Credit Case Study:

Assessing U.S. Mortgage-Backed Credit Stress in 2020

D E Shaw & Co

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Introduction

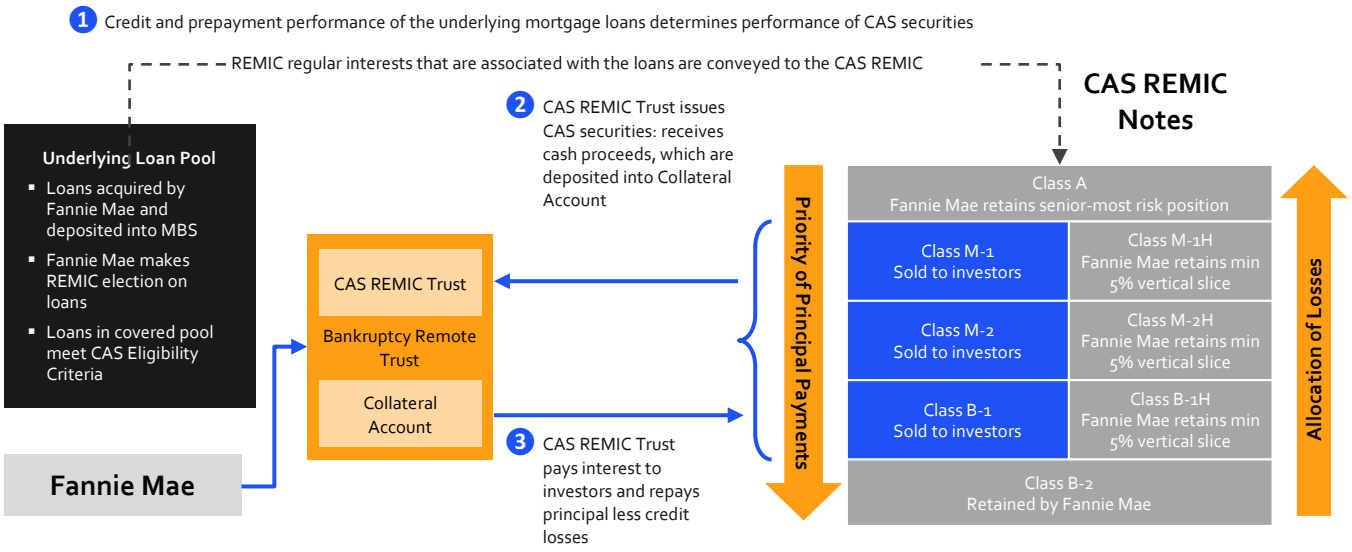
This paper presents a case study of investment dynamics in the U.S. structured credit market during the 2020 COVID-19 crisis. The case study focuses on the residential mortgage-backed securities ("RMBS") segment of the market, and in particular a portfolio of government-sponsored enterprise ("GSE") credit risk transfer bonds, a category of securities that came under enormous pricing pressure during the crisis.

We analyze the dynamics of the credit risk transfer ("CRT") bond market during the COVID-19 crisis by detailing the investment approach we deploy to identify opportunities in the market for those securities. We combine advanced quantitative techniques and qualitative insights to analyze the relationships between cohort characteristics and instrument cashflows, with the goal of investing where we believe market prices fail to reflect those links. As this case study illustrates, investment opportunities in structured credit often arise from the intersection of top-down thematic concepts and bottom-up individual asset mispricings.

The following pages describe how we generally seek to:

- Utilize a proprietary database to assess bond performance during periods of economic stress
- Apply top-down and scenario-based analyses to assess the current landscape
- Identify dislocations and attractive investment opportunities

Backdrop: CRT Securities



If underlying mortgage loans experience losses, CAS notes are written down by a corresponding amount, starting with Class B and continuing in reverse sequential order.

- CRT bonds typically offer higher yields than agency mortgage-backed securities ("MBS") because they are not guaranteed by the GSEs, but instead transfer a portion of the credit risk of the agency mortgage pools from the GSEs to private CRT investors.
- CRT securities issued by Fannie Mae and Freddie Mac are known as Connecticut Avenue Securities ("CAS") bonds and Structured Agency Credit Risk ("STACR") bonds, respectively.

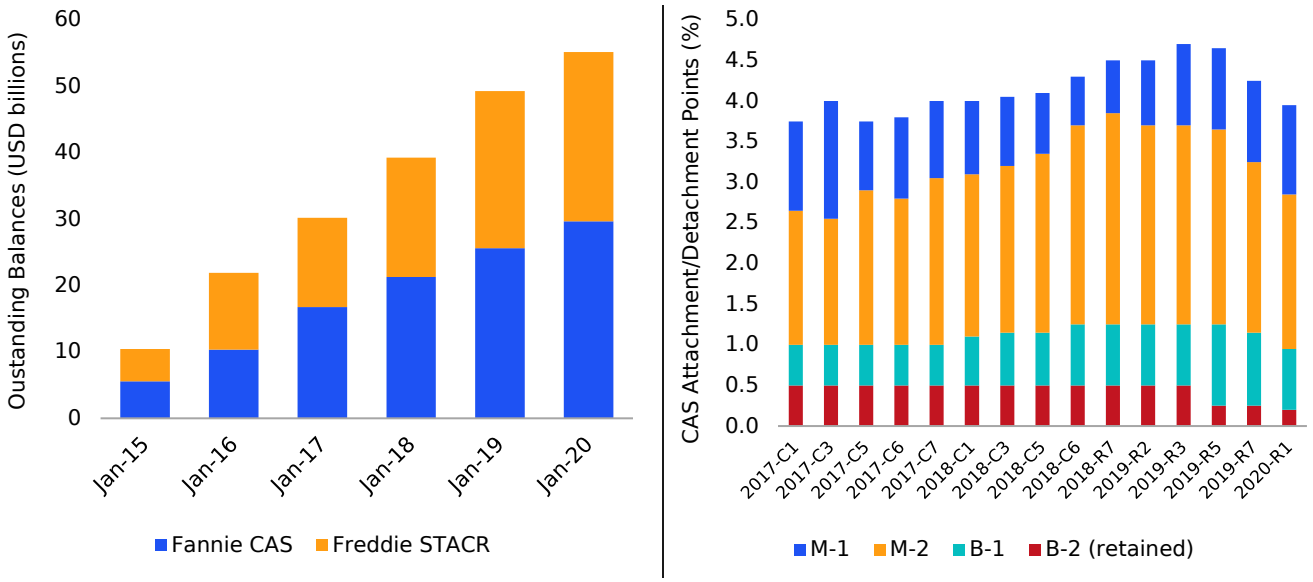
Note: This paper is authored by the D. E. Shaw group. Certain first-person statements (i.e., those using "we" or "our") relate to the D. E. Shaw group generally, while others relate to the firm's Asset-Backed Strategies team (the "ABS team") specifically. In particular, it should be noted that the investment approach described herein is deployed by the ABS team.

- Beginning in 2013, Fannie Mae and Freddie Mac issued CRT securities as unsecured debt obligations of the agencies. More recently (since late 2018 for Fannie Mae's CAS and since mid-2019 for Freddie Mac's STACR), CRT securities have been issued as debt of bankruptcy-remote trusts—real estate mortgage investment conduits ("REMICs")—sponsored by the GSEs.
- Performance of the securities is linked to a reference pool of residential mortgages that have been sold into MBS guaranteed by the respective GSE, and is based on a cashflow waterfall similar to that typical of RMBS. The GSE/REMIC pays interest on the CRT notes and repays principal based on the prepayment and credit performance of the underlying loans. If the underlying mortgages incur credit losses, the CRT notes, starting with class B, are written down, and the GSE/REMIC is no longer obligated to repay that portion of principal to investors.

Backdrop: CRT Bond Market Developments Since Inception

- From the beginning of the CAS and STACR programs in 2013 through the end of 2019, the GSEs issued approximately US $80 billion in single-family mortgage CRT securities referencing approximately US $2.7 trillion of unpaid principal balance ("UPB"). As of January 2020, CAS and STACR outstanding balances were approximately US $55 billion.
- Strong demand for CRT securities allowed GSEs to loosen the structure and terms of some recent bond issuances. For example, in 2019 Fannie Mae sold more leveraged credit risk in its class B-1 tranche for low loan-to-value ("LTV") deals by lowering the attachment point on the notes from 0.5% to 0.25%.
- Moreover, in its first 2020 deal, Fannie Mae further reduced the attachment point on the B-1 notes from 0.25% to 0.2%; M-2 and M-1 bonds attached at 0.95% and 2.85%, respectively. The attachment/detachment points on the tranches sold to private investors were 0.20%/3.95% in the first 2020 deal versus 0.50%/3.75% in the first 2017 deal.

CRT bond balances and low-LTV CAS attachment and detachment points over time



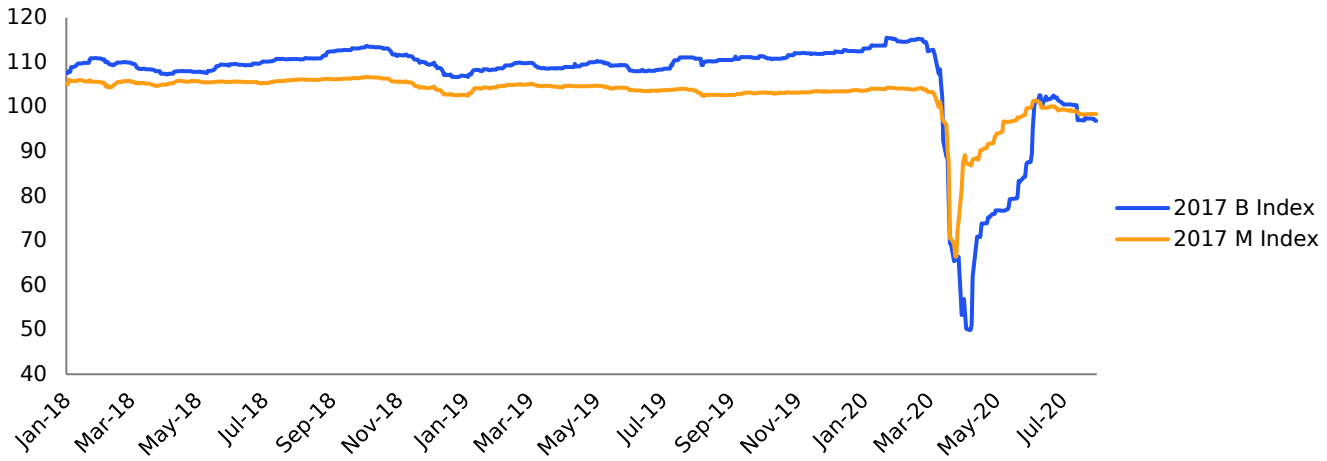
Source: Barclays Research; the D. E. Shaw group.

Note: M-1, M-2, and B-1 securities are sold to private investors, while the remaining portions of the capital structure are retained by Fannie Mae.

CRT Bonds During The Covid-19 Crisis Onset

During the market crisis that began in March 2020, CRT securities came under severe pricing pressure, with most CAS and STACR bond prices falling well below par; these were extraordinary levels for a market that was accustomed to trading at par for new issues and at a premium in the secondary markets for seasoned bonds.

Vista 2017 CRT Indices (par = 100)



Source: Vista Data Services; the D. E. Shaw group.

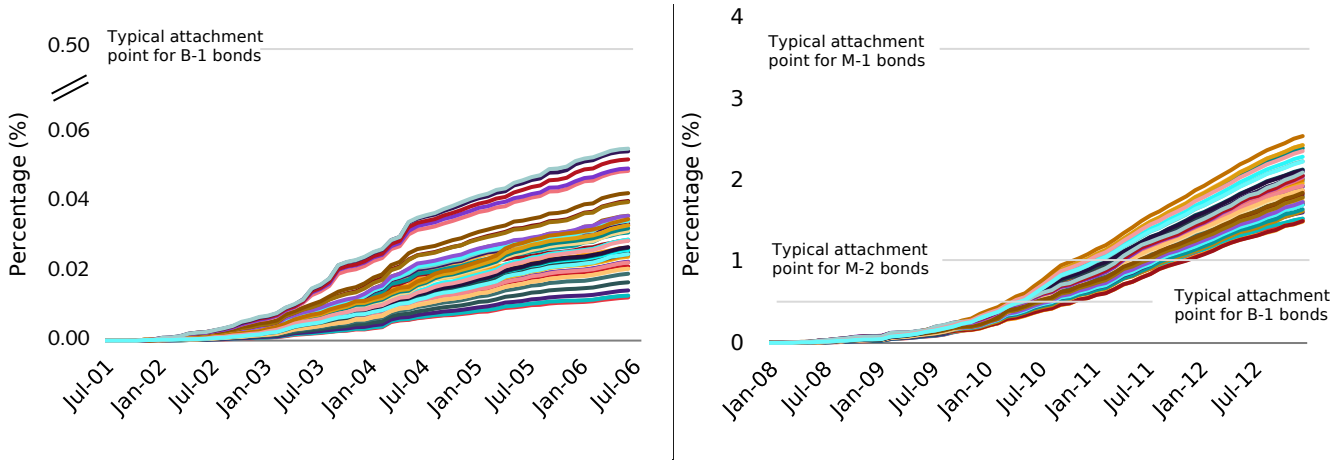
- As an example of the precipitous drop in values, by March 25, indices tracking the dollar prices of approximately $9.5 billion in outstanding B-1 and M-2 bonds issued by Fannie Mae and Freddie Mac in 2017 had fallen to the mid-60s; the B-1 index fell further in the following days before leveling out just below 50 on April 7.
- These steep declines implied the securities would incur future principal losses despite seasoning of the underlying collateral (*e.g.*, due to home price appreciation) and credit enhancement associated with pool amortization. As context, the collateral pools for 2017 deals had been paid down to ~70% of the original pool balances with negligible losses as of the beginning of 2020. So, for M-2 bonds with attachment points of ~1%, future credit losses would need to exceed 1.4% (1/0.7) on the remaining collateral for the bonds to be intrinsically worth less than par.

Bottom-Up Assessments

Given the limited history available for CAS and STACR bonds, we turned to our GSE database containing loan-level information on 67 million agency mortgages dating back to 1999, as well as our knowledge of the collateral pools and cashflow structures of the 104 CRT deals that had been issued through March 2020, to inform our view on the intrinsic value of existing CRT bonds.

- After assembling pools of pre-CRT mortgages to mimic the collateral profiles of existing CAS and STACR reference pools (considering characteristics such as LTV, debt-to-income ("DTI"), and FICO score), we used the experiences of the 2001 recession and 2008 global financial crisis ("GFC") to simulate deal performance during these periods of economic stress.
- Under the 2001 recession scenario, our analyses of CAS and STACR deals indicated that cumulative net losses would have been modest as a percentage of original balances and would not have impacted principal amounts for their respective B-1, M-2, or M-1 bonds. Under the GFC scenario, our analyses showed cumulative net losses for the deals would have risen to 1.5–2.5% of original balances, suggesting B-1 bonds would have been wiped out and M-2 bonds would have sustained write-downs.

Expected cumulative net losses on selected CAS deals based on 2001 recession (lhs) and GFC (rhs) scenarios



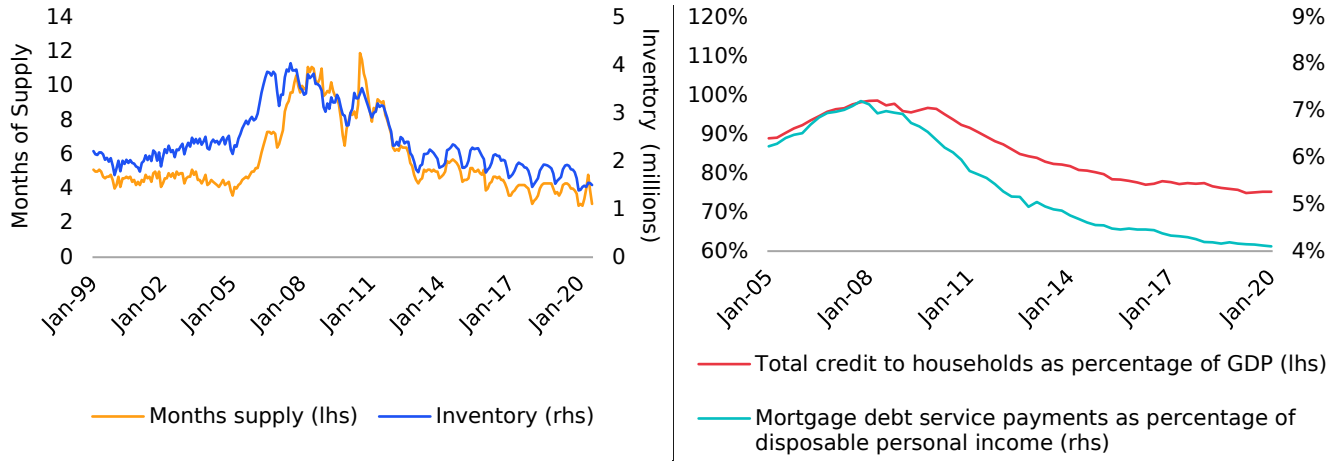
Source: the D. E. Shaw group.

No assurances can be given that any aims, assumptions, expectations, and/or goals described in this document will be realized. Please refer to the notes at the end of this document for additional information regarding these charts.

Top-Down Views

For purposes of this assessment, we believed that the 2001 recession scenario of a substantial, but relatively short-lived, employment-led economic contraction was more relevant than the GFC scenario. Although outcomes similar to those experienced during the GFC were possible, we considered them unlikely and believed they involved a much higher degree of stress.

Housing market and household health were better entering this crisis compared to the GFC



Source: National Association of Realtors; Bank of International Settlements and Federal Reserve Bank of St. Louis; the D. E. Shaw group.

No assurances can be given that any aims, assumptions, expectations, and/or goals described in this document will be realized.

- The cause of the 2020 crisis was a sudden exogenous shock to the economy. We believed that observing how borrowers and other market participants, such as the GSEs and mortgage servicers, reacted to sudden disruptions in employment caused by past natural disasters, like hurricanes, would provide more relevant insights than the GFC.
- Observable collateral factors (*e.g.*, LTV, DTI, and FICO score) at loan origination have materially improved post-GFC, suggesting that reference pools were higher quality entering the COVID-19 induced crisis. We believed GSE underwriting

standards and practices (for example, additional document requirements), perhaps in preparation for an exit from federal conservatorships, had improved and that they have remained relatively tight since the GFC.

- The underlying economic and financial landscape entering the current crisis was dissimilar to that present at the onset of the GFC. In particular, unlike the few years leading up to the GFC, home prices increased in recent years (suggesting LTVs for recently issued mortgages had decreased post-origination), and measures of the condition of the housing market and household health were better entering 2020. In short, current borrowers appeared to have options other than default (*e.g.*, sale, loan modification).

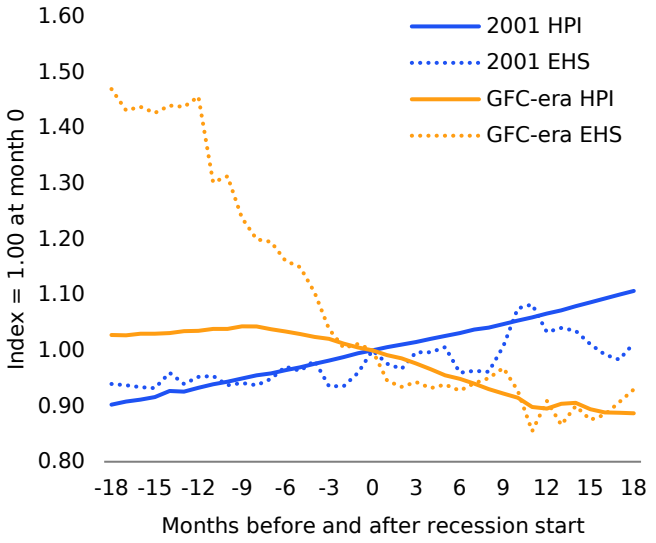
Alternative Scenarios

Leveraging our experiences from prior crises and natural disasters, and considering policy actions to help consumers that were unfolding in late March 2020, we also set out to estimate potential losses should borrowers obtain mortgage forbearance, subsequently modify their loans, and then experience a credit event.

We also considered evolving policy actions and looked to historical housing data

Expected Modification Losses for Sample CAS Deal

Change in Housing Prices	Modification Rate (% of UPB) 2.0%	4.0%	6.0%	8.0%	10.0%
0.0%	0.13%	0.25%	0.38%	0.50%	0.63%
-2.5%	0.13%	0.27%	0.40%	0.53%	0.67%
-5.0%	0.14%	0.29%	0.43%	0.57%	0.71%
-7.5%	0.15%	0.31%	0.46%	0.62%	0.77%
-10.0%	0.17%	0.34%	0.51%	0.67%	0.84%
-12.5%	0.18%	0.37%	0.55%	0.74%	0.92%
-15.0%	0.20%	0.40%	0.60%	0.80%	1.00%
-17.5%	0.22%	0.44%	0.65%	0.87%	1.09%
-20.0%	0.24%	0.47%	0.71%	0.94%	1.18%
-22.5%	0.25%	0.51%	0.76%	1.02%	1.27%
-25.0%	0.27%	0.54%	0.82%	1.09%	1.36%



Source: Freddie Mac; National Association of Realtors; the D. E. Shaw group.

Note: HPI = Freddie Mac's Housing Price Index; EHS = National Association of Realtors' measure of existing home sales.

Please refer to the notes at the end of this document for additional information regarding these charts.

- Under the U.S. CARES Act signed into law in late March, borrowers with federally or GSE-backed mortgages facing economic hardship as a result of COVID-19 were eligible for mortgage forbearance for up to 12 months, without it counting as a default. Our assessment was that while this action should help limit initial defaults, CRT bondholders could experience modification losses if loan terms were to be permanently modified after the forbearance period.
- We used CRT deal structure waterfalls and our knowledge of GSE modification processes in order to stress test post-forbearance modification scenarios against depreciating home prices. Although we believed that home prices were unlikely to drop materially, we wanted to understand the sensitivity of losses to various modification rates and negative home price movements.

CRT Purchases

Ultimately, we believed the CRT bond market had become dislocated during the COVID-19 crisis onset and that some CAS and STACR bonds were priced at significant discounts to intrinsic value.

- We believed that marketplace participants were over-relying on experiences from the GFC to value CRT securities. We also suspected that technical factors were influencing market behavior. In recent years, asset managers and REITs made up material portions of new issue demand, including for riskier and less-liquid CRT securities such as M-2 and B-1 bonds. These investors were put under stress by redemption requests and margin calls.
- Based in part on the analysis described above, over the course of March and April 2020, we purchased in excess of $400 million in CAS and STACR bonds at a significant discount to par. Because the bonds identified for purchase generally differed in terms of expected investment horizon and levels of uncertainty in value realization, we allocated those purchases across different pools of capital according to those characteristics.

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Notes

Notes to Entire Document

THIS DOCUMENT IS BASED UPON A CASE STUDY ORIGINALLY PUBLISHED BY THE D. E. SHAW GROUP IN NOVEMBER 2020.

Notes to Third-Party Charts and Data Generally

Please note that, where a third-party chart or third-party data have been used in this document, the source of the chart or data may contain explanatory notes and/or disclaimers that may be useful to a reader but are not reproduced in this document. Reference is hereby made to the notes and disclaimers contained in such original sources.

Notes to Visual on Page 1

This visual is derived from a similar visual published in a Fannie Mae Investor Presentation for Connecticut Avenue Securities® from July 2020, which is publicly available at https://capmrkt.fanniemae.com/resources/file/credit-risk/pdf/cas-program-investor-presentation.pdf.

Notes to Charts on Page 2

These charts are derived from charts published in a February 2020 Barclays credit research report titled "An updated primer on GSE CRT securities."

The right-hand-side chart reflects the attachment and detachment points of M-1, M-2, B-1, and B-2 bonds for a selection of low-LTV CAS issuances by Fannie Mae from January 2017 to February 2020. Low-LTV transactions are those in which the original LTV on the loan is between 60% and 80%. The attachment point reflects the minimum amount of pool-level losses at which the given bond begins suffering losses. The detachment point reflects the amount of pool-level losses at which the given bond is completely written down.

Notes to Chart on Page 3

The chart is based on "Dollar Price" data for the 2017 B Index and the 2017 M Index provided by Vista Data Services.

According to Vista Data Services' Index Definitions, publicly available at https://vistadataserv.wpengine.com/wp-content/uploads/2020/01/VISTA-Index-Definitions-2020.pdf, the 2017 B Index reflects 15 B-1 securities in total (all 2017-issued CAS 1B-1 and 2B-1 securities, as well as all 2017-issued STACR DNA B-1 and HQA B-1 securities), while the 2017 M Index reflects 15 M-2 securities in total (all 2017-issued CAS 1M-2 and 2M-2 securities and all 2017-issued STACR DNA M-2 and HQA M-2 securities).

Each index's "Dollar Price" equals the average of the composite CRT security prices, weighted by the amount outstanding of each CRT security in the index. "Dollar Prices" are rebalanced on the 25th day of each month, or the next business day if the 25th falls on a weekend or holiday.

Notes to Charts on Page 4: "Expected cumulative net losses on selected CAS deals based on 2001 recession and GFC scenarios"

Both charts reflect our modeled expectations of five-year cumulative net losses for all CAS issuances made by Fannie Mae from 2013 to the present had such issuances been made during the 2001 recession (left-hand-side chart) and the GFC (right-hand-side chart). For the avoidance of doubt, Fannie Mae did not issue CAS during the 2001 recession or the GFC; these charts reflect our expectations of how various CAS issuances may have hypothetically performed during the 2001 recession and GFC based on known default rates and collateral characteristics. We assumed an issuance date of June 1, 2001 and December 1, 2007 for modeling the hypothetical performance of CAS securities during the 2001 recession and GFC, respectively. Each line reflects the cumulative net loss we modeled for each CAS issuance in the sample, assuming conditions similar to those experienced during the 2001 recession and GFC.

The typical attachment point for B-1 bonds reflects the mode (*i.e.*, most frequently observed) attachment point (0.5%) of B-1 bonds of low-LTV CAS issuances by Fannie Mae from January 2017 to February 2020. The typical attachment point for M-2 bonds reflects the mode attachment point (1.0%) of M-2 bonds of low-LTV CAS issuances by Fannie Mae from 2017 to the present. The typical attachment point for M-1 bonds reflects the mode attachment point (3.7%) of M-1 bonds of low-LTV CAS issuances by Fannie Mae from 2017 to the present. Low-LTV transactions are those in which the original LTV on the loan is between 60% and 80%. The underlying data for these charts was sourced from the aforementioned February 2020 Barclays credit research report (see "Notes to Charts on Page 2").

No representation is being made that the investment approach or computational methodology used to generate these modeled expectations is accurate or will result in profitable investments.

Notes to Charts on Page 4: "Housing market and household health were better entering this crisis compared to the GFC"

The left-hand-side chart is based on data from the National Association of Realtors. Copyright © 2020 "Existing Home Sales." *National Association of Realtors*®. All rights reserved. Reprinted with permission. November 2, 2020, https://www.nar.realtor/research-and-statistics/housing-statistics/existing-home-sales.

The chart reflects for a given point in time (a) the number of months it would take for inventory to be sold, given the pace of sales at such time, shown on the left-hand vertical axis, and (b) the inventory, or number of properties actively for sale, in the United States, shown on the right-hand vertical axis.

The right-hand-side chart is based on (a) Total Credit to Households (Core Debt) as a Percentage of GDP data from the Bank of International Settlements and retrieved by the D. E. Shaw group on October 9, 2020, shown on the left-hand vertical axis, and (b) Mortgage Debt Service Payments as a Percentage of Disposable Personal Income data from the Board of Governors of the Federal Reserve System (US) and retrieved by the D. E. Shaw group on September 18, 2020, shown on the right-hand vertical axis. The Board of Governors of the Federal Reserve System (US) data is publicly available at https://fred.stlouisfed.org, and the Bank of International Settlements data is publicly available at stats.bis.org.

Notes to Table on Page 5

This table reflects our efforts to model potential pool-level losses for a sample CRT bond as a function of changes in housing prices and losses due to loan modifications.

Loan modifications can cause losses on CRT notes. Such losses generally result from interest rate reductions, principal forbearance, and/or principal forgiveness. Modification losses are passed through to noteholders on a monthly basis once a permanent modification takes effect. No losses are incurred during a forbearance or modification trial period, which typically lasts 3 months, but under the CARES Act could last up to 12 months.

At the time of our analysis, it was not clear what modification options would be offered to borrowers. We believed that the GSEs would adopt a stance similar to that taken in response to previous natural disasters and offer borrowers, upon conclusion of the forbearance period, the opportunity to participate in (i) the Extend Modification for Disaster Relief or Cap and Extend Modification for Disaster Relief programs (collectively, "Disaster Relief options") and/or (ii) the Flex Modification program. The Extend Modification for Disaster Relief option, which simply extends the term of a mortgage by the amount of time that payments were missed (not to exceed 12 months) without capitalizing arrearages, and the Cap and Extend Modification for Disaster Relief option, which extends the term and allows the capitalization of arrearages, are for situations when homeowners are able to resume making full pre-disaster monthly payments on an ongoing basis. Flex Modification is an option for Fannie Mae and Freddie Mac borrowers who can no longer afford their pre-forbearance payment.

This sensitivity table shows our estimate of the modification losses, expressed as a percentage of UPB, for the underlying deal pool (*i.e.*, the aggregate reduction in capital) of CAS 2019-R06 G2 under various modification rate and negative housing price scenarios. The modification rate reflects the portion of a deal's collateral pool, expressed as a percentage of UPB, that, for purposes of this analysis, we assumed would obtain a loan modification under one of the Disaster Relief programs or the Flex Modification program. Based on our assessment, CAS 2019-R06 G2 was estimated to be the deal pool most susceptible to modification losses.

No representation is being made that the investment approach and computational methodology used to generate these modeled expectations is accurate or will result in profitable investments.

Notes to Chart on Page 5

The right-hand-side chart is based on Housing Price Index ("HPI") data from Freddie Mac and Existing-Home Sales ("EHS") data from the National Association of Realtors, Copyright © 2020 "Existing Home Sales." *National Association of Realtors*®. All rights reserved. Reprinted with permission. November 2, 2020, https://www.nar.realtor/research-and-statistics/housing-statistics/existing-home-sales.

The chart reflects trends in home prices and home sales 18 months before and 18 months after the start of the 2001 recession and GFC. (The chart uses the start dates of recessions published by the National Bureau of Economic Research; as such, it reflects a March 2001 start for the 2001 recession and a December 2007 start for the GFC.) The values for Existing-Home Sales and the Housing Price Index have been indexed at the start (effectively month 0) of each recession, at value 1.00.

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The Existing-Home Sales data reflects the seasonally adjusted number of sales of existing homes in the United States. The Housing Price Index data reflects the seasonally adjusted index of home prices provided by Freddie Mac, and was retrieved by the D. E. Shaw group on September 10, 2020. This data is publicly available at http://www.freddiemac.com/.

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