

Credit Risk Transfer and the Pricing of Mortgage Default Risk

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1. Introduction

In response to Fannie Mae's and Freddie Mac's rapidly mounting default losses and rising funding costs during the financial crisis of 2007-8, federal regulators placed the GSEs¹ into conservatorship and set up a capital backstop that continues to ensure the safety of their debt and guarantee obligations to investors. The Housing and Economic Recovery Act (HERA), which authorized those emergency actions, also prescribed structural and operational changes in the regulatory and oversight functions that were designed to reduce the ongoing risk to taxpayers of government backing of the GSEs. Following this legislation, the Federal Housing Finance Agency (FHFA) through an annual scorecard² has required the GSEs to implement mechanisms to pay private investors to assume a portion of the exposure to losses on mortgages guaranteed by the GSEs. Those mechanisms are collectively referred to as Credit Risk Transfer (CRT).

Requiring CRT has several potential benefits. Importantly, it can help to provide financial institutions, regulators, homebuyers and investors with information about the cost and perceived risk of the mortgage guarantee business, and forward-looking signals about the overall health of the housing market. Post conservatorship and prior to the introduction of CRT, there was almost no information about the market price of default risk for the multi-trillion-dollar conforming mortgage market. The information extracted from CRT transactions can serve a variety of purposes, including to adjust the GSE's guarantee fees (g-fees) and the pricing on privately originated mortgages so as to discourage leverage when markets are overheating and support it when conditions are more benign.

Some have suggested that protecting taxpayers from losses is also an important function of CRT, and perhaps the primary one. However, because investors must be fully compensated for the cost of the risks they absorb, there could only be a net benefit to taxpayers in terms of allocative efficiency if shifting default risk from the government to the private sector serves to lower overall costs to society. In evaluating the costs and benefits of CRT that are related to the efficiency of risk allocation, a useful benchmark is that if the government and the private sectors were equally efficient at allocating mortgage default risk, then frictionless CRT transactions between the two sectors would be neutral in terms of the efficiency of risk-bearing. There is also the related question of whether CRT reduces systemic risk. Were the GSEs to be privatized, CRT could be used as a partial substitute for capital or other measures to mitigate systemic risk. It is unclear exactly how CRT would reduce systemic risk if either the capital levels are adjusted to keep the probability of insolvency constant or the market for CRT evaporates during periods of stress. However, while operating in conservatorship, CRT is unlikely to ameliorate the sorts of systemic risks that the GSEs may cause.³

¹ Fannie and Freddie are Government Sponsored Enterprises or GSEs, and referred to collectively by that abbreviation here.

² See the FHFA 2022 Scorecard for the GSE for detail on the CRT requirements:
<https://www.fhfa.gov/AboutUs/Reports/ReportDocuments/2022-Scorecard.pdf>

³ Lucas (2014) suggests that the GSEs operating in conservatorship are a source of systemic risk through the far-reaching effects of their administrative pricing decisions rather than a lack of risk-absorbing capacity.

In this analysis we focus on CRT securities--the Structured Agency Credit Risk (STACR) notes and Connecticut Avenue Securities (CAS) issued by Freddie Mac and Fannie Mae, respectively. Those issuances are the predominant mechanism by which the GSEs have transferred credit risk to the private sector since the start of the CRT programs. CRT securities are akin to highly structured catastrophe bonds or credit default swaps. As such, investors in CRT securities own claims whose cash flows are reduced as a function of the default losses experienced on a reference pool of GSE-guaranteed mortgages. Different tranches have varying exposures to default losses, with the most subordinated claims in a first loss position and the most senior claims designed to rarely experiencing a loss. The value of the CRT securities is also affected by expectations about prepayments on the reference pool mortgages, which in turn affect prepayments on the CRT securities.

A concern about CRT securities as currently designed is that they may be a relatively inefficient way to transfer risk, and hence unnecessarily costly to mortgage borrowers and taxpayers. Specifically, the current arrangements may offload less risk, at a higher cost, and with less useful information content, than could be achieved with alternative mechanisms.⁴ The difficulty of estimating and pricing tail risk can shrink the pool of potential investors in CRT, reducing competition and liquidity in the CRT market. Furthermore, the securities' complexity and illiquidity tend to limit the information content in CRT prices. It has been observed that during periods of market stress, when price discovery on new issuances is particularly valuable, the elevated cost of buying CRT protection may discourage the GSEs from undertaking a meaningful amount of risk transfer.⁵

A broader consideration is that many economists believe that the government is relatively efficient at spreading tail risks that markets are not good at pricing. Hence, it may be more efficient for the GSEs while in conservatorship to simply retain more of the risk; and if they are privatized to pay a fee to the government for a backstop similar to FDIC insurance for banks.

The shortcomings of CRT could go largely unrecognized, or be allowed to persist, for a number of reasons: The securities are complicated, and the market is small and concentrated. There are institutional impediments to exploring and implementing alternative arrangements while the GSEs are operating in government conservatorship with no shareholders to benefit from the savings. The existing investor base benefits from the status quo with limited competition. The benefits to other market participants and taxpayers from addressing the shortcomings are diffuse.

The above observations motivate the main goal of this analysis, which is to develop and apply an analytic framework to evaluate the information content of the most widely used CRT securities, and the programs' cost efficiency as a risk transfer mechanism.

⁴ Schmitz, et al. note the potentially more favorable pricing that might be obtained by reinsurers over capital market investors. Others, including Zandi et al. (2017), point out that early prepayment of CRT securities can leave the GSEs more exposed to default losses.

⁵ Finkelstein et al. observe that the GSE's regulator, FHFA, anticipates in its CRT policy guidelines that the GSEs may choose to defer transferring risk during periods where its cost is elevated.

The heart of the analysis is the development of a CRT valuation model, which in conjunction with data on CRT pricing and supplementary dynamic models of prepayment and default, is used to infer the dynamics of expected returns and risk premiums over time. The analysis is applied to individual CRT tranches, and aggregated to infer market price signals for pools of whole mortgages. It also allows us to estimate the cost, on a market value basis, of the GSE's residual exposure to default losses, and the variation of that exposure over time. Of particular interest is how prices and risk transfer were affected by the recent stress event caused by the COVID19 pandemic. Finally, the framework provides a tool to examine the sensitivity of outcomes to changes in market expectations about default risk, and to structural choices in the design of CRT securities. For example, we can explore how the prepayment rules for CRT securities affect the amount of tail risk that is transferred from the GSEs to investors.

This appears to be the first academic paper to propose a detailed model with which to study the distribution of CRT returns and their relation to returns in other markets; and to make use of the [Vista Data Services](#) secondary market pricing data. Information about pricing and performance is provided by the GSEs and in practitioner reports, but those depend on very simple assumptions. For example, the GSEs' standard investor disclosures report outcomes for a broad range of static performance assumptions, whereas the analysis here takes into account the joint distributions and dynamics of default rates, recovery rates, and prepayment rates over time. It provides an alternative measure of yield spread dynamics to the "discount margin" used by the industry, which is calculated holding constant unrealistic assumptions about prepayment rates and realized loss experience. There is a relatively small academic literature on GSE CRT (e.g., Gete et al., 2020, Wachter, 2018). CRT and related instruments have been more extensively studied as a tool to reduce the risk of systemically important financial institutions such as large banks, and as a mechanism to provide price signals about mounting risks in Too-Big-To-Fail institutions. While financial stability considerations are less relevant for the GSEs in conservatorship than for banks, the value of generating market price signals about risks that otherwise would not be priced because they are absorbed by governments applies similarly to the GSEs.

The rest of the paper is organized as follow: Section 2 describes CRT securities in more detail. Section 3 presents the data and explains the construction of data-based indicators for default cost and share of risk transferred. Section 4 looks at trends in default cost and share of risk transferred, and their relation to guarantee fees (g-fees) and other market variables. It includes an analysis of time series data on primary and secondary CRT market prices and their relation to other variables.⁷ Section 5 presents the CRT pricing model and its base case calibration. Section 6 reports findings on the model's predictions for realized returns on CRT securities, and compares them to returns on similarly rated corporate securities. It also examines the sensitivity of returns to the initial assumption about current loss severity. Section 7 concludes.

2. Structure of CRT securities

⁷ The term "primary market prices" is used here to refer to the underwritten prices on new issuances, and "secondary market prices" are those based on subsequent market quotes.

Figure 1 illustrates the structure of a typical STACR securitization.⁸ The “reference pool” is a collection of recently issued 30-year conforming mortgages whose performance affect the CRT securities’ (each referred to as a tranche or class) cash flows. Realized losses on the underlying pool reduce the principal balances of the CRT securities sequentially, starting at the bottom of the stack.⁹ Freddie Mac retains a pro-rata share of risk in the B and M tranches, and fully holds the first loss (Class B3-H) and a residual senior claim (Class A-H). The size and subordination structure of the H classes relative to that of the securities sold to investors determines how much risk is effectively transferred.

The money raised through the issuance of CRT securities is invested in safe assets, whose investment income generally covers the LIBOR part of the coupon paid on the CRT securities.¹⁰ The spread over 1-month LIBOR¹¹ is the insurance premium paid by Freddie Mac to investors.

As the mortgages in the reference pool are prepaid, and if loss rates are below prescribed triggers, the principal balances on the CRT securities are also prepaid. Prepayments reduce principal starting at the top of the stack, which shortens the average life of the more senior securities relative to the more subordinated ones.

Although linked to LIBOR, most CRT securities have a considerably longer duration than a pure floating rate security because of the substantial fixed spread component of the coupons. Hence, their value can be quite sensitive to changes in market interest rates, and relatedly to changes in expected prepayment rates.

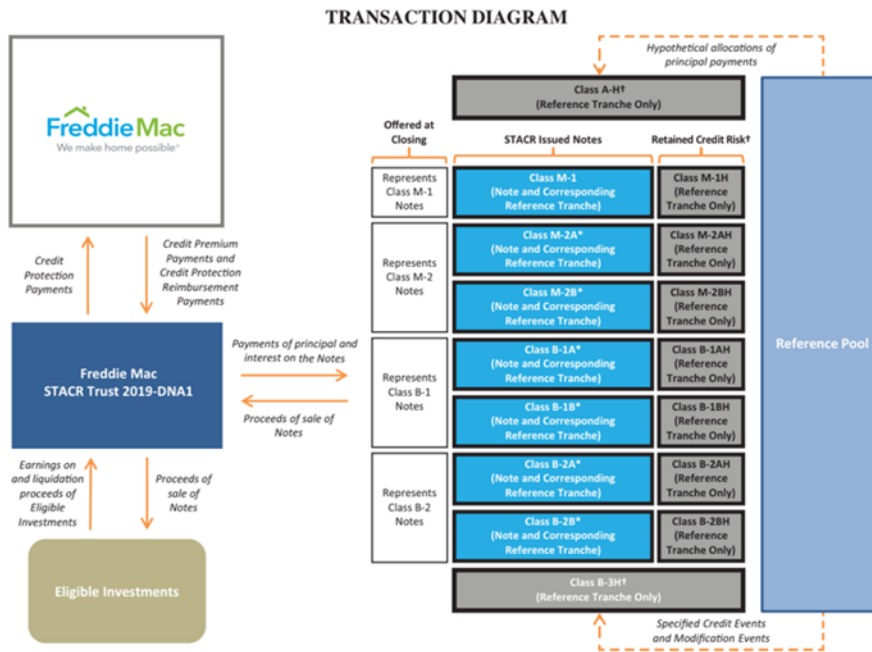
⁸ Fannie Mae’s CAS securitizations have a similar structure.

⁹ Subsequent recoveries increase principal balances that have been diminished, with are distributed in reverse order in the stack to write-downs.

¹⁰ The reference pool of mortgages is funded in the usual way via securitization.

¹¹ New issuances of CRT have moved to the SOFR index starting in October 2020.

Figure 1. Structure of a recent STACR securitization.



Source: Freddie Mac, Private Placement Memorandum for STACR Trust 2019-DNA1 Notes.

Table 1 shows the initial subordination levels, coupon rates, and expected ratings for the multiple classes of securities created from the offering memorandum for STACR Trust 2019-DNA1. This offering is also used below to illustrate the construction of CRT cost and incidence (i.e., share of cost transferred to investors) variables.

Table 1: Summary Data for STACR Trust 2019 DNA1

Classes of Reference Tranches	Initial Class Notional	Subordination	Coupon	Rating
Class A-H	\$23,561,926,526	4.250%	--	NR
Class M-1 and Class M-1H	\$ 307,596,952	3.000%	LIBOR + .9%	BBB
Class M-2A and Class M-2AH	\$ 233,773,684	2.050%	LIBOR + 2.65%	B+
Class M-2B and Class M-2BH	\$ 233,773,684	1.100%	LIBOR + 2.65%	B+
Class B-1A and Class B-1AH	\$ 61,519,391	0.850%	LIBOR + 4.65%	B-
Class B-1B and Class B-1BH	\$ 61,519,391	0.600%	LIBOR + 4.65%	B-
Class B-2A and Class B-2AH	\$ 61,519,390	0.350%	LIBOR + 10.75%	NR
Class B-2B and Class B-2BH	\$ 61,519,390	0.100%	LIBOR + 10.75%	NR
Class B-3H	\$ 24,607,757	0.000%		

Notes: 1-month LIBOR; Rating is expected from S&P; coupons are only notional for H classes

In this example, the “H” portions retained by Freddie Mac represent 30% of the class totals for the M1, M2, B1 and B2 securities. Although the total principal value of the CRT securities sold

assessment of the cost of default, and the share of loss exposure that is transferred from the GSEs to investors via CRT, varies over time. Importantly, this measure only captures the initial cost rate; the cost rate will change over time as CRT principal is paid down and the size of the reference pool changes.

The annual dollar cost of risk for the reference pool is calculated as the weighted average of the reported coupon rate spreads, where the weights are the initial principal amounts for each tranche. That annual cost is divided by the principal value of the reference mortgage pool to express the cost in basis points. The GSEs also report the size of each tranche that they retain. Weighting the spreads using only the principal for investor classes, and then only for GSE classes, determines the share of the total cost of each.

The cost calculations rely on several assumptions. For the retained tranches that are parallel in subordination to those in an investor class, the reported coupon rate for the investor class is applied to obtain the value of the retained portion. For the tranches retained entirely by the GSEs, no market coupon rate exists. In instances when a GSE holds an entire first loss tranche, we take the reported notional spread as the best available indicator of its market value. That value should be relatively insensitive to spikes in expected default losses because its principal will frequently be exhausted under average loss conditions. More problematic is the most senior tranche, which is always full retained, and typically represents 96% of the total reference pool's value. Because of its seniority, the senior tranche is very unlikely to absorb significant losses. Nevertheless, severely adverse events could cause losses to occur, and there is likely to be a significant risk premium associated with that possibility. Generally, no notional spread is reported for the retained senior tranche. We consider the effect of assuming a small spread on the senior retained tranche to illustrate the sensitivity of various inferences to that assumption.

To illustrate the cost and incidence calculations, Table 2 shows the computations for STACR 2019-DNA1.¹² For this issuance, 70% of each of the M1, M2, B1 and B2 tranches was sold to investors and 30% was retained by Freddie Mac. The weighted average spread on those tranches is 3.34%. Also taking into account the size and cost of the B3-H tranche, which is reported to have a notional spread of 25%, and dividing by the principal value of the reference pool, the overall cost of default risk for the reference pool is 16.3 bps.¹³ Freddie Mac retained 40.7% of that cost, assuming a zero spread is fair pricing for the A-H tranche. If a fair market spread on the A-H tranche were 10 bps, then the overall cost would increase to 25.9 bps and Freddie Mac's retained share would increase to 62.6%.

Table 2: Calculation of weighted average cost and retained share for STACR 2019-DNA1

¹² The calculation also uses the information in Table 1 to infer the size of the H tranches.

¹³ This estimate of cost only applies to the first few months. It will change over time as prepayments and defaults change the size of the reference pool and the size of the CRT tranches.

Closing date	30-Jan-19							
	original balance	coupon	expected rating	H balance		H bal/ bal	bal/(H bal + bal)	
M-1	215	LIBOR + .9%	BBB	92.6		0.430683	0.698967	
M-2A	163.5	LIBOR + 2.65%	B+	70.3		0.42981	0.699393	
M-2B	163.5	LIBOR + 2.65%	B+	70.3		0.42981	0.699393	
B-1A	43	LIBOR + 4.65%	B-	18.5		0.430684	0.698967	
B-1B	43	LIBOR + 4.65%	B-	18.5		0.430684	0.698967	
B-2A	43	LIBOR + 10.75%	NR	18.5		0.430684	0.698967	
B-2B	43	LIBOR + 10.75%	NR	18.5		0.430684	0.698967	
	714	sum		307.2	sum		1045.8	sum w/B3-H
							0.0425	
				spread	wtd avg	wtd avg H		
M-1	215	LIBOR + .9%		0.9	193.500	83.33726		
M-2	327	LIBOR + 2.65%		2.65	866.550	372.4522		
B-1	86	LIBOR + 4.65%		4.65	399.900	172.2303		
B-2	86	LIBOR + 10.75%		10.75	924.500	398.1669		
	714				3.340	3.340		
B3-H		LIBOR + 25%	0.25	24.6	amt			
A-H			0.001	23561.9	amt			
total ref pool	24607.7					24.60679		
Total annual value of insurance if A-H is worth nothing and 25% is right for B3-H								
40.25636698								
Annual rate relative to ref pool								
0.001635924								
Cost share H								
0.407683758								
SENSITIVITY								
Total annual value of insurance if A-H is worth D23 and D22 is right for B3-H								
63.81826698								
Annual rate relative to ref pool								
0.002593424								
Cost share H								
0.626368732								

4. Trends

Combining the default cost and retained share variables constructed above with additional data on g-fees, the Intercontinental Exchange® (ICE) index of BB option-adjusted spreads, and 90-day delinquency rates, we can characterize the time series behavior of these quantities and their co-movements. The most recent data, which covers the first seven months after the onset of the COVID-19 pandemic, is of particular interest as an example of how CRT investors and the GSEs respond to a major stress event.

4.1 Cost of default and incidence

The time series of default cost and incidence (i.e., how much of the default cost is retained by the GSE and how much goes to investors) are shown in Figures 2 and 3. The data points are constructed from STACR DNA and STACR HQA securities, following the procedure described in Section 3.2. Freddie Mac began to issue both types of securities in 2015, with three or four issuances a year. The DNA and HQA structures are similar, but for the DNAs the reference pools have mortgages with an initial loan-to-value (LTV) ratio of less than or equal to 80%, and for the HQAs the initial LTV is greater than 80% and the mortgages have supplementary private

mortgage insurance (PMI). The combined principal of the underlying mortgages totals \$923.8 billion.

Figures 3 and 4 illustrate the sensitivity of these inferences to the unobservable cost of the risk borne by the senior A-H tranche. Going from zero cost to a relatively small cost of 10 bps increases the average cost from 16.7 to 26.2 bps, and increases the average share of the cost borne by Freddie Mac from 48.0% to 67.8%. In reality the cost of risk on the A-H tranche probably varies with its subordination level and market conditions; a fuller examination of this issue is left for a future paper.

Figure 3:

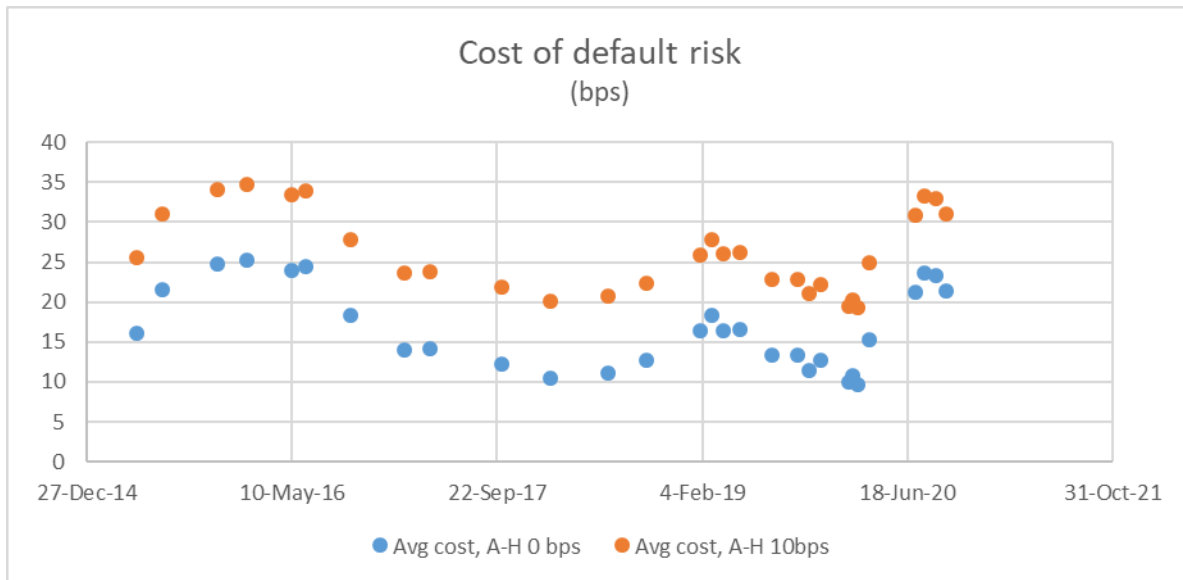
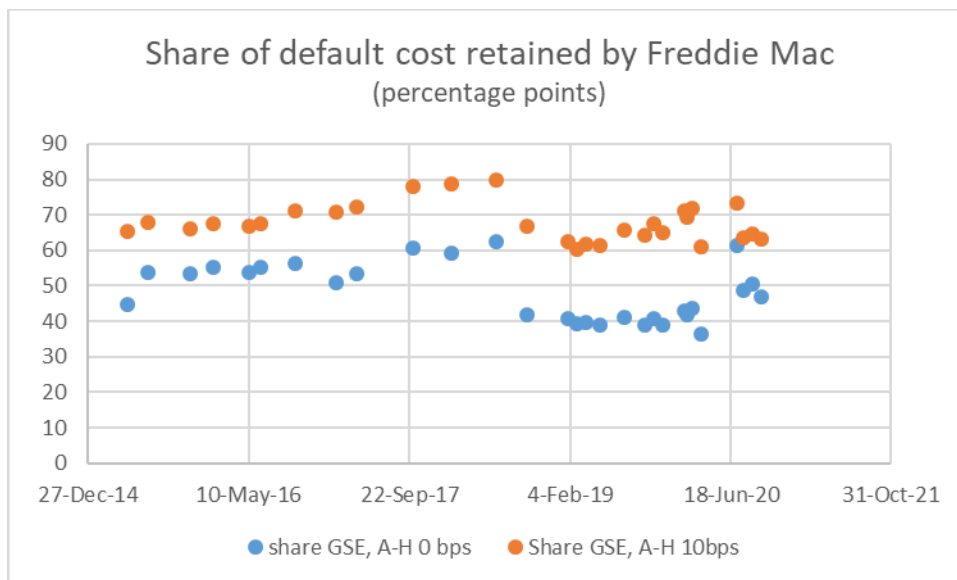


Figure 3 shows the considerable variation over time in the market value of default risk on 30-year conforming mortgages, henceforth referred to as “default cost.” That cost increased sharply after the onset of the COVID-19 pandemic, but it rose to levels that were no higher than for 2015 issuances. The estimated cost is highly sensitive to the assumption about the cost of risk to the senior (A-H) tranche. In general, because the A-H tranche always represents over 94% of the reference pool principal in this data, an increase in the A-H spread translates almost one-for-one into the cost of default risk.

Figure 4:



The variation over time in the retained share of default cost is driven by several factors: it depends on GSE decisions about the subordination levels of the different tranches and the relative size of the retained pieces; and on the market-determined spreads associated with each tranche.

Figure 4 shows how the retained share has varied over time, and as a function of the cost of risk to the A-H tranche. Interestingly, even our low-end estimates of retained risk appear to be significantly higher than what is suggested in Freddie Mac’s 10Q, which reports that 23% of the risk is retained on mortgages covered by CRTs. They use an undisclosed methodology based on the “Conservatorship Capital Framework.” As with our calculations of default cost, the retention share is highly sensitive to the assumption about the unobserved fair spread for the A-H tranche; it averages 48% when the A-H tranche has no spread, and 67.8% when it has a spread of 10 bps. Note that whether the finding of a low effective rate of risk transfer should be viewed as a good or bad policy depends on the purpose and efficiency of risk transfer. If the primary economic purpose is price discovery and transfers involve high transaction costs, then it may be optimal to only transfer enough risk to obtain a reliable price signal.

A notable finding is that the retained shares of issuances during the pandemic period are not elevated, nor are the sizes of those issuances smaller than is typical for Freddie Mac. (Note Fannie Mae was not active in the market during the initial period of Covid-19, but returned to the market in October 2021.) This may allay some concerns about whether the GSEs would continue to use CRT during stress events. However, there are several caveats to that conclusion. Our calculations hold the spread on the A-H tranche constant, whereas its fair market value may have increased post-pandemic. Assuming even a modest increase in the A-H tranche spread could lead to the conclusion that considerably more risk was retained during the pandemic period, e.g., if the spread was zero pre-pandemic and 10 bps in August and September, the share retained would have increased by about 20 percentage points. Furthermore, a more convincing stress test would require a larger jump in cost than was experienced through September 2020. Finally, the decision not to sell STACR securities in the April to June period, when the spreads on high yield bonds

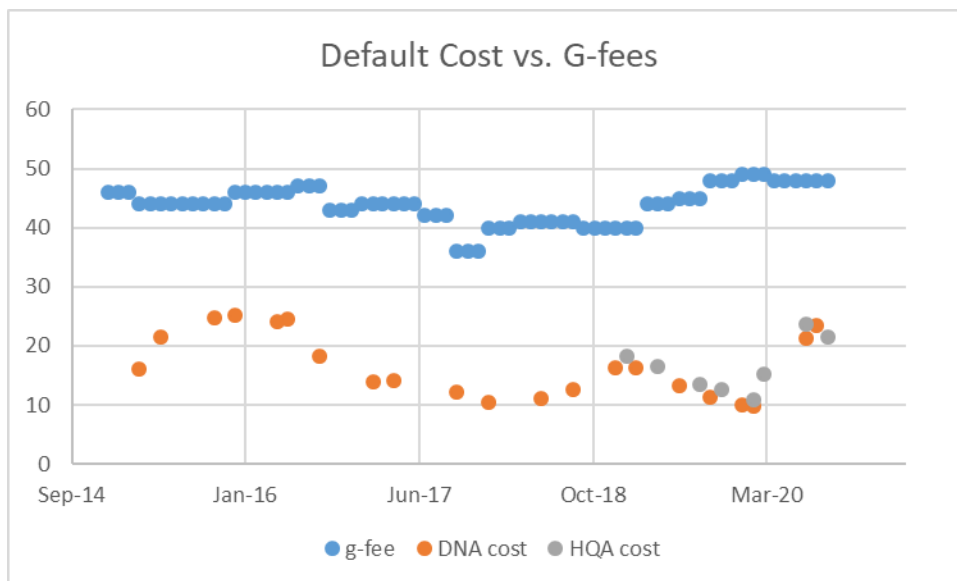
were most elevated, might be interpreted as evidence that the GSEs will stop transferring risk when it becomes expensive to do so.¹⁴

Finally, note that these estimates of the retained share of losses is downward biased relative to the universe of mortgages purchased by the GSEs. That's because about 5% of the mortgages the GSEs purchase are screened out of the reference pools, including all mortgages that default in the first few months after origination. A rule of thumb is that these probably account for 10% of losses.

4.2 Is default cost passed through to g-fees?

Comparing the time series of default cost to the g-fees charged to borrowers on newly originated mortgages is informative about whether the information in CRT securities pricing is being passed through to borrowers via mortgage interest rates.

Figure 5:



As is evident in Figure 5, market-based estimates of default cost change at a much higher frequency than do administratively set g-fees. The correlation between the two series is only 0.15. The consistently positive difference between the default cost and g-fees, which averages 28 bps in this data, can be interpreted, in part, as covering the administrative costs of managing the guarantee program, including the transactions costs such as dealer fees associated with CRT. and, in part, because credit risk is only one of many risks faced by the GSEs. It also helps cover other expenses associated with the GSEs' operations.

The co-movement is informative about the extent to which the price signals generated from CRT transactions are passed through to borrowers. This is important because it is the mechanism by which the price signals are most likely to have a direct effect on the real economy, by moderating

¹⁴ Milliman, in a September 2020 White Paper "The GSE CRT market reopens post COVID-19 disruption: A new normal? Or more troubles on the horizon?," makes this argument.

the demand for housing when default risk is high, and vice versa. While it may be a policy objective to smooth g-fees relative to price signals, the very low correlation between the two series suggests the information in CRT pricing has had little influence on guarantee pricing decisions.

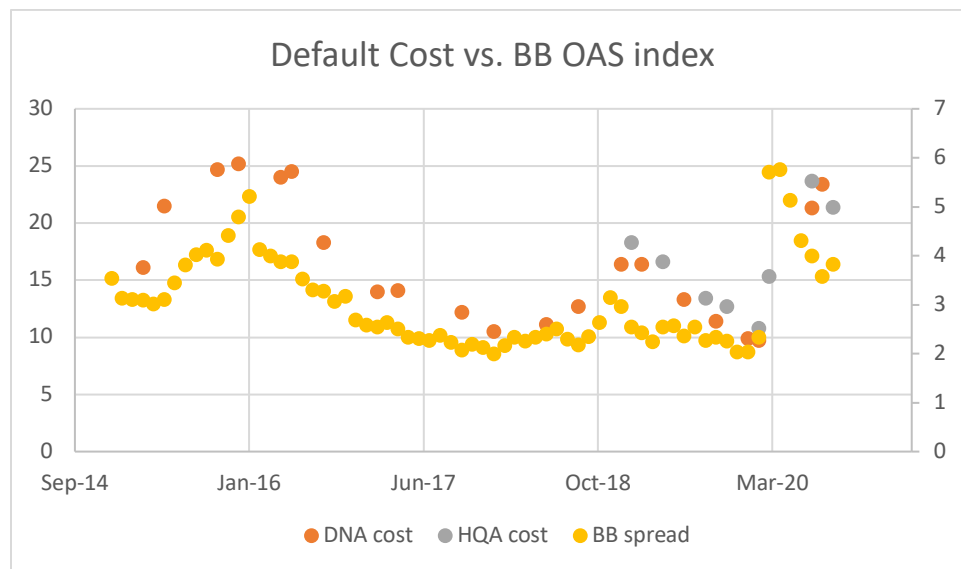
Because new issuances of CRT securities are infrequent, the GSEs could also use the price signals from secondary market CRT transactions as a more timely input into setting g-fees. We return to the relation between g-fees and secondary market prices in Section 6.

4.3 What correlates with default cost?

To begin to evaluate whether default costs derived from CRT prices are providing forward-looking information on mortgage performance that is not available elsewhere, we look at how much of the variation in default cost can be explained by other factors. The factors considered are 90-day delinquency rates, and the options-adjusted spread on the ICE/BAML BB US High Yield Index. To the extent that delinquency rates are positively correlated over time, higher delinquency rates should predict higher future default costs. Some of the more risk-sensitive tranches of CRT are typically rated BB, and if similar investors participate in the high yield and CRT markets, spreads in the two markets may be similar.

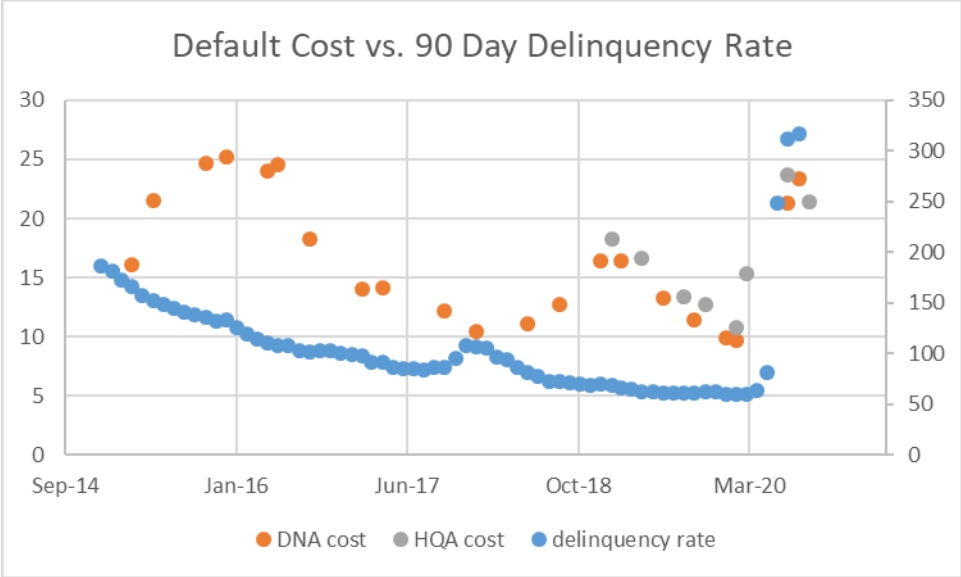
Figures 6 and 7 show the relation between default cost and the BB index, and between default cost and delinquency rates, respectively. The correlation between cost and the BB index is .72, consistent with investors viewing these securities as sharing risk characteristics with high yield bonds. The correlation between default costs and delinquency rates is .55.

Figure 6



Left hand scale is for default cost in basis points. Right hand scale is for index yield in percentage points.

Figure 7



Left hand scale is for default cost in basis points. Right hand scale is for delinquency rate in basis points.

A multiple regression of default costs on delinquency rates and the BB index finds the BB index to be significant in explaining default costs and delinquency marginally so. The total explanatory power is high (R^2 of .59). Relative to a univariate regression on the BB index, adding delinquency only marginally increases the explanatory power of the regression. The high explanatory power of the BB index for default cost suggests that there may be relatively little information in CRT pricing that is specific to the housing market rather than to general market conditions.

Table 2: Regression of default costs on BB index and delinquency rate

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>
Intercept	4.82978652	2.176754309	2.218802
Delinquency	0.02180867	0.010554439	2.066303
BB index spread	3.11710963	0.769050914	4.05319

4.4 Secondary market CRT prices

The time series data on secondary market prices, for individual CRT tranches and for aggregated vintages, show a sharp drop in prices that started in mid-March of 2020 and persisted between April and June, a period during which Freddie refrained from new STACR issuances.

The price histories shown Figure 8 are for the B1 and M2 tranches of 2019 STACR DNA1. Secondary market prices are reported starting a few days after issuance and through the end of September, 2020. The behavior of 2019 STACR DNA1 is typical of all the DNA and HQA vintages in the Vista data. B1 prices are generally more volatile than M2 prices because changing perceptions of default loss rates have a larger impact on more subordinate tranches.

The increasing price of the B1 tranche over the pre-pandemic period is consistent with the decline in BB rate spreads and a generally strong economy at that time. Figure 8 shows the time path of coupon rates for the two 2019 STACR DNA1 tranches. The coupons for both tranches move in parallel with changes in the one-month LIBOR rate.

Figure 8.

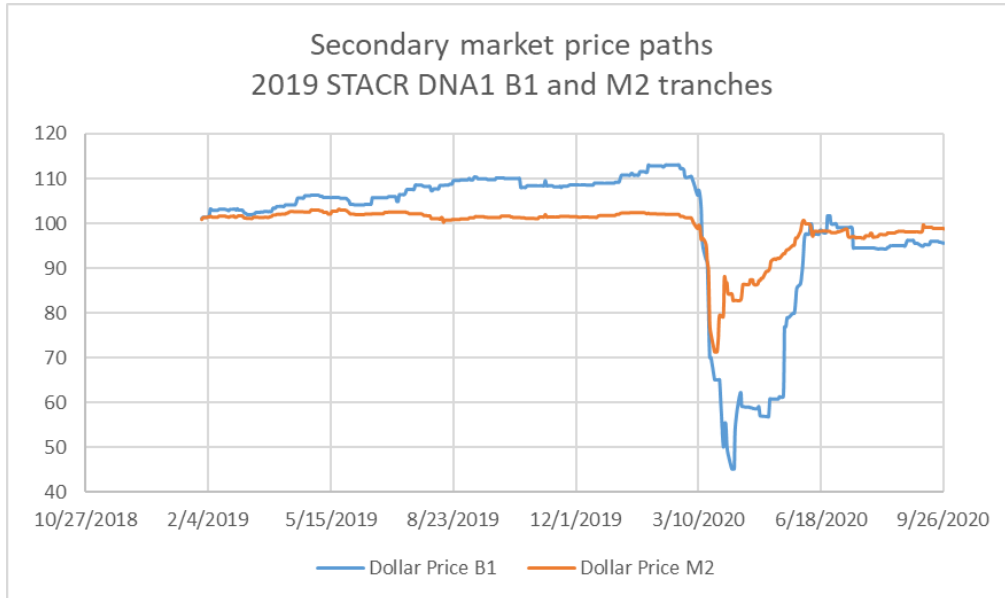
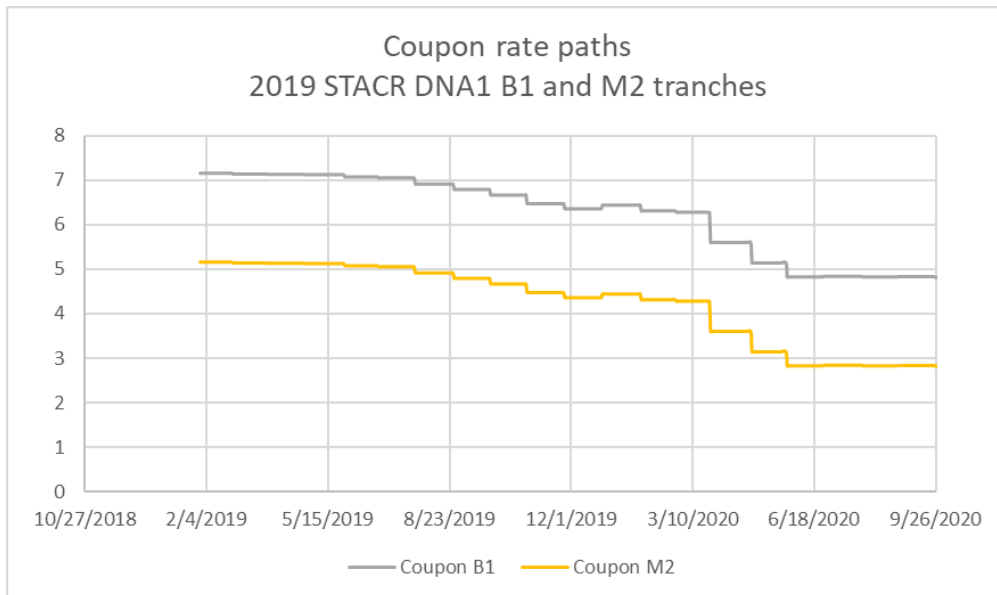


Figure 9.



It seems unlikely that changes in expected default losses could fully account for the large price declines that started around March 13 and that continued for several weeks. Declines persisted even after passage on March 25 of the CARES Act, which put a stay on foreclosures through

year-end, and that instituted policies allowing distressed borrowers with GSE-insured loans to skip mortgage payments for up to 360 days.

4.4.1 Secondary market illiquidity

The lack of daily transactions prices for each security raises the question about the liquidity and depth of the CRT market, and the trading costs involved in this market. Illiquidity for CRT securities will tend to raise the cost of CRT to the GSEs. It is not possible to directly measure the size of such effects, but some data that is suggestive about liquidity is available.

Table 3 shows summary statistics drawn for a variety of sources around liquidity along with our calculation of transactional costs associated with the issuance of CRT securities.

Table 3: Data on Liquidity and Depth of Market		
Number of investors at issuance	~50	
Unique investors at issuance	~200	
Number of TRACE trades/month (STACR)	~400	Equates to about one trade per week with higher rated tranches more likely to trade
Volume of TRACE trades/month (STACR)	\$1.2 B	
Average trade size	~\$3M	
Sources: FMCC disclosures and TRACE data		

4.4.2 Cost to GSEs of premium pricing in secondary market

Comparing STACR and CAS security prices at issuance with their average price during the first five days of secondary market trading, the weighted average price in the secondary market is on average 3% higher than at issuance.¹⁵ That premium, which provides compensation to the dealers who participate in primary offerings and then resell the securities to other investors, represents an additional cost to the GSEs which is excluded from financial reports because it is not a cash item, but rather an opportunity cost.

To put the cost of the premium in units that are comparable to the default cost, a 3% premium on a typical 4% subordination level is 12bps relative to the reference pool principal. About 70% of the principal value of CRT securities are sold to investors, for an average additional issuance cost of 8.4 bps. That is similar to the total default cost that is transferred in the first year to investors of approximately 8.35 bps (based on a total default cost of 16.7 bps and a 50% share of default cost retained by the GSEs).

5. CRT valuation model

¹⁵ Separating the STACR and CAS issuances shows similar costs for the two, with STACR premiums being slightly lower on average.

The above analysis shows how the initial default cost associated with pools of newly issued 30-year conforming mortgages, measured at market value, has varied over time. While informative about changing market sentiment, those statistics provide little information about the returns that investors are expecting on CRT securities, or how those expected returns compare to those on other credit instruments with similar risk. While market prices enter into the calculation of initial default cost through the coupon rate spreads on CRT securities, estimating expected returns requires additional information on future cash flows, which will depend on prepayments and default losses over the life of the reference mortgage pool, and on the rules (i.e., the “waterfall”) governing the cash flows for each tranche.

The CRT valuation model developed here provides estimates of the expected returns to CRT investors, and the sensitivity of expected returns to different assumptions about the stochastic processes driving default losses and prepayments. It does so by combining CRT price information with estimates of the distribution of future CRT cash flows to produce a distribution of realized yields for each tranche. The difference between the expected yields generated and a risk-free rate provides an estimate of the combined risk, liquidity, and term premiums (henceforth simply referred to as a risk premium) investors expect to earn on CRT securities. The model is also used to produce estimates of how much the price of a CRT security would be expected to change in response to a specified change in default, recovery or prepayment rates; and how much the price would change for a specified change the risk premium, holding the distribution of future cash flows fixed.

The model is numerical, and the results are generated using Monte Carlo simulation. In this paper, the waterfall and security structure are calibrated to match the information in the offering document for STACR 2019-DNA1. Those parameters can be changed to analyze other STACR and CAS offerings although given the similarities of structures, we would not expect the results to vary dramatically.

5.1 Stochastic processes for default, recovery and prepayment

Projecting cash flows for the various tranches of CRT securities requires first modeling the joint distribution of default, recovery and prepayment rates on the reference pool of mortgages. The rates evolve from specified initial conditions according to:

$$\begin{aligned}
 x_{i,t+1} &= x_{i,t} + \rho_i(\bar{x}_i - x_{i,t}) + \sigma_i \varepsilon_t + I_{j,i} J_i & (1) \\
 x_{i,t+1} &= \max(x_{i,t+1}, x_{i,\min}) \\
 x_{i,t+1} &= \min(x_{i,t+1}, x_{i,\max})
 \end{aligned}$$

where $x_{i,t}$ is the rate in period $t+1$, ρ_i is the speed of mean reversion, \bar{x}_i is the mean-reverting rate, σ_i is the standard deviation of a standard normal shock, ε_t , $I_{j,i}$ is an indicator variable that a jump has occurred, J_i is the fixed size of a jump that has probability p_j , of occurring, and $[x_{i,\min}, x_{i,\max}]$ is the range of permitted values; $i=d, R, \text{ or } pp$ for default, recovery or prepayment.

All three rates are modeled as truncated mean-reverting processes. In addition, the default and recovery processes have a common jump component that induces a negative correlation between the current default rate and the recovery rate one year later. (The jump is set to zero for the prepayment rate.) The jump reflects that default rates rise significantly, and subsequent recovery rates fall, following infrequent but severe shocks to the economy or to financial markets. The speed of mean reversion is used to match the persistence of the effect of shocks over time.

Standard forecasting models for these driving processes include additional variables such as house prices, interest rates, coupon rates, and remaining maturity. The parameter estimates for those models are generally unstable, necessitating frequent re-estimation. Our goal here is not short-term forecast accuracy. Rather, it is to be able to generate a plausible joint distribution of these processes over the life of the reference pool, and to be able to easily modify parameters to reflect different initial conditions or changes in expectations. The base case calibration is chosen to match summary statistics on the joint distribution of these variables historically.

5.2 Cash flows and waterfall

Each period, CRT investors receive a coupon payment based on the current period coupon rate multiplied by the remaining principal balance of the tranche, and possibly a partial or full prepayment of principal. The principal balances going into the next period are adjusted for default losses and prepayments according to the rules embedded in the waterfall.¹⁶

To determine the cash flows to each tranche, it is first necessary to track the unpaid principal balance of the reference pool (UPB), which declines with scheduled principal and interest payments, and also because of stochastic prepayments and default losses. Total time t default losses are calculated as the product of three factors: (1) the share of the unpaid balance of the reference pool at t that is designated as having defaulted at t , $x_{d,t}$, (2) the unpaid principal balance on the reference pool, UPB_t , and (3) one minus the recovery rate, $x_{R,t}$. The total time t default losses are assumed to affect CRT cash flows with a two-year lag, at $t+24$. This accounts for the timeline between initial default on the mortgage by the homeowner and the disposition of the property by the GSE.

The waterfall allocates default losses according to seniority, starting with the most subordinated tranche (B3-H in the STACR 2019-DNA1 example). Whether the current period default loss causes a decline in the principal for a given CRT tranche depends on the cumulative amount of previous default losses, and whether there is sufficient principal in any remaining more subordinated tranches to absorb the losses. If not, the uncovered losses are deducted from the principal balance. If the principal is exhausted before the entire loss is absorbed, the remaining portion is deducted from the next most senior tranche, and so forth.

The return of principal triggered by prepayments occurs in reverse order, with the most senior CRT securities being paid off. The size of the prepayments to CRT securities depends not only on the size of prepayments in the reference pool, but also on its cumulative default experience.

¹⁶ Subsequent additional recoveries may cause a write-up of principal. This is infrequent, and we notionally collapse all the effects of default write-downs and recoveries into a single default loss event.

The aim of these rules is to ensure that sufficient loss-absorbing capacity is likely to remain in place over the life of the reference pool. It is possible, however, that a situation with initially high prepayment rates and low default rates, followed by a period of very high default rates, could cause even the most senior tranches to experience losses. The model can be used to assess the likelihood and severity of such events.

5.3 Summary of model logic and output

Fixed parameters are set at the beginning of a program run for the driving processes; the reference pool (average coupon, remaining maturity); and the initial principal value and coupon spread for each CRT tranche.

At the beginning of each Monte Carlo run, all quantities that update over time are reset to their time 0 values. In each subsequent period t , draws from a random draw determines the current realizations for default, recovery and prepayment rates for the reference pool. The size of the reference pool is adjusted down with realized defaults, realized prepayments, and scheduled payments. There is a two-year lag between when defaults occur and when the associated losses are deducted from CRT principal balances.

For each t , the cash flows paid to each CRT tranche i is calculated and recorded, and the principal balance is then updated to its value at the start of the next period. Coupon payments are based on the beginning-of-period tranche principal and the current coupon rate. Principal is repaid or written down according to the rules of the waterfall. Partial prepayments of principal may be paid out and included in cash flows, starting with the most senior tranches, depending on realized prepayments and loss performance tests. The realized defaults cause write-downs on CRT principal balances starting with the most subordinated tranche, as described earlier.

The model allows us to see how the average cost of coupons paid to investors evolves over time. In interpreting this statistic, it is important to recognize that while its initial value incorporates current market prices, its subsequent value is mechanically determined by contractual terms and realizations of default losses and prepayments.

The main outputs of the model are distributions of cash flows. The cash flows received on each tranche are recorded for each time period and for each Monte Carlo run. Combining those cash flows with tranche prices either at issuance or in the secondary market implies a distribution of yields (i.e., realized rates of return). Taking the average yield across Monte Carlo runs provides an estimate of expected returns for each tranche implied by its price. Conversely, we can use the model to ask what the price of a particular tranche would be if investors discounted cash flows at a specified rate, e.g., a risk-free rate. That calculation suggests the size of the risk premium investors assign to each tranche.

The model can be used to evaluate whether CRT pricing is in line with other credit markets, or whether the GSEs pay a premium to transfer risk in this way. This is done by comparing the expected returns inferred from the model with the yields on corporate bonds with similar ratings, adjusting the comparison yields for historical default loss rates.

It can also be used to interpret the sharp secondary market price drops brought on by the COVID-19 pandemic in terms of yield changes. We use the model to ask (1) how much default loss expectations would have to have changed to justify the price drops; and (2) if expected default losses only increased modestly, how much did the implied risk premium change?

5.4 Calibration

The tranche structure is based on the STACR 2019 DNA-1 offering, as summarized in Tables 1 and 2, and with stylized rules for the waterfall based on the offering document.¹⁷ The parameters for the driving processes described by equation (1) are shown for the base case in Table 4.

Table 4: Parameters for driving rate processes, monthly basis for default and prepayment

	Mean-reverting level	speed revert	std dev	lower bound	upper bound	prob jump	jump value	initial value
default	0.00020	0.1466	0.00004	0.0000	0.0010	0.0250	0.0010	0.0002
recovery	0.60000	0.2308	0.0300	0.3000	0.9000		0.3000	0.6000
prepay	0.01600	0.3500	0.0050	0.0000	0.0400		0.0000	0.0160

The 1-month LIBOR rate is fixed at 2.51%, its value on the issuance date.

6. Results from valuation model

Monte Carlo simulation of the model yields the distribution of realized returns for each tranche, given a purchase price. That is, for each stochastic path of cash flows, the yield to maturity is calculated based on the initial underwritten issue price of par. Table 5 shows the summary statistics for realized returns for the base case driving processes.

Table 5: Summary statistics for realized returns by tranche, annualized rates, base case

	M1	M2	B1	B2
mean	0.0342	0.0528	0.0740	0.1003
std dev	0.0002	0.0000	.00001	0.0208
max	0.0346	0.0528	0.0740	0.1344
min	0.0341	0.0528	0.0726	-0.0304
median	0.0341	0.0528	0.0740	0.1040
count	500	500	500	500

A striking finding is that default has no effect on returns of either the M1 or M2 tranches. The average rate of return on the M2 tranche of 5.28% seems surprisingly high given its minimal exposure to default risk. The return on the B1 tranche is moderately risky and on average about 2

¹⁷ The code is available from the authors upon request.

percentage points higher than the M2 tranche. The B2 return is extremely risky, and the 500 Monte Carlo runs are insufficient to accurately compute its mean.

To examine how sensitive realized returns are to the assumed default process, Table 6 reports the same statistics for two variants on the default process. In the first, all parameters are as in the base case, but at issuance default rates and recovery rates are at their maximum and minimum rates respectively, rather than being set to their mean-reverting level as in the base case. It answers the question, how much would expected returns fall with a sharp increase in near-term default rates and fall in recovery rates, all else held constant? In the second, the mean-reverting default rate, and jump rate (representing a crisis), are both doubled. Table 6 reports the outcomes for both variants for the M2 and B1 tranches.

Table 6: Summary statistics for realized returns by tranche, annualized rates, elevated default

	Starting values at crisis levels		Default parameters doubled	
	M2	B1	M2	B1
mean	0.0528	0.0694	0.0523	0.0100
std dev	0.0000	0.0081	0.0027	0.0647
max	0.0528	0.0740	0.0528	0.0740
min	0.0528	0.0238	0.0263	-0.3102
median	0.0528	0.0739	0.0528	0.0278
count	500	500	500	500

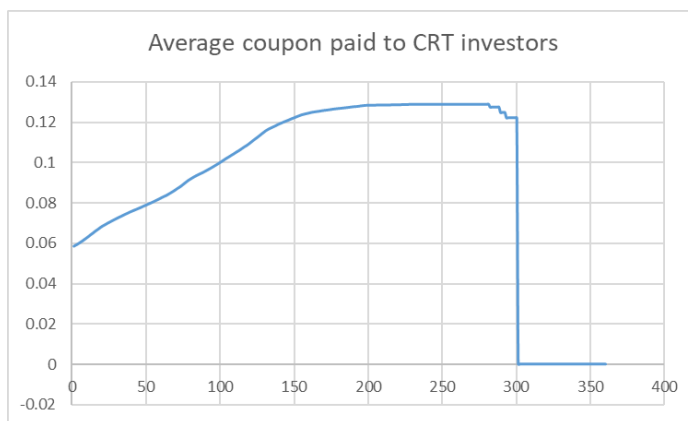
Even starting in a crisis situation, the M2 tranche is extremely unlikely to experience default losses. When the default parameters are doubled--implying default rates well above historical experience--the M2 tranche has some exposure to default losses, but the minimum return over 500 Monte Carlo simulations was still slightly higher than LIBOR. As expected, B1 returns are more affected by either variant are M2 returns. Starting at crisis levels also has a fairly small effect on B1 returns. That finding is sensitive to the speed of mean reversion of the default rate and a much slower mean reversion, e.g., a decade long depression, would lower yields. That, however, does not describe the environment when the security was issued..

How do these rates compare with contemporaneous market rates for securities with similar ratings? STACR 2019 DNA-1 was issued on January 30, 2019. Its B1 tranche had an expected rating of B-, and the M2 tranche had an expected rating of B+. The coupon spread on the B1 tranche is 4.65%, and on the M2 tranche is 2.65%. The BAML single-B options adjusted spread on the same day was 4.7%. A simple comparison between the index rate and the coupon rates on those CRT tranches suggests that the securities received favorable pricing from the market. However, the model-generated risk profile of returns to these tranches suggests the assigned ratings were very conservative. According to Standard and Poor's, over the period 1981 to 2018 the weighted average annual default rates on single-B rated bonds globally was 3.44%, with a standard deviation of 3.29%. Assuming a 50% recovery rate, the expected return spread on B-rated security was roughly $4.7\% - .5(3.44\%) = 2.98\%$. The M2 tranche, whose return is insensitive to default risk, has an expected return spread that is nearly as high as on the much

riskier B index. The simulated returns on the B1 tranche appear much less volatile than the default rates on the index, and the expected return on the B1 tranche appears to be significantly higher than on the index. We conclude that the pricing received by the GSEs on these securities appears to be unfavorable relative to the high-yield corporate market.

The model also can be used to show how the average coupon paid to CRT investors evolves over time. Recall that the default cost defined in Section 3 was based on the principal-weighted average coupon rate at issuance. Figure 10 shows the increase in the weighted average coupon paid to investors as the more senior tranches are paid down as the reference pool mortgages prepay, for the base case parameterization. It drops to zero at month 300 because we assume a clean-up call by the GSEs at that time. Because default rates are much lower than prepayment rates, prepayment has the dominant effect on average coupon.

Figure 10: Average investor coupon by month



7. Summary and Conclusions

CRT can provide valuable price signals to investors, regulators, the GSEs, and other market participants. That is particularly important while the GSEs are in conservatorship. If they are privatized, CRT could be beneficial in reducing systemic risk. However, equity capital is an alternative form of protection. Regulatory capital requirements need to incorporate the relative effectiveness of CRT relative to traditional equity capital. By addressing the efficiency of CRT under multiple scenarios, this analysis is relevant to that issue. We find that CRT securities may be a relatively expensive means of risk transfer, and the price signals are likely to be opaque, due to complexity, illiquidity, and other factors.

In this paper, data from CRT offering memorandums are used to construct a time series of default costs, and of the share of the default cost retained by the GSEs. Our analysis shows that:

- The default cost varies considerably over time. It rose sharply during the COVID-19 pandemic, but to levels that were not unusually high by historical standards.

- The default cost is highly correlated with the BB OAS index, which raises the question of how much information it contains about the housing market and mortgage risk.
- The guarantee fees charged to borrowers by the GSEs are very weakly correlated with default cost, suggesting that CRT information is not being used by the GSEs for risk pricing.
- The share of default cost retained is in the range of 40 to 70%. That statistic is significantly higher than the 23% of risk retention reported.
- The share of default risk retained did not rise significantly for the several issuances that occurred after the start of the pandemic. However, the GSEs did not issue CRT securities during the months when market spreads were most elevated.
- The default cost and the share of it retained by the GSEs is highly sensitive to the unobserved cost of default risk for the senior A-H tranche retained by the GSEs.

Our paper also used secondary market data from Vista Data Services. Analyses of these data show a very large price decline in March 2020, around the same time that other markets including the high yield market fell in response to concern about the pandemic's consequences. Prices have largely recovered on more senior tranches.

In general, the secondary market price in the first few days of trading averages about 3% over the underwritten issuance price. That premium represents a significant issuance cost that is not reported in financial statements. Furthermore, compared to liquid markets, low volumes and sizes of secondary market trades, and quite limited number of participants.

Our paper uses a valuation model to assess the distribution of returns on CRT securities, and thereby to have a more complete measure of the cost of risk transfer and how it compares to the cost of risk in other markets. Application to STACR 2019 DNA-1 and comparison with high yield bond spreads suggests that the mezzanine tranches have almost no exposure to default risk under a realistic base case parameterization, yet their expected return is several percentage points higher than LIBOR. The B1 tranche is riskier than the M2 tranche, but it absorbs less credit risk and has a higher expected return, than corporate bonds with comparable ratings. Expected returns on the mezzanine tranches are fairly insensitive to significant increases in assumed default risk.

In summary it would appear that CRT securities are a relatively expensive way to transfer risk. And because mezzanine tranches bear so little default risk and yet carry substantial risk premiums, it may be more efficient for the GSEs to lower typical subordination levels so that only risk-sensitive securities are sold to the public.

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