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MSR Convexity Risk Explained – Part 1

For hedging purposes, convexity risk is a very important driver of MSR hedge cost and effectiveness, but it is not necessarily an easy concept to grasp. The purpose of this paper is to describe MSR convexity risk in terms that are easy to understand, to illustrate how to identify convexity risk in an MSR rate shock profile and risk metrics, and to explain the relationship between MSR convexity risk and projected prepayment speeds. At the time of writing in December 2019, mortgage rates are near historic lows and many MSR portfolios are deep "in-the-money", which means that they have large refi incentives. As explained below, as the refi incentive increases, there eventually comes a point at which MSR convexity turns positive, and many MSR portfolios are at or near that point now. This is not intended to be a discussion of this current, unusual phenomenon, but rather a more general discussion of MSR convexity risk as it has been observed in the past from higher rates and less "in-the-moneyness".

Identifying Convexity Risk in MSR Value Curve and Risk Metrics

The examples that follow will be more helpful than definitions and formulas, but we must start with some basic definitions. Convexity is closely related to duration as follows: Duration measures the sensitivity of value to changes in rates ("first order"), and convexity measures the sensitivity of duration to changes in rates ("second order").

In the examples that follow, we will use the following generic MSR portfolio with unpaid principal balance of $3 billion.

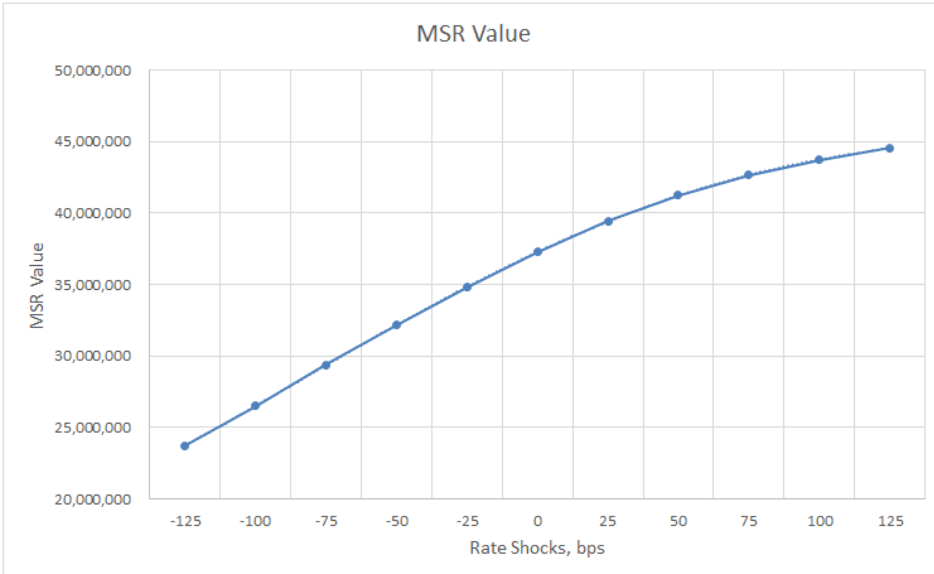
Figure 1:

	MSR Value at Rate Shocks										
	-125	-100	-75	-50	-25	0	25	50	75	100	125
MSR Value	23,700,856	26,518,134	29,344,335	32,151,085	34,812,475	37,249,269	39,415,683	41,246,608	42,652,681	43,709,236	44,532,778
Change from Base	(13,548,413)	(10,731,135)	(7,904,933)	(5,098,184)	(2,436,793)	0	2,166,414	3,997,339	5,403,413	6,459,967	7,283,509

You can get an idea of the convexity risk from the value change profile. Notice that the losses at the DOWN shocks are greater than the gains at the UP shocks. This is the first sign of negative convexity. The larger the difference between the loss at a DOWN shock and the gain at an UP shock, the greater (more negative) the convexity risk.

The convexity risk can also be observed from the shape of the value curve below.

Figure 2:



If the curve takes the shape of a "crooked frown", it is negatively convex. If it looks like a "crooked smile", it is positively convex, and if it looks like a straight line, then there is little or no convexity. This curve looks like a crooked frown, so it is negatively convex.

Now let's calculate the DV01's at the shock points. DV01 is a measure of duration risk. It stands for the Dollar Value of 1 bp, and it measures the change in value for a -1 bp change in rates. In this case, it is calculated based on +/-25 bp shocks around each point on the profile.

Figure 3:

	Rate Shocks, bps										
	-125	-100	-75	-50	-25	0	25	50	75	100	125
DV01	(103,287)	(112,870)	(112,659)	(109,363)	(101,964)	(92,064)	(79,947)	(64,740)	(49,253)	(37,602)	(30,612)

Starting from the zero shock or center point, notice that the DV01 decreases as rates fall (larger negative values) and increases as rates rise (smaller negative values). This is another sign of negative convexity. Stated in terms of duration risk, the MSR asset gets shorter in a rally and longer in a back-up, which is another definition of negative convexity. The hedging implications of MSR convexity will be covered in Part 2, but this is a good point to introduce a hedging concept. If you are hedging a position that gets shorter in a rally and longer in a back-up (with Treasuries or Swaps only), then you are forced to add duration at higher prices and shed duration at lower prices. As you do this over time, you will most likely incur losses due to "whipsaw" or retracement, which is a cost of hedging a negatively convex asset.

Now let's calculate the convexity at the shock points. The convexity metric that we will use is "CV01", which is the change in the DV01 for a -1 bp change in rates.

Figure 4:

	Rate Shocks, bps										
	-125	-100	-75	-50	-25	0	25	50	75	100	125
CV01	752	14	(31)	(233)	(359)	(433)	(537)	(680)	(559)	(373)	(186)

The interpretation of the CV01 is as follows: At the zero shock or center point, the DV01 in Figure 3 above is -$92,064. If rates fall by 10 bp, the DV01 is expected to change to -$96,394 (-92,064 plus -4,330), and if rates rise by 10 bp, it is expected to change to -$87,734 (-92,064 minus -4,330).

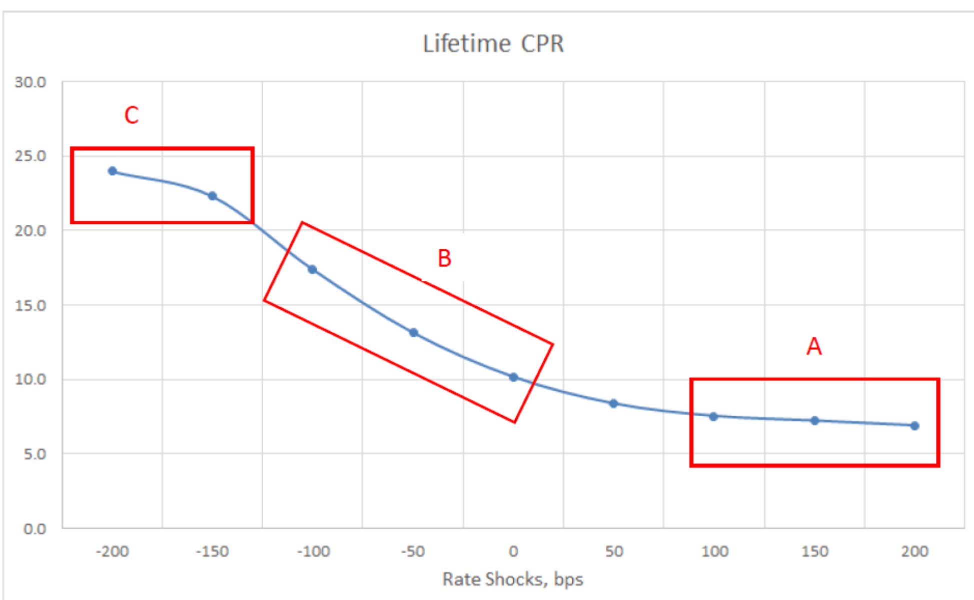
A couple of observations:

- Convexity is negative until you get down to very low rates (which is again not far from where we are at the time of writing)
- There is an inflection point at UP 50 bp. This is the point at which prepayment speeds start to accelerate due to refinancing activity. You can also see the large step-up in DV01 around that point in Figure 3.

Prepayment Curve

Now that we have defined convexity risk and learned how to spot it in the MSR value profile and risk metrics, let's now discuss the source of convexity risk. In a nutshell, the size and sign of convexity risk depends on the shape of the curve of projected prepayment speeds. The curve below shows the modeled lifetime prepayment speeds in CPR for this MSR portfolio at different levels of rates. This is sometimes called the 'S-curve" because of its shape. The three sections labeled A, B and C are discussed below.

Figure 5:



Section A: Prepayment speeds are mostly insensitive to rate changes because prepayments are dominated by purchases. There is very little convexity at these rates, as you can see on the CV01 table above (Figure 4).

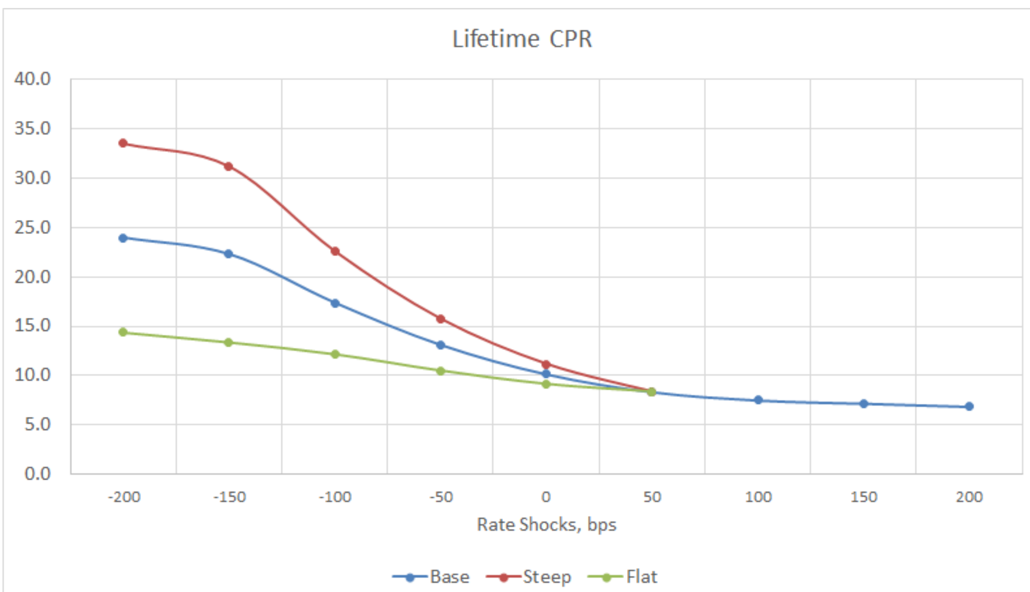
Section B: Prepayment speeds ramp up as refi's kick-in. This is called the 'Refi Elbow'. **The steepness of the refi elbow is the biggest driver of MSR convexity risk**, as discussed further below.

NOTE: In an OAS model, convexity risk is also affected by the volatility inputs to the interest rate model, as well as the shape of the yield curve. For this discussion, we used the rate shock profile from a static valuation model to measure the DV01, CV01 and lifetime CPR. If you prefer OAS models, you can think of it as an OAS profile assuming constant OAS, constant volatility and parallel shocks to the yield curve.

Section C: Refi speeds decelerate as MSR portfolio goes deeper in-the money, and the remaining loans have proven to be less responsive to rate changes. This is called 'burnout'. MSR convexity is positive at these points.

Finally, we will now explain how the steepness of the refi elbow drives MSR convexity risk. The prepayment 'S-curve' is shown again below, with two additional, hypothetical curves added.

Figure 6:



It is a very simple rule: **The steeper the refi elbow, the worse (more negative) the MSR convexity risk**. So, the Steep curve would create more convexity risk (larger negative CV01 values) than the Base curve, and the Flat curve would create less convexity risk (smaller negative or even positive CV01 values).

Evidence of this relationship can be seen in the MBS market, in which originators and resellers create "Specified Pools" of mortgages with characteristics that are historically less responsive to refi incentives; i.e., they have a flatter refi elbow. The largest such category of specified pools is Low Loan Balance pools. These pools trade at a pay-up to TBA's because they have less convexity risk.

Finally, if you see an MSR profile that looks too good to be true from a convexity standpoint, check the lifetime CPR's at the rate shocks. You might find that the refi elbow is mild or missing altogether, just as the elbow is missing from the Flat curve above. If so, the next question is whether there is something special about the MSR portfolio that makes it less responsive to refi incentives than the mortgage universe as a whole, such as small loan sizes, low FICO's or geographic concentration in states that have slower refi speeds, such as New York. If not, then we would recommend close examination of the prepayment model to ensure that projected refi speeds at lower rates are fully capturing the prepayment risk.

In Part 2 coming soon, we will discuss the implications of negative convexity on MSR hedge performance and costs. We will also review some hedging strategies to manage MSR convexity risk.