



Mortgage Servicing Rights Valuation with an ALM Focus

A White Paper and Case Study
on QuantityPhi's MSR Valuation Model

AUTHOR

Adam Stone
President of QuantityPhi
QuantityPhi™ Balance Sheet Optimization
Corporate Central Credit Union

(414) 433-0176
6262 South Lowell Place
Muskego, WI 53150
quantityphi.com

May 2024

Introduction

Many credit unions have a program in place to fund mortgage loans to their members and sell them, typically to agencies like Fannie Mae and Freddie Mac, who then package the loans together and sell them as securities to investors. Credit unions retain the servicing rights to the mortgage, meaning they collect principal and interest payments on the loans and pass them through, as well as deal with paperwork, collections, and all the hardships that come with servicing a loan. For the troubles of servicing a loan, credit unions get a monthly servicing fee, typically around 25 basis points of the remaining balance of the loan. The servicing fee decreases proportionally to the paydown of the loan as balances decline.

On their quarterly call reports, credit unions must report the dollar amount outstanding of real estate loans that have been sold in which they retain the servicing rights. Credit unions must also report the dollar amount of Mortgage Servicing Rights (MSR) recorded as an asset on their call report under Other Assets. The value of MSRs must be the Net Present Value (NPV) of all expected future income from servicing the loans.

QuantyPhi has built a sophisticated model to calculate the NPV of a credit union's MSR portfolio, with an emphasis on interest rate risk.

Key highlights and benefits of QuantyPhi's MSR model include:

- Each loan is examined individually.
- Advanced process to determine forecasted prepayment speeds, combining multiple prepayment projections and market consensus on large pools of outstanding mortgages with excellent geographic dispersion. Projections are based on underlying prepayment projections on pools of tens of millions of individual mortgages with a current amount measured in the trillions.
- Prepay projections are segregated by loan term (10-year, 15-year, 20-year, and 30-year), loan origination year, and loan interest rate to determine the best prepayment rate for each individual loan based on the loan's specific characteristics.
- The model uses a dynamic discount rate that combines the loan spread at origination date and the current yield curve to calculate a present value for each individual loan.
- Results are provided showing a base prepayment, zero prepayment, +300 bps, +200 bps, +100 bps, -100 bps, -200 bps, and -300 bps interest rate scenarios. This provides a good range of expected valuations should rates change one way or another.
- QuantyPhi provides a detailed final report including our process, results, and recommendation.

Background

This white paper and case study endeavors to illustrate the importance of viewing MSR valuations with an interest rate risk and ALM focus. The case study will prove the volatility inherent in calculating MSR NPVs during periods of time in which market interest rates are rapidly changing. Further, the case study will highlight the effectiveness of QuantyPhi's MSR valuation model in projecting changes in NPVs as market rates change. Utilizing a proper MSR model that forecasts NPVs across a spectrum of interest rate scenarios will provide you with the required information to understand your MSR risk profile and add relevance to your broader ALM program.

It is vital to perform a thorough valuation of your real estate loans sold portfolio at least annually. It is further recommended to perform a valuation more frequently if market rates change significantly, and this case study will show the significance of doing so. Additionally, a thorough MSR model should value your entire portfolio, not just newly originated and sold loans, to capture the always shifting dynamics of prepayment expectations for all loan vintages.

Understanding the variables impacting MSR valuations, namely prepayment expectations and discount rates, can assist in broader strategy and ALM discussions and planning. Accurate and timely measurement and monitoring of all interest rate risk on a credit union's balance sheet is fundamental to a sound risk management program. The asset value of real estate loans sold with servicing retained is one component, and this case study will highlight the importance of measuring risk across potential future interest rate scenarios.

Case Study

To highlight the effectiveness of QuantyPhi's MSR model and prove the benefits of viewing MSR valuations with an ALM and interest rate risk focus, a detailed case study was conducted. The case study is based on characteristics of actual credit union real estate loans sold portfolios and spans multiple years and significant changes in market interest rates.

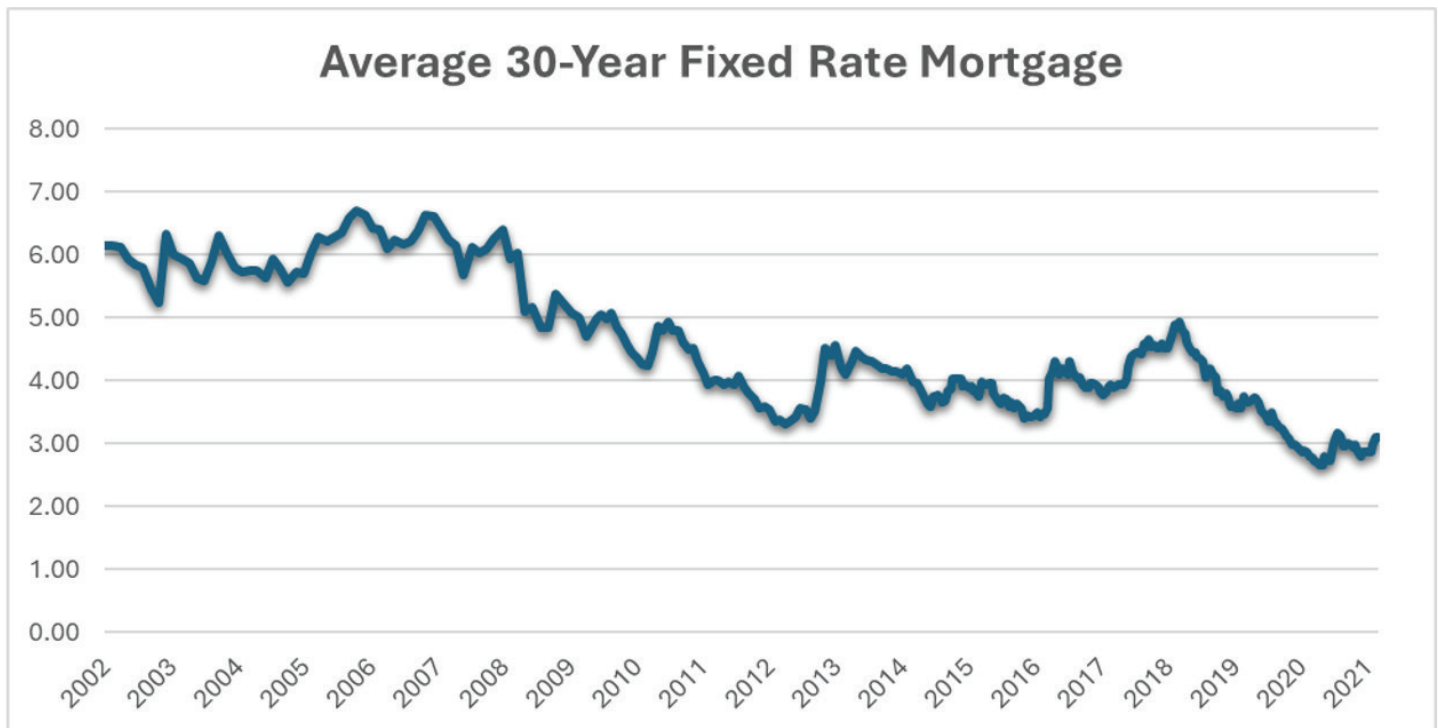
(a) First Valuation – September 30, 2021

(i) Background

The case study begins with the valuation of MSR on a real estate loans sold portfolio as of September 30, 2021. Below are the characteristics of the portfolio:

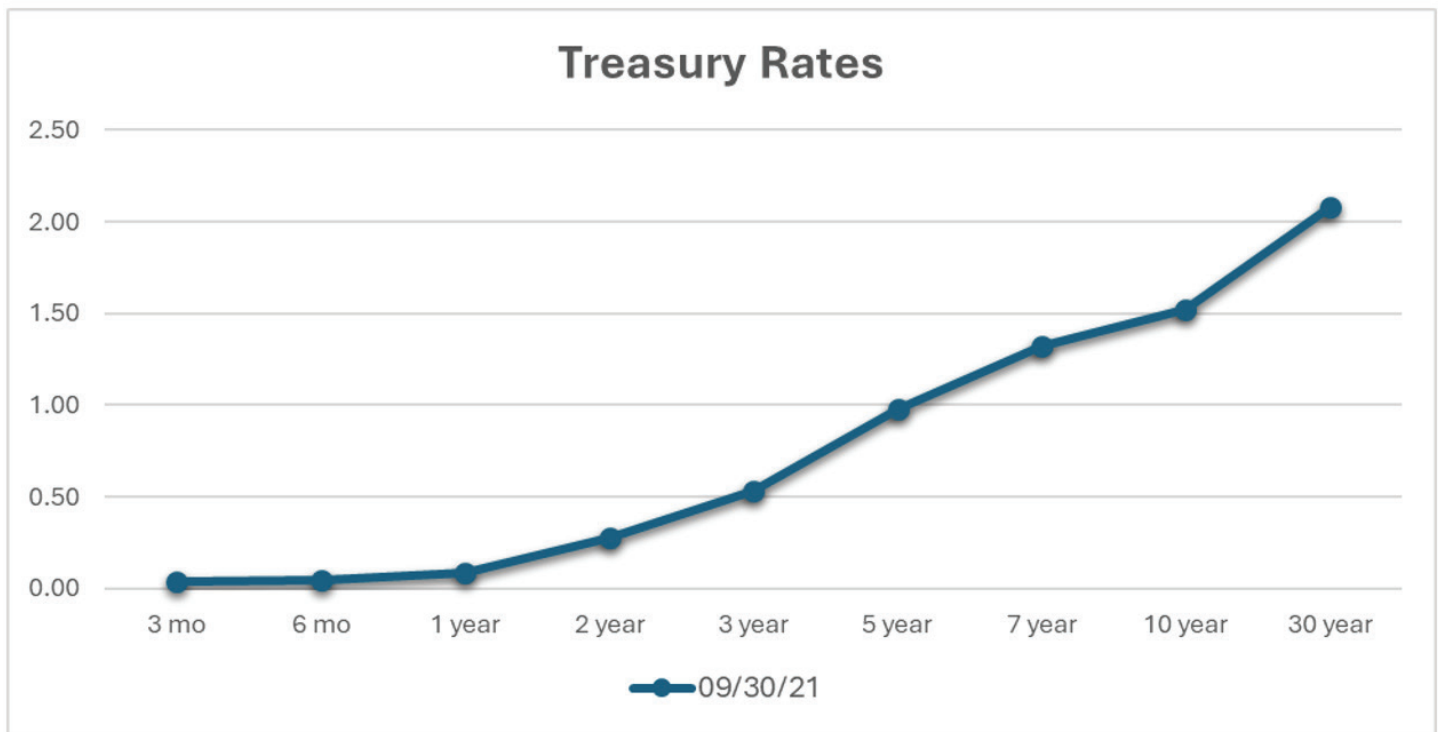
- 500 individual fixed rate mortgage loans
- Current total balance of \$59.8 million
- 28 ten-year loans, 43 fifteen-year loans, 22 twenty-year loans, and 407 thirty-year loans
- Loans originated between 2002 and 2021
- Rates reflect prevailing mortgage rates at times of origination, ranging from 2.67% to 6.71%
- Servicing rate earned of 25 basis points for all loans

The initial valuation date of September 30, 2021, was a period of historically low interest rates. The Federal Reserve maintained a target Fed Funds range of 0.00% to 0.25%, a range that began in early 2020 as a result of rapid easing due to market disruptions from the pandemic. 30-year mortgage rates were near all-time lows and closed the month averaging below 3.00%. Average mortgage rates encompassing the period of loans sold for our case study can be seen below.



Source: Freddie Mac, 30-Year Fixed Rate Mortgage Average in the United States [MORTGAGE30US], retrieved from FRED, Federal Reserve Bank of St. Louis

The Treasury curve to be used for discounting cash flows from servicing fees on the sold loans portfolio is depicted below. The curve is upward sloping, with short term rates near 0.00% and not exceeding 1.00% until the five-year point on the curve, underscoring this era of historically low interest rates.



Source: U.S. Department of the Treasury, Daily Treasury Par Yield Curve Rates as of September 30, 2021

(ii) Results

The results table from the MSR model includes several data points across the modeled interest rate scenarios:

- **Scheduled Payment:** The amount of contractually scheduled principal payments for the underlying real estate loans
- **Prepayment:** The number of principal prepayments on the underlying real estate loans based on projected prepayment speeds resulting from the modeled interest rate shocks
- **Total Principal Payment:** Total scheduled payments plus total prepayments, or the cumulative amount of principal cash flows to be received on the duration of the real estate loan portfolio's remaining life
- **Weighted Average Life (WAL):** The calculated weighted average length of time that the real estate loan portfolio will remain outstanding
- **Servicing Fee – Gross:** The calculated total dollar amount of servicing fees expected to be received on the underlying real estate loans across the duration of the portfolio's remaining life, not discounted to present value
- **Servicing Fee – NPV:** The calculated total dollar amount of servicing fees expected to be received on the underlying real estate loans across the duration of the portfolio's remaining life, discounted to a Net Present Value (NPV)

The model performs MSR calculations across eight distinct interest rate scenarios:

- **Base Prepay:** Applies the current forecasted CPR to each loan based on current market conditions. This is the recommended scenario to use for recording the asset value of your MSR NPVs.
- **Zero Prepay:** Assumes all future principal payments are scheduled payment amounts only with no prepayments. This is not a realistic scenario but is included for informational purposes.
- **+300 bps:** Applies a CPR to each loan representing an immediate and sustained 300 bp rise in market rates.
- **+200 bps:** Applies a CPR to each loan representing an immediate and sustained 200 bp rise in market rates
- **+100 bps:** Applies a CPR to each loan representing an immediate and sustained 100 bp rise in market rates.
- **-100 bps:** Applies a CPR to each loan representing an immediate and sustained 100 bp drop in market rates.
- **-200 bps:** Applies a CPR to each loan representing an immediate and sustained 200 bp drop in market rates.
- **-300 bps:** Applies a CPR to each loan representing an immediate and sustained 300 bp drop in market rates.

Results from the September 30, 2021, MSR model performed on the case study real estate loans sold portfolio are shown in the table below.

	+300 bps	+200 bps	+100 bps	Base Prepay	-100 bps	-200 bps	-300 bps	Zero Prepay
Scheduled Payment	\$30,744,329	\$28,578,063	\$26,472,354	\$24,291,954	\$21,490,772	\$19,614,202	\$17,150,353	\$59,796,605
Prepayment	\$29,052,277	\$31,218,543	\$33,324,251	\$35,504,652	\$38,305,833	\$40,182,403	\$42,646,253	\$0
Total Principal Payment	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605
Weighted Average Life	5.39	4.88	4.37	3.88	3.26	2.86	2.35	12.19
Servicing Fee - Gross	\$792,681	\$717,525	\$640,398	\$567,075	\$475,310	\$414,622	\$339,195	\$1,809,627
Servicing Fee - NPV	\$639,481	\$610,959	\$574,216	\$531,120	\$459,922	\$404,038	\$331,602	\$1,434,764

Results show a base prepay NPV servicing amount of \$531,120, with that amount increasing as interest rates rise and decreasing as interest rates fall. There are two main factors impacting the NPV of servicing income: prepayment projections and discount rates.

- Impact of Prepayment Rates:** As indicated earlier, September 2021 was a period of historically low interest rates. Mortgage rates had been trending down for several years, providing existing mortgage holders ample time and opportunity to refinance to a lower rate, which results in a 100% prepayment and, therefore, exclusion from the case study portfolio. The current portfolio of real estate loans sold is primarily comprised of mortgage holders that cannot or will not refinance for a variety of reasons or are simply unaware or uneducated on their ability to do so. That is in addition to loans originated during 2019, 2020, and 2021 that already have low interest rates and no current rate-based incentive to refinance.

Projected prepayment rates across interest rate scenarios reflect speeds that increase as rates fall and speeds that decrease as rates rise, which is to be expected no matter the current rate environment. However, the magnitude and specific speeds by origination year and interest rate must be understood and incorporated within the model to provide a true forecast.

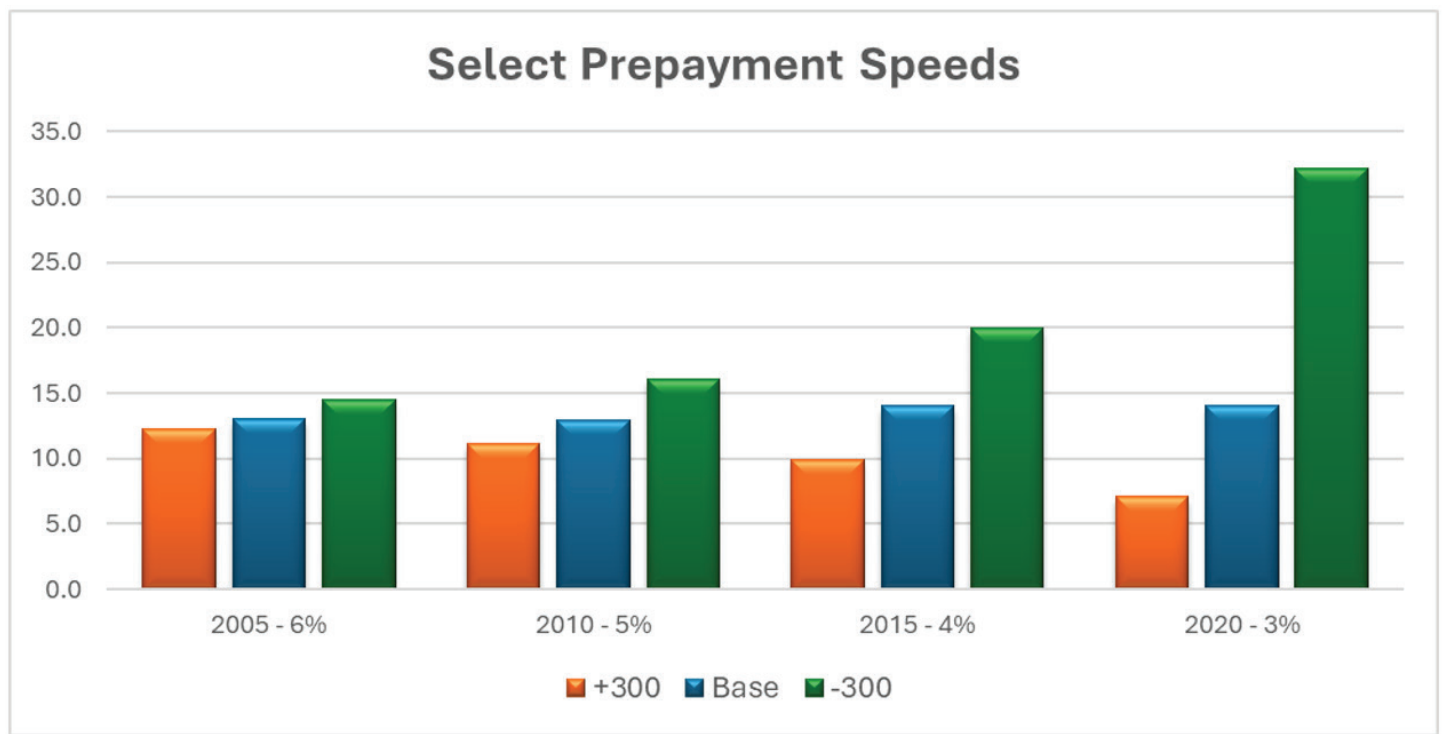
The tables below show Basecase, +300 bps, and -300 bps prepayment speed projections that were used in the case study to model the 30-year term loans within the real estate loans sold portfolio, as of September 30, 2021. The years shown horizontally across the table represent the origination year for the underlying loans and the rates shown vertically down the table represent the interest rate on the loan, rounded to the nearest one-half percentage point. Highlighted cells indicate the real estate loans sold portfolio contains an underlying loan with that unique origination year and rate combination. The values shown in the table are the corresponding Conditional Prepayment Rate, or CPR, for that modeled interest rate scenario.

Base Case																				
30-Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
2.00																				
2.50																			12.8	11.6
3.00																			14.1	12.0
3.50											13.3	13.1		14.8	14.4			17.1	14.7	
4.00									13.7	13.3	13.0	13.6	13.9	14.0	14.5	15.5	18.1	16.5		
4.50								12.7	13.0	12.9		13.4	13.6		16.1	15.5	16.4	16.1		
5.00		13.3					13.2	12.6	12.9	12.9							16.5			
5.50		13.1	12.8	13.1			13.2	13.0												
6.00	13.4	12.9	12.7	13.0	13.0	13.2	13.3													
6.50		13.4	13.1	13.7	13.1	13.4	13.7													
7.00																				

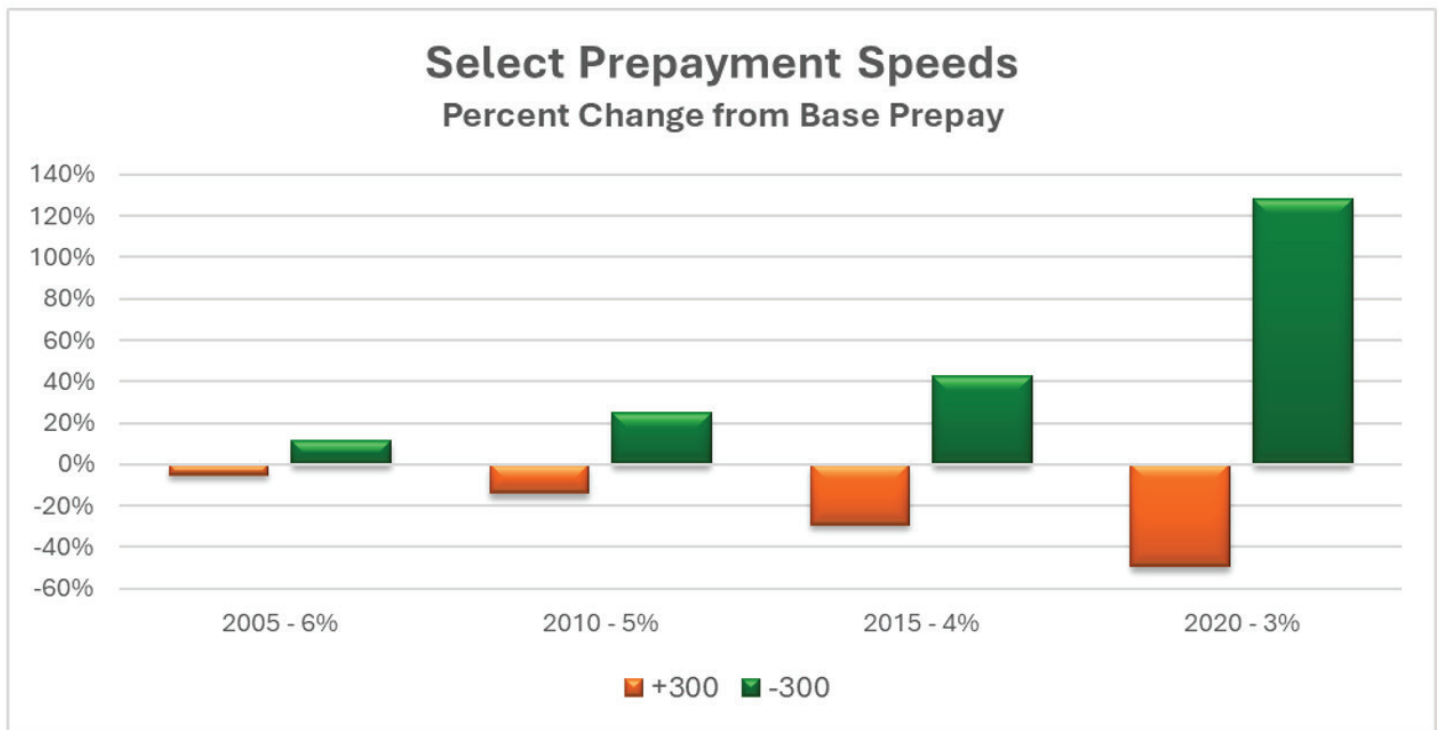
+300																				
30-Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
2.00																				
2.50																			6.2	5.7
3.00																			7.1	6.3
3.50											8.8	8.7		8.3	8.3			8.5	8.2	
4.00									9.9	9.7	9.9	9.7	9.7	9.9	9.8	9.1	9.3	9.4		
4.50								10.6	10.5	10.4		11.1	11.2		12.2	11.1	10.7	11.1		
5.00		12.6					11.8	11.1	11.1	11.3							13.6			
5.50		12.5	12.1	12.2			12.0	12.1												
6.00	12.9	12.3	12.1	12.3	12.2	12.3	12.3													
6.50		12.9	12.5	13.0	12.4	12.7	13.0													
7.00																				

-300																				
30-Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
2.00																				
2.50																			40.5	47.1
3.00																			32.2	41.0
3.50											23.2	22.2		28.0	26.4			33.1	25.7	
4.00									21.4	20.5	17.5	20.4	21.3	20.0	20.9	26.2	32.5	28.1		
4.50								16.6	17.8	17.5		16.7	16.9		19.8	21.3	25.7	24.4		
5.00		14.7					15.8	15.1	16.1	15.8							22.1			
5.50		14.4	14.2	14.7			15.3	14.7												
6.00	14.7	14.0	14.0	14.5	14.4	14.7	15.0													
6.50		14.6	14.3	15.1	14.4	14.8	15.0													
7.00																				

These tables clearly show prepayment speeds decreasing as rates rise and accelerating as rates drop. However, the magnitude of change is not consistent, with prepayment speeds generally increasing at a faster pace as rates decrease than the degree to which they decrease as market rates rise. To evidence this, the graph below shows four representative origination year and interest rate combinations and their corresponding projected prepayment rates under a base prepay scenario, as well as +300 bps and -300bps. Shown are 2005 6% loans, 2010 5% loans, 2015 4% loans, and 2020 3% loans.



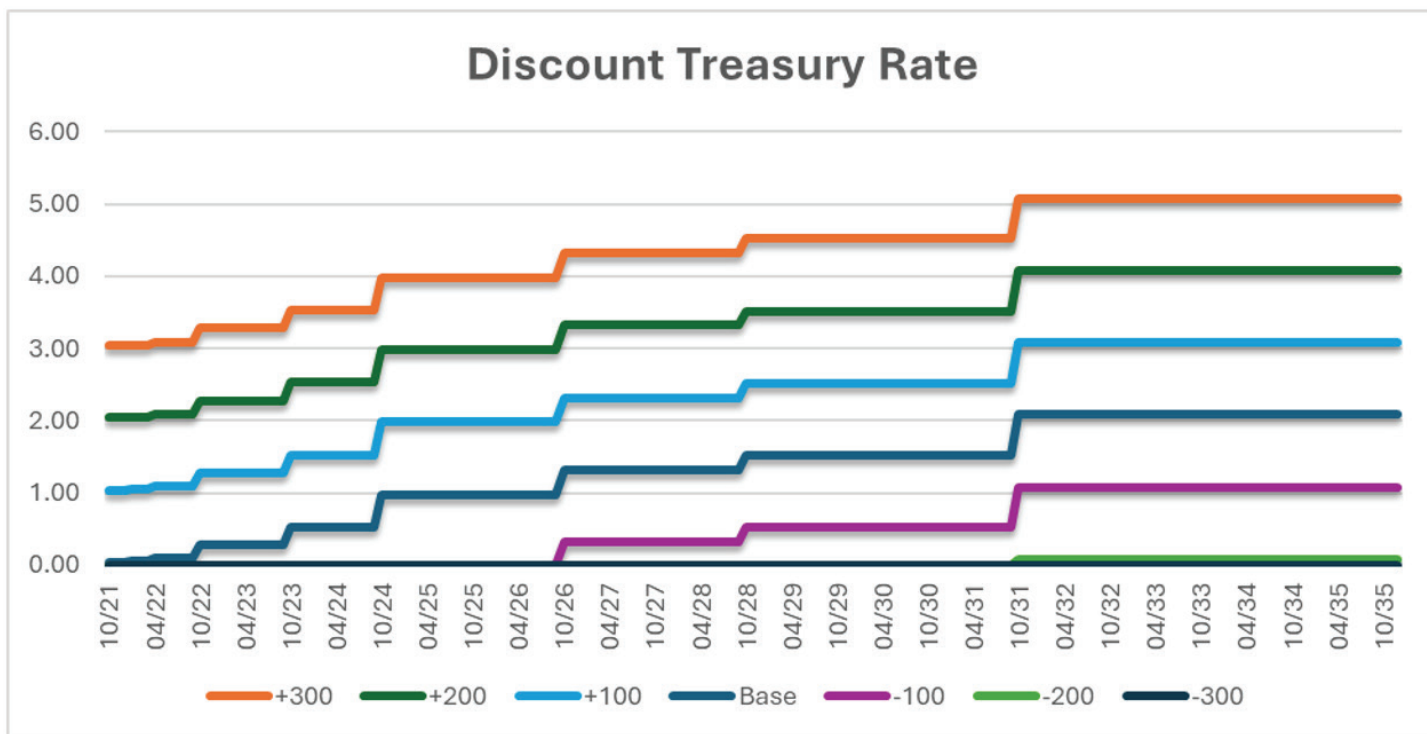
The differing degree of impact can further clearly be demonstrated by showing the shocked prepayment rate percentage change from the base prepayment rate in the graph below.



To summarize, shortening of the length of expected cash flows resulting from a steep increase in prepayment levels as market rates decline is having a larger relative impact on gross servicing values than seen as cash flows extend when market rates rise, and prepayment speed projections decrease. Simply said, the impact of interest rate shocks hurts servicing rights valuations in decreasing rate environments more than it helps in rising rate environments, as of September 30, 2021, and the composition of the case study loan portfolio, market environment, and forecasted prepayment projections at that time.

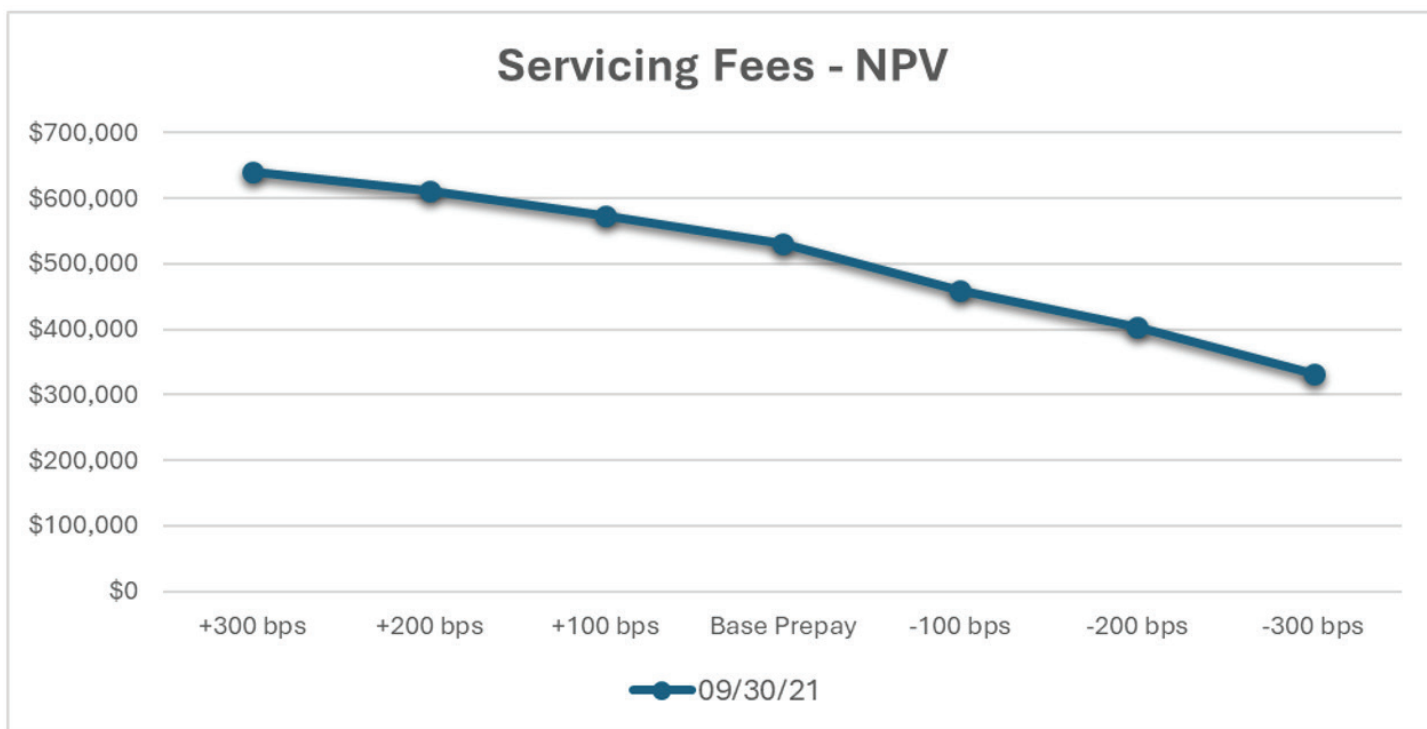
- Impact of Discount Rates:** Each individual real estate loan is assigned a discount rate representing a calculated loan spread, plus a representative U.S. Treasury rate. To determine the appropriate discount rate for each loan, first, a loan spread is calculated by subtracting the rate of the closest term US Treasury (10, 20, or 30 year) from each loan's interest rate at the time of origination. This spread represents the borrower's credit risk on top of the risk-free rate. The second discount rate component is the US Treasury rate, as of the valuation date corresponding to the time to discount, i.e. the 3-year Treasury is used for discounting projected cash flows in 3-years. Using this discount rate, the NPV is then calculated for each period of gross servicing income anticipated under each of the eight forecasted prepayment rate scenarios. A loan's discount rate varies depending on the length of time used to determine the discount due to the shape of the US Treasury curve, i.e. for an upward sloping curve, cash flows farther in the future will carry a higher discount rate.

Due to the low-rate environment in September 2021, the degree of NPV impact in rates-down scenarios is muted as it is assumed US Treasury rates have a floor of zero. The discount rate component representing the September 30, 2021, US Treasury curve is shown below, with rates in -100, -200, and -300 either fully or partially bottoming out at zero during the cash flow periods.

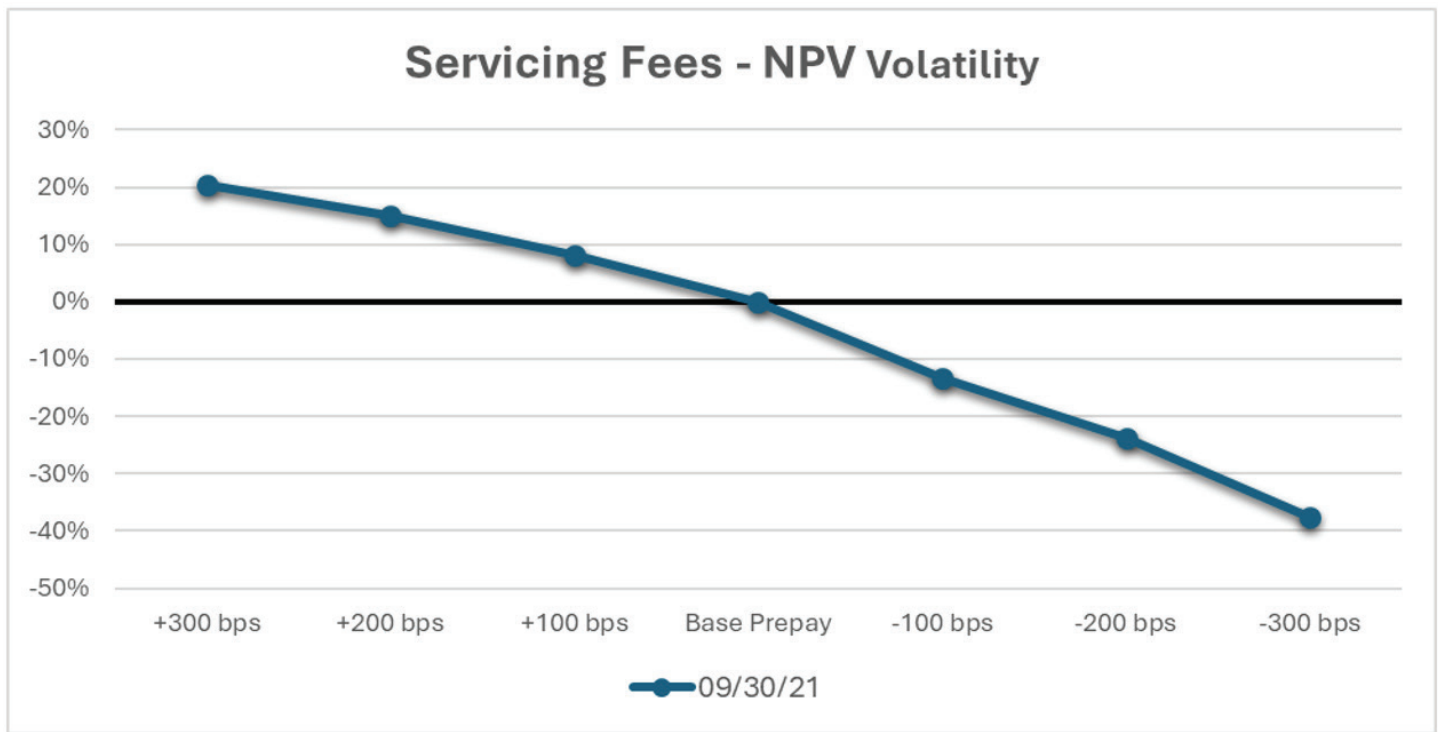


As explained above, the effects on servicing rights NPV due to prepayment changes and discount rate changes as interest rates are shocked up and down are competing forces. It is important to understand how characteristics of the underlying real estate loans and the current interest rate environment shape the magnitude each will have on the results of an MSR servicing valuation, at any point in time.

Revisiting the results from the September 30, 2021, case study, shown below in linear fashion, it becomes clear NPV's rise steadily and predictably as rates increase, but fall at faster pace as rates decrease.



Analyzing the NPV volatility shown below highlights this disparity even further. NPV's increase by 8%, 15%, and 20%, respectively, in a +100, +200, and +300 shock scenario, but fall at a -13%, -24%, and -38% rate, respectively, in a -100, -200, and -300 scenario.



(iii) Results Summary

As rates increase, prepayments slow down, extending the duration of cash flows on the underlying real estate loans, thereby extending the duration to receive servicing income, putting upward pressure on gross servicing fees. However, the increase in rates also elevates the applicable discount rates, putting downward pressure on the value when calculating the cumulative NPV. As of September 30, 2021, the power of a slowdown in prepayments outweighed the impact of rising discount rates, and as rates rise, NPV's are forecast to rise as well.

As rates decrease, prepayments accelerate, shortening the timing of the receipt of cash flows on the underlying real estate loans, thereby reducing the time to receive servicing income, putting downward pressure on gross servicing fees. As shown earlier, the degree to which prepayments accelerate as market rates drop is greater than the degree in which they slow down as market rates increase, leading to higher relative volatility levels from a base prepayment scenario in a down rate shock. Also relevant, the decrease in rates lowers the applicable discount rates, minimizing the negative effects of discounting future cash flows. But, due to the low-rate environment and floor of zero, even as rates fall further in more extreme rate shock scenarios, there are no incremental benefits to be realized from a discounting perspective. This allows the downward pressure from higher prepayments to fully dictate the resulting NPV amounts. In short, volatility is more severe in down rate scenarios due to prepayment projections at that time and as evidenced by the case study results.

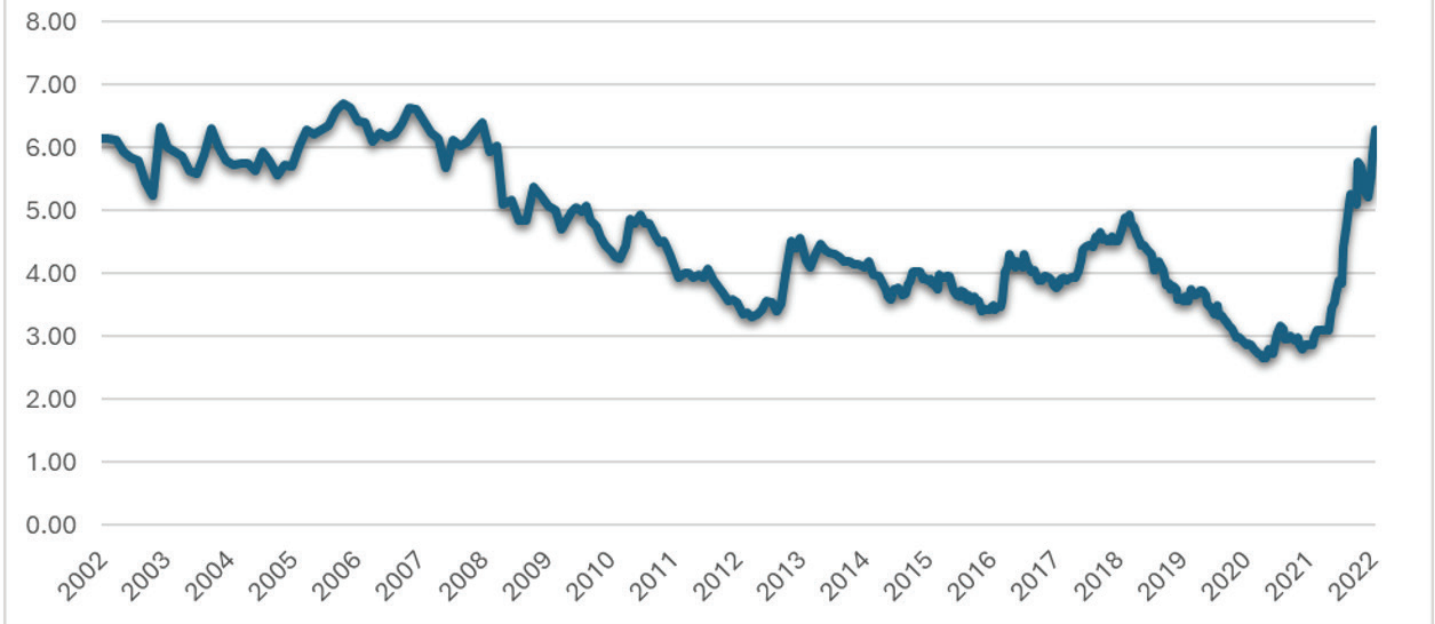
(b) Second Valuation - September 30, 2022

(i) Background

The second servicing rights valuation date for the case study occurs one year later on September 30, 2022, using the same portfolio of real estate loans sold as a starting point to show the efficacy of the modeled NPV projections from the initial valuation date, and also provide a new NPV forecast under the new prevailing market conditions.

Between September 2021 and September 2022, the Federal Reserve began rapidly increasing the Fed Funds rate to bring down increasing inflation measures. On September 30, 2022, the target Fed Funds range was 3.00% to 3.25%, or 300 basis points higher than one year prior. 30-year mortgage rates at the end of the period averaged 6.29%, or 341 basis points more than the same period the prior year. Average mortgage rates encompassing the period of loans sold for our case study can be seen below, highlighting the steep rise between 2021 and 2022.

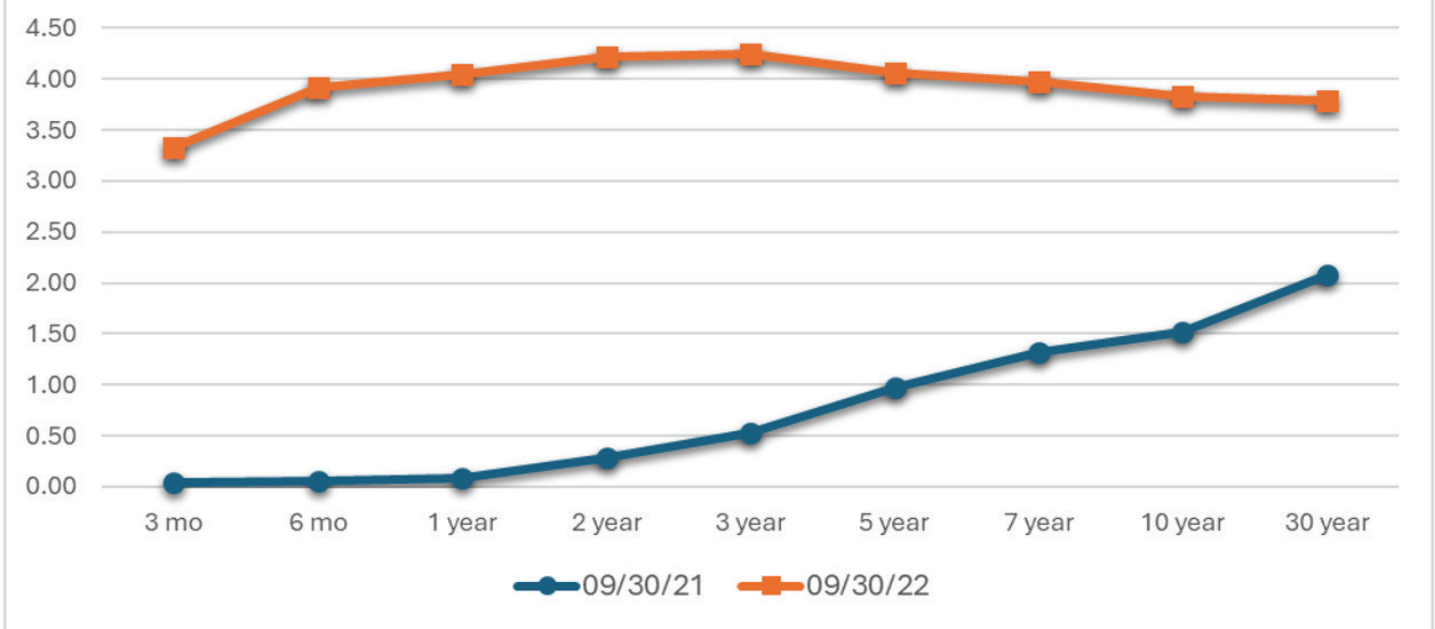
Average 30-Year Fixed Rate Mortgage



Source: Freddie Mac, 30-Year Fixed Rate Mortgage Average in the United States [MORTGAGE30US], retrieved from FRED, Federal Reserve Bank of St. Louis

The Treasury curve to be used for discounting cash flows from servicing fees on the sold loans portfolio is depicted below, along with the 1-year prior curve for reference. The curve is now upward sloping, until the 3-year point, and inverted thereafter. The 1-year rate is now 4.05%, a 396 basis point increase, and the 5-year rate is now 4.06, a 308 basis point increase.

Treasury Rates



Source: U.S. Department of the Treasury, Daily Treasury Par Yield Curve Rates as of September 30, 2021 and September 30, 2022

(ii) Results

For this case study, results from the second valuation date will be shown two different ways to illustrate separate and important points:

- 1. New Rates, Same Portfolio:** Using the prevailing prepayment projections and discount rates as of September 30, 2022, but on the exact same loan portfolio, including outstanding balances, as of September 30, 2021. This is a backtesting exercise to show how accurate the model predicted NPVs to change as market rates change.
- 2. New Rates, New Portfolio:** Using the prevailing prepayment projections and discount rates as of September 30, 2022, as well as an updated loan portfolio, including payments made, both scheduled and prepayments, throughout the year. It also includes new loans originated during the time period to replace payments made to bring the overall portfolio outstanding balance back to level with the previous year's amount. This will show the effectiveness of the MSR model, as well as reestablishing a baseline for the case study going forward and examining the NPV impacts under the new interest rate environment.

1. New Rates, Same Portfolio

Results from the September 30, 2022, MSR model performed on the case study real estate loans sold portfolio, under the parameters of the New Rates, Same Portfolio exercise, are shown in the table below. These results are displayed using updated prepayment and discount rates, but on balances from the initial valuation date, to show an apples-to-apples comparison and back test the shocked NPV projections from the initial valuation.

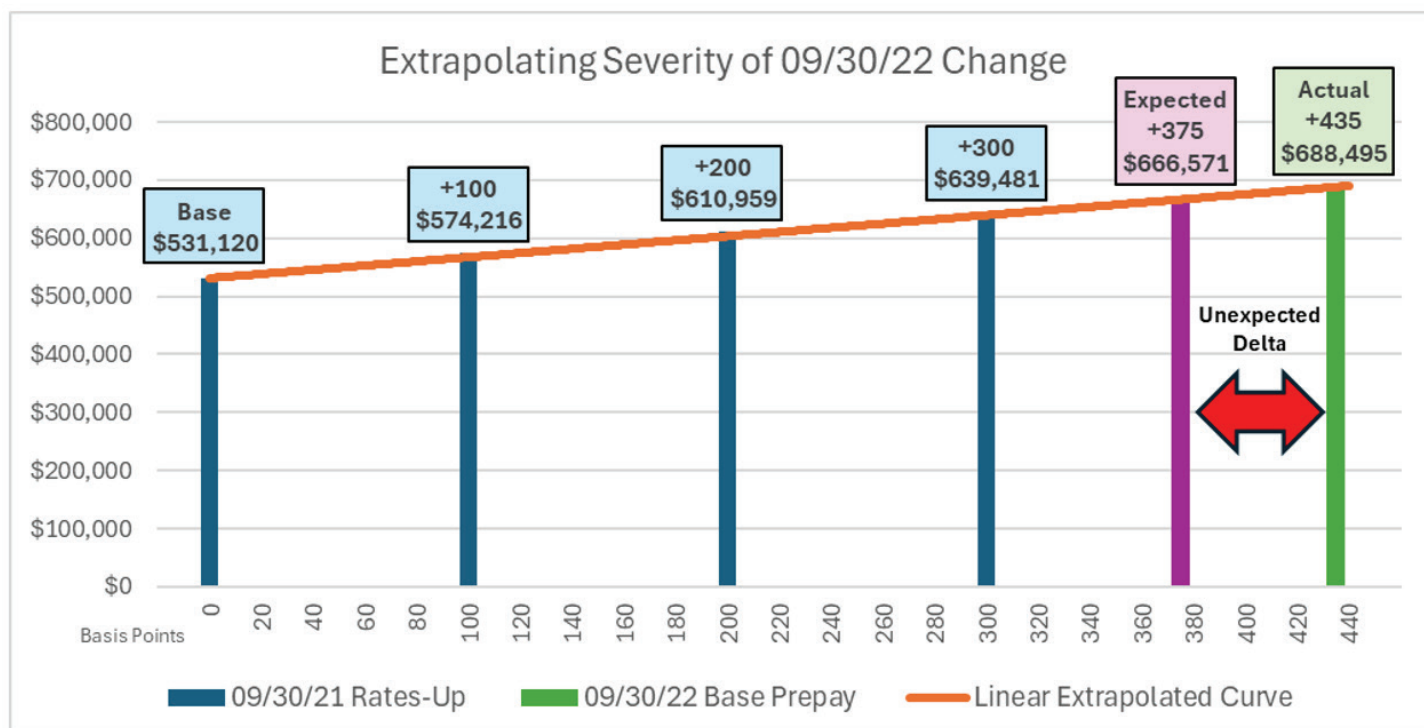
09/30/22	+300 bps	+200 bps	+100 bps	Base Prepay	-100 bps	-200 bps	-300 bps	Zero Prepay
Scheduled Payment	\$40,064,952	\$39,808,470	\$39,352,253	\$38,494,404	\$36,980,527	\$34,894,159	\$32,308,440	\$59,796,605
Prepayment	\$19,731,654	\$19,988,135	\$20,444,352	\$21,302,201	\$22,816,078	\$24,902,446	\$27,488,165	\$0
Total Principal Payment	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605
Weighted Average Life	6.17	6.11	6.01	5.81	5.42	4.78	3.94	12.19
Servicing Fee - Gross	\$909,598	\$901,495	\$886,501	\$856,527	\$797,892	\$702,626	\$576,819	\$1,809,627
Servicing Fee - NPV	\$643,361	\$663,794	\$680,962	\$688,495	\$673,971	\$625,590	\$539,446	\$1,230,481

For reference, below are the results from the initial valuation date of September 30, 2021.

09/30/21	+300 bps	+200 bps	+100 bps	Base Prepay	-100 bps	-200 bps	-300 bps	Zero Prepay
Scheduled Payment	\$30,744,329	\$28,578,063	\$26,472,354	\$24,291,954	\$21,490,772	\$19,614,202	\$17,150,353	\$59,796,605
Prepayment	\$29,052,277	\$31,218,543	\$33,324,251	\$35,504,652	\$38,305,833	\$40,182,403	\$42,646,253	\$0
Total Principal Payment	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605
Weighted Average Life	5.39	4.88	4.37	3.88	3.26	2.86	2.35	12.19
Servicing Fee - Gross	\$792,681	\$717,525	\$640,398	\$567,075	\$475,310	\$414,622	\$339,195	\$1,809,627
Servicing Fee - NPV	\$639,481	\$610,959	\$574,216	\$531,120	\$459,922	\$404,038	\$331,602	\$1,434,764

So, as of the initial valuation date of September 30, 2021, the NPV was \$531,120 and expected to increase to \$639,481 in a rates +300 bps shock scenario. However, rates saw almost unprecedented increases during the 12-months between the first and second valuation dates, with mortgage rates increasing almost 350 basis points, and parts of the Treasury curve rising nearly 400 basis points. Under the New Rates, Same Portfolio case study, the updated base prepay NPV was \$688,495, exceeding the +300 bps shock amount from September 30, 2021, which is to be expected considering rates did indeed increase more than 300 bps.

A simple extrapolation exercise can help understand the basis point shock equivalent of the September 30, 2022, results relative to the September 30, 2021, projected levels.



To summarize the above chart, as of September 30, 2021, the MSR model projected a NPV of \$639,481 in a +300 shock scenario, or 20.4% higher than the base prepay levels. Actual market movements across relevant mortgage and Treasury markets increased 350-400 basis points during the year-ended September 30, 2022. There are multiple curves and reference rates factored into the model, with an average change of roughly 375 basis points, which will be used as a proxy for an interest rate shock to calculate an expected NPV amount. This extrapolates to an expected new base prepay amount of \$666,571 as of September 30, 2022, or a 25.5% increase from the 2021 base. The actual new base amount as of September 30, 2022, was \$688,495, which equates to the equivalent of a 435 bps increase, or a 29.6% rise. So, while the model was extremely accurate in predicting the direction and relative magnitude of NPV changes in rising rate environments, it did under-predict the realized amounts by about 4% of both notional NPV gains and NPV volatility.

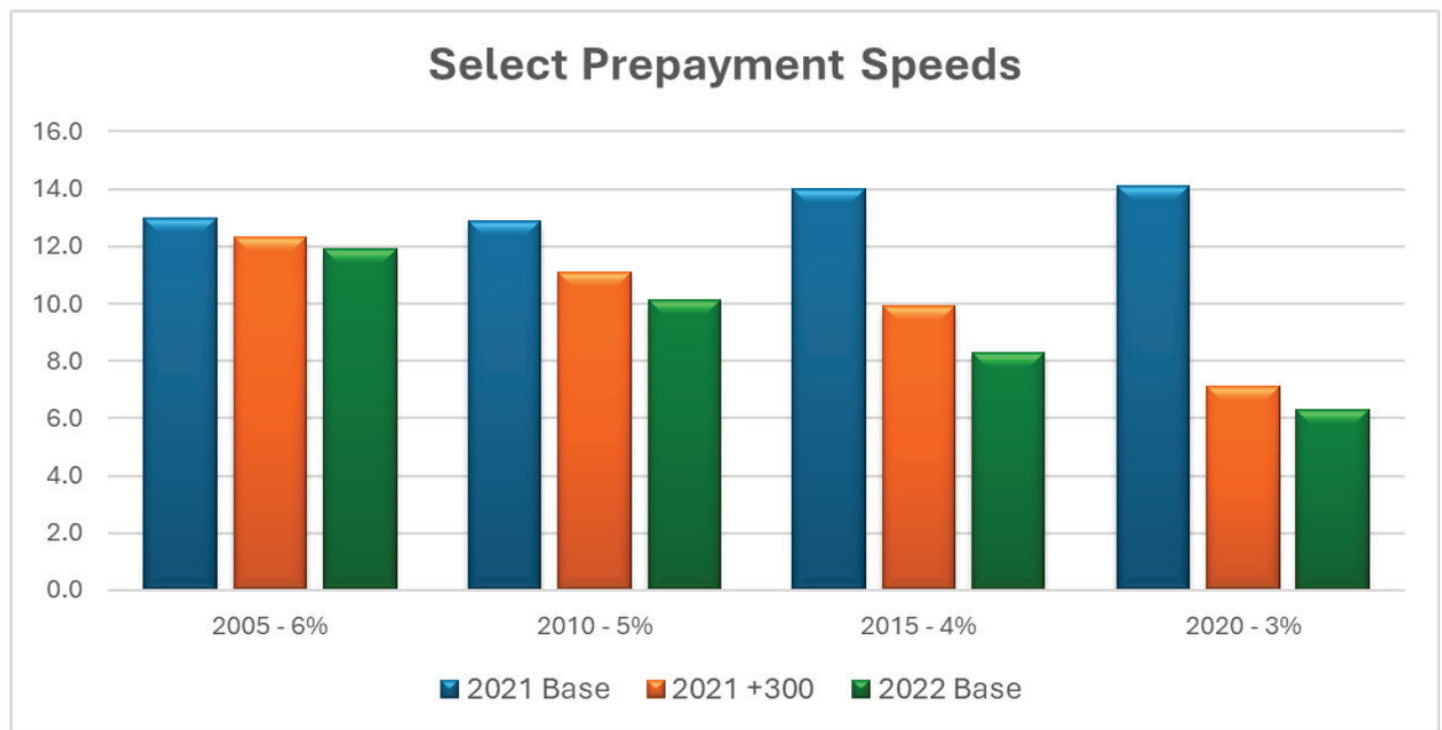
While prepayment rates and discount rates are both meaningful drivers in calculating NPVs across rate shock scenarios, prepayment rates have the most significant impact, especially when performing a backtesting exercise to gauge changes in prepayment speeds following a realized rate shock, versus expected prepayment speeds in a rate shock projection. Discount rates, in contrast, have a much more predictable impact, so this backtesting exercise will focus on the impact provided by changes in prepayment rates. The tables below show projected prepayment speeds, in CPR, on 30-year mortgages for September 30, 2021, base prepay and +300 bps, as well as September 30, 2022, base prepay, in an exercise to explain how slowdowns in prepayment speeds were more severe than the prepayment model suggested in 2021, leading to the larger than expected NPV volatility in our case study.

2021 Base Case Projection																				
30-Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
2.00																				
2.50																			12.8	11.6
3.00																			14.1	12.0
3.50											13.3	13.1		14.8	14.4			17.1	14.7	
4.00									13.7	13.3	13.0	13.6	13.9	14.0	14.5	15.5	18.1	16.5		
4.50								12.7	13.0	12.9		13.4	13.6		16.1	15.5		16.4	16.1	
5.00		13.3					13.2	12.6	12.9	12.9							16.5			
5.50		13.1	12.8	13.1			13.2	13.0												
6.00	13.4	12.9	12.7	13.0	13.0	13.2	13.3													
6.50		13.4	13.1	13.7	13.1	13.4	13.7													
7.00																				

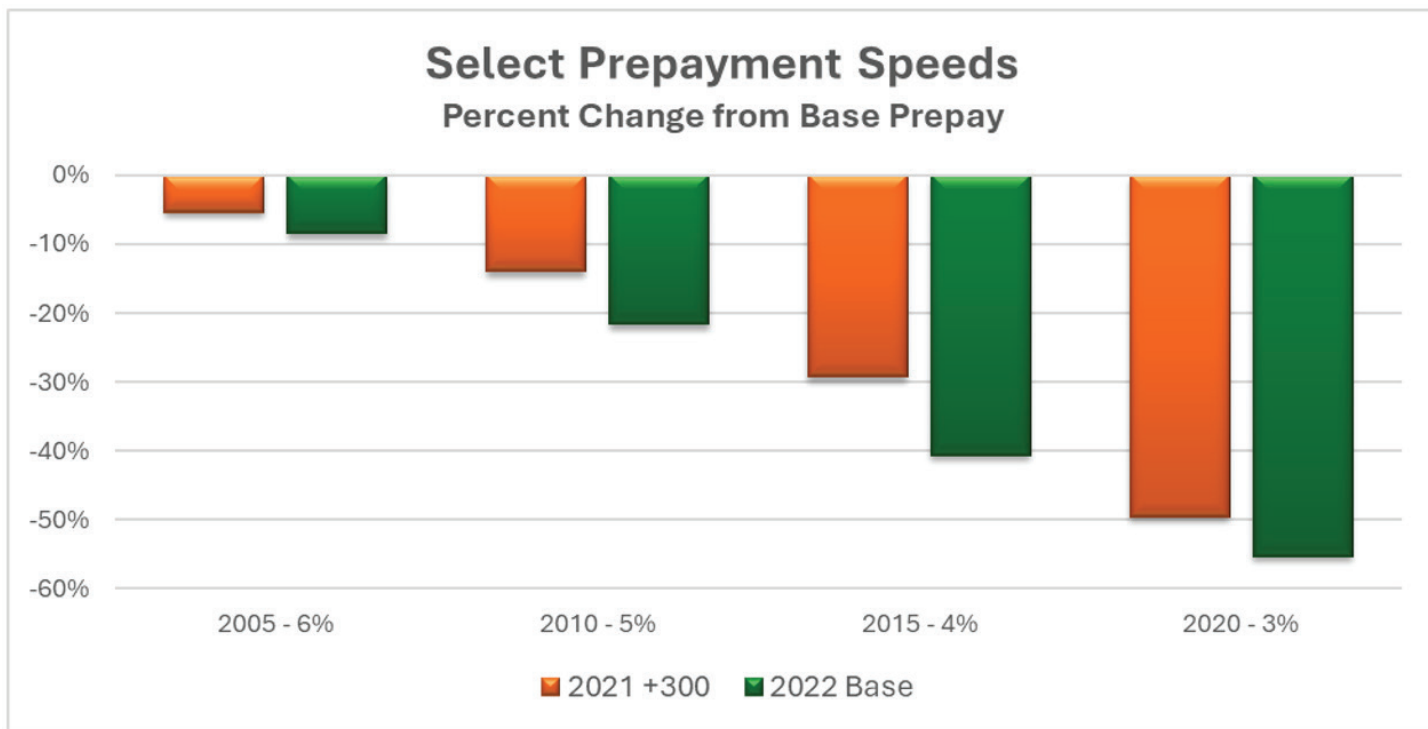
2021 +300 Projection																				
30-Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
2.00																				
2.50																			6.2	5.7
3.00																			7.1	6.3
3.50											8.8	8.7		8.3	8.3			8.5	8.2	
4.00									9.9	9.7	9.9	9.7	9.7	9.9	9.8	9.1	9.3	9.4		
4.50								10.6	10.5	10.4		11.1	11.2		12.2	11.1	10.7	11.1		
5.00		12.6					11.8	11.1	11.1	11.3							13.6			
5.50		12.5	12.1	12.2			12.0	12.1												
6.00	12.9	12.3	12.1	12.3	12.2	12.3	12.3													
6.50		12.9	12.5	13.0	12.4	12.7	13.0													
7.00																				

2022 Base Projection																				
30-Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
2.00																				
2.50																			5.7	5.5
3.00																			6.3	5.9
3.50											8.1	7.9		7.3	7.2			6.9	7.0	
4.00									9.0	8.8	8.7	8.4	8.3	8.3	8.1	7.5	7.2	7.3		
4.50								9.9	9.6	9.4		9.3	9.2		8.9	8.6	8.3	8.4		
5.00		12.7					11.2	10.4	10.1	10.0							9.9			
5.50		12.7	12.0	11.9			11.6	11.1												
6.00	13.2	12.4	11.9	11.9	12.0	12.0	11.8													
6.50		12.6	12.0	12.1	12.1	12.1	11.9													
7.00																				

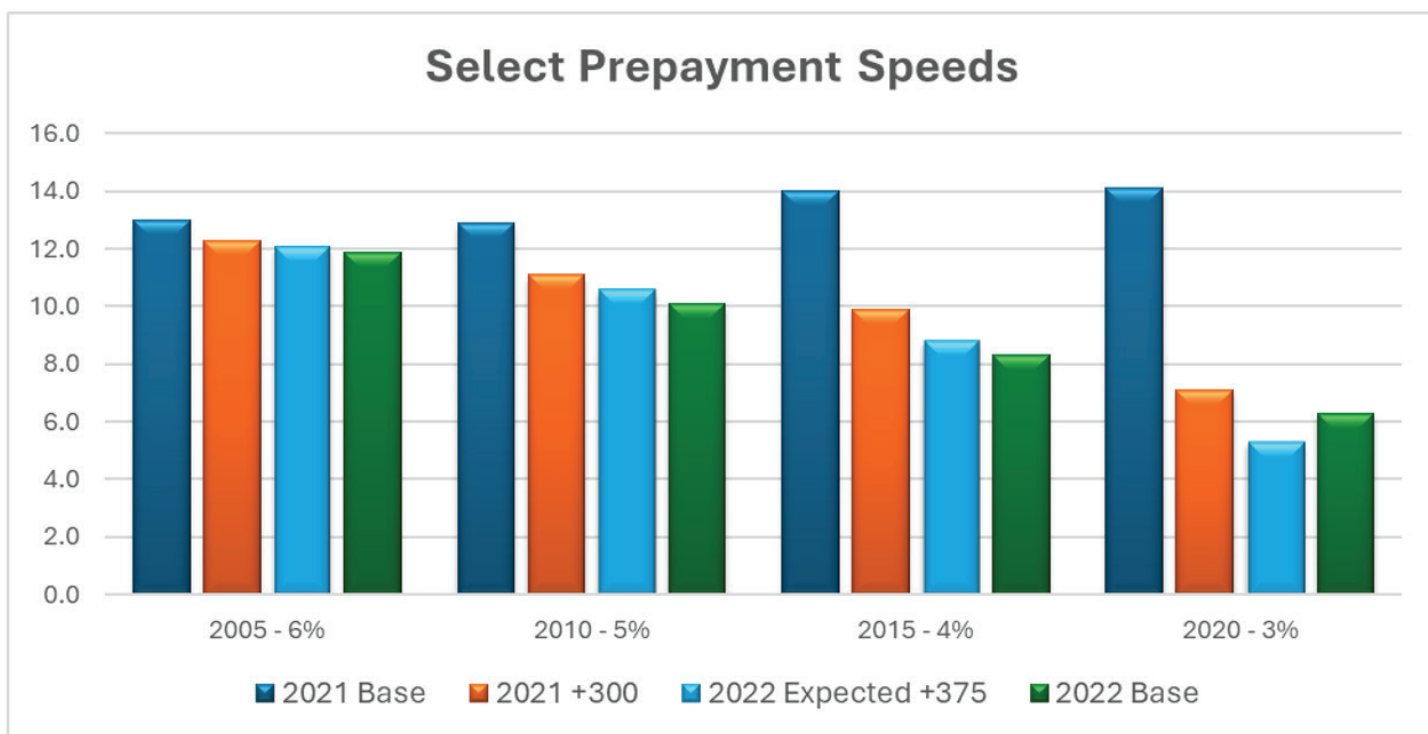
These tables show base prepayment speeds as of September 30, 2022, lower than the expected prepayment speeds in the September 30, 2021, +300 bps scenario, which is the expected outcome since market rates increased more than 300 bps. To dig deeper, the graph below shows the same four representative origination year and interest rate combinations as used in a prior example, and their corresponding projected prepayment rates under a base prepay and +300 bps scenario as of September 30, 2021, as well as a base prepay scenario as of September 30, 2022.



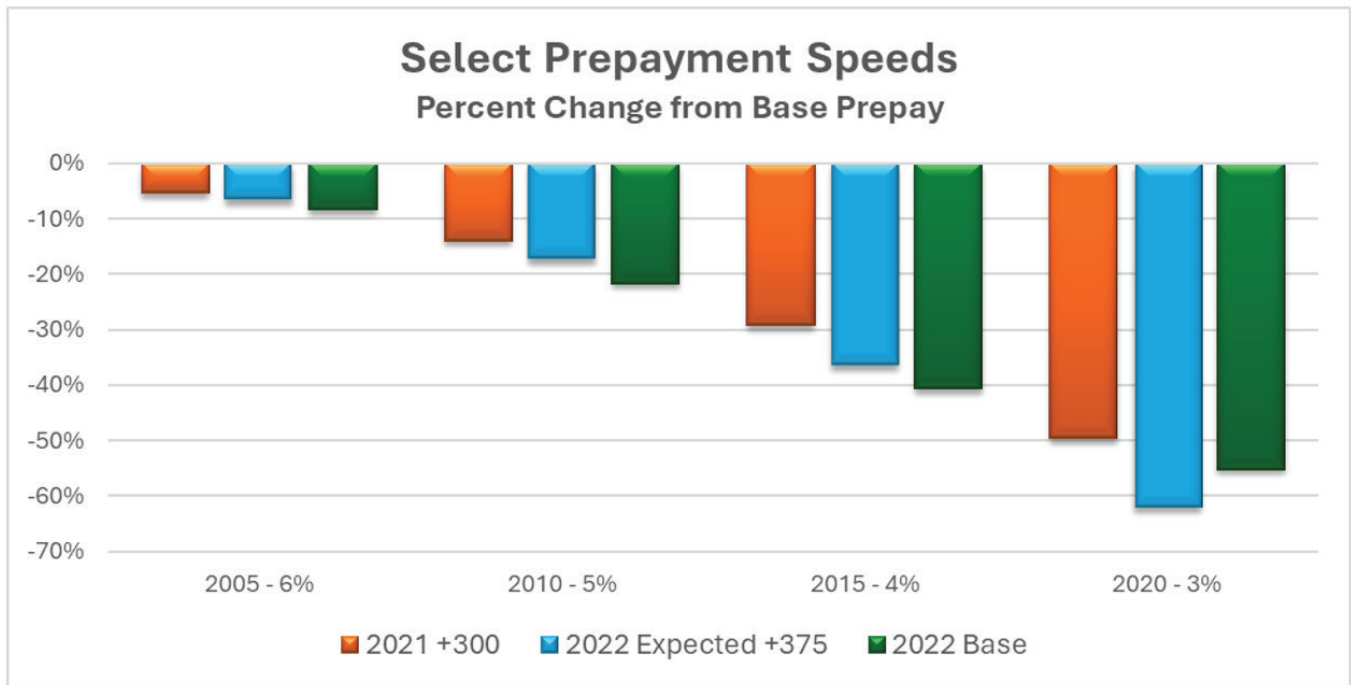
The differing degree of impact can further be clearly demonstrated by showing the shocked prepayment rate percentage change from the 2021 base prepayment rate in the graph below.



Since we now know that the expected basis point equivalent of shocked change experienced between September 30, 2021, and September 30, 2022, was 375 basis points, we can extrapolate starting prepayment curves to derive an expected prepayment rate from September 30, 2021, and compare against September 30, 2022, base prepay rates. The graph below provides this illustration.

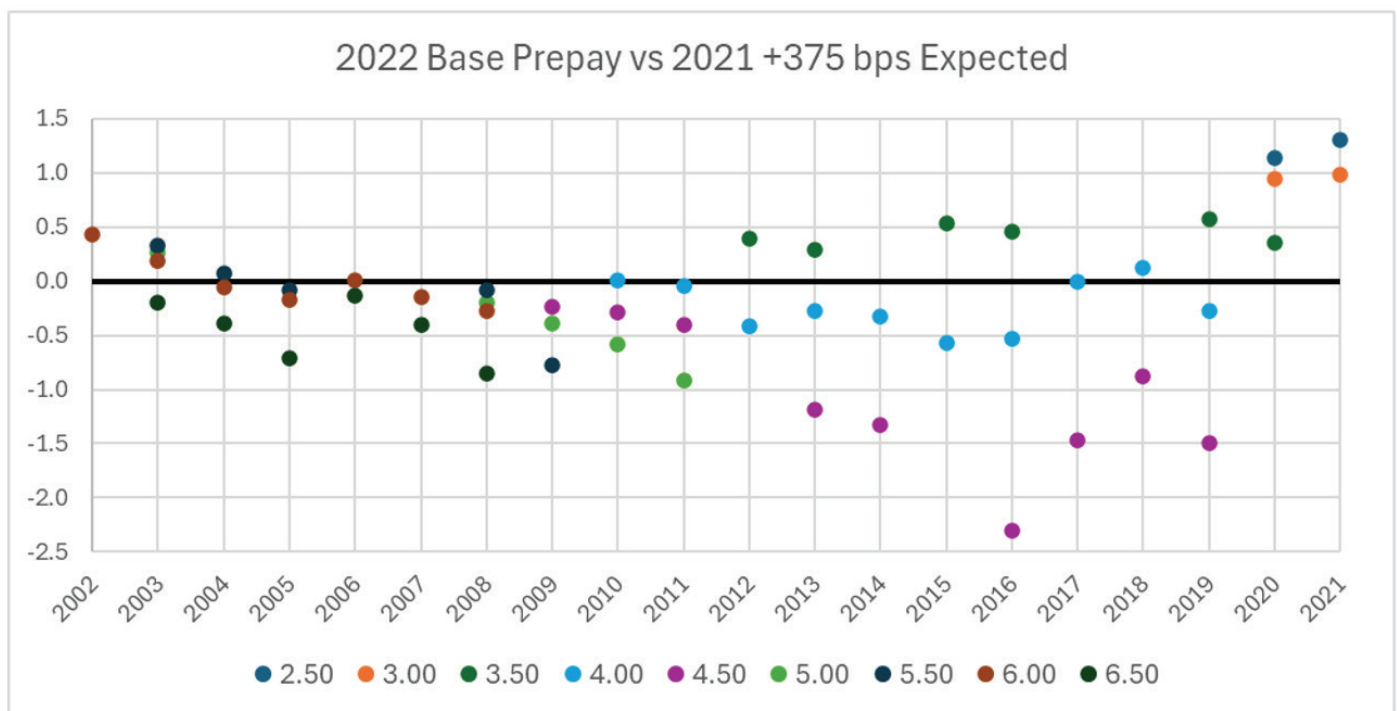


The differing degree of impact can also be demonstrated by showing the shocked prepayment rate percentage change from the 2021 base prepayment rate in the graph below.



These graphs clearly show that in three out of the four tested prepayment year and rate combinations, the 2022 base prepay rate experienced a more drastic reduction in speed than a 375 basis point shock would imply. Prepayment models are constantly being updated to account for changing market conditions, new economic environments, and shifts in consumer behavior. We can tell that after a year of seasoning in the prepayment models, they now anticipate fewer prepayments from mortgage holders than they were projecting while estimating changes in speeds during shock testing the prior year. This is the main driver that caused the 2022 base prepay NPV amounts to be higher than the anticipated 375 bps shock would project.

Further evidence can be seen when comparing the anticipated 375 bps shock prepay speeds against the actual 2022 prepay speeds. The chart below shows all 52 combinations of origination year and interest rate relevant for the case study real estate loans sold portfolio. A positive reading indicates that the 2022 base prepay speed, measured in CPR, was higher than the 2021 anticipated level in a +375 bps projected scenario, and a negative reading indicates that the 2022 base prepay speed was lower than the projected amount. Of the 52 speeds, 34 of them were lower than expected, whereas only 18 of them were higher than expected.



To conclude, NPV estimates calculated under the parameters of the New Rates, Same Portfolio case study exercise were 4% higher than expected because prepayment models recalibrated throughout the year and now, on average, predict slower prepayment speeds than anticipated the previous year. Slower prepayment speeds extend the duration of the real estate loans sold cashflows, and therefore, extend the life under which the credit union will receive payments for servicing, leading to higher NPV amounts.

2. New Rates, New Portfolio

Results from the September 30, 2022, MSR model performed on the case study real estate loans sold portfolio under the parameters of the New Rates, New Portfolio exercise are shown in the table below. These results are calculated using updated prepayment and discount rates as of September 30, 2022, as well as updated loan characteristics including payments made, both scheduled and prepayments, throughout the year. It also includes new loans originated during the time period to replace payments made to bring the overall portfolio outstanding balance back to level with the previous year's amount.

09/30/22	+300 bps	+200 bps	+100 bps	Base Prepay	-100 bps	-200 bps	-300 bps	Zero Prepay
Scheduled Payment	\$44,096,674	\$43,889,083	\$43,516,096	\$42,803,104	\$41,510,172	\$39,672,815	\$37,361,148	\$59,796,605
Prepayment	\$15,699,931	\$15,907,522	\$16,280,509	\$16,993,501	\$18,286,433	\$20,123,790	\$22,435,457	\$0
Total Principal Payment	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605
Weighted Average Life	6.12	6.06	5.93	5.69	5.24	4.56	3.71	11.64
Servicing Fee - Gross	\$903,161	\$893,736	\$874,733	\$837,549	\$770,786	\$669,685	\$542,507	\$1,728,199
Servicing Fee - NPV	\$637,088	\$656,648	\$671,473	\$674,284	\$653,058	\$597,993	\$508,350	\$1,181,092

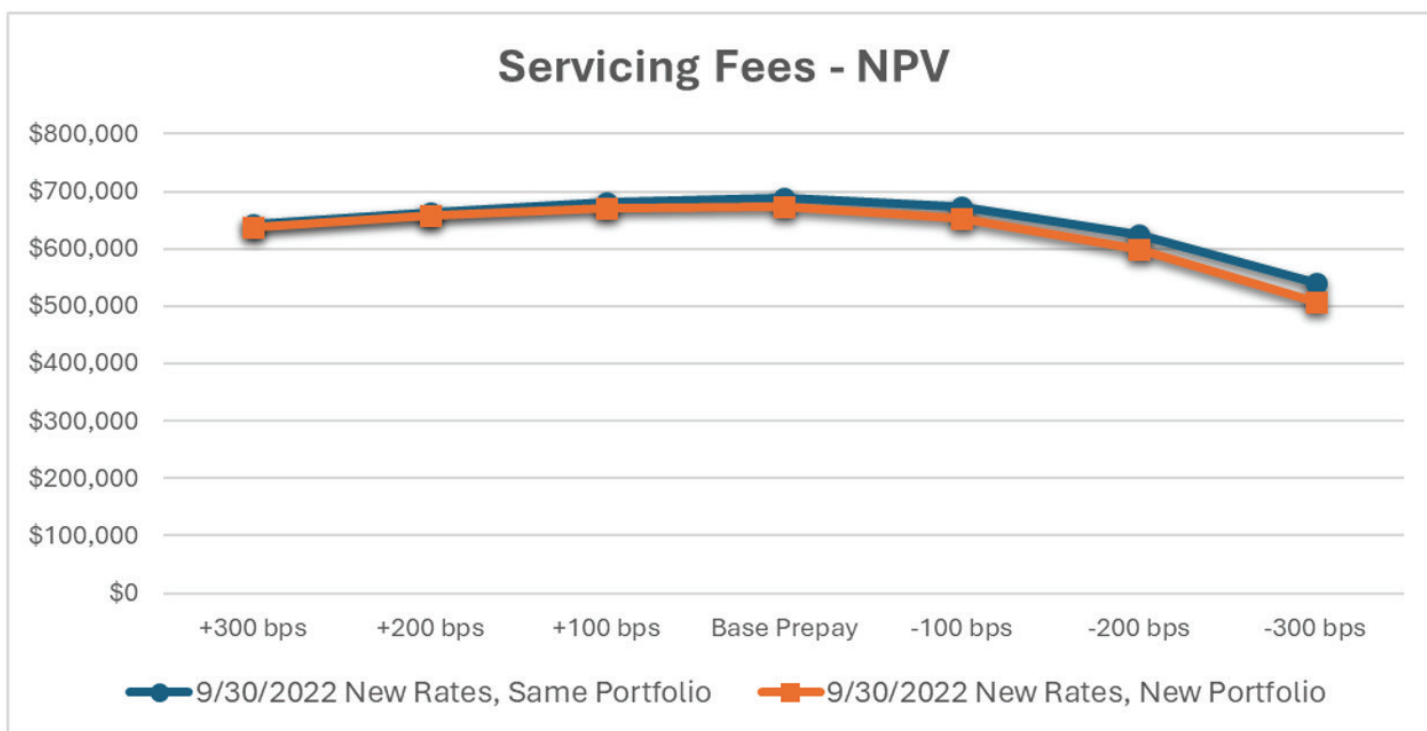
For reference, below are the results from the New Rates, Same Portfolio exercise.

09/30/22	+300 bps	+200 bps	+100 bps	Base Prepay	-100 bps	-200 bps	-300 bps	Zero Prepay
Scheduled Payment	\$40,064,952	\$39,808,470	\$39,352,253	\$38,494,404	\$36,980,527	\$34,894,159	\$32,308,440	\$59,796,605
Prepayment	\$19,731,654	\$19,988,135	\$20,444,352	\$21,302,201	\$22,816,078	\$24,902,446	\$27,488,165	\$0
Total Principal Payment	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605
Weighted Average Life	6.17	6.11	6.01	5.81	5.42	4.78	3.94	12.19
Servicing Fee - Gross	\$909,598	\$901,495	\$886,501	\$856,527	\$797,892	\$702,626	\$576,819	\$1,809,627
Servicing Fee - NPV	\$643,361	\$663,794	\$680,962	\$688,495	\$673,971	\$625,590	\$539,446	\$1,230,481

Between September 30, 2021, and September 30, 2022, the case study real estate loans sold portfolio saw \$8.01 million in principal paydown, including scheduled payments and prepayments. The entirety of paid-down balances were replaced with new loans originated and sold under prevailing mortgage rates at time of origination.

The effectiveness of the MSR model was tested and verified under the New Rates, Same Portfolio case study using a backtesting exercise. Since the New Rates, New Portfolio exercise contains newly originated loans not present in the 2021 portfolio, a similarly detailed exercise will not be conducted. However, comparing the results of the two simulations can show how the newly originated loans differ in expected prepay and NPVs versus the loans that paid off or paid down. The comparison also reinforces the effectiveness of the model as the New Rates, New Portfolio results are largely in-line with those seen in the New Rates, Same Portfolio exercise. Shown below is a comparison of NPV results for the two distinct comparison exercises performed during the second valuation period.

NPV	+300 bps	+200 bps	+100 bps	Base Prepay	-100 bps	-200 bps	-300 bps	Zero Prepay
9/30/2022 New Rates, Same Portfolio	\$643,361	\$663,794	\$680,962	\$688,495	\$673,971	\$625,590	\$539,446	\$1,230,481
9/30/2022 New Rates, New Portfolio	\$637,088	\$656,648	\$671,473	\$674,284	\$653,058	\$597,993	\$508,350	\$1,181,092
Difference (%)	-0.98%	-1.08%	-1.39%	-2.06%	-3.10%	-4.41%	-5.76%	-4.01%



Results from the New Rates, New Portfolio model show a Base Prepay NPV servicing amount of \$674,284, with that amount decreasing as interest rates both rise and fall. The impact of updating the portfolio with actual payments and newly originated loans has a more severe impact on expected NPV amounts in rates-down simulations than in rates-up. There are two main factors impacting the NPV of servicing income: prepayment projections and discount rates.

- Impact of Prepayment Rates:** As indicated earlier, September 2022 was a period amid rising rates. Mortgage rates were near historic lows for a long time during 2019, 2020, and 2021 before sustaining rapid increases. Mortgage holders with loans originated prior to 2019 had ample time and opportunity to refinance to a lower rate. The ones that did not, for a variety of reasons, now lost that opportunity and are now viewed within prepay models as unlikely to do so at a future date, regardless of their financial incentive. As a result, prepayment speeds for loans originated before 2019 show minimal volatility during rate shock scenarios as behavior by mortgage holders has proved to be largely unaffected by changing market rates.

Additionally, loans originated during 2019, 2020, and 2021 have low interest rates, well below new market levels, and therefore, are unlikely to refinance in the near-term as well. Loans issued during the new modeling period between September 30, 2021, and September 30, 2022, have interest rates ranging from 3.50% up to over 6.00%, showcasing the rise in market rates during the period. These new loans, especially those with a higher coupon, are more susceptible to prepayment risk in decreasing rate environments, which is why the New Rates, New Portfolio shows a greater degree of volatility as interest rates decrease than in the backtesting exercise conducted in the New Rates, Same Portfolio exercise. The new base prepay, +300 bps, and -300 bps tables for 30-year mortgages within the case study loans sold portfolio can be seen below.

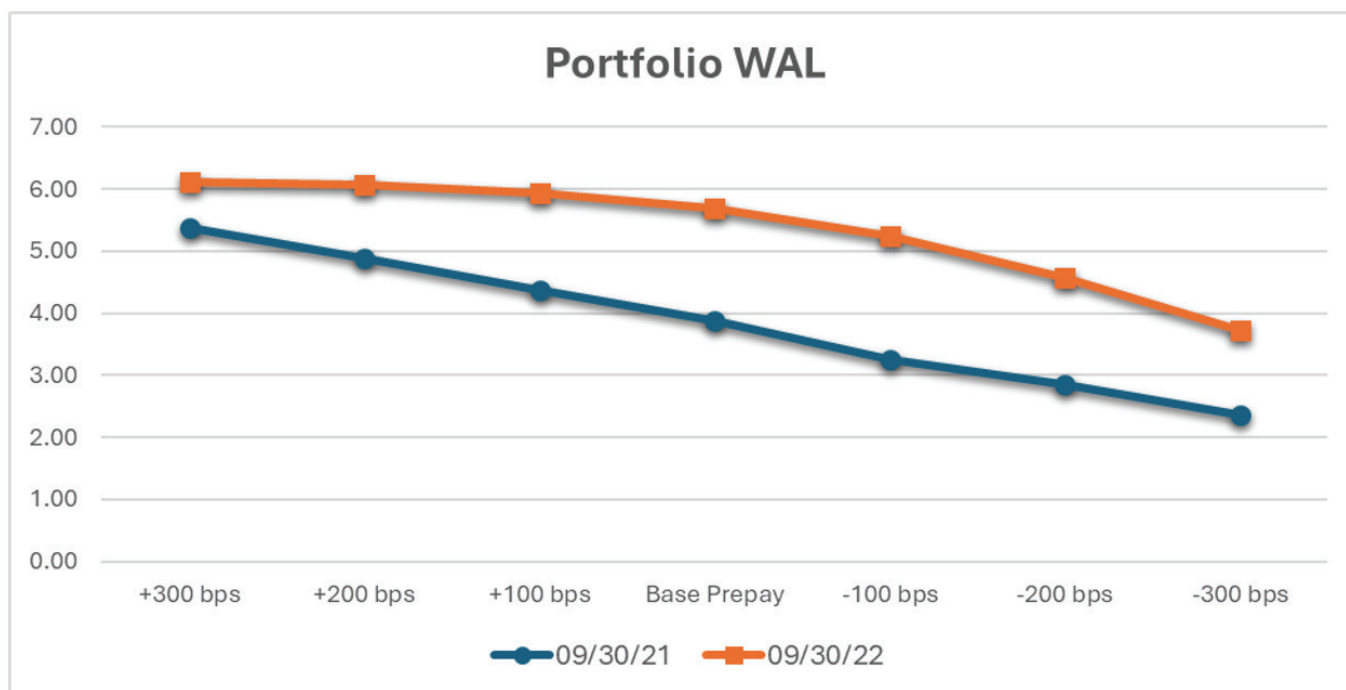
Base Case																					
30-Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
2.00																					
2.50																			5.7	5.5	
3.00																			6.3	5.9	
3.50											8.1	7.9		7.3	7.2			6.9	7.0		5.5
4.00									9.0	8.8	8.7	8.4	8.3	8.3	8.1	7.5	7.2	7.3			5.9
4.50								9.9	9.6	9.4		9.3	9.2		8.9	8.6	8.3	8.4			6.7
5.00		12.7					11.2	10.4	10.1	10.0							9.9				8.1
5.50		12.7	12.0	11.9			11.6	11.1													10.0
6.00	13.2	12.4	11.9	11.9	12.0	12.0	11.8														12.4
6.50		12.6	12.0	12.1	12.1	12.1	11.9														
7.00																					

+300																					
30-Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
2.00																					
2.50																			5.5	5.3	
3.00																			5.9	5.6	
3.50											7.3	7.1		6.6	6.6			6.2	6.3		5.0
4.00									7.9	7.7	7.6	7.3	7.2	7.2	7.0	6.6	6.2	6.3			5.0
4.50								8.5	8.1	7.9		7.7	7.6		7.4	7.1	6.8	6.8			5.0
5.00		11.4					9.3	8.6	8.3	8.1							7.5				5.2
5.50		11.4	10.7	10.4			9.5	9.0													5.4
6.00	12.0	11.2	10.6	10.5	10.4	10.1	9.8														5.8
6.50		11.4	10.8	10.7	10.6	10.4	10.1														
7.00																					

-300																					
30-Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
2.00																					
2.50																			10.2	9.5	
3.00																			12.8	11.3	
3.50											12.9	13.0		14.0	13.5			17.5	14.2		18.9
4.00									14.7	14.4	13.7	15.1	15.3	14.7	14.7	16.4	18.2	17.3			32.2
4.50								14.5	14.4	14.2		14.6	14.6		15.0	15.9	17.9	17.2			35.6
5.00		14.4					14.3	14.0	14.1	14.0							16.8				33.6
5.50		14.2	13.7	13.9			14.0	13.2													34.6
6.00	14.5	13.6	13.2	13.5	13.6	13.8	13.7														36.4
6.50		13.7	13.2	13.5	13.5	13.6	13.4														
7.00																					

- **Impact of Discount Rates:** The new yield curve as of September 30, 2022, is elevated and flatter compared to September 30, 2021. Under a traditional upward sloping yield curve, cash flows farther out have a larger discount rate than near-term cash flows. However, with a flatter curve, that disparity is muted. Additionally, with nearly all points on the curve up several hundred basis points, the absolute value of discount rates has a more drastic impact when discounting the cash flows from a gross to net value than the prior year.

The loans sold portfolio is now stuck in a position where NPVs are expected to decrease, no matter the movement in interest rates. As rates increase, cash flows extend and the WAL of the portfolio increases to 6.12 years in a +300 bps scenario from 5.69 years in a base prepay scenario, a gain of 0.43 years. However, as of September 30, 2021, the WAL of the portfolio was projected to increase to 5.39 years in a +300 bps scenario from 3.88 years in a base prepay scenario, a gain of 1.51 years. The extension risk decreased from 1.51 years to 0.43 years on a year-over-year basis in a +300 bps shock scenario. The projected WAL curves between September 30, 2021, and September 30, 2022, can be seen below.



Simply put, cash flow extension already occurred as rates increased between the testing periods in 2021 and 2022, and any additional increases in rates have minimal further impact. Therefore, in the battle between cash flow extension from prepayment slowdown and an increase in discounting rates, the discounting rates have a larger impact in rising rate environments, leading to lower forecasted NPVs as interest rates rise. This is the opposite impact as seen during the September 30, 2021, period, and highlights the importance of understanding the model inputs as it relates to the current rate environment.

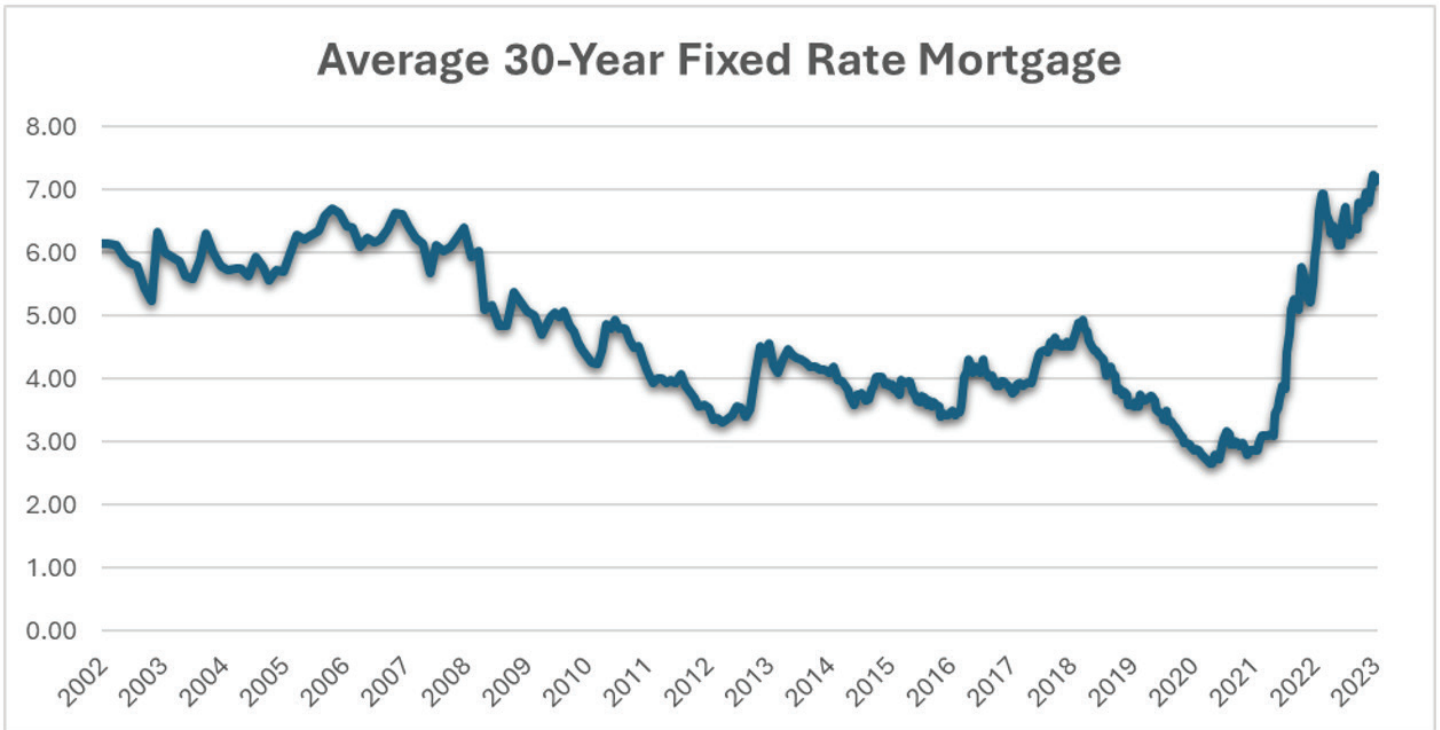
In a rates down scenario, NPVs are still forecasted to decrease, same as the prior year, but not as significantly. Legacy loan holders from before 2019 are less likely to change their payment behavior as rates decrease if they did not take advantage of the 2019-2021 low-rate environment and refinance. New loans issued in 2022 with a higher coupon are likely to prepay or refinance if rates drop significantly, leading to volatility not seen in newly issued loans since before 2019. The shortening of cash flows caused by those elevated levels of prepayments in rates down scenarios has a larger impact than the reduction in discount rates, leading to declining NPVs as interest rates decline.

In summary, severe changes in interest rates between the testing period of September 30, 2021, and September 30, 2022, had major impacts on the projected NPVs of our case study real estate loans sold portfolio. The new baseline in a base prepay environment is significantly higher than one year prior. However, NPVs are projected to decline in both rates up and rates down scenarios for reasons described within this section. The entire portfolio extended as evidenced by a new, longer base WAL, and new additions to the portfolio reflect underlying prepayment risks of higher coupon mortgages. For the purposes of continuing this case study, this is the new baseline as we look towards the next valuation period.

(c) Third Valuation - September 30, 2022

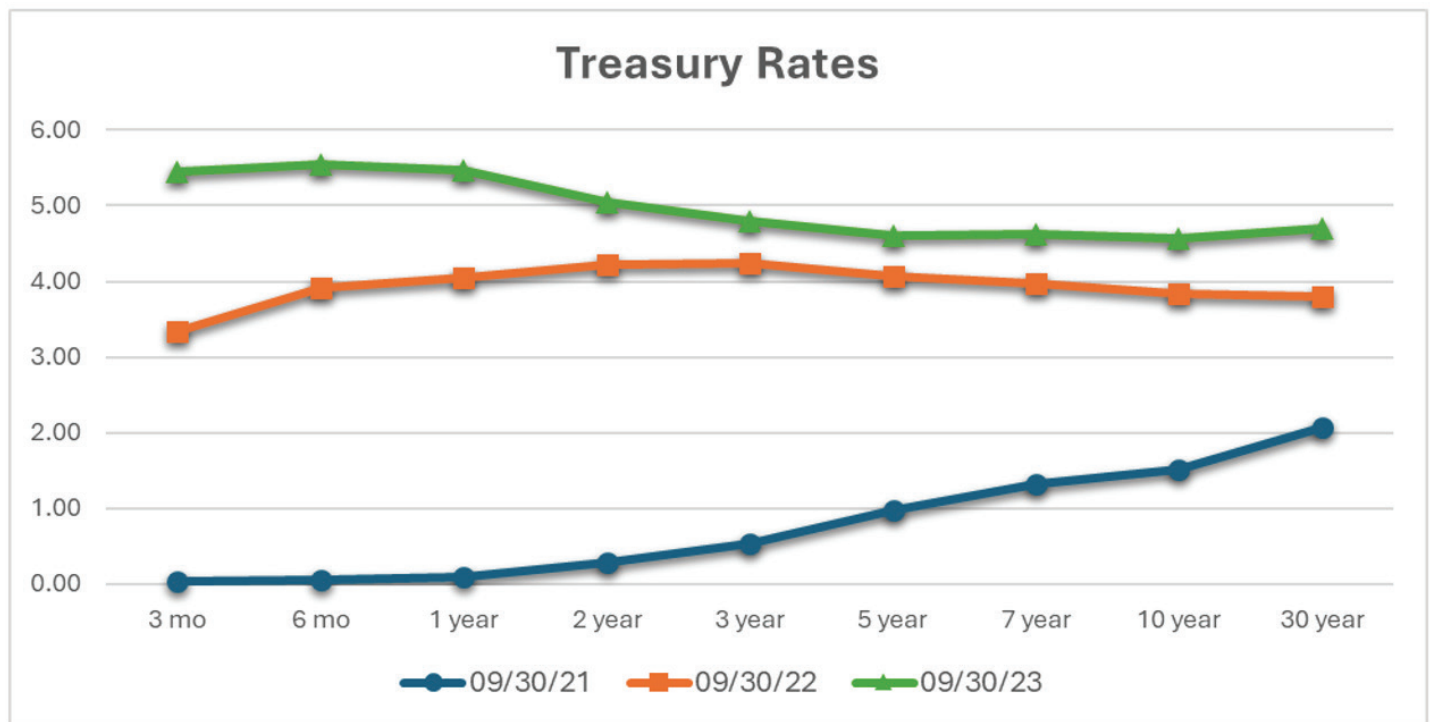
(i) Background

The third servicing rights valuation date for the case study occurs one year later on September 30, 2023, using the updated portfolio of real estate loans sold as of September 30, 2022, as a starting point. Between September 2022 and September 2023, The Federal Reserve continued increasing the Fed Funds rate in an ongoing attempt to bring down increasing inflation measures. On September 30, 2023, the target Fed Funds range was 5.25% to 5.50%, or 225 basis points higher than one year prior. 30-year mortgage rates at the end of the period were 7.19%, or 90 basis points more than mortgage rates at period end one year prior. However, the average mortgage rate between September 30, 2022, and September 30, 2023, was 221 basis points higher than the average for the period of September 30, 2021, and September 30, 2022, capturing the effects of rapidly rising rates. Average mortgage rates encompassing the period of loans sold for our case study can be seen below, highlighting the continuing rise between 2022 and 2023.



Source: Freddie Mac, 30-Year Fixed Rate Mortgage Average in the United States [MORTGAGE30US], retrieved from FRED, Federal Reserve Bank of St. Louis

The Treasury curve to be used for discounting cash flows from servicing fees on the sold loans portfolio is depicted below, along with the one-year ago and two-year ago curves, for reference. The curve is more elevated on the short end, with the 3-year point up 212 basis points year-over-year, and is also more drastically inverted, with a 1-year rate of 5.46% and a 5-year rate of 4.61%.



Source: U.S. Department of the Treasury, Daily Treasury Par Yield Curve Rates as of September 30, 2021, September 30, 2022, and September 30, 2023

(ii) Results

Once again, results from the third valuation date will be shown two different ways to illustrate separate and important points:

- 1. New Rates, Same Portfolio:** Using the prevailing prepayment projections and discount rates as of September 30, 2023, but on the exact same loan portfolio, including outstanding balances, as of the updated loans sold portfolio for the period ending September 30, 2022. This is a backtesting exercise to show how accurate the model predicted NPVs to change as market rates change.
- 2. New Rates, New Portfolio:** Using the prevailing prepayment projections and discount rates as of September 30, 2023, as well as updated loan characteristics including payments made, both scheduled and prepayments, throughout the year. It also includes new loans originated during the timeframe to replace payments made to bring the overall portfolio outstanding balance back to level with the previous year's amount. This will show the effectiveness of the MSR model as well as help to understand the NPV impacts on payment and origination activity throughout the year.

1. New Rates, Same Portfolio

Results from the September 30, 2023, MSR model performed on the case study real estate loans sold portfolio under the parameters of the New Rates, Same Portfolio exercise are shown in the table below. These results are shown using updated prepayment and discount rates but on balances from the second valuation date to show an apples-to-apples comparison and back test the shocked NPV projections from the second valuation date.

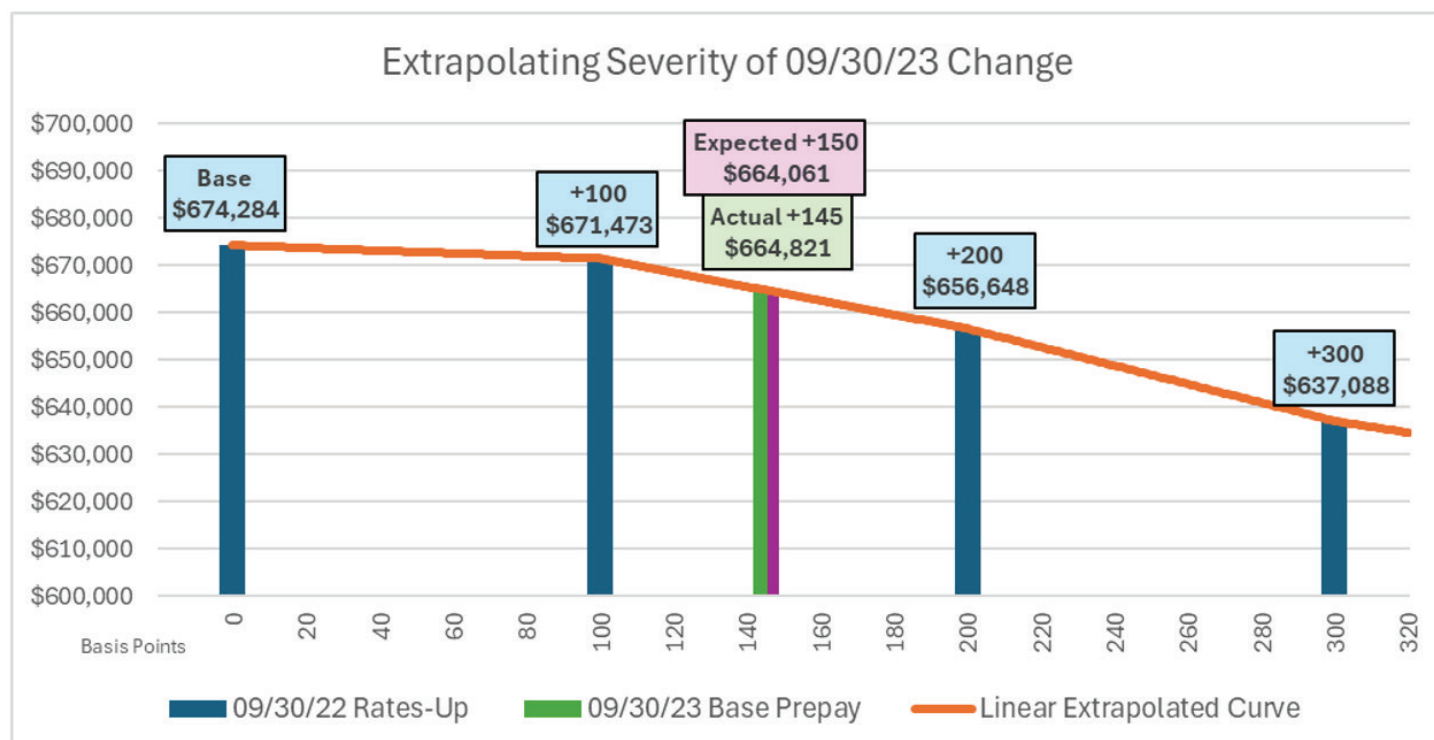
09/30/23	+300 bps	+200 bps	+100 bps	Base Prepay	-100 bps	-200 bps	-300 bps	Zero Prepay
Scheduled Payment	\$37,100,955	\$36,662,977	\$35,998,046	\$34,981,870	\$33,417,962	\$31,199,778	\$27,948,730	\$59,796,605
Prepayment	\$22,695,649	\$23,133,628	\$23,798,559	\$24,814,735	\$26,378,642	\$28,596,827	\$31,847,875	\$0
Total Principal Payment	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605
Weighted Average Life	6.27	6.16	6.01	5.77	5.41	4.91	4.20	11.30
Servicing Fee - Gross	\$924,198	\$908,736	\$885,512	\$850,552	\$797,039	\$722,169	\$615,688	\$1,677,100
Servicing Fee - NPV	\$629,723	\$646,604	\$659,558	\$664,821	\$655,520	\$625,149	\$560,350	\$1,099,609

For reference, below are the results from the second valuation date of the updated portfolio on September 30, 2022.

09/30/22	+300 bps	+200 bps	+100 bps	Base Prepay	-100 bps	-200 bps	-300 bps	Zero Prepay
Scheduled Payment	\$44,096,674	\$43,889,083	\$43,516,096	\$42,803,104	\$41,510,172	\$39,672,815	\$37,361,148	\$59,796,605
Prepayment	\$15,699,931	\$15,907,522	\$16,280,509	\$16,993,501	\$18,286,433	\$20,123,790	\$22,435,457	\$0
Total Principal Payment	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605
Weighted Average Life	6.12	6.06	5.93	5.69	5.24	4.56	3.71	11.64
Servicing Fee - Gross	\$903,161	\$893,736	\$874,733	\$837,549	\$770,786	\$669,685	\$542,507	\$1,728,199
Servicing Fee - NPV	\$637,088	\$656,648	\$671,473	\$674,284	\$653,058	\$597,993	\$508,350	\$1,181,092

So, as of September 30, 2022, the NPV was \$674,284 and expected to decrease to \$671,473 in a rates +100 bps shock scenario and to \$656,648 in a rates +200 bps shock scenario. During the 12-months between valuation dates, the Fed Funds rate increased by 225 basis points. Average mortgage rates during the periods in comparison increased by 221 basis points and by 90 basis points when just comparing period-end levels, and the treasury curve increased by 212 basis points on the short end as measured by the 3-month point and by 55 basis points in the belly of the curve as measured by the 5-year point. Under the New Rates, Same Portfolio case study, the updated base prepay NPV was \$664,821, firmly in the middle of the +100 bps and +200 bps projected levels from the prior year, reinforcing the accuracy of the MSR model.

A simple extrapolation exercise can help understand the basis point shock equivalent of the September 30, 2023, results relative to the September 30, 2022, projected levels.



To summarize the above chart, as of September 30, 2022, the MSR model projected a NPV of \$671,473 in a +100 shock scenario and \$656,648 in a +200 shock scenario, both decreases from the projected base prepay NPV level. Actual market movements across relevant mortgage and Treasury markets increased anywhere from 55 to 221 basis points during the year-ended September 30, 2023. There are multiple curves and reference rates factored into the model with an average weighted change of roughly 150 basis points, which will be used as a proxy for an interest rate shock to calculate an expected NPV amount. This extrapolates to an expected new base prepay amount of \$664,061 as of September 30, 2023. The actual new base amount as of September 30, 2023, was \$664,821, which corresponds to the equivalent of a 145 basis point increase, well within any reasonable margin of error when compared to the expected amount. Subsequently, it can be concluded that the model was extremely accurate in predicting both the direction and magnitude of NPV changes resulting from market movements between the valuation periods.

As noted earlier, prepayment rates and discount rates are both meaningful drivers in calculating NPVs across rate shock scenarios. Further, they represent competing forces driving the directional volatility in NPVs during stress testing exercises. Between 2021 and 2022, our case study proved that as interest rates increased dramatically, slowdowns in prepayment speeds were the dominant force and overpowered the downward pressure caused by higher discount rates, leading to increases in NPVs as interest rates rose. However, between 2022 and 2023, even though interest rates rose even further, the incremental slowdowns in prepayment speeds were not enough to overcome the impacts of rising discount rates, and NPVs are shown to trend down slightly as rates rise.

To understand this further, the case study will next explore the projected versus actual slowdowns in prepayment speeds to highlight the relatively minimal impacts, as compared to the more severe impacts witnessed the prior year. The tables below show projected prepayment speeds, in CPR, on 30-year mortgages for September 30, 2022, base prepay, +100 bps, and +200 bps, as well as September 30, 2023, base prepay, in an exercise to explain the impact on NPVs caused by slowdowns in prepayment speeds.

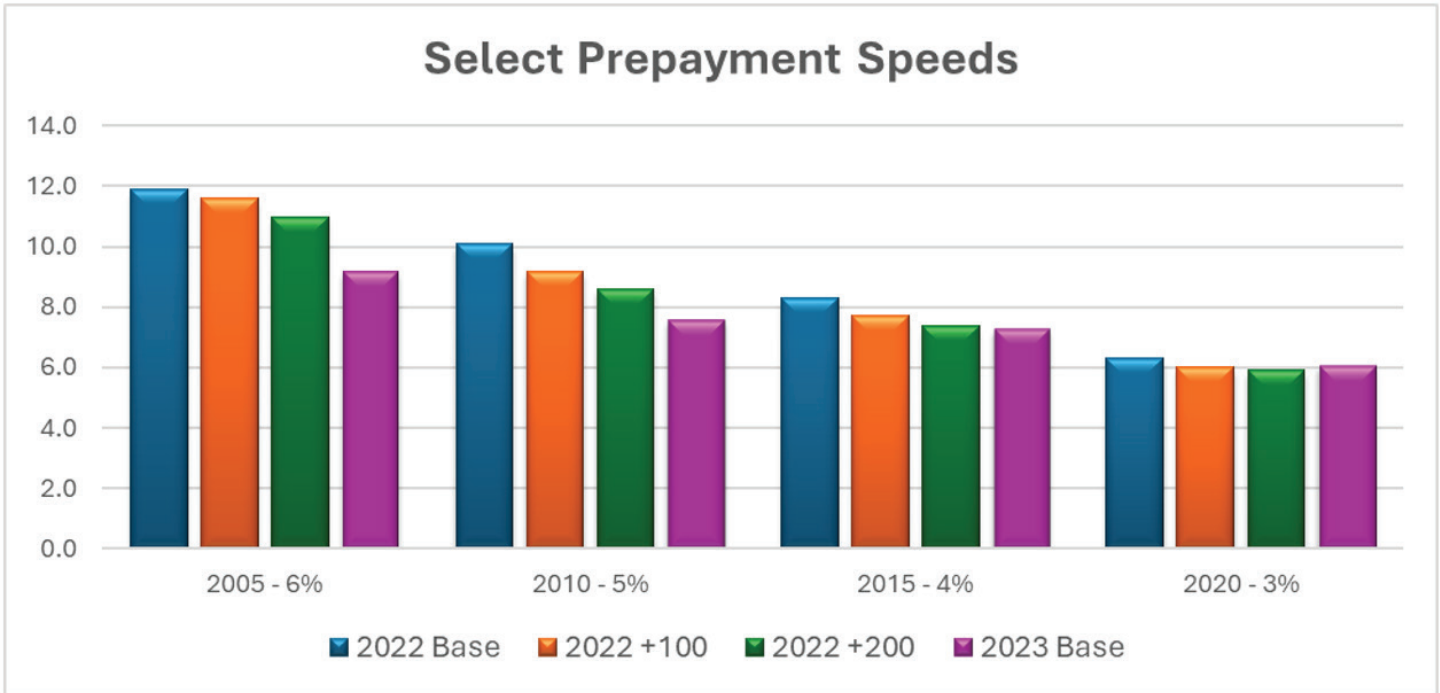
2022 Base Case Projection																					
30-Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
2.00																					
2.50																			5.7	5.5	
3.00																			6.3	5.9	
3.50											8.1	7.9		7.3	7.2			6.9	7.0		5.5
4.00									9.0	8.8	8.7	8.4	8.3	8.3	8.1	7.5	7.2	7.3			5.9
4.50								9.9	9.6	9.4		9.3	9.2		8.9	8.6	8.3	8.4			6.7
5.00		12.7					11.2	10.4	10.1	10.0							9.9				8.1
5.50		12.7	12.0	11.9			11.6	11.1													10.0
6.00	13.2	12.4	11.9	11.9	12.0	12.0	11.8														12.4
6.50		12.6	12.0	12.1	12.1	12.1	11.9														
7.00																					

2022 +100 Projection																					
30-Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
2.00																					
2.50																			5.6	5.4	
3.00																			6.0	5.7	
3.50											7.7	7.4		6.9	6.9			6.4	6.6		5.2
4.00									8.4	8.2	8.2	7.8	7.7	7.7	7.5	6.9	6.6	6.7			5.3
4.50								9.2	8.8	8.6		8.4	8.4		8.0	7.7	7.4	7.4			5.6
5.00		12.2					10.3	9.5	9.2	9.0							8.5				6.1
5.50		12.3	11.6	11.5			10.8	10.2													7.0
6.00	12.9	12.1	11.6	11.6	11.6	11.5	11.2														8.6
6.50		12.2	11.6	11.7	11.8	11.7	11.5														
7.00																					

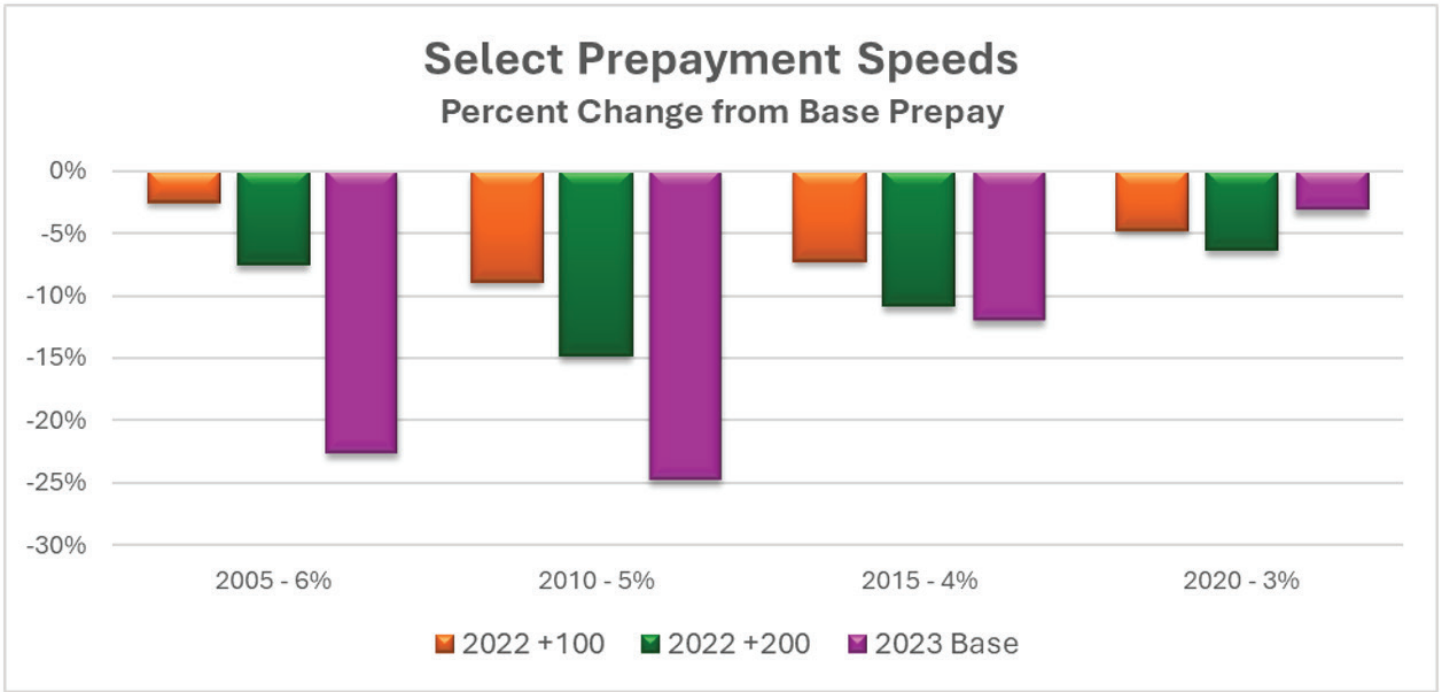
2022 +200 Projection																					
30-Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
2.00																					
2.50																			5.5	5.3	
3.00																			5.9	5.6	
3.50											7.4	7.2		6.7	6.7			6.2	6.4		5.1
4.00									8.1	7.9	7.8	7.5	7.4	7.4	7.2	6.7	6.3	6.4			5.1
4.50								8.7	8.4	8.2		8.0	7.9		7.6	7.3	7.0	7.0			5.2
5.00		11.8					9.7	9.0	8.6	8.4							7.8				5.4
5.50		11.8	11.1	10.9			10.0	9.4													5.9
6.00	12.5	11.6	11.1	11.0	11.0	10.7	10.4														6.6
6.50		12.0	11.3	11.3	11.3	11.1	10.8														
7.00																					

2023 Base Case Projection																					
30-Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
2.00																					
2.50																			5.3	5.0	
3.00																			6.1	5.8	
3.50											6.8	6.8		6.7	6.7			6.7	6.8		5.4
4.00									7.2	7.1	7.2	7.2	7.2	7.3	7.3	7.0	6.9	7.2			5.9
4.50								7.8	7.5	7.4		7.6	7.6		7.8	7.7	7.7	7.8			6.6
5.00		10.4					8.4	8.0	7.6	7.5							8.7				7.4
5.50		10.3	9.6	9.3			8.6	8.1													8.4
6.00	10.7	9.9	9.4	9.2	9.1	8.9	8.8														10.1
6.50		9.9	9.4	9.3	9.2	9.0	8.9														
7.00																					

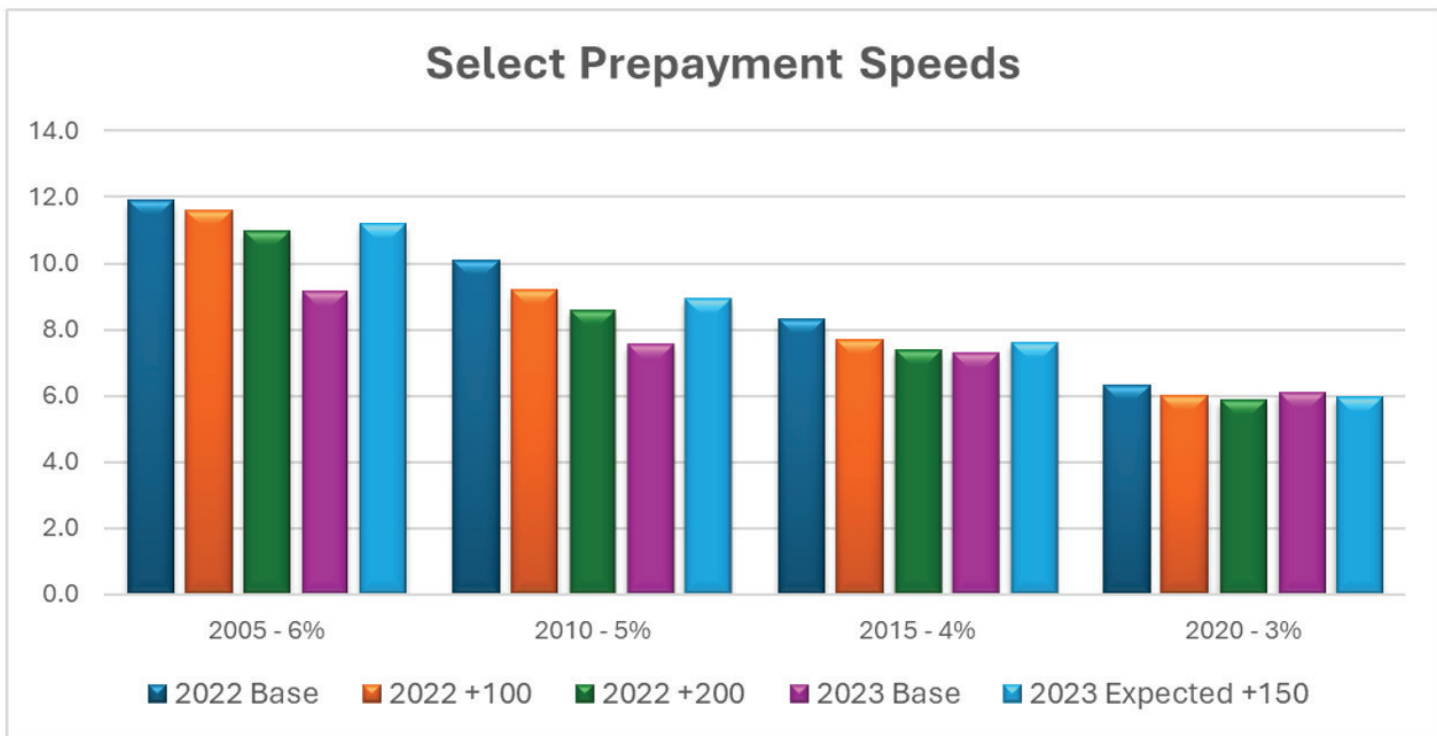
These tables show base prepayment speeds as of September 30, 2023, predominately lower than base prepayment speeds as of September 30, 2022, which is the expected outcome since market rates increased during the period leading to a slowdown in prepayments. To dig deeper, the graph below shows the same four representative origination year and interest rate combinations as used in prior examples, and their corresponding projected prepayment rates under a base prepay, +100 bps, and +200 bps scenario as of September 30, 2022, as well as a base prepay scenario as of September 30, 2023.



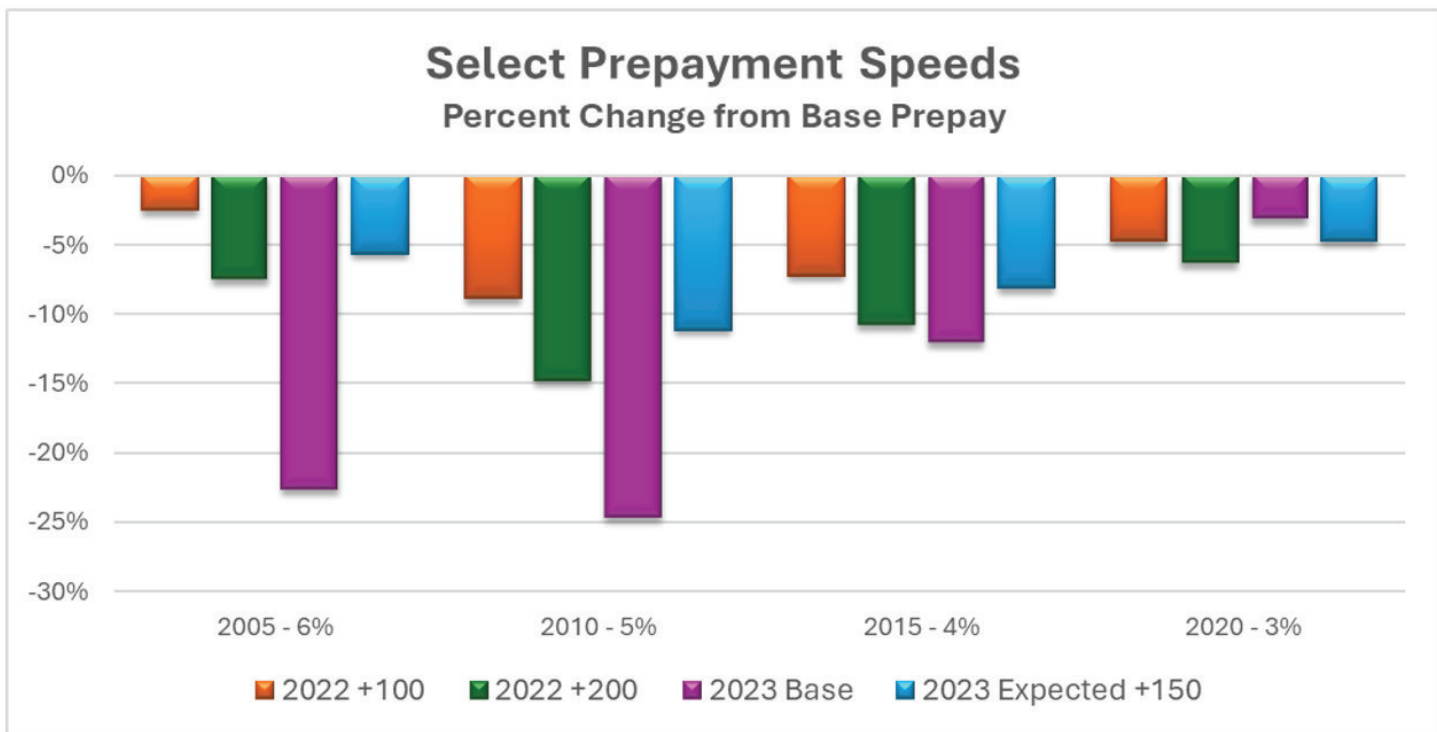
The differing degree of impact can further clearly be demonstrated by showing the shocked prepayment rate percentage change from the 2022 base prepayment rate in the graph below.



Since we now know that the expected basis point equivalent of shocked change experienced between September 30, 2022, and September 30, 2023, was 150 basis points, we can extrapolate starting prepayment curves to derive an expected prepayment rate from September 30, 2022, and compare against September 30, 2023, base prepay rates. The graph below provides this illustration.



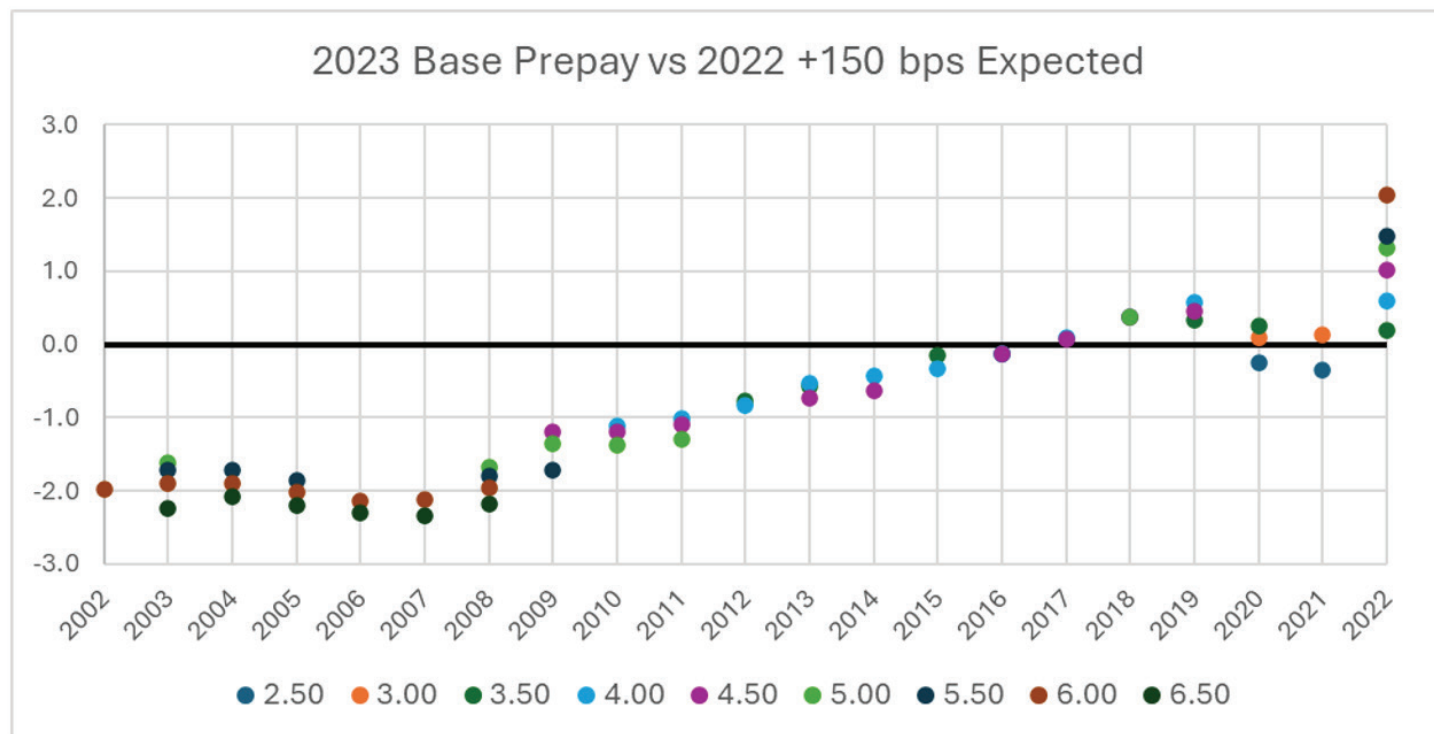
The differing degree of impact can also be demonstrated by showing the shocked prepayment rate percentage change from the 2022 base prepayment rate in the graph below.



These graphs clearly show that in three out of the four tested prepayment year and rate combinations, the 2023 base prepay rate experienced a more drastic reduction in speed than a 150 basis point shock would imply. The expected prepayment speed is mathematically in the center of the expected +100 bps and +200 bps speeds, however, the 2023 base prepay speed is shown to have larger volatility than anticipated in three of the four tested scenarios, specifically on the older vintage 2005, 2010, and 2015 loans. The exception comes from the 2020 3% coupon tested loans in which prepay speeds did not even slow down enough to match the +100 bps projected amount.

Prepayment models are constantly being updated to account for changing market conditions, new economic environments, and shifts in consumer behavior. Even though individual prepayment speeds show certain variances while compared against expected amounts on a year-over-year basis, in aggregate while calculating the cumulative effects across the loans sold portfolio, the resulting weighted average prepayment speeds are very much in line with what the model from September 30, 2022, projected.

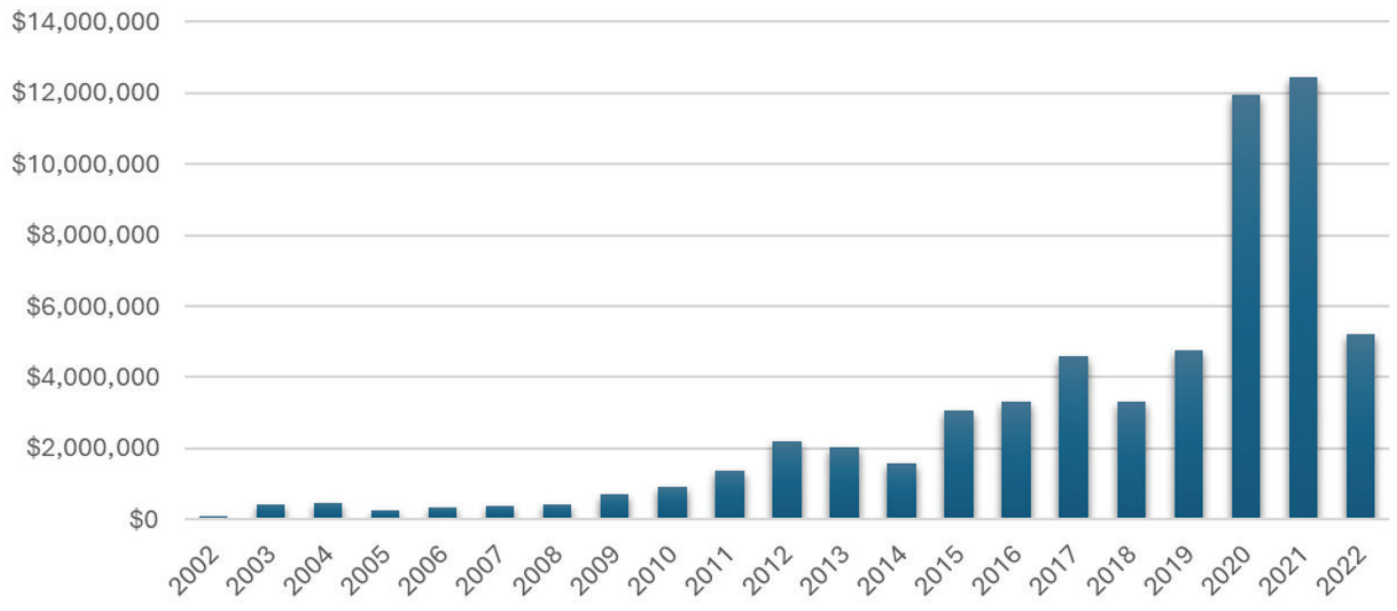
Further evidence can be seen when comparing the anticipated 150 bps shock prepay speeds against the actual 2023 prepay speeds. The chart below shows all 59 combinations of origination year and interest rate relevant for the case study real estate loans sold portfolio. A positive reading indicates that the 2023 base prepay speed, measured in CPR, was higher than the 2022 anticipated level in a +150 bps projected scenario, and a negative reading indicates that the 2023 base prepay speed was lower than the projected amount. Of the 59 speeds, 42 of them were lower than expected, whereas only 17 of them were higher than expected.



In summary, the prepayment model as of September 30, 2022, under projected the slowdown in prepayments for loans originated before 2017, and over projected the slowdown in prepayments for loans originated in 2017 and beyond. Put another way, the number of prepayments made on older vintage loans was lower than the prepayment model estimated and the amount of prepayments made on newer vintage loans was higher than the prepayment model estimated. The prepayment model did correctly estimate the trajectory of prepayments trending down across the board as interest rates continued to rise, and it is shown that the magnitude of variance in expected versus realized change correlates closely to origination year.

The MSR model aggregates projected NPVs across the entire loans sold portfolio to calculate a current value. While 42 individual prepayment speed slowdowns were under projected, the sum of current balances on those loans issued before 2017 account for only \$17.5 million, or 29% of the total outstanding current balances. Meanwhile, 17 individual prepayment speed slowdowns were over projected, but those loans issued in 2017 and after account for \$42.3 million, or 71% of the total. The breakdown of outstanding loan balances by origination year can be seen in the graph below.

Outstanding Balances by Origination Year



To conclude, NPV estimates calculated under the parameters of the New Rates, Same Portfolio case study exercise were directly in line with estimated amounts. Variances were noted on specific origination year prepayment projections, but on a cumulative basis, the results were exactly as anticipated. However, between September 30, 2022, and September 30, 2023, the impact due to a slowdown in prepayments was not as extreme as witnessed between September 30, 2021, and September 30, 2022. Therefore, the discounting effect caused by increasing discount rates as market rates increased was stronger than gross servicing revenue gains due to extending cash flows, and the resultant NPV decreased, as projected by the MSR model.

2. New Rates, New Portfolio

Results from the September 30, 2023, MSR model performed on the case study real estate loans sold portfolio under the parameters of the New Rates, New Portfolio exercise are shown in the table below. These results are calculated using updated prepayment and discount rates as of September 30, 2023, as well as updated loan characteristics including payments made, both scheduled and prepayments, throughout the year. It also includes new loans originated during the time period to replace payments made to bring the overall portfolio outstanding balance back to level with the previous year's amount.

09/30/23	+300 bps	+200 bps	+100 bps	Base Prepay	-100 bps	-200 bps	-300 bps	Zero Prepay
Scheduled Payment	\$37,036,026	\$36,365,323	\$35,422,878	\$33,982,858	\$32,038,071	\$29,780,588	\$26,517,543	\$59,796,605
Prepayment	\$22,760,579	\$23,431,282	\$24,373,727	\$25,813,746	\$27,758,534	\$30,016,016	\$33,279,062	\$0
Total Principal Payment	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605
Weighted Average Life	6.32	6.14	5.90	5.53	5.06	4.56	3.85	11.45
Servicing Fee - Gross	\$931,913	\$905,895	\$870,137	\$814,925	\$744,198	\$668,558	\$562,490	\$1,699,296
Servicing Fee - NPV	\$627,443	\$639,902	\$646,398	\$639,235	\$615,970	\$581,558	\$513,571	\$1,087,683

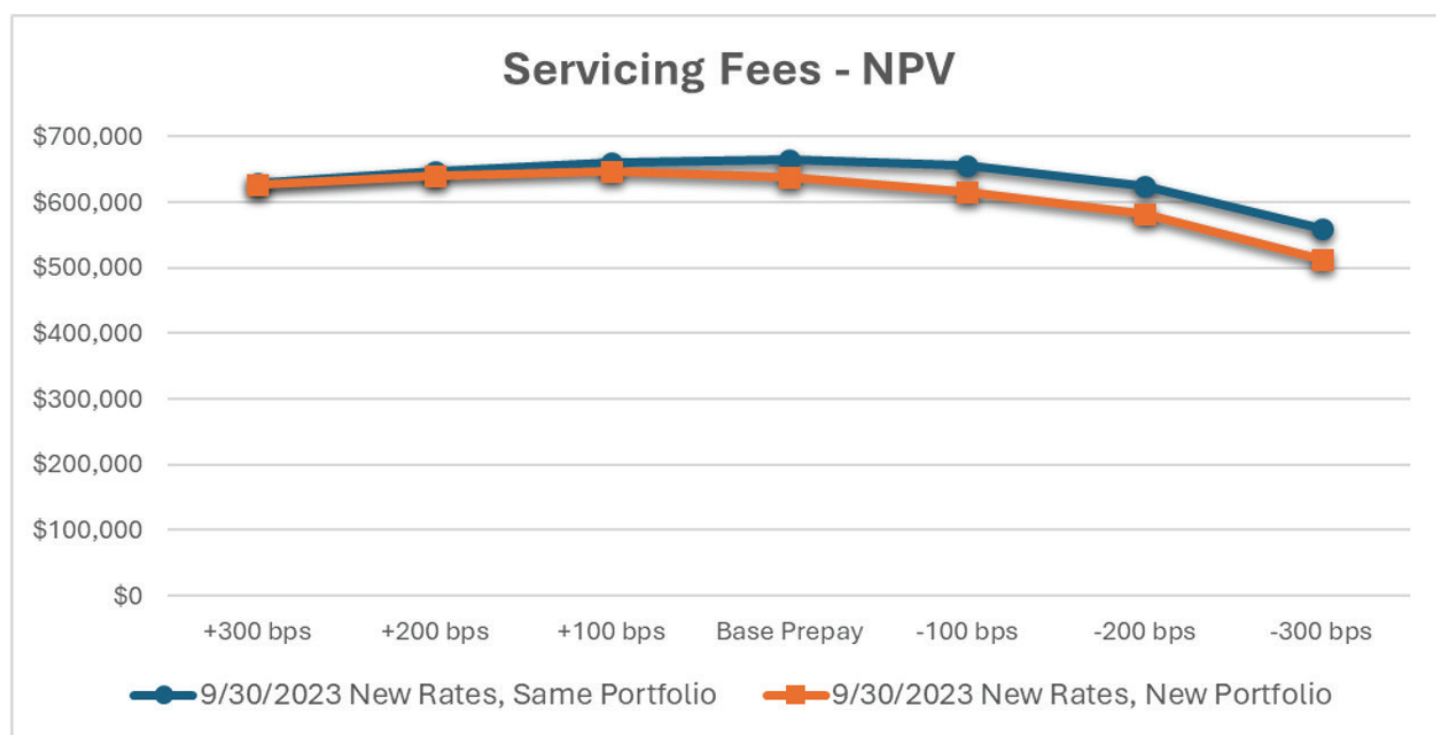
For reference, below are the results from the New Rates, Same Portfolio exercise.

09/30/23	+300 bps	+200 bps	+100 bps	Base Prepay	-100 bps	-200 bps	-300 bps	Zero Prepay
Scheduled Payment	\$37,100,955	\$36,662,977	\$35,998,046	\$34,981,870	\$33,417,962	\$31,199,778	\$27,948,730	\$59,796,605
Prepayment	\$22,695,649	\$23,133,628	\$23,798,559	\$24,814,735	\$26,378,642	\$28,596,827	\$31,847,875	\$0
Total Principal Payment	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605	\$59,796,605
Weighted Average Life	6.27	6.16	6.01	5.77	5.41	4.91	4.20	11.30
Servicing Fee - Gross	\$924,198	\$908,736	\$885,512	\$850,552	\$797,039	\$722,169	\$615,688	\$1,677,100
Servicing Fee - NPV	\$629,723	\$646,604	\$659,558	\$664,821	\$655,520	\$625,149	\$560,350	\$1,099,609

Between September 30, 2022, and September 30, 2023, the case study real estate loans sold portfolio saw \$7.2 million in principal paydown, including scheduled payments and prepayments. The entirety of paid-down balances were replaced with new loans originated and sold under prevailing mortgage rates at time of origination.

The effectiveness of the MSR model during this valuation period was tested and verified under the New Rates, Same Portfolio case study using a back testing exercise. Since the New Rates, New Portfolio exercise contains newly originated loans not present in the 2022 portfolio, a similarly detailed exercise will not be conducted. However, comparing the results of the two simulations can show how the newly originated loans differ in expected prepay and NPVs versus the loans that paid off or paid down. The comparison also reinforces the effectiveness of the MSR model as the New Rates, New Portfolio results are largely in-line with those seen in the New Rates, Same Portfolio exercise, with predictable and explainable differences. Shown below is a comparison of NPV results for the two distinct comparison exercises performed during the third valuation period.

NPV	+300 bps	+200 bps	+100 bps	Base Prepay	-100 bps	-200 bps	-300 bps	Zero Prepay
9/30/2023 New Rates, Same Portfolio	\$629,723	\$646,604	\$659,558	\$664,821	\$655,520	\$625,149	\$560,350	\$1,099,609
9/30/2023 New Rates, New Portfolio	\$627,443	\$639,902	\$646,398	\$639,235	\$615,970	\$581,558	\$513,571	\$1,087,683
Difference (%)	-0.36%	-1.04%	-2.00%	-3.85%	-6.03%	-6.97%	-8.35%	-1.08%



Results from the New Rates, New Portfolio model show a base prepay NPV servicing amount of \$639,235, with that amount decreasing as rates fall. As interest rates rise, the projected NPV amount is anticipated to increase in a +100 bps scenario before tending down in rates +200 bps and +300 bps scenarios. The impact of updating the portfolio with actual payments and newly originated loans has a more severe impact on expected NPV amounts in rates-down simulations than in rates-up. There are two main factors impacting the NPV of servicing income: prepayment projections and discount rates.

- **Impact of Prepayment Rates:** As indicated earlier, September 2023 was a period following rapid and dramatic rate increases. Mortgage rates had been at near historic lows for an extended period of time during 2019, 2020, and 2021 before sustaining quick increases that continued into this case study's third valuation period between September 2022 and September 2023. Mortgage holders with loans originated prior to 2019 had ample time and opportunity to refinance to a lower rate. The ones that did not, for a variety of reasons, now lost that opportunity and are also viewed within prepay models as unlikely to do so at a future date, regardless of their financial incentive. That change in expected behavior for older vintage loans was again reinforced as prepayment rates as of September 30, 2023, are largely projected to be lower than September 30, 2022, forward looking projected levels would have implied, as discussed in the previous section.

As a result, prepayment speeds on older vintage loans show minimal volatility during rate shock scenarios as behavior by mortgage holders has proved to be largely unaffected by changing market rates. Additionally, loans originated during 2019, 2020, and 2021 have low interest rates, well below new market levels, and therefore are unlikely to refinance in the near-term. Loans issued during the first modeling period between September 30, 2021, and September 30, 2022, have interest rates ranging from 3.50% up to over 6.00%, and loans issued during the second modeling period between September 30, 2022, and September 30, 2023, have interest rates ranging from 5.80% to 7.23%, highlighting the rise in market rates during these periods. These new loans, especially those with a higher coupon including the entirety of newly issued loans during the third valuation period, are more susceptible to prepayment risk in decreasing rate environments, which is why the New Rates, New Portfolio shows a greater degree of volatility as interest rates decrease than in the backtesting exercise conducted in the New Rates, Same Portfolio exercise.

In short, scheduled and unscheduled payments were replaced with new, higher interest rate loans that shift the cumulative risk profile towards greater prepayment risk, and therefore greater risk of declining NPVs as rates drop and cash flows shorten. The new base prepay, +300 bps, and -300 bps tables for 30-year mortgages within the case study loans sold portfolio can be seen below. Notice the sharp rise in prepayment projections on 2022 and 2023 vintage loans under the -300 bps shock scenario.

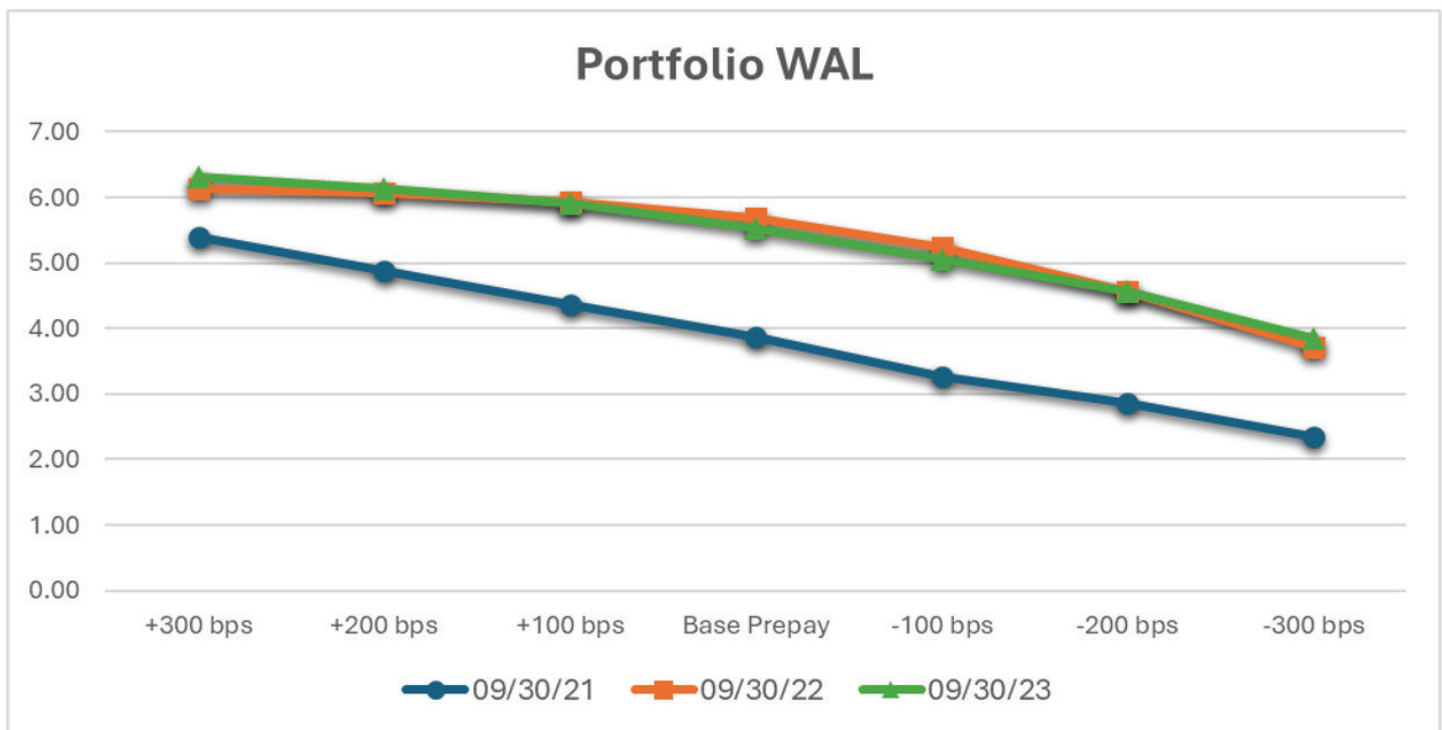
Base Case																						
30-Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
2.00																						
2.50																			5.3	5.0		
3.00																			6.1	5.8		
3.50											6.8	6.8		6.7	6.7			6.7	6.8		5.4	
4.00									7.2	7.1	7.2	7.2	7.2	7.3	7.3	7.0	6.9	7.2			5.9	
4.50								7.8	7.5	7.4		7.6	7.6		7.8	7.7	7.7	7.8			6.6	
5.00		10.4					8.4	8.0	7.6	7.5							8.7				7.4	
5.50		10.3	9.6	9.3			8.6	8.1													8.4	
6.00	10.7	9.9	9.4	9.2	9.1	8.9	8.8														10.1	10.3
6.50		9.9	9.4	9.3	9.2	9.0	8.9														12.3	12.8
7.00																					14.2	14.5

+300																						
30-Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
2.00																						
2.50																			4.6	4.4		
3.00																			5.3	5.0		
3.50											6.3	6.2		5.9	5.9			5.5	5.9		4.3	
4.00									6.6	6.5	6.5	6.5	6.4	6.5	6.4	6.0	5.5	5.9			4.3	
4.50								7.2	6.8	6.7		6.7	6.7		6.8	6.5	6.3	6.4			4.5	
5.00		9.8					7.7	7.2	6.8	6.7							7.0				4.8	
5.50		9.7	8.9	8.6			7.8	7.3													5.1	
6.00	10.1	9.3	8.7	8.5	8.4	8.1	7.9														5.5	5.3
6.50		9.2	8.7	8.6	8.5	8.2	8.0														6.1	5.8
7.00																					6.9	6.7

-300																						
30-Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
2.00																						
2.50																			8.7	8.3		
3.00																			10.1	9.5		
3.50											9.2	9.4		10.4	10.4			13.4	11.9		12.3	
4.00									10.3	10.1	9.8	10.9	11.3	11.1	11.3	12.6	15.5	15.2			19.4	
4.50								11.0	11.1	11.0		11.7	11.7		12.4	13.7	15.5	15.3			25.3	
5.00		11.9					11.3	10.7	10.8	10.9							15.7				26.4	
5.50		11.8	11.1	11.1			11.2	10.3													28.9	
6.00	12.2	11.5	10.8	10.9	10.8	10.8	10.8														34.7	38.5
6.50		11.4	10.9	10.9	10.6	10.4	10.4														36.5	38.5
7.00																					36.2	37.1

- **Impact of Discount Rates:** The new yield curve as of September 30, 2023, is elevated and more inverted compared to September 30, 2022. Under a traditional upward sloping yield curve, cash flows farther out have a larger discount rate than near-term cash flows. However, with an inverted curve, the opposite is true. Additionally, with the short end of the curve increasing at a faster rate than the medium and long portions, discounting of short-term cash flows has a larger relative impact on year-over-year change than longer duration cash flows.

The loans sold portfolio is now in a position where NPVs are again expected to decrease as interest rates drop due to accelerated prepayments shortening the cash flows on which servicing income is earned. As rates increase, cash flows extend and the WAL of the portfolio increases to 6.32 years in a +300 bps scenario from 5.53 years in a base prepay scenario, a gain of 0.79 years. The projected WAL curves between September 30, 2021, September 30, 2022, and September 30, 2023, can be seen below. The majority of the loan portfolio's extension occurred as interest rates rose between September 30, 2021, and September 30, 2022. Changes between September 30, 2022, and September 30, 2023, are more nuanced and dependent on individual vintages and rates of the underlying loans rather than a broader across the board extension.



Simply put, cash flow extension on older vintage loans already occurred as rates increased between the testing periods in 2021, 2022, and 2023, and any additional increases in rates have minimal further impact. Newer originated loans in the higher rate environment of 2022 and 2023 have significant prepayment risk in down rate environments as incentives for refinance increase. As the composition of the loan portfolio shifted in 2023 due to older vintage payments and origination of new loans, the risk profile of the cumulative portfolio began skewing towards higher risk to the downside caused by accelerating prepayments in decreasing interest rates shock scenarios. Conversely, rates are already elevated and further increases have minimal incremental impact on projected prepayment behavior.

As a result, in the battle between cash flow extension from prepayment slowdown and an increase in discounting rates, the two competing forces lead to uneven results as NPVs are forecasted to slightly increase in a +100 bps scenario before trending down as higher discount rates eventually win the battle.

In a rates down scenario, NPVs are still forecasted to decrease, same as the prior years. Legacy loan holders from before 2019 are less likely to change their payment behavior as rates decrease if they did not take advantage of the 2019 through 2021 low-rate environment and refinance. New loans issued in 2022 and 2023 with a higher coupon are likely to prepay or refinance if rates drop significantly, leading to a continuation of the volatility introduced in the second valuation period. The shortening of cash flows caused by those elevated levels of prepayments in rates down scenarios has a larger impact than the reduction in discount rates, leading to declining NPVs as interest rates decline.

(d) Case Study Conclusion

In summary, the Federal Reserve increased the Fed Funds rate from a range of 0.00% to 0.25% all the way to a range of 5.25% to 5.50% during our valuation periods in this case study. This resulted in sharp increases in mortgage rates and increases across the treasury curve, ultimately ending in an elevated and inverted curve still in place today. The risk profile and expected NPVs of servicing income for the case study real estate loans sold portfolio saw drastic changes as the underlying loans reacted to changing prepayment expectations and increasing discount rates.

QuantyPhi's MSR model accurately predicted both the direction and magnitude of impact changing interest rates would have on NPVs. This case study is a real life example showing the effectiveness of QuantyPhi's MSR model, as well as highlighting the importance of understanding the composition of your loans sold portfolio, the variables that impact the resulting NPVs, and stressing the significance of viewing your MSR valuation through an ALM lens, and testing and understanding the various impacts your balance sheet asset will undergo as market rates change.

It is imperative to perform a thorough valuation of your real estate loans sold portfolio at least annually and more frequently if market rates change significantly. It is also important to value your entire portfolio, not just newly originated and sold loans, to capture the always shifting dynamics of prepayment expectations for all loan vintages. Credit unions need to record the NPV of their loans sold with servicing retained portfolio as an asset on their balance sheet. This case study has provided evidence of the severe impact changing market rates can have on that asset value. QuantyPhi has built a sophisticated and thorough model to help you perform these valuations and will provide model results across a range of interest rate shock scenarios and the supplemental data you need to understand your risk profile.

As a trusted credit union partner for balance sheet risk management, QuantyPhi is eager to help you incorporate advanced MSR valuation capabilities into your broader planning, strategy, and forecasting activities.