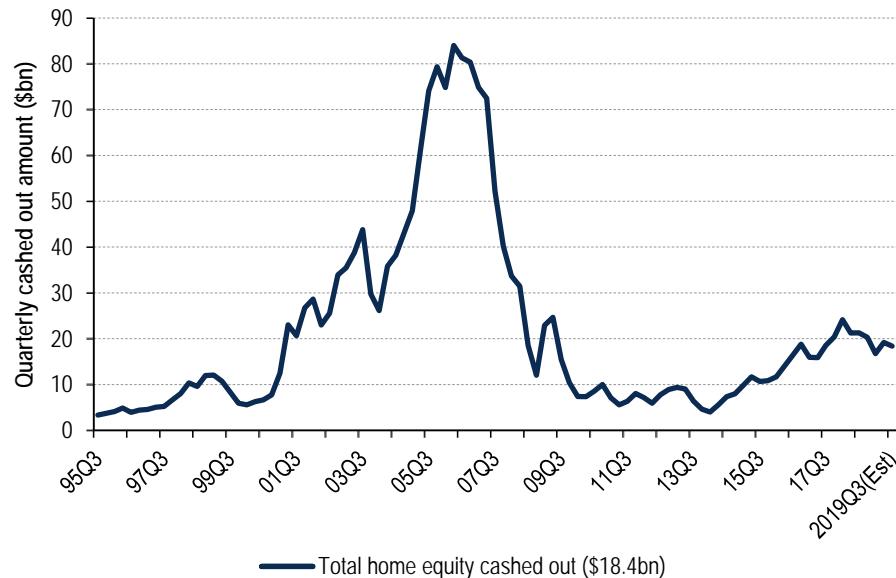
Source: BofA Global Research



Net supply driver: cashouts

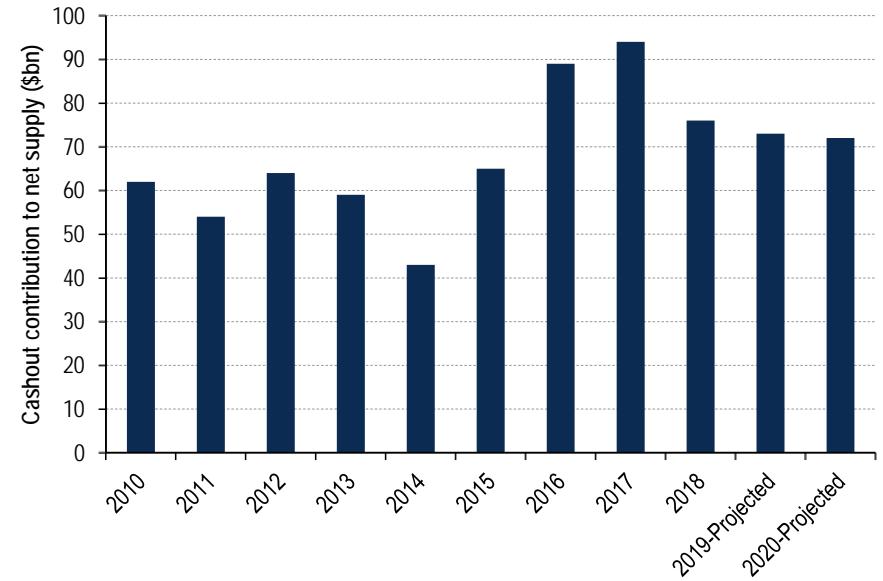
- Cashout refinance – higher balance on the new loan, compared to the one being paid off, creates net MBS supply.
- Cashout dollars, inclusive of all capitalized closing costs and LLPAs contribute to the net supply.
- Cashout volumes, as estimated by Freddie Mac, have been around \$20bn per quarter. 2016 and 2017 has seen a local peak due to rising HELOC consolidations from 2006 and 2007, as payments on these loans rose after the 10-year IO period ended.

Chart 227: Quarterly refinance volumes have been around \$20bn per quarter since 2017



Source: BofA Global Research

Chart 228: Estimated cashout contribution to net supply



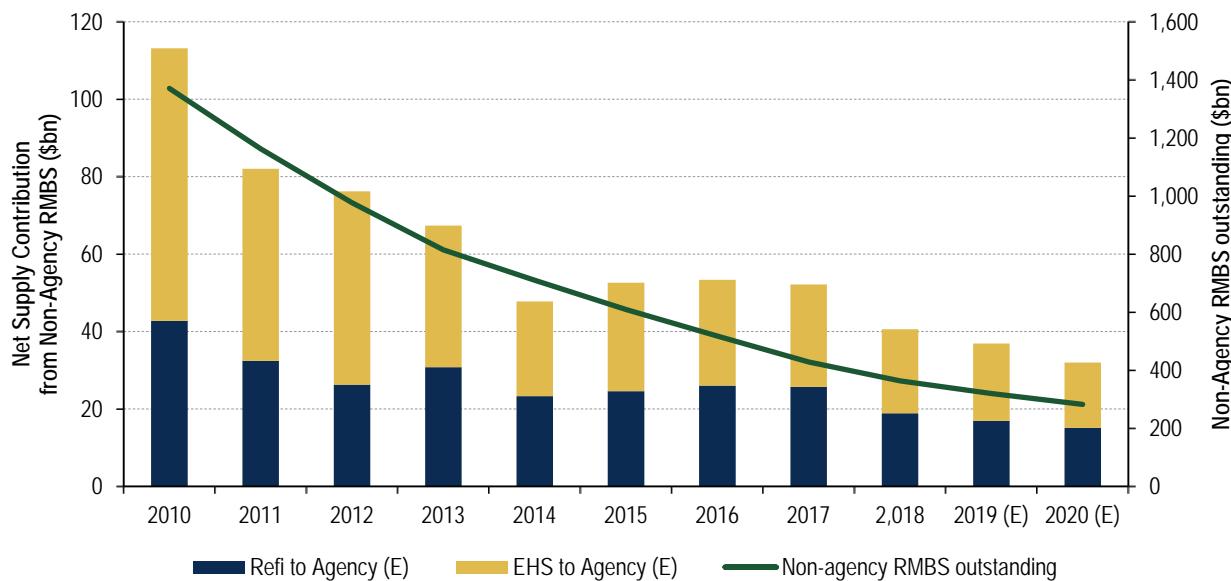
Source: BofA Global Research



Net supply driver: non-agency RMBS market decline

- The legacy non-agency sector has shrunk post-crisis, adding net supply to Agency MBS. The decline is driven by a combination of limited originations, scheduled amortization, voluntary prepayments, and involuntary liquidations.
- The transmission channel includes borrowers refinancing from a non-agency loan into an agency loan and properties sold either via turnover or liquidations, ultimately financed through agency loans.
 - Tightening credit spreads, potential for higher g-fees and LLPAs, could cause this to reverse. For example, high LLPA investor loans can often obtain better execution via PLS, possibly shifting supply away from the GSEs.

Chart 229: Legacy non-agency RMBS market is shrinking, contributing net supply to Agency MBS



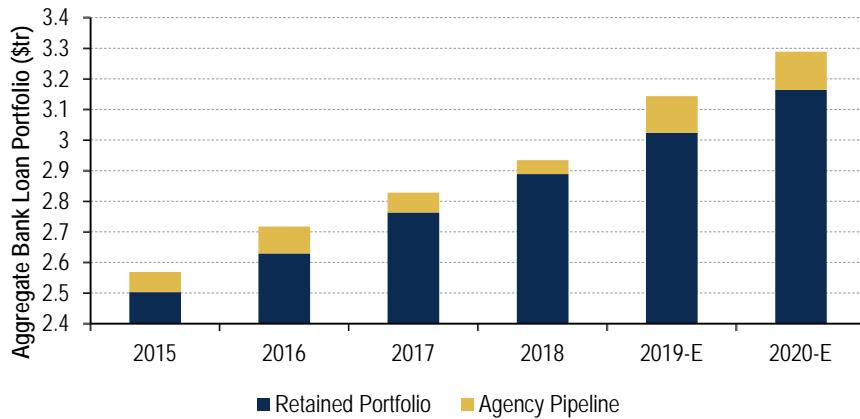
Source: BofA Global Research



Net supply driver: bank and GSE securitization/retention

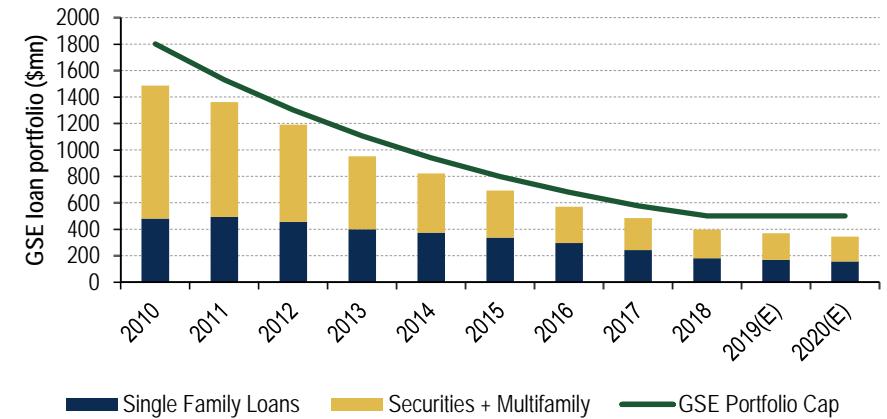
- Away from Agency MBS, banks and GSEs are the primary balance sheet holders of mortgage loans. Net supply of mortgages is thus absorbed between these institutions and Agency MBS. To the extent they increase retention, Agency MBS supply is reduced. Similarly, when they increase the rate of securitization Agency MBS net supply rises.
- Bank loan retention can be separated into origination pipeline-related, and core portfolio. The former is related to rates and prepayments. Newly produced loans sit temporarily on the balance sheet of the originator for 1-2 months before being securitized. Thus, when rates rally and refi pipelines expand, net supply decreases temporarily. Similarly, a flush-through of the pipeline into rising rates temporarily increases net supply.
- Excluding pipeline changes, the retained loan portfolio growth at the banks has remained relatively steady, ~5% YoY on average in the past 5 years.
- Net GSE securitization/retention stems from loan portfolio runoff and buyouts. Loan portfolio runoff increases net supply, while buyouts decrease it. GSEs have reached their individual mandated \$250bn limits in 2017, so are no longer required to reduce. Widespread GSE buyouts in 2010 following FAS 166/167 implementation turned net supply negative in that year.

Chart 230: Pipeline changes cause supply volatility while retained portfolios grow steadily



Source: BofA Global Research, Federal Reserve

Chart 231: GSE portfolio run off has contributed to net supply in recent years



Source: BofA Global Research



Net demand in a post-crisis regime

- Every MBS produced is owned by an investor. Thus, net supply equals net demand. The principal Agency MBS investor groups post-crisis include banks, Fed, overseas investors, mREITs, and money managers. Each group faces unique considerations and drivers of demand.
- Banks** – invest in MBS to satisfy liquidity requirements and boost net interest margins (NIM). Prior to the financial crisis, MBS was often used as a substitute for loans. Growth can be separated into passive and active components.
- The Fed** – a price insensitive investor added MBS through QE1 and QE3. MBS portfolio runoff since 2017 creates private investor net demand needs, equivalent to additional net supply.
- Overseas investors** – invest dollar reserves and excess liquidity into MBS. Primarily based out of Asia historically. Investors span foreign central banks, banks, and insurance companies. Official demand tends to be sensitive to exchange rates. Overall yield levels also play a role as MBS is viewed as a Treasury substitute. For the same reason, there is a heavy preference for GNMAs.
- Mortgage REITs** – invest into MBS by issuing equity and leveraging it up 6-10x via repo. Typically hedged with swaps, and tend to favor specified pools.
- Money managers** – relative value investors who buy MBS for total and relative return potential, evaluating it versus Treasuries and other asset classes such as high grade credit. Mandates span total return funds, separate corporate accounts, hedge funds.
- Other investor groups include the GSEs, insurance companies, dealers. Net demand from these tends to be small in recent years. US Treasury bought Agency MBS during the crisis, but no longer does so.

Table 48: Post-crisis net MBS supply / demand broken

Net Supply	Bank	Fed	GSE	Insurance	MM	Overseas	REIT	Street	US Treasury
2009	438	50	908	14	0	-508	-56	14	-126
2010	-145	107	79	-262	-15	-87	8	38	36
2011	15	110	-151	-89	12	86	35	105	-117
2012	33	-30	94	-89	-30	23	-23	107	12
2013	232	61	601	-77	-21	-205	-19	-83	-26
2014	69	-4	250	-47	-20	-153	23	8	11
2015	163	174	11	-43	-29	47	55	-50	-2
2016	229	132	-13	-43	-5	101	117	-28	-17
2017	315	161	19	-1	-20	51	64	55	-15
2018	281	38	-148	-16	2	279	89	18	19
2019Q1	33	18	-44	3	-2	-2	21	32	5
2019Q2	37	73	-54	-5	-22	-6	17	21	14
2019Q3	66	21	-56	3	2	73	4	5	14

Source: BofA Global Research



Fed balance sheet runoff creates net demand needs

- US Treasury MBS purchases in 2008 and the subsequent Fed purchases under QE1 and QE3 has turned the Fed into the second largest investor group after banks.
- The Fed has begun unwinding its holdings in 2017, capped to \$20bn per month. Paydowns in excess of \$20bn are being reinvested into MBS. Since 2019, Fed has begun reinvesting its proceeds from MBS, up to the cap amount, into USTs, effectively selling basis.
- Fed runoff, or negative net demand, needs to be offset by private investors. When borrowers pay off their mortgages held at the Fed, excess reserves are destroyed, or offset by Fed's purchases of USTs. The new loan, either a purchase or a refi, needs to be absorbed by private investors.
 - Fed's gross reinvestments are performed by taking TBA delivery, and CUSIPs are never sold. Therefore Fed ends up with cheapest to deliver bonds, cleaning up the TBA float. Fed's unwind has contributed to the convexity deterioration of the TBA since 2017.

Table 49: Mechanics of Fed balance sheet unwind for a \$100 refinance of Fed-held mortgage

Private investor can buy the new loan by drawing down deposits, proceeds go to the Fed:

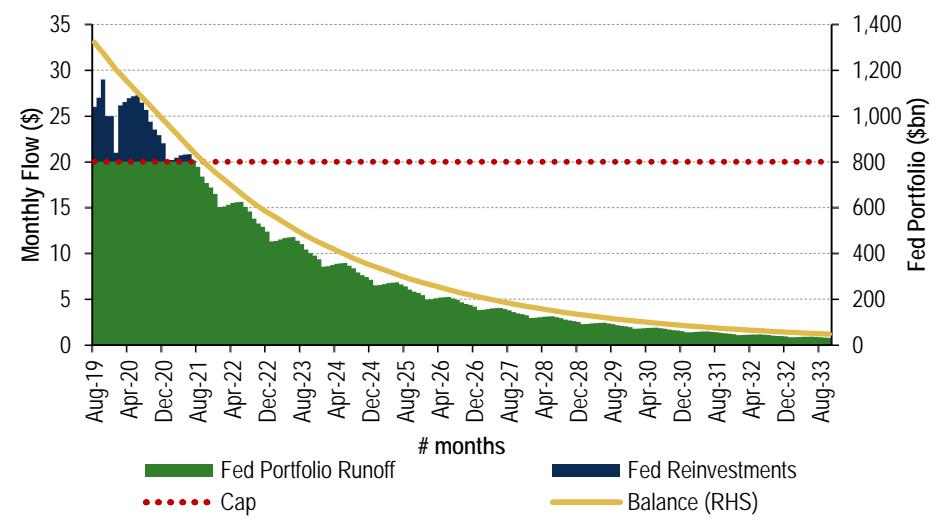
Δ Fed		Δ Bank		Δ Private holders	
Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
Bonds -100	Reserves -100	Reserves -100	Deposits -100	Cash Deposit -100	Other 0
				Bond +100	

Or the bank can buy the bond, leaving deposits unchanged:

Δ Fed		Δ Bank		Δ Private holders	
Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
Bonds -100	Reserves -100	Reserves -100	Deposits 0	Cash Deposit 0	Other 0
		Bond +100			

Source: BofA Global Research

Chart 232: Projected Fed balance sheet runoff at 1.2% 10s



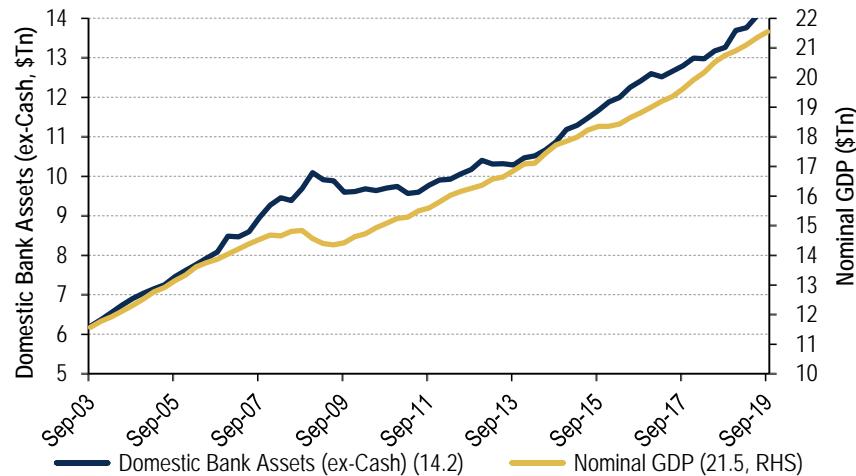
Source: BofA Global Research



Breaking down bank demand for MBS

- Aggregate bank demand can be separated into active and passive components.
- Passive demand is driven by bank balance sheet expansion, keeping allocations unchanged. No active portfolio decisions needed.
 - Under the LCR regime banks need to grow their liquid securities portfolios to support the associated growth in deposits as new loans are made.
 - Bank allocations to Agency MBS have been stable post-crisis, at around 12% of assets ex-cash.
 - Generally speaking, for every dollar of b/s growth, we expect to see ~10 to 12 cents into Agency MBS if current allocations stay stable going forward.
- Active demand for MBS is regulatory policy, event, and relative value driven.
 - 2012 – Negative active demand as Fed crowded out private investment with QE3.
 - 2014 – Negative active demand as the removal of the AOCI filter and lack of final LCR guidance for MBS led banks to add Treasuries with no MBS added.
 - 2015 – LCR rules finalized, rotating out of Treasuries into Agency MBS.
 - 2017 – Rotation into MBS out of Treasuries to boost NIM stretches allocations.
 - 2018 – Rate selloff created AOCI concerns and deposit duration uncertainty, looser LCR rules for mid-tier banks, all negative for demand.

Chart 233: Balance sheets grow by ~85c for every dollar of nominal GDP



Source: BofA Global Research, Bloomberg

Chart 234: Bank allocation to MBS is stable post-crisis at ~12%, creating stable passive demand



Source: BofA Global Research, Fed H8



Overseas demand - China, Japan and Taiwan

- The majority of foreign demand for Agency MBS is from Asia, with China, Japan and Taiwan being the dominant players. Their holdings are heavily concentrated in GNMA.
- Treasury International Capital (TIC) transactions data provides monthly update on foreign country's purchase of Agency MBS, and the TIC holdings data, one month lagged, shows holdings of MBS. The holdings data is more reliable as the transactions data does not capture monthly paydowns.
- Official demand for MBS tends to correlate to the exchange rate, with monetary authorities buying mortgages when the dollar is weaker.
- Bank and life insurance company purchases tend to be more yield and spread driven. In Japan, the comparable asset might be 30- or 40-year JGB, having similar rate volatility to shorter USTs and MBS. Japanese banks tend to be dollar funded, and less sensitive to exchange rates, while many insurers evaluate MBS on FX hedged basis.

Chart 235: China and Japan led foreign buying recently

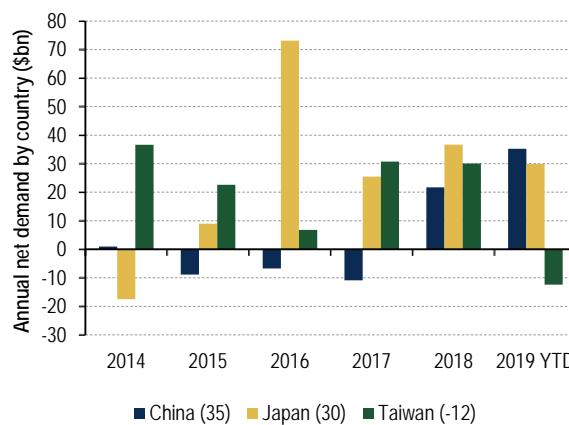


Chart 236: Taiwan purchases correlate to TWD

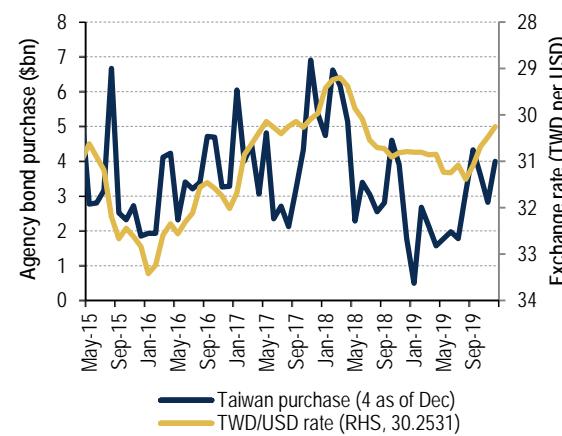
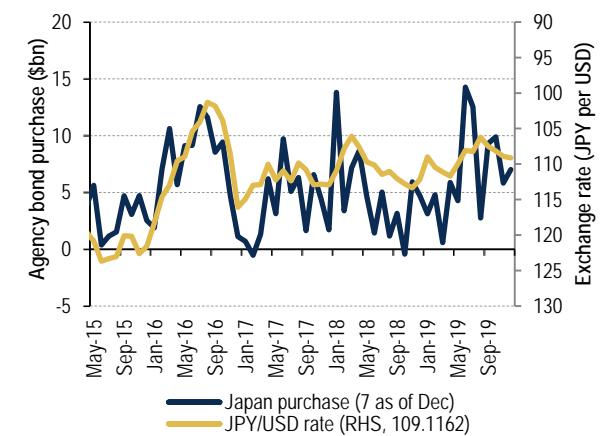


Chart 237: Japan purchases correlate to JPY



Money managers as the marginal buyer

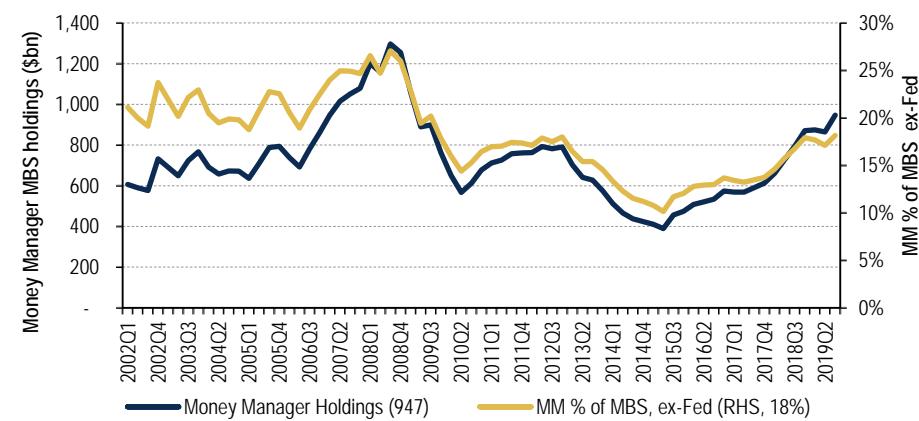
- Money manager holdings of MBS have been on the rise as the Fed is unwinding its holdings. Money managers account for 20% of private MBS holdings, compared to 13% when the Fed started to run off the balance sheet in 2017.
- Just like banks, money managers have an active component to their demand, and a passive one.
- Passive demand comes from money manager fund inflows. These can be driven by a number of potential investors, from domestic pension funds, to corporate treasuries and foreign central banks. Assuming allocations are close to the index weights, each dollar of inflows results in 25-30 cents of MBS purchases.
- Active allocations occur in funds where portfolio managers have discretion, evaluating total return potential of MBS versus other assets such as USTs or high grade credit. Investors typically track large core bond funds that have allocation to MBS to gauge a sense of how active money managers are positioning.

Table 50: Public bond funds have seen assets grow, and are overweight MBS vs. benchmark

	Total Net Assets (\$mn)	Agency MBS OW/UW	MBS Holdings (\$mn)	MBS %	Benchmark %
Aggregate Total Return Funds (ex 100% MBS funds)	2018Q2	948,076	-0.75	250,574	26.4
	2018Q3	1,087,971	-0.16	277,900	25.5
	2018Q4	1,122,467	2.11	316,006	28.2
	2019Q1	1,103,832	0.31	284,706	25.8
	2019Q2	1,242,405	0.46	318,199	25.6
	2019Q3	1,296,802	1.43	341,568	26.3

Source: BofA Global Research, Fund reports

Chart 238: Money manager MBS holdings have been on the rise as Fed is exiting

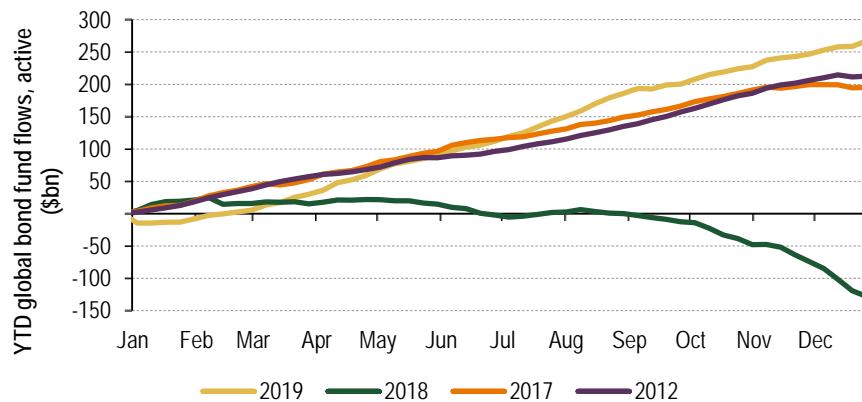


Source: BofA Global Research, Federal Reserve

Active vs. passive bond fund flows

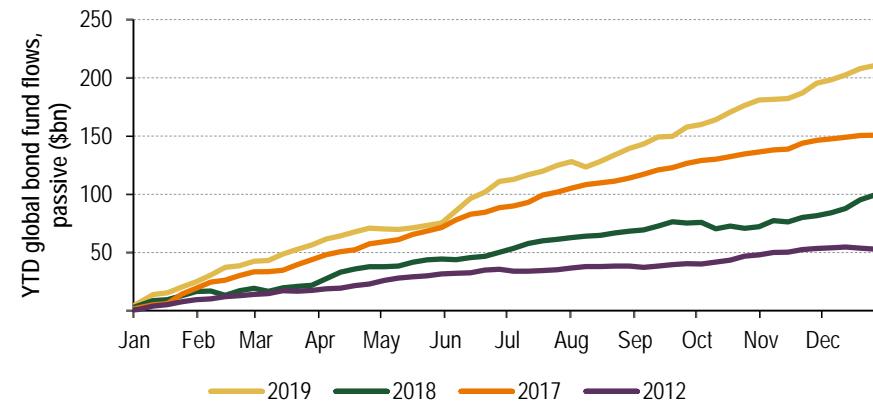
- The changes in the trend of active versus passive bond fund flows reflect changes in the broader economy and how investor appetites are affected. 2019 has witnessed a historically high passive fund inflow, both in the U.S. and globally, owing to the central bank policy accommodation and dovishness around the world. Money managers are thus, made forced buyers, passively allocating more towards mortgages nominally.

Chart 239: Cumulative YTD global bond fund flows, active (\$bn)



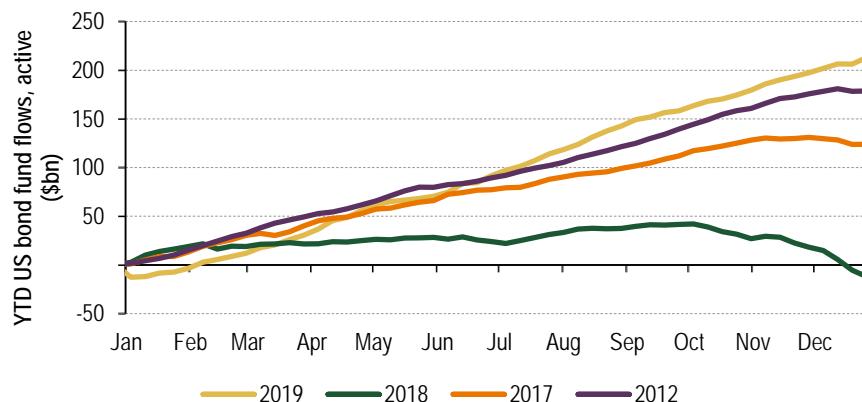
Source: EFPR

Chart 240: Cumulative YTD global bond fund flows, passive (\$bn)



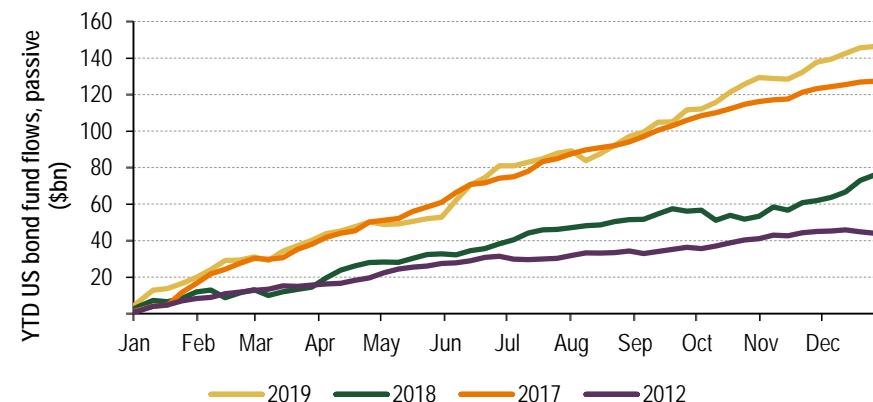
Source: EFPR

Chart 241: Cumulative YTD US bond fund flows, active (\$bn)



Source: EFPR

Chart 242: Cumulative YTD US bond fund flows, passive (\$bn)



Source: EFPR



Appendix



Table 51: Mortgage-related Bloomberg functions and Indices

Function	Description
BVAL	Bloomberg Valuation
CLC	Collateral Composition
CLC GEO	Geographic Distribution Table
CLP	Collateral Performance
D	Quick Descripton
DES	Security Description
DURA	Duration Analysis
HTR	Historical Total Return
LLD	Loan Level Description
OAS1	OAS Analysis
PDI	Paydown Information
RA	Roll Analysis
RAM	Roll Analysis Matrix
TYPE	Agency Pool Program
WALG	Weighted Average Life Graph
YT	Yield Table
YTH	Historical Speeds
YTI	I-spread
YTN	N-spread
YTZ	Mortgage Z-spread
Pool Tickers and Indices	
<i>MBS pools</i>	
FNCL 3.5 Mtge	UMBS 30yr 3.5 coupon delivery in January 2020
FNCI 2.5 Mtge	UMBS 15yr 2.5 coupon delivery in Jauary 2020
G2SF 3.5 Mtge	Ginnie Mae II 30yr 3.5 coupon delivery in January 2020
GNSF 3.5 Mtge	Ginnie Mae I 30yr 3.5 coupon delivery in Janaury 2020
FNCL 3.5 2018 Mtge	UMBS 30yr 3.5 coupon 2018 vintage
<i>MBS Index</i>	
LUMSTRUU Index	Bloomberg Barclays U.S. MBS Index
MOAO Index	ICE BofA US Mortgage Backed Securities Index
<i>MBA Indices</i>	
MBAVREFI Index	MBA US Refinancing Index SWDA
MBAVPRCH Index	MBA US Purchase Index SA
MBAVCMRS Index	MBA US Conventional Market Refinance SWDA
MBAVGMRIS Index	MBA US Government Refinance SWDA
MBAGFHRS Index	MBA US Government Market FHA Refinance Index SWDA
MBAGVARS Index	MBA US Government Market VA Refinance Index SWDA
MBALSREFI Index	MBA US Total Refinance Average Loan Size
<i>Mortgage Rates</i>	
NMCMFUS Index	Freddie Mac 30yr Survey Rate
ILM3NAVG Index	Bankrate.com US Home Mortgage 30 Year Fixed National Avg
ILM1NAVG Index	Bankrate.com US Home Mortgage 15 Year Fixed National Avg



Table 51: Mortgage-related Bloomberg functions and Indices***Primary Dealer Inventories***

PDPPGSEP Index	Primary Dealer Positions Net Outright FA and GSE Residential Passthrough MBS
PDPPGSER Index	Primary Dealer Positions Net Outright All Other FA and GSE Residential MBS

Foreign Demand and Holdings of MBS

FRNTUSGV Index	Foreign Net Transaction of US Govt Agency Bonds
TFORASNT Index	Agency Securities Foreign Net Transactions
FPCHPGOV Index	China Gross Purchases of US Govt Agency Bonds
FPCHSGOV Index	China Gross Sales of US Govt Agency Bonds
FPTNPGOV Index	Taiwan Gross Purchases of US Govt Agency Bonds
FPTNSGOV Index	Taiwan Gross Sales of US Govt Agency Bonds
FPSJPGOV Index	Japan Gross Purchases of US Govt Agency Bonds
FPSJSGOV Index	Japan Gross Sales of US Govt Agency Bonds

Bank Holdings

ALBNTMBS Index	Dom Chartered Commercial Banks Treasury/Agency MBS NSA
ALBNCIND Index	Dom Chartered Commercial Banks Commercial and Industrial Loans NSA
ALBNOTRE Index	Dom Chartered Commercial Banks Closed End Resident Loans NSA

Source: Bloomberg, BofA Global Research



Table 52: Glossary

Term	Description
%OAS	A common relative value metric, defined as the ratio of actual payup to model payup.
4bd	The fourth business day of month
Amortization	The regular paydowns of mortgages
AOCL	Accumulated Other Comprehensive Income, P&L on available for sale (AFS) securities passed through to capital.
AOLS	Average Original Loan Size
ARM	Adjustable-Rate Mortgage - borrower payment fluctuates with a floating rate index rather than fixed for the entire term.
ARRC	Alternative Reference Rate Committee
Breakeven CPR	Market-implied prepayment speed for TTB pools from the observed roll and financing cost.
Breakeven financing rate	This is the rate at which the investor is indifferent between rolling and taking delivery at a given CPR and market observed roll price.
BU/BD	Buy-up/Buy-down
Burnout	The pools are called burnout when the borrowers most attentive to rates and able to refi already prepaid out of the pool.
Butterfly	A butterfly is a long and a short position in the two adjacent swaps around a given coupon.
Buydown	Where the GSE is selling IO for
Buyout	Buying the delinquent loans out of the pools to increase pools' credit profile.
Buyup	Where the GSE is paying for IO
Carry	Total return on MBSTotal return on MBS, typically over a one-month horizon, assuming static interest rates and volatility
Cashout	Taking out a new loan carrying a higher balance and LTV to pay off existing loan.
CBR	Constant Buyout Rate
CC	Current Coupon rate. The coupon of a hypothetical par-priced mortgage bond, an estimate of the prevailing secondary market mortgage rate.
CME	Chicago Mercantile Exchange
CMO	Collateralized Mortgage Obligation, REMIC (Real estate Mortgage Investment Conduit) trusts whose assets consist solely of agency MBS pools.
Conforming Loan Limit	Loan balance limit of underlying loans to GSE MBS
Contraction risk	CPRs increase when interest rates rally.
Conventionals/conforming loans	Underlying loans to GSE MBS
Coupon swap	It is a long TBA position hedged with another TBA of the same issuer, maturity and settle date but lower coupon, used to express an up- or down-in-coupon view.
CPB	Constant Prepayment Balloon model (for ARM valuations) - prepays at 15 CPR during the fixed rate period and a balloon payment of the entire remaining balance upon reset to the floating rate.
CPR	Cumulative Prepayment Rate
CSP	Common Security Platform
CSS	Common Securitization Solutions
Curtailment	Certain borrowers attempt to pay down their mortgages more quickly, for example, in preparation for retirement.
Directionality	Performance, contingent on higher or lower rates. MBS underperform in rates selloffs and outperform in rallies.
Dollar roll	A dollar roll transaction is a 1-month funding method for MBS, similar to a repo agreement.
DTI	Debt-to-Income, a DTI > 43 is considered high.
Effective Convexity	The second order sensitivity to interest rates, or the curvature of the price function at any given yield. Convexity is usually quoted in percent.
Effective Duration	A bond's first order, linear sensitivity to interest rates.
EHS	Existing Home Sales
Extension risk	CPRs decline when rates sell off and bond becomes more of a discount.
Fallback language	The language in the original loan document in case that LIBOR is unavailable.
FG	Freddie Mac security (typically followed by a two-letter code: LMC, CI, etc.)
FHA	Federal Housing Administration
FHFA	Federal Housing Finance Agency
FHLB	Federal Home Loan Bank
FHLMC	Federal Home Loan Mortgage Corporation
FN	Fannie Mae security (typically followed by a two-letter code: CL, CI, etc.)
FNMA	Federal National Mortgage Association, Fannie Mae
Forward Yield	Similar to yield-to-maturity, except prepayments and cashflows are projected assuming the forward curve is realized.
Free float	Pools that are TBA eligible and not locked up in permanent holdings (Fed, CMOs, HTM books)



Table 52: Glossary

Term	Description
FRM	Fixed-Rate Mortgage
GEO	Mortgages by state
G-Fee	Government-sponsored entity Fee
GN, G2	Ginnie Mae security (typically followed by a two-letter code: SF, JO, etc.)
GNMA	Government National Mortgage Association, Ginnie Mae
GSE	Government-Sponsored Entity
GWAC	Gross-Weighted Average Coupon
HAC	Hedge-Adjusted Carry, carry of MBS net of that forgone on any interest rate, duration and/or convexity, hedges.
HARP	Home Affordable Refinance Program
HECM	Home Equity Conversion Mortgage
HELOC	Home Equity Line Of Credit
HERA	Housing and Economic Recovery Act of 2008
HFA	Housing Finance Authority
HLB	High Loan Balance: pools have max loan size of \$110k-\$150k
HPA	Home Price Appreciation
HPI	Home Price Index
HQLA	High-Quality Liquid Assets
HR	Hedge Ratio
HTM	Held-to-Maturity
HUD	U.S. Department of Housing and Urban Development
IIO	Inverse Interest-Only securities
In-the-money/out-of-the-money	Refi incentive is positive/negative.
IO	Interest Only. A bond only entitled to receive interest, but not principal, is called an Interest Only strip.
IOS	Interest-Only Swap
KRD	Key Rate Durations are used to measure MBS sensitivity to individual points on the spot curve.
LCR	Liquidity Coverage Ratio, minimum liquidity requirement forcing demand for high quality liquid assets (HQLA).
LIBOR	London Interbank Overnight Rate, slated to phase out by the end of 2021
LLB	Low Loan Balance: pools have max loan size of \$85k
LLPA	Loan-Level Pricing Adjustment
Lock-in effect	Borrowers are locked in their current homes when prevailing mortgage rates are higher than their existing mortgage rate.
LTV	Loan-To-Value
MBA	Mortgage Bankers Association
Media effect	S-curves tend to steepen out when new lows in rates are reached.
MHA	Making Home Affordable program
MIP	Mortgage Insurance Premium
MLB	Medium Loan Balance: pools have max loan size of \$85k-\$110k
MMI	Mutual Mortgage Insurance
Mortgage basis	The spread between the current coupon MBS and Treasuries or swaps.
MPE	Mortgage Payment to Earnings ratio
mREIT	Mortgage Real-Estate Investment Trust
MSR	Mortgage Servicing Rights
Negative convexity	Due to the embedded option of MBS, MBS should underperform non-callable bond when rates move in either direction, all else being equal.
Net worth/earnings/profit sweep	All profits of the GSEs are relinquished to the US Treasury via the Senior PSPA since 2010, temporarily ending starting September 2019.
NHS	New Home Sales
Nominal/WAL spread	The yield differential between a mortgage security and a benchmark interest rate security with a maturity matching the weighted average life of the MBS.
NTB test	Net Tangible Benefit test, introduced for FHA and VA streamline refinancing to prevent churning.
OAS	Option Adjusted Spread. The expected excess return on MBS hedged across the entire curve as well as hedged for the embedded interest rate options.
OO	Owner-Occupied



Table 52: Glossary

Term	Description
P/S spread	Primary /Secondary spread
PACs	Planned Amortization Class are designed to protect against extension and call risk by creating a companion or support bond which absorbs excess prepayment variability.
Passthrough strips	A CMO structure where all principal from the underlying CMO collateral is paid directly to the CMO tranche.
Passthroughs	MBS pools
Payup risk	This is the residual risk to the nominal payup after duration has been hedged.
PIH	Office of Public and Indian Housing
PIW	Property Inspection Waiver
Platinums	Ginnie special pools that contain other pools
PLS	Private Label Securitization
PMI (or MI)	Private Mortgage Insurance
PMMS	Primary Mortgage Market Survey rate
PO	A passthrough strip with a coupon of 0% is called a Principal Only strip.
Pool Factor	Ratio of current bond balance to the original balance, released on 4bd of month
PSA	Public Securities Association
Putback risk	Created by the fact that GSEs forced the banks to repurchase delinquent loans they originated.
QM/QRM	Qualified Mortgage
R&W	Representations and Warranties - GSEs forced the banks to repurchase delinquent loans they originated based on this.
Refi incentive/moneyness	Note rate - primary mortgage rate
Refinancing	Borrowers refinance into lower mortgage rate loans to realize monthly payment savings when interest rates drop sufficiently.
RELO	Relocation Loan
RESPA	Real Estate Settlement Procedures Act
RHS	Rural Housing Service
RMBS	Residential Mortgage-Backed Security
Roll specialness	Difference between market observed roll price and a theoretical price at an assumed prepay rate and financing rate.
RRP	Reverse Repurchase Agreement
SATO	Spread At Time of Origination - the difference between the note rate on the loan and the prevailing PMMS rate at origination, which implies borrower credit quality.
SCRT	Seasoned Credit Risk Transfer Trust
S-curve	A plot of observed prepay speeds vs. the refi incentive, shape like the letter S
Seasoning	Refis slow down as loan ages.
Senior PSPA	Senior Preferred Stock Purchase Agreement
SEQ/Sequentials	A CMO structure where principal is paid out to tranches in specified order.
SLR	Supplementary Leverage Ratio. Leverage constraint on banks, regardless of risk weight.
SMM	Single Monthly Mortality
Supers	UMBS special pools that contain other pools
TACs	Targeted Amortization Class CMOs are similar to PAC but does not provide extension protection.
TBA	To Be Announced securities, an over the counter (OTC) futures contract used as a financing and delivery mechanism of MBS pass-through pools.
TIC	Treasury International Capital System
Tick	One tick is 1/32nds
TRID	TILA/RESPA Integrated disclosure
TTB	Through-The-Box, delivered under TBA contracts
Turnover	Borrowers prepay their loans when the property is sold.
UMBS	Uniform MBS
USDA	United States Department of Agriculture
VA	Veterans Affairs
VADM	Very Accurately Defined Maturity CMO
VADMs	Very Accurately Determined Maturity bonds are similar to PACs in that they pay on a predetermined schedule. The companion bond is called a Z-bond. VADM principal is paid out of interest proceeds due to the Z.
Volatility duration	Volatility duration measures the price sensitivity of MBS to the shocks in implied volatility levels.



Table 52: Glossary

Term	Description
VPR	Voluntary Prepayment Rate
WAC	Weighted Average Coupon
WAC spread	The difference between the gross and net coupons of pools.
Whipsaw risk	A rally in rates that pays down the support bond before a back-up that extends the PAC.
Yield-to-maturity	Traditional yield measure of MBS cashflows computed with either a fixed CPR vector or a base case prepayment projection at static prevailing interest rates.
ZVOAS	Zero-Volatility Option-Adjusted Spreads, The projected excess return on MBS along the realized forward curve, hedged across the entire interest rate curve.

Source: BofA Global Research



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